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Functional Requirements and Clinical Scenarios v1

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

Dem@Care - FP7-288199

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Other contributors:	Ioannis Kompatsiaris (CERTH), Athina Kokonozi (CERTH).
Authors (Partner)	Kate Irving, Desmond O'Mahoney (DCU), Veronique Journier (CHUN), Stefan Sävenstedt (LTU)
Responsible Author — **Name**	Kate Irving (DCU)
Responsible Author — **Email**	kate.irving@dcu.ie
Internal Reviewer(s)	Prof. Magda Tsolaki.
EC Project Officer	Griet Van-Caenegem
Abstract **(for dissemination)**	This report details the application scenarios and describes the Functional Requirements defined at this stage of the project. It also presents the methodology and outcomes of the process towards determining the first functional requirement parameters for Dem@care.

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Executive Summary

This report contains the details of the application scenarios defined by the medical team of the project and the first set of clinical requirements defined by the same team after several feedback iterations from the technical partners.

It also includes a state of the art literature review on assistive technologies for diagnosis, enablement and safety; a report of two Focus Groups with professional and informal carers of people with dementia culminating in an iterative process of mapping the functional needs and the various prioritisations by partners.

Functional requirements defined at this stage of the project are can be found in Appendix 7. Appendices 1- 6 contain Power Point presentations used in the Focus Groups discussions.

Abbreviations and Acronyms

PwD	Person(s) with Dementia
(AD)	Alzheimer's disease
ICT	Information and Communication Technologies
MCI	Mild Cognitive Impairment
WHO	World Health Organization
ESM	Experience Sampling Method
ADL	Activities of Daily Life
IADL	Instrumental Activities of Daily Life
EEG	Electro-Encephalogram
ECG	Electro-Cardiogram
EOG	Electro-Oculogram
CES	Cranial Electrical Stimulation
MSB	Mini Stationary Bike
PSMS	Personalised Self Management System
SPT	Stimulated Presence Therapy
EMA	Electronic Memory Aid
GPS	Global Positioning System
SMS	Short Message Service
CANE	Camberwell Assessment of Needs for the Elderly
BPSD	Behavioural and Psychological Symptoms of Dementia

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1   Introduction

Deliverable 2.2: Functional Requirements and Scenarios v1, is the first deliverable in WP2 alongside the ethical literature review. This report details the methods used to develop the functional requirements and the results of these processes. The main concepts that have underpinned the work in this deliverable are the central role that the user plays in this work package and that, at this early stage of the research we need to maintain broad interests to allow for personalisation of the final system. The first objective of this report is to give a state of the art overview of the literature pertaining to technology for people with dementia. The second objective is to report the results of the user needs and acceptability focus groups held by CHUN and LTU with carers of a person with dementia (PwD) and with health care professionals involved in the care of PwD.

Three main themes have been identified for the project. The first focuses on early stage dementia or MCI to investigate to what extent technologies can assist in the **diagnosis** of dementia. The objectives are not only in the diagnosis of dementia through assessment of functionality but also the diagnosis of related states such as apathy, depression and balance problems.

The aim of the second theme is to investigate at which extent technology can enable independence and provide **enablement and support** in the early stages of dementia. While typically decline in functional status is most notable at a later stage, more subtle deterioration in areas such as sleep quality and meal preparation can occur at early stages of dementia and are thus suitable for assessment.

The third theme, addresses the needs for **safety** arising for PwD. Enabling people with dementia can reduce risks to their wellbeing. Our system intends to enable people to maintain activity, social connectivity and general independence maintenance. However, with independence comes risk and these will have to be carefully weighed and addressed for each individual.

The project will examine how these themes can be addressed in three different environments: (i) in controlled laboratory-based, i.e. an experimental room equipped with daily objects and adequate monitor and sensing technologies, focusing on the diagnosis theme, (ii) the everyday

home environment of the PwD allowing more personalized, long-term and comparative monitoring also suitable for support and safety themes and (iii) people living in nursing homes, and the extent to which technology can support them or support the staff caring for people in nursing homes. Sections of this report will be very pertinent to the third theme, however it will be more fully explored in a future version of the functional requirements and clinical scenarios, on Month 21.

The report draws together a template of functional requirements that can be drawn on in each of the three themes above and will allow for personalisation of the system, to suit the needs of the PwD, carer and research ethics.

2   State of the Art

This review is organised into several sections for ease of reading. The first section covers the published literature on the use of technologies for diagnostic purposes. The second section looks at technology for enablement, support and safety and is guided by research on the promotion of cognitive health. The research into user needs is presented and more details are given on the three environments addressed in this research, the laboratory environment, the home environment and the nursing home.

2.2   Technology for diagnosis of PwD

Clinical expertise and scientific literature review has indicated that ICT is not able today to provide a direct diagnosis of Alzheimer's disease (AD) and related disorders. Diagnosis remains a complex process of exclusion of other illnesses with no definite biological markers. However ICT provides information for the assessment of specific domains (behaviour, cognition, activity of daily living). So these indicators contribute with other clinical and biological data to the diagnosis of AD and related disorders. The following paragraphs describe recent studies in different clinical domains where ICT was used as a consideration in the diagnosis of AD and related disorders. In addition the boundaries of what is normal and what is MCI and what is dementia are known to be very indistinct and individual. Psychometric tests can give us some perspectives on a person's status however ICT has the potential to explore these boundaries from an alternative perspective adding more sophistication and in the future less stress to the person in the process of making a diagnosis.

2.2.1   Assessment of behavioural disturbances

Ambulatory Actigraphy is widely used to monitor locomotor activity based on a sensor placed on the chest or the wrist of the person. This technology was proposed as an observer-independent assessment method in different disorders including sleeping/waking disorders

(Yesavage et al., 1998; Paavilainen et al., 2005; Boonstra et al., 2007*)*, attention deficit and hyperactivity disorder (Dane et al., 2000), agitated behaviour in neurodegenerative disorders (Mahlberg et al., 2007; Nagels, 2006*)*, as well as psychomotor retardation in psychiatric disorders (Volkers et al., 2002). More recent studies have shown also the interest of this technology to assess behavioural and psychological symptoms in dementia such as the severity of apathy in patients with dementia (David et al., 2010; David et al., 2011; Müller et al., 2006; Kuhlmei et al., 2011). Results of these studies showed that motor activity (expressed by the mean of motor activity) was correlated negatively with apathy scores on neuropsychiatric assessment scales validating the use of this objective assessment for evaluating the self-initiated action of participant during different time period of observation in different environments (controlled and uncontrolled).

2.2.2 Assessment of cognitive abilities

Plancher (2011) used virtual reality for characterizing episodic memory profiles in amnestic mild cognitive impairment and Alzheimer's disease and the influence of active and passive encoding. Three different populations: healthy older adults, patients with amnestic mild cognitive impairment, and patients with early to moderate Alzheimer's disease were included. Participants were successively immersed in two virtual environments: the first for an active exploration (as a driver of a virtual car) and the second for a passive exploration (as a passenger of a virtual car). Participants were instructed to encode all elements of the environment as well as the associated spatiotemporal contexts. Following each immersion, participant's recall and recognition of central information, contextual information and lastly the quality of binding were assessed and were compared with classical memory test and a subjective daily memory complaint scale. Results highlighted specific cognitive differences between the three populations that may provide additional insight into the early diagnosis and rehabilitation of pathological aging.

2.2.3 Assessment of physical activity

Scientific literature review shows that studies of physical activities in elderly people are essentially focused on three different types of physical activity: gait and postures assessment,

and activity patterns (mobility) assessment.

Firstly, several studies focused on the gait parameters description (e.g., walking speed, stride, length step) using two type of technology. GaitRite System based on a carpet including 26 000 pressure sensors was used to analyse gait by measuring spatio-temporal parameters. From this system, Chamberlain (2005) showed gait pattern differences (walking speed, stride length/width, and double support time) in patients with a preexisting fear of falling. Moreover, Sterke (2012) showed that gait parameters as measured with GaitRite System can be also used for the prediction of short-term fall risk in nursing home residents with moderate to severe dementia. Then, using the same technology, two studies showed that cognitive impairment in dual tasks modify gait pattern directly as well as indirectly through decreased gait velocity (Hollman et al 2006; Van Iersel et al., 2007) in healthy and physically fit elderly patients living in community. Triaxial accelerometers were also used to discriminate walking type between healthy young and elderly participants and then classify participants' walking type according to groups defined based on a wavelet-based fractal analysis of the acceleration signal (Sekine et al., 2002).

Secondly, analyses of posture based on accelerometers technologies ActivPAL are also conducted to qualify the level of physical activity in elderly people (Denkinger et al., 2010; Taraldsen K et al, 2011) but results of technological performance are not yet so promising to extract clinical conclusions.

Thirdly, Hayes (2008) described an integrated system using X-10 motion sensors and contact sensors to monitor participants' activity patterns in the home as well as comings and goings from the home. This unobtrusive and continuous in-home assessment highlighted that Mild Cognitive Impairment patients had greater variation of activity daily pattern than healthy control participants. So these results show that this system could be used for an early detection of clinically relevant changes not only affecting cognition but for a number of other neurologic and general medical conditions.

2.2.4   Assessment of activity of *daily* living completion

ANR TecSan Sweet-Home project (Romdhane et al, 2012) based on the use of an Automatic Video Monitoring System purposes an ecological assessment of functional and

cognitiveabilities of elderly people. This assessment takes place in an experimental room equipped with daily objects (controlled environment). During this clinical protocol, participants have to complete predefined activities (physical exercise, carry out instrumental activities of daily living such as preparing some tea or watching TV according to specific order). During all the assessment, participants are recorded by 2D video camera capturing all their activities in the room. After recording session, data are processed by a platform of video signal analysis for extracting kinematic parameters about the participant gait profile (e.g., walking speed) and detecting activities undertaken by the participant and assessing their performance to carry out them correctly with the respect of instructions given. Results showed that patients with dementia need more time to complete activities and had more difficulties to organize correctly the list of activities.

2.2.5 Summary

Technology has much to offer the state of the art in contributing to a diagnostic procedure and to the tracking of the disease process when a diagnosis has been made. For the foreseeable future diagnosis will remain a complex procedure involving many different metrics. Dem@care is committed to building on the available metrics to inform a diagnosis. There are many authorities such as Alzheimer's Europe and the WHO, which support the view that diagnosis is the most important step towards empowering and being able to support PwD. Time to diagnosis from first complaint varied widely across the European member states. The sooner someone can get a diagnosis the sooner they can plan for the future, assert their wishes and develop coping strategies that will support them in the inevitable frustrations of living with dementia.

2.3 State of the art technology for enablement of PwD

Technology has been identified as one tool that can be used to support independent living and improve quality of life for people with mild dementia and their carers (Topo 2009). Assistive technologies may take several forms, for example, devices that are operated by the person with dementia, systems or devices that others have installed or maintain, or monitoring and

surveillance systems and devices (Cahill, et al. 2007). State of the art assistive technology has the potential to enhance the lives of people with dementia and their caregivers through detecting and compensating for functional decline, delaying the onset of disablement and postponing movement to residential care (Sixsmith, et al. 2007). Such technologies primarily include cognitive aids and physiological and environmental sensors, which can help to maintain skills and support independence and personal identity. Technologies being developed to support Instrumental ADL in people with mild dementia, however, run the risk of doing things for people with dementia rather than with them. This could become problematic as it threatens their ability to do things for themselves (Astell 2006). Assistive technology should therefore assume a holistic view of the quality of life of the individual and emphasise proactive, rather than reactive, management of the illness and independent living (Biswas, et al. 2010).

Recent advances in computing technologies, telecommunications and the widespread uptake of the Internet have presented new and innovative ways in which care can be provided (Nugent 2007). However, issues surrounding how people with dementia interact with state of the art technologies need to be addressed. Recent research suggests that people with dementia have difficulties using technology such as mobile phones and computers (Rosenberg, Nygård and Kottorp 2009). With this in mind it is recommended that technology designed for people with dementia should require very little learning, look familiar, and not remove control from the user. In accordance with previous research, technology designed for people with dementia should adhere to the following principles;

- User interaction with assistive technology (AT) should be kept to a minimum (Orpwood, Gibbs, Adlam, Faulkner & Meegahawatte, 2005; Bjorneby et al., 2004; Orpwood, Faulkner, Gibbs & Adlam, 2003), intervening only to provide prompts. Over-complex technology will discourage the user from engaging (van Hoof & Kort, 2009).

- Appearances should be familiar, since persons with dementia will have difficulty learning to use new technologies (Orpwood et al., 2005; Bjorneby et al., 2004; Orpwood et al., 2003). AT should be familiar to the person with dementia, not the

designer. AT can be built into pre-existing familiar devices, such as televisions and radios (van Hoof & Kort, 2009), ideally items that would be familiar from the user's early adulthood (Fleming, Forbes &Bennett, 2003).

- Design needs to be empowering, encouraging the person with dementia to solve their problems themselves rather than taking control away from them (Orpwood et al., 2005; Bjorneby et al., 2004; Bjorneby, Topo & Holthe, 1999; Orpwood et al., 2003). Empowerment can take the form of memory support, communication enablement and entertainment.

- AT needs to be reassuring since persons with dementia can often become confused (Orpwood et al., 2005; Bjorneby et al., 2004; Orpwood et al., 2003). This can take the form of vocal messages from loved ones.

- Design needs to take into account the fact that human behaviour is highly variable, and algorithms should be developed on the basis of a large amount of real-life data (Orpwood et al., 2005; van Hoof & Kort, 2009).

- AT needs to be fiddle-proof and robust, since persons with dementia will often fiddle with unfamiliar devices (Orpwood et al., 2005; Adlam et al., 2004; Orpwood et al., 2003).

- Finished AT products should have an aesthetic too – the person with dementia will have to live with them and accept them (van Hoof & Kort, 2009).

- AT products should benefit the person with dementia, and be person-centred, rather than carer-centred (Bjorneby et al., 2004; Bjorneby et al., 1999).

- AT should give a feeling of independence to the person with dementia (Bjorneby et al., 1999)[6].

- AT should treat the user as a person with abilities (Bjorneby et al., 1999), rather than emphasising disabilities.

- AT should be designed firstly with carers, since prototypes are often problematic. Only when the product is more mature should it be introduced into the life of the person with dementia (Orpwood et al., 2003).

- Design needs to emulate carer behaviour (Orpwood et al., 2005; Orpwood et al., 2003)' reminding, supporting and reassuring the person with dementia.

Furthermore, Kenner (2008) has suggested that people with dementia are in danger of becoming surveillance targets as technologies designed to support them to age in place, are, infact, creating a new form of social control. In order to counteract this it is important to place the emphasis on technologies that can be used to maximise independence of people living with dementia. This can be achieved through the inclusion of people with dementia in the development of new technologies so that they can be tailored to their specific needs (Wallace et al. 2010). Although there are some issues in relation to acceptance of new technology by people with dementia, research has shown that effective use of new technology occurs when it satisfies an unmet need and when the usage design reflects the typical cognitive profile of the user (Westphal, Dingjan and Attoe 2010).

Five major focuses of clinical phenomena have been explored in depth in terms of what technology can offer to PwD: Sleep, Activity / Exercise, Activities of Daily Live and Instrumental Activities of Daoily Life (IADL), Social Connectivity and Mood. These are fundamental human needs but also represent some specific threats to people with dementia. They have all been implicated as warning signs for admission to long terms care or as particularly correlated with poor cognitive health. It is important to note that a person with early stage dementia may face challenges in one or more of these areas, which suggests that a personalised approach to supporting challenges in these areas is preferable. Adopting a personalised approach ensures that persons with early stage dementia will not receive support in areas in which they are still functioning well, since this may lead to loss of skills. Each area of focus will be discussed in turn.

2.3.1 Monitoring and enablement of optimal sleep pattern

Degenerative neurological disorders that cause dementia are known to intensify age-related changes in sleep (Deschenes and McCurry 2009). These age-related changes may include falling asleep earlier and awakening earlier, more fragmented sleep patterns, insomnia and sleep apnoea-hypopnea (Augusto, et al. 2011). 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 (McCurry, et al. 2008). Sleep disturbance could potentially have far-reaching negative consequences for the person with dementia. Research suggests that there is an important association between the severity of sleep disruptions and cognitive and functional decline in Alzheimer's Disease (Cooke, et al. 2009). Disordered sleep patterns canimpact on the quality of life of the person with dementia and lead to increased behavioural problems. This in turn can put additional pressure on caregivers and lead to early institutionalisation and risk of injury (Eeles 2006). Once disordered sleep patterns are established they can be difficult to change, therefore the prevention of such patterns through regulation and monitoring is essential. The Dem@Care system aims to measure factors such as sleep onset, duration, wake time and number and length of night-time awakenings. Sleep quality is known to deteriorate in late life and is not solely associated with late stage dementia; a more subtle and insidious decline can be observable among cognitively intact older adults, and those with mild cognitive impairment, or early stage dementia (Ancoli-Israel, 1997; Beaulieu-Bonneau & Hudon, 2009; Vitiello, Prinz, Williams, Frommlet & Ries, 1990). By monitoring specific metrics and searching for subtle changes in sleep patterns, we can better manage and predict more pronounced sleep pathologies common as dementia progresses. This fine-grained approach to data collection will be common to all functional areas of interest in the current research, since it is important to note that difficulties in these areas are not specific to persons with advanced dementia. In addition to nocturnal sleep patterns the system should monitor day-time sleeping behaviour and ambient light and sound levels in the home. State of the art technology is continually being developed to monitor these factors in order to facilitate optimal sleep patterns in people with mild dementia.

Measurement of Sleep Architecture

Advances in technology are enabling a move towards accessible and affordable home sleep testing (HST) (Golish 2008). Sophisticated wireless monitoring devices such as CleveMed's SleepScout[TM] are capable of assessing sleep-disordered breathing and periodic leg movements and record outputs onto a standard removable secure digital (SD) card. The technology is based on a full polysomnogram system, is battery operated and practical for use in unattended

sleep studies (Schmidt 2012). In people with mild dementia this device may be useful in assessing sleep quality and identifying disorders such as sleep apnoea-hypopnea. Another example of the uses of a portable polysomnogram system was demonstrated by Fonareva et al. (2011) in a study on sleep architecture. Measures of overnight sleep quality were obtained using a battery-operated device capable of recording data from multiple domains including electroencephalogram (EEG), which records the brains electrical activity; electro-oculogram (EOG), which records eye movements; electrocardiogram (ECG), which records electrical activity of the heart; respiration; and movement over a 24 hour period. EEG, EOG and ECG electrodes were applied to participants in a lab, two accelerometers were attached to the head and upper arm to record muscle activity and movement, and an elastic respiration belt was placed around the participant's abdomen. The electrodes, accelerometers and respiration belt were then connected to the ambulatory device, which was placed in a small carrying bag so as not to constrain movements. When the recording ended the electrodes were removed in the participant's residence.

Actigraphy is a widely used, non-invasive method for the study of rest-activity in dementia patients (Littner, et al. 2003, Ancoli-Israel, et al. 2003). A recent study by Borazio and Van Laerhoven (2011) predicted sleeping behaviour using long-term activity data from a wearable wrist sensor. This actigraph-like sensor was worn on the non-dominant wrist and recorded inertial data from a 3D accelerometer. This technology is capable of detecting the amount of motion during sleep, the duration of sleep, and the falling asleep and waking up times. Rest activity can also be recorded using an Actiwatch (Merrilees, et al. 2009). Actiwatches are similar to a small wristwatch and use an accelerometer to monitor the occurrence, degree and speed of motion. Twenty-four hour sleep/wake patterns can also be measured using an actigraph (Richards, et al. 2005). For example, the sleep quality of persons with Alzheimer's disease has been measured using an Actillume (McCurry, et al. 2008, McCurry, et al. 2005). This wrist movement recorder contains an accelerometer as well as a photometric transducer to record illumination readings in order to provide both activity and light data.

Mobile phone technology may provide a simple and cost effective method of monitoring sleep patterns. The Sleep Cycle iPhone app (Drejak 2012) monitors movement during sleep

using the built-in accelerometer in the iPhone. The iPhone is placed facedown on the bed and generates a nightly sleep graph illustrating the individual's sleep cycle. This app also features an alarm clock which uses this information to wake the individual during the lightest sleep phase (within a 30 minute alarm window). There are other mobile phone accessories that perform similar functions, such as the Wakemate ("Wakemate» 2012). The Wakemate is a small Bluetooth USB device enclosed in a wristband to be worn while sleeping. It uses actigraphy to monitor sleep cycles and then uploads the data to an iPhone or other smartphone upon waking. It can then provide information on sleep quality (in the form of a score out of 100), as well as information on sleep patterns. It is however, not as cost effective as the Sleep Cycle app.

Monitoring daytime and night-time activity

Movement sensors are widely used to monitor both daytime and night time activity in persons with dementia. The Just Checking system is a portable activity monitoring system for people with dementia and is currently being used by 65 local authorities and mental health trusts in the UK (Price 2009). Small wireless movement sensors monitor when a person gets up and whether or not they had a disturbed night. Campo et al (2002) devised a non-intrusive monitoring system for people with dementia, which tracked activities using low cost positioning sensors. The recorded data included number of times he/she got up, went back to bed, visited the toilet, left the bedroom, and the distance covered during the night. Unobtrusive infra red technologies have also proved effective and accurate in monitoring people with dementia (Banerjee, et al. 2009, Nakano, et al. 2002). This type of information can then be used to tailor care arrangements to individual needs. Cameras and microphones are also sometimes used in addition to sensors, however this approach is considered by many to be intrusive (Schikhof and Mulder 2008).

The NOCTURNAL (Night Optimised Care Technology for UseRs Needing Assisted Lifestyles) project (Augusto, et al. 2011) provides specialised night time support to people at the early stages of dementia. The technological infrastructure of the NOCTURNAL system utilises pressure mats in bed, Passive Infra-Red (PIR) sensors and lighting control to monitor restlessness, bed occupancy and movement around the home. Activities are recorded as events

in a database and are monitored by specialised agents. The data can provide profiles of the sleeping and movement patterns of a specific person in a specific period of time. Central to the system is a bedside audio visual unit that collects in-house sensor information. It also displays pictures and plays music for reminiscence therapy which has been shown to alleviate anger, confusion and tension. The goal of the NOCTURNAL project is to encourage good sleeping habits through a combination of movement sensors, changing light levels and reminiscence therapy (Augusto, et al. 2010).

Baruch et al (2004) have outlined a case study on the development of a personalised computing system designed to orientate and support a person with mild dementia living alone. A computer screen was placed in the bedroom of a person with dementia with the time on it written in words, supported by numbers and a message 'It is night-time, stay in bed'. The clock remains on at all times. It was found that the computer screen was effective in reducing the patient's stress and reminding her to stay in bed if she woke during the night.

Technology to enable optimal sleep patterns
Cranial Electrical Stimulation (CES) therapy uses a small, battery operated device to deliver low levels of alternating electrical current to the head via clips attached to the earlobes (Rose, et al. 2008). CES therapy has been found to increase blood and cerebrospinal fluid levels of serotonin, norepinephrine and β-endorphin in depressed patients and in healthy individuals with no known medical conditions (Shealey, et al. 1998). CES may have fewer adverse effects than medications and can be conducted in the home environment. However, there is a need for further research to determine the effects of CES in persons with early-stage dementia (Rose, et al. 2008).

Previous research has shown that limited exposure to bright light can affect circadian rhythms and contribute to sleep problems (Connell, Sanford and Lewis 2007). A study by McCurry et al (2005) increased daily light exposure for people with Alzheimer's disease using a 'Sun-Ray Light Box', within a 3-hour window of bedtime. This treatment was coupled with a 30 minute daily walking exercise. It was found that participants spent an average of 36 minutes less time awake at night and had 5.3 fewer awakenings during the night.

2.3.2 Summary: ICT for sleep

From the literature it is apparent that the measurement of sleep architecture can be achieved through the use of polysomnography, actigraphy, and movement sensors. A polysomnogram system is capable of recording data from multiple domains including EEG, EOG, ECG, respiration and movement. In some instances however, this method may prove restrictive due to the equipment involved. Actigraphy in the form of wrist monitors and smartphone technology can provide insight into sleep quantity and quality while remaining non-invasive and cost effective. Actigraphy also has the potential to monitor activity both day and night without interfering with daily activities or disturbing natural sleep patterns. The sleep quality of persons with Alzheimer's disease has been measured using an Actillume which contains an accelerometer as well as a photometric transducer to record illumination readings in order to provide both activity and light data. Non-invasive sensor technology can successfully monitor both daytime and night-time activity and may provide a less intrusive alternative to cameras and microphones. Technologies that may help enable optimal sleep patterns include cranial electrical stimulation and increased light exposure through use of a Sun-Ray Light Box.

2.3.3 Monitoring and enablement of optimal exercise habits

Research suggests that regular exercise can help prevent a more rapid deterioration in people with dementia (Dunk, Longman and Newton 2010). Older adults with dementia are more likely to be physically inactive than those without dementia (Galik 2011). Low activity levels have been shown to reduce endorphin release and may have a negative impact on mood, sleep and functional ability (Eggermont and Scherder 2006). Technology could potentially play a role in raising activity levels through monitoring and enabling exercise habits and motivating the person with early stage dementia to maintain an active lifestyle. The Dem@Care system will monitor factors such as walk speed and gait, distance travelled, accelerator counts per minute, time taken to sit down and stand up, onset times of exercise and exercise duration. As well as enabling continued physical activity, the Dem@Care system will monitor lack of activity as a measure of time spent in sedentary behaviour. Sedentary behaviour yields different but complementary information to physical activity and is also required if a full representation of exercise habits is to be obtained (Lord, et al. 2011). Monitoring of sedentary

patterns is important as it has been found that inactivity produces physiological responses that are qualitatively different from exercise responses and can increase the potential for major clinical and public health concerns (Hamilton, Hamilton and Zderic 2007).

Smartphone Apps

A number of Smartphone Apps are available to monitor and support exercise behaviour in people with dementia. The Runtastic Pedometer App ("Runtastic Pedometer» 2012) keeps track of every step taken and allows the user to see if they are meeting their recommended daily target. The app's on-board acceleration sensor will track the user's steps. Distance and elapsed time during activities are also clearly displayed.

Many smartphones also contain accelerometers capable of monitoring activity in a convenient and unobtrusive manner. A study by Zhang et al. (2010) succeeded in using data from a smartphone equipped with an embedded 3D-accelerometer to identify 6 activities – walking, posture transition, gentle motion, standing, sitting and lying. This could provide a general overview of the daily exercise habits and sedentary behaviour of a person with dementia.

Digifit Apps ("Digifit» 2012) are available for smartphones and are capable of tracking cardio and blood pressure patterns when used with connectable sensors such as a heart rate monitor and blood pressure cuff.

Lin et al. (2011) developed and evaluated a smartphone application "Motivate" designed to encourage a healthier lifestyle by suggesting simple physical activities. The App provides personalised and contextualised advice based on geo information, weather, user location and agenda.

Coaching and monitoring devices

Research indicates that increased levels of physical activity can have a preventative effect and simple information and communication technologies (ICT) such as coaching systems can be used successfully as motivating tools for people with specific impairments (Nugent 2007). Zheng et al. (2006) developed a SMART rehabilitation system for stroke patients which they claim can be applied to other healthcare related systems. The system consists of three components: a motion tracking unit; a base station unit; and a web-server unit. Sensors are

attached to the user to track movement. The information is then sent wirelessly to the base station where the data is stored and analysed. Healthcare professionals can then assess and monitor movements remotely via the internet by accessing the central server and provide feedback to patients and carers.

Activity monitoring as well as activity-aware reminders may help to improve lifestyle and wellbeing (Zhang, et al. 2011a). Activity monitoring systems and reminder aids have the potential to motivate people to maintain a healthy lifestyle and to assist elderly people to live independently at home (Osmani, Zhang and Balasubramaniam 2009). An activity monitoring and reminder delivery framework, iMessenger (Zhang, et al. 2011b), has the ability to infer inconsistencies between what the user was expected to do and what the user is actually doing. It can then provide feedback to encourage the user to follow their predefined agendas correctly.

Walking can provide a form of exercise and an enhanced sense of independence and well-being in people with dementia (McShane and Skelt 2009). A device that incorporates a GPS location system could give people with mild dementia the confidence to continue with established walking habits in the knowledge that, should they become lost, the device could assist them in finding their way home independently (Dunk, Longman and Newton 2010). GPS systems are now frequently embedded in mobile phones.

Smart carpet technology could be used to measure walking speed and/or gait and thereby help identify possible deterioration in physical ability (Carrillo, Dishman and Plowman 2009). This technology uses sensors to record pressure in addition to motion. Capacitive proximity sensors could be used to monitor activity levels in the home through gathering information about the occupancy of certain furniture, and also the posture of a user on the occupied furniture (Große-Puppendahl, Marinc and Braun 2011). This kind of sensor information could be useful in determining exercise habits in people with dementia.

ActivPAL^{TM} (PAL Technologies Ltd., Glasgow, UK) is a small, lightweight accelerometer sensor worn on the thigh. It is capable of identifying changes in postures from seating and lying to standing or walking. It can also record number of steps and cadence of walking bouts and estimates energy expenditure. In a study by Lord et al. (2011) several variables were

successfully extracted from ActivPAL data to represent characteristics of active and sedentary behaviour. These included volume (the total amount of walking time expressed as a percentage of the total recording time); frequency (represented by the number of sit to stand transitions); intensity (the total metabolic equivalents); and patterns of activity and sedentary behaviours.

Technology to enable exercise

Research suggests that cognitive degeneration can be reduced by a combination of physical and mental exercise (Colcombe and Kramer 2003, Cabeza, Nyberg and Park 2005). Chilukoti et al. (2007), created an assistive technology system to promote both physical exercise and cognitive stimulation for people with dementia. Physical exercise is provided by a portable and lightweight Mini Stationary Bike (MSB). The MSB targets large muscle groups throughout the lower body via repetitive movement and can also be operated as an ergometer (an instrument that measures muscle power) by using the arms. Exercising these particular muscle groups can build strength and balance. Chances of fall or injury are low as cycling and ergometry can be completed in a seated position. Cognitive stimulation in the form of a visual multiple choice game has been incorporated with the MSB. A graphical user interface displays questions that have been designed to stimulate particular areas of the brain. When the user answers a multiple choice question correctly they are prompted to use the MSB to begin pedalling. After five revolutions another question is displayed. The session is completed once the user has correctly answered 30 questions.

The SMART (Self Management supported by Assistive, Rehabilitation and Telecare Technologies) Project (SMART Consortium 2007) is developing a Personalised Self Management System (PSMS) for use in home and community environments for people living with long term conditions. The project aims to develop a comprehensive and Personalised Self Management System by integrating technologies like mobile devices, wrist sensors, pedometry and lifestyle or activity monitoring in order to enable people with long term conditions to manage their condition at home. The first step involves working with a health professional to assess individual needs and capabilities. The second step involves setting end goals which the PSMS can then assess and encourage through, for example, a computerised

exercise toolkit. Feedback is provided to help the user achieve these goals. Currently the PSMS is being developed for people living with the long term conditions of stroke, chronic pain and congestive heart failure, but could potentially be applied to other conditions such as dementia (McCullagh et al. 2010).

2.3.4   Summary: Activity / exercise

There are a number of technologies available to assist in the monitoring and enablement of exercise / activity habits in people with dementia. The success of different approaches however will depend on individual factors, such as the users current physical health and their confidence in the use of new technologies (Costa and Doughty 2009). Smartphone Apps that monitor activity such as pedometers and accelerometers, provide a convenient and cost-effective means of enabling exercise behaviour in people with dementia. There are also apps available capable of tracking cardio and blood pressure patterns and of motivating exercise using personalised and contextualised suggestions. Monitoring of sedentary patterns is important as inactivity can increase the risk of health problems. Accelerometers can be effectively used to monitor both activity and sedentary patterns of behaviour, thus providing a comprehensive view of exercise habits. Activity monitoring systems and reminder aids could potentially motivate people to maintain a healthy lifestyle. In addition, GPS technology could be used to give people with mild dementia the confidence to maintain already established walking habits. In terms of enablement, exercise equipment such as the Mini Stationary Bike (MSB) have been developed specifically for people with dementia and aim to combine physical and mental exercise in order to prevent cognitive degeneration. A Personalised Self Management System (PSMS) that integrates technologies like mobile devices, wrist sensors, pedometry and lifestyle or activity monitoring could potentially enable people with dementia to manage their condition at home. Currently, however, the PSMS is only being developed for people living with the long term conditions of stroke, chronic pain and congestive heart failure.

2.3.5 Monitoring and enablement of optimal social connectivity

One of the consistently reported areas of perceived need from the perspective of the person with dementia is the area of social interaction (Naumann et al. 2011). It is clear that communication is of great importance in maintaining an individual's sense of self and place in the world. Dubuc and Blackwell (2005) describe four categories of difficulty in communication for people with dementia (cognitive, physical, social and identity) (Fig. 1) which can be used to understand the obstacles that hinder communication in dementia.

This section of the review explores ICT that can serve people with mild dementia to sustain social relations and create new contacts. The Dem@Care system will aim to use such technologies to monitor the number of people encountered per day, speech patterns, number of conversations and communication attempts, as well as frequency of communication initiation by PwD.

D2.2 – Functional Requirements and Clinical Scenarios V1

Figure 1. Taxonomy of obstacles to communication in dementia

Cognitive
- memory loss
- language impairments (semantic and pragmatic errors)
- reasoning difficulties
- prone to distraction
- confabulation

Physical
- impaired vision
- reduced hearing
- illness
- depression

- caregiver fatigue

Person with Dementia

Conversational Partner

Social
- segregation
- loss of social roles

- aversion
- fear of contamination
- stigma/stereotyping
- repetition
- one-sided conversations

Identity
- learned helplessness
- self-fulfilling prophecy
- reduced confidence
- fear of embarrassment
- loss of personhood
- boredom
- frustration

- "unbecoming"
- frustration
- operating in "best interest"
- lowered expectations (perceived incompetence)
- guilt
- helplessness
- unresolved issues

FIGURE 1: Taxonomy for classifying obstacles to conversation in dementia.

Monitoring and Enabling connectivity through technology use

Early technology attempts were devised to increase connectivity between carers who can be geographically distant. The Talksbac project stores personal sentences and stories for a user and offers probable selections later for retrieval during conversation (Waller, et al. 1998). Baruch et al. (2004) and Woods and Ashley (1995) describe a system to link a PwD to their

carer through a computer picture and voice sounds and a further paper describes Stimulated Presence Therapy (SPT) where PwD listened to audio tapes of their carers voice. However this solution was aimed at people with more advanced dementia than is the case in Dem@care and the technology seems outdated today. Several more recent studies have shown positive benefits of ICT mediated social interaction (Nugent 2007, Shapira, Barak and Gal 2007, Fokkema and Knipscheer 2007). Topo et al. (2009) examined an easy to use telephone and found that it eased making a phone call and in some cases helped to remember who called and what was discussed although existing difficulties still persisted.

Visser, Vastenburg and Keyson (2011) discussed the design implications for subtle interactions for social interconnectedness. Three principles were described, that the device should be able to move from the foreground to the background of the users awareness so that it blends into the daily life of the user without moving out of sight; the use of tangible interface supports and easier blend with the home environment; and subtle communication of awareness information can be powerful in supporting 'thinking about each other' and 'closeness' which are dimensions of social connectedness. The interventions arrived at in this study included a number of interfaces, such as digital picture frames which when waved at showed in the relative's home that the other was in, a wall tree where a user could stroke a branch of a tree to get the attention of the family member and stimulate further in depth communication.

Psymate ("PsyMate" 2012) uses the experience sampling method (ESM) to facilitate the monitoring of daily life experience, mood and behaviour. The device can be programmed to emit a beep at unpredictable moments of the day and participants then use a touch screen to complete short questionnaires on current mood state, social context and current activities. Data is immediately stored and can be analysed automatically for graphical display. To date

PsyMate has been used to monitor the symptoms of depression and psychosis, but is currently being applied to people with dementia to monitor physical and mental health, social connectivity and exercise habits.

The Telematics Applications Supporting Cognition (TASC) project (Ager and Aalykke 2001) aimed to develop a microcomputer-based system to support decision-making, planning and

communication for people with cognitive disabilities. The software consisted of five modules: The PLANNER, for planning and time management in relation to daily activities; the COMMUNICATOR, for communication by mobile phone; the PROMPTER, for guidance in relation to certain activities or tasks; the SUPERVISOR, for environmental control such as monitoring closure of doors; and the INFORMATION PROVIDER, for information provision such as weather and travel timetables. It is possible to use one, some or all of the modules depending on user needs. Both the carer's and the user's interface is presented on screen. The carer's interface allows for creation of the user's profile in terms of contacts, activities, appointments, etc. The user's interface presents information tailored to their needs which have been assessed prior to service introduction. Information can be presented in a number of formats including text, pictures, symbols and sound, and includes personalised information such as photographs and voice-input. While there have been some problems with system reliability, TASC has been found to promote independence and increased social contact and has been designed to accommodate wide variation both between and within user groups.

The Ambient Assisted Shared Living for the elderly (AMASL) (Lilgenau and Mayer 2010) project was not designed specifically for PwD but it could have some application in terms of the approach to improving connectivity between families where one person has dementia. The approach used home sensors and audio-visual equipment to allow friends and family to interact, play cards or have an interactive dinner with their family members.

The Florence project is exploring the use of service robots in the homes of people with dementia (Bargh, et al. 2011). The team are at an early stage in this project and their focus is currently on improving acceptability of the robots to people with dementia. The robot will be able to make suggestions to the PwD about engaging in certain activities, one of which could be to call a relative etc. One of the goals of this team is to find a system that can support the interaction among family-members/care givers.

The use of an Electronic Memory Aid (EMA) (Oriani, et al. 2003), which can automatically recall an appointment, may be effective in supporting prospective memory in people with Alzheimer's disease.

The appointment or task is vocally recorded. At a given date an audio alarm is activated to which the PwD has to react by pressing a button. The EMA itself is a mnemonic task in that the user has to remember what it is for, how to use it, and to routinely carry it with them. It is therefore considered suitable for people with mild dementia where memory and general cognition are less impaired

One of the complexities of this domain is the multifaceted and subjective nature of social interaction. An interesting area for exploration which may be amenable to technological assessment is the 'head turning sign' (Fukui, Yamazaki and Kinno 2011). On its own observation of the PwD turning their head towards the carer may represent an executive strategy when facing memory related difficulties that are beyond the cognitive capability of the person. It may also be a sign of dependency on and trust in a caregiver (Fukui, Yamazaki and Kinno 2011). Taken with other measures of social interaction the head tuning sign could help to build a picture of communication abilities which could help tailor intervention.

Quality of Life

The INDEPENDENT study (Orpwood, et al. 2007) looked at 4 quality of life issues and how they could be enabled: access to music, social isolation, conversation prompting and supporting sequences. The music was facilitated by an adapted MP3 player that was more intuitive for the PwD. In addressing social isolation the team used a remote camera with an RF link to a receiver plugged into a TV. People were interested in what was going on in their local environment if it involved both people and wildlife. They discuss the idea of taking this idea to remotely streaming images over the internet between the home of the person with dementia and a next of kin. There would be a means of remotely knocking on the door of the person and being invited in and perhaps a way to say 'time to go now'?

The Conversation prompter approach was developed using an explorative approach which found that the most helpful response to prompt conversation was to remind the talker about the kind of topic they were just talking about – even repeating the last few words did seem to

help. Sequence support (with grooming, cleaning and making tea for example) within this study was reported to still require much work.

PwD and Carer Dyad

More recently ICT solutions which have focussed on the dyad (PwD and Carer) for example the ACTION programme was a comprehensive multimedia education and support approach for people living with dementia. It included an education section on using the technology, a lifestory multimedia programme, a 12 week education package, communication facilities including a video phone, PC with internet, chat forum (both on line and telephone with other carers in the area), and a local call centre staffed by nurses who also ran the support group sessions. There were built-in cognitive training packages and fun games such as patience which were widely used for fun or relaxation. The contents of the package were collaboratively built up through intensive user co-design (Hanson, et al. 2007) and clearly show that under these circumstances people with early stage dementia and their families benefitted from user-friendly ICT. It was also clear that intensive support and education maximised these gains. According to the users, blending technology and use of face to face contact was integral to the success of this programme. Finally, participants gained significant satisfaction from being able to meet and talk with other people in a similar situation. Some cases of recent social isolation were reversed (Hanson, et al. 2007).

Also to address the dyad of carer and PwD is the shared diary, a visible screen that supports a PwD to plan the week, add shopping list items (perhaps for a relative to pick up). The relative can click done when they are done so that they are visible to the PwD (Naumann et al. 2011). The same authors also came up with a simplified meeting application to increase the visibility of clubs and events in the community and support inviting others. The application has very simple textual outputs and few buttons.

The Pocket buddy is a virtual journal (Carrillo, Dishman and Plowman 2009). Daily entries are automatically uploaded to a server that can be accessed through a webpage. Over the

course of days and months, entries can be charted. This level of information was found to be useful in gisting life patterns.

Reminiscence Therapy

CIRCA is a multimedia computer system developed to support and promote communication between people with dementia and caregivers based on reminiscence. In a study using CIRCA the researchers make a case for the use of computers to promote and maintain conversation in groups of people with dementia in long term care settings (Astell, et al. 2010, Alm, et al. 2004). Smith et al. (2009) also take a reminiscence focus to increasing interaction through the production of 12 multimedia biographies (MBs). Participants and family members enjoyed the production and screening of the MBs and reported it helped them reminisce and engage in stimulating conversations about past experiences.

Nilsson et al. (2003) in the Nostalgia project used an old style radio combined with an interactive tabletop interface to allow individuals to listen to old music and news from the 20th century.

Music applications, such as Picture Gramaphone (PG), were designed to provide visual and auditory stimulation using individualised music selections (Topo 2009, Gilliard and Hagen 2004). Reminiscence packages could also be envisaged that could build on the life story approach here (music memory lane and video memory lane) (Alm, et al. 2004) .

Also, aimed at promoting fun and meaningful involvement, Age Invaders (Khoo, Merritt and Cheok 2009) is designed to facilitate intergenerational family entertainment by enabling one or two different generations to play games together from different locations. The systems take account of differences in, for instance, reaction times between older and younger players, effectively handicapping younger players to make a level virtual playing field.Moving on from such digital patterns, Sensecam offers the option to provide digital traces in a picture of daily life. 'These pictures were different to the past recollected by participants and yet brought a sense of wonder, depth and felt life that was enriching' (Harper et al. 2007). This interest in SenseCam and memory has drawn people to investigate the possibilities of its use

for PwD. A failure of autobiographical memory is critical to quality of life. Firstly, nearly all future actions are based on past experiences, so practical day to day planning can be hard. Secondly past experiences are key to a sense of identity (Hodges, Erzinçlioğlu and Patterson 2006). For example, shared memories cement relationships which in turn affects self concept and these losses can contribute to a downward spiral. Sensecam has been applied by different teams to people with dementia to help support episodic memory or promote discussion to maintain a sense of identity (Piasek, Irving and Smeaton 2011). For instance, the MemoryLane ("MemoryLane" 2012) mobile device automatically records images, audio and possibly video of each day's events. At the end of each day the PwD and their carer can review the activities and add information about names of people, places and objects. This helps to build episodic memories of the day. There remains much work to be done in the area of life logging for PwD but early indications support the use of sensecam to promote recall and stimulate conversation.

Mobility

There is a number of systems designed to help the PwD to get out and about safely in their community. Opportunity Knocks (Patterson, et al. 2004) is a navigational system for outdoors. It is a cell phone embedded device using GPS chip and bluetooth that teaches the subjects standard routes in the community and alerts the subject of a navigational error by making a knocking sound and re-rout the lost individual. There are also devices designed for indoor navigation fitted to a walking frame, for example, IMP – indoor navigation system (Bharucha, et al. 2009). It seems these devices are targeted for later symptoms of dementia.

Summary: Social connectivity

Several technologies have been identified that can potentially enable social connectivity in people with mild dementia. For example, the TASC project supported cognition using a microcomputer-based system and was found to promote independence and increase social

contact through mobile phone communication. Technologies such as digital picture frames, electronic memory aids and service robots can potentially facilitate interactions with carers and increase connectivity. Technologies such as Sensecam have been found to promote recall and stimulate conversation and can also be used to monitor daily social contact patterns. Observation of the 'head turning sign' may also help build a picture of communication abilities which could help tailor intervention. Monitoring aids such as Psymate may be particularly useful in garnering information social connectivity at specific points throughout the day and may prove less invasive than sensor technology as the PwD manually enters information into the device rather than the information being automatically recorded. Other technologies focusing on the PwD and carer dyad were demonstrated through the ACTION programme. This comprehensive multimedia education and support approach included an education section on using technology, a lifestory multimedia programme, a 12 week education package, communication facilities including video phone, PC with internet, chat forum (both online and telephone) and a local call centre staffed by nurses. This programme was successful in reversing some cases of social isolation. Easy to use technologies such as a shared diary and smartphone applications such as a meeting application facilitated social interaction while allowing the carer to monitor certain activities. Technologies to support and promote communication between people with dementia and caregivers based on reminiscence include CIRCA (a multimedia computer system), multimedia biographies, music applications such as the Picture Gramaphone and an old style radio, and intergenerational family games aimed at promoting fun and meaningful involvement. Navigational systems such as 'Opportunity Knocks', use GPS technology to enable the PwD to access the community safely.

2.3.6   Monitoring and enablement for ADL/IADL

In light of demographic shifts predicting an increase in the prevalence of dementia in the coming years, a host of cognitive aids, environmental sensors, audio and video technologies, and advanced integrated sensor systems are being developed (Bharucha, et al. 2009). Reminder aids, monitoring technologies and telecare services are under development to monitor health, safety, well-being and activities of daily living (ADL/IADL) of people with

dementia. These technologies could potentially reduce the total duties of caregivers and medical professionals, and allow the PwD to remain in their own home (Adams, Schmitt and Zaleski 2010). The Dem@Care system will aim to acquire information on the quality if the PwD's diet by identifying the process of eating and drinking, where food/drink consumption occurs, the frequency of food drink purchases and the possible indicators of food/drink preparation.

Technology to monitor ADL/IADL

Interactive video monitoring has been found to improve the ability of people with early-stage dementia to take their medicine correctly and eat their meals (Smith, et al. 2007). The COACH prompting system (Mihailidis, et al. 2008) is a video monitoring and tracking technology that helps individuals with everyday tasks. The current prototype focuses on hand-washing but the technology has the potential to be applied to other behaviours. The video tracking monitors hand positions in relation to the sink, soap, towels, etc., and it determines whether or not the task has been completed successfully. Built in prompts can then help the person complete the task if necessary.

Sensors are generally used to monitor a person's activity in their own home over a period of time (Alzheimer's Society 2012). Sensors are frequently used to monitor health and safety in people with dementia. For example, The MIDAS 3 Lifestyle Reassurance solution ("Midas 3" 2012) comprises of sensors, a social alarm system and MIDAS 3 Server. The sensors include Passive Infra-Red, door usage, electrical usage, bed occupancy and chair occupancy sensors. Data is collected to capture behavioural patterns and is transmitted to a server each day. The data can then be securely monitored by the care provider. This technology could be used for in home location monitoring and appliance usage.

Technology to enable ADL/IADL

To help people undertake certain types of time-linked tasks or activities (e.g. meal preparation) various types of automatic reminders or Electronic Memory Aids (EMAs) have been developed (Lauriks, et al. 2007). EMAs may include such technologies as reminder messages, clocks and calendars, and locator devices (Alzheimer's Society 2012). The success of different approaches depends on several individual factors such as the confidence of the user in the use of new technologies, their hearing and visual acuity, and the supportive role of carers (Costa and Doughty 2009).

The Routine Organiser (de Oliveira Assis, et al. 2010) was designed to help orient the PwD with daily activities. The device displays a written description of the day's tasks, including the time for each task to be performed. It also includes an easy to read clock and a programmable alarm. The device has been rated useful by occupational therapists specialising in gerontology. A digital calendar and message board developed in Norway (Holthe and Walderhaug 2010) demonstrated the potential to support older people living at home, particularly those with memory problems who need additional support conducting their daily activities such as meal preparation. The calendar consists of an individual internet-based digital plan displayed as a calendar page that can be edited by carers who wish to add appointments and messages.

Digital TV prompts could potentially assist cognitively impaired people with a wide variety of day-to-day activities, for example, reminding people about lunch or telling them what medication to take and when (Carrillo, Dishman and Plowman 2009). There are several different formats which this technology could take, from simple picture displays to voice-overs to video messages, and it can therefore be easily tailored to individual preferences. A mini personal computer (miniPC) or a handheld personal digital assistant (PDA) can be used to enter the prompts. Mobile phone-based prompting systems could be used in a similar way (Donnelly et al. 2008). Caregivers can pre-record video messages to be delivered on a scheduled basis.

The Neuropage and the Lifeline Connect+ (Costa and Doughty 2009) are examples of telecare in which a remote monitoring centre takes responsibility for programming and control of reminders. Therefore these devices can be used regardless of the availability of a family carer.

The Neuropage involves messages being sent to a call centre via phone or email where they are loaded into the computer system. The system then sends a radio signal to the patient at the appropriate times. The messages are received on a pager unit, however this technology could potentially be applied to SMS messaging via a mobile telephone. The Lifeline Connect+ can be programmed to ring the home telephone and play back a recorded voice message at specified times of the day, and would therefore only be suited to someone who spends considerable time at home. These devices could both be used as reminder aids with regard to general IADL and therefore facilitate the performance of daily activities.

The Voice Organiser (Van den Broek, et al. 2000) is a device on which a message can be recorded by the user. The user can then specify a particular time and date when the message will be played back to them. In patients with memory problems it was found that prospective memory improved directly after the device was taken into use. This technology is now available as an iPhone app ("Voice Organiser" 2012) and may help to support independence in people with mild dementia. The device can be used to enable several activities of daily living. A study by Yasuda et al. (2006) involving a similar device, the Sony IC Recorder, found that automatic output of music and messages was highly effective for guiding the person with dementia to eat more meals.

The Cook's Collage provides memory support for general cooking tasks using camera technology (Rogers and Fisk 2006). Cameras are mounted overlooking the countertop and visual snapshots of hand activity are presented on a flat-panel display. The display highlights the chronological steps of cooking actions. This device can enable a person to recover from an interruption in the middle of meal preparation.

A study by Lancioni et al (2010) examined the use of verbal instructions and support technology in helping persons with mild to moderate dementia perform daily activities (i.e. coffee preparation, table setting and meal preparation). The technology consisted of battery-powered, radio-frequency photocells, light reflecting paper, an amplified MP3 player with USB pen drive connection, a pen containing the recording of the verbal instructions relating to the particular activity, and a microprocessor-based electronic control unit. The photocells and light-reflecting paper were placed at opposite ends of the workspace so that the

participants' would interrupt the photocells' light beam when they reached for an item. This would then trigger the MP3 player to present the instructions. It was found that the technology significantly improved performance in the daily activities tested. Furthermore, activity engagement appeared to help some of the participants improve their mood.

Computing Assistive Technologies

Pocket Buddy is software that has been developed around pocket PCs to create virtual environments that can be shared among older adults, their family members and caregivers (Carrillo, Dishman and Plowman 2009). Central to this is a journal that is updated on a daily basis, automatically uploaded to a server, and accessed through a web page. This journal is useful for tracking behaviour over time and ensures that carers are aware of daily events and any problems that may have been encountered. The interface has been designed for ease of use and includes large keys, an easy touch screen and menus that are easily navigated.

'It's Done' ("It's Done!" 2012) is an iPhone App that can be used with iPhones, iPad or iPod Touch to help reassure a person with mild dementia that they have completed certain daily tasks, such as food and drink consumption. Rather than reminding users to do things, this App is designed to help the user recall with certainty whether a task is actually done. The App allows the user to compile a list of daily tasks and check-mark 'done' upon completion. If in doubt later on they can check if the task has been ticked, eliminating worry. Tasks can be set up as one-time, recurring, or scheduled for future dates. It's Done can automatically generate a text message or email to alert carers when a task is completed. This App could be useful for monitoring and enabling activities and instrumental activities of daily life.

Intelligent assistive technologies are being developed to monitor and enable certain activities of daily living. The Proactive Activity Toolkit (PROACT) (Bharucha, et al. 2009) could be used to monitor the activity performance and determine whether or not particular tasks such as meal preparation are being conducted. A study was conducted where radiofrequency (RF) technology was used to determine the performance characteristics of PROACT in automatically recognising the activity of daily living that was being performed and the quality

of its execution. Certain objects in a home were instrumented with 108 RF identification tags and the signals transmitted by these tags were recorded by a prototype glove worn by the participants. It was found that PROACT could correctly infer that an activity had occurred 88% of the time. Furthermore, it correctly identified the specific activity in 73% of cases.

Summary

Monitoring technology in the form of interactive video monitoring and sensors can be useful in gathering information on daily activities. With regard to certain types of time-linked tasks or activities such as food consumption, Electronic Memory Aids (EMAs) such as reminder messages, clocks and calendars, have demonstrated effectiveness. These technologies are generally simple to use and can often be incorporated into digital TV's or mobile phone devices. Telecare such as Neuropage and Lifeline Connect+ are capable of providing reminders at specified times of the day via mobile phone or home phone. Voice recorder technologies allow the user to record verbal prompts that can be played back at a specified time. This technology was highly effective in guiding the person with dementia to eat more meals. The Cook's Collage provides memory support using camera technology to monitor the steps involved in meal preparation. Virtual journals and iPhone apps such as 'It's Done' have been designed to reassure PwD and carers that a particular task has been conducted. Using this technology carers could potentially monitor daily activities. Radio Frequency technology such as PROACT could also be used to monitor various activities in the home, including food and beverage consumption.

2.4   Needs and unmet needs among people with mild dementia

Review of research on needs and unmet needs experienced by people with dementia revile that very little research is published that directly focus on the concept of needs and unmet needs in this target group, even though needs are studied indirectly (Bossen, Pringle Specht, & McKenzie, 2009). Most studies are conducted in institutional settings with the need of

carers in focus and there is a lack of research on needs involving persons with mild dementia living at home (Topo, 2009).

User-driven development of assistive technical devices among people with mild dementia focusing on meeting their expressed needs has been described by some researchers (Orpwood et al. 2004; Orpwood et al., 2007) and (Van der Roest et al., 2008). An example of user driven development of assistive device for persons with mild dementia was the COGKNOW project (Davies et al., 2009). The COGKNOW device consists of a stationary and a mobile device with touch screens and sensors that are placed in the home. The final prototype of the device integrated functions to support needs among persons with dementia in the areas of memory support, social contact, daily activities, and enhancing feelings of safety. A conclusion was that even if the device was thoroughly developed in a user-driven development and adapted to individual needs, the acceptance and use was strongly connected to in what way the device supported the participants needs of maintaining their self-image (Karlsson, Axelsson, Zingmark & Sävenstedt, 2011).

Identified needs among persons with dementia in the review (Bossen, Pringle Specht, & McKenzie, 2009) were those of early diagnoses, to be heard, and support of information, safety, together with emotional and cognitive support. The most frequently identified unmet needs are in the areas of information, memory problems, communication and psychological distress (Walters, See Tai, & Orrell, 2000; Beattie, Daker-White, Gilliard, & Means, 2002, 2004). In addition, subjective needs described are the need of being accepted as you are, needs to find adequate coping strategies and the need to come to terms with their situation (Van der Roest et al., 2007). Other identified areas of needs are the possibility of participation in care planning, to be heard, and the need of promoting their own health. Meany, Croke and Kirby (2005) found high levels of unmet needs in the areas of behaviour, mental state and daytime activities.

In a large Dutch survey among people with dementia living in the community and their carers Van der Roest et al. (2009) they identified needs by using the instrument Camberwell Assessment of Needs for the Elderly (CANE) (Walters, Iliffe, See Tai, & Orrell, 2000). More than 50 percent of the people with dementia indicated met needs of support in the areas of

preparing food, household activities, memory and financial help. The most reported unmet needs were needs of memory support, information, company, psychological distress and daytime activities.

3   User involvement studies

3.2   Methodology used

This section describes the assessment of the perception of health personnel and carers on perceived needs among people with mild and severe dementia in the areas of daily routine activities, sleep pattern, eating, social interaction, and outdoor activities, using a method for focus group discussions (Kreuger, 1997). The intention of the discussion specifically organized and performed in the framework and for the objectives of Dem@Care was to provide an opportunity for the participants to consider their own views and perceptions in the context of the others views (Patton, 2002). These studies focus on healthcare professionals involved with formal care environments; on the whole it is likely that persons with dementia living in institutions may be more dependent than those living in the community. While these reported needs are a good starting place when aiming to support community-based persons with dementia, we must remain cognisant of the individual's needs and maintain a personalised approach to deployment in later home-based studies.

Participants and procedures

Participants were health personnel in Nice, France and in Luleå, Sweden. In Nice there were 15 participants with different health professions participating in one focus group and in Luleå it was eight health personnel recruited from two dementia care units participating in two focus group interviews. There was also a focus group discussions with nine informal care givers in Nice. In all, 31 participants participated in four group discussion sessions.

Data collection

The focus group discussions used a semi-structured interview guide focusing on six areas of daily life, daily routine activities, sleep pattern, eating, social interaction, and outdoor activities, similarly to the areas described in the previous SoA section. For each question area

two main questions were posed, what are the person's needs in this area, and how do you perceive the acceptability to meet those needs with various sensors proposed to be used in the Dem@Care project.

In order to facilitate the discussion on perceptions a power point based vignette (attached as Appendices in separate files) was used (Savenstedt, Sandman, Zingmark, 2006; Harrefors, Axelsson, Sävenstedt, 2010). The vignette was divided into two parts, one presenting a person with dementia with a new slide for each of the six question areas and with the question, what are the person's needs in this area of daily life. The second part showed the same pictures with the difference that possible solutions in form of sensors were presented and the question was this time, when and how is it acceptable to use these sensors to support the person? The vignettes were slightly different between the one presented to discuss needs and acceptability of use of sensors in the private home environment and the one for discussing the needs and acceptability in a nursing home environment. The difference was that the examples given on slides were adjusted to fit the two contexts.

Compiling of data

The data from each focus group discussion was compiled and synthesized for each area of daily life and for each user group separately.

3.2.1   Findings form the focus groups with formal carers

On 3rd April, 2012 a focus group was held for formal carers in Nice. The aim of the group was to assess the perceived needs of the PwD in a formal care setting as well as the acceptability of a sensorised environment. There were a total of 15 participants which included: 3 caregivers, 2 nurses, 1 doctor, 1 housekeeper, 3 hotel agents, 1 facilitator, 1 psychologist, and 3 not indicated. Two Powerpoint presentations were used to elicit views. The first presentation (Appendix 1) described a person who has been living in an eldercare unit for a couple of years. The following areas were specifically addressed: daily routine; sleep pattern; eating habits; social interaction; and outdoor activity. Approximately one third of the

allocated time was then spent discussing the person's perceived needs for each specific activity. The second presentation (Appendix 2) described various sensors (such as actigraphy and kinect), which could potentially be used to meet those needs. The views of the focus group on the acceptability of these sensors were recorded. Findings with regard to (A) needs and (B) acceptability for each daily activity are outlined below:

1) **Daily routine activities**

A: What information about her daily life activities is important in order to support her?

- Time of awakening (exact time when the patient woke up)

- What occupies the patient when he/she is alone in their room

- Hygiene: Did the patient shower correctly? How much time per day was dedicated to personal hygiene? How autonomous is the patient with regard to personal hygiene?

  ➢ Suggestion of a system that detects if the 'morning toilet' was carried out correctly

- Detecting when a patient is no longer able to differentiate between clean and dirty clothes

- Detection of difficulties in dressing and choosing clothes

- How patients can find and recognize the bathroom, the toilet, their own room - they often get lost inside the nursing home

- Recognizing if a patient gets lost (in the home)

- Verification that the patient is oriented in time and space; Establishing sleeping patterns – monitoring time patient goes to sleep and wakes up (are they going to sleep too early and waking up in the middle of the night?); patients sometimes forget when it is appropriate to go to bed

- Identifying the moment when the patient starts to need additional supports, for instance, when they start to do things differently; tracking unusual behaviour patterns and alerting the staff immediately so that early intervention can take place.

B: When and how is it acceptable to use ICT and when not?

- Objects worn by the person will very often be removed due to discomfort or because the patient doesn't understand their function

  ➢ Sensors should be therefore small, invisible and not noticeable

  ➢ Their function should be explained carefully to the patient and his/her family to make them feel more comfortable

- Cameras that don't show globally the whole person, maybe just certain body parts, would be preferably (or where the face for example is not identifiable)

- For emotion recognition audio recording of speech could be employed, preferably not the sentences said, just HOW it's said (prosody) in order to be less intrusive to the patient

- The acceptability of ICT by the staff (in a nursing home) is important; if they don't feel comfortable, the presence of ICT will impact on the relationship between patient and nursing home staff. It is in danger of becoming less natural, more artificial

  ➢ ICT should be introduced in nursing homes as an additional support to their work rather than as a way to replace their work, or evaluate it.

2) Sleep pattern

A: What information about her sleep pattern is important in order to support her?

- Amount of hours slept

- amount of time spend in bed

- amount of time spend napping

- exact awakening time

- amount of wake ups during the night

- presence of pain or other problems during the night

- amount of movements during the night

- amount of times the patient gets out of bed or falls

- amount of times the patient goes to the toilet

B: When and how is it acceptable to use ICT and when not?

- Automatic lights in the hallways that will help patients to find their way during the night would be helpful (eg. going to the bathroom, back to their room, etc.)

- Practical idea: sensors in the mattress that can recognize movements, postures, pressure, time spend in bed, times when the patient leaves the bed etc. This solution could provide relevant information about sleep pattern and quality without being as intrusive as a camera

- Sensors and cameras in the bathroom would, in general, be less acceptable; cameras that don't show the face of the patients may be a solution to this

3) Eating

A: What information about her eating habits is important in order to support her?

- Identification of the moment when the patient forgets how to use the cutlery correctly, eg. mixes up the use of fork and knife

- Early identification of a patient's changing eating habits: when does he/she eat less/more than usually and why? Reason for change in food preferences (eg. suddenly changing preference from sweet to salty)

- Optimal eating times for the patient: these can vary from one individual to the other - sometimes the fixed meal hours of the nursing home are not suitable for the patient

- Identifying if a patient begins to accumulate food in his/her bedroom; very often this is only detected when the food starts to smell

  ➢ Bottom line: identifying when a patient changes their eating habits and the possible triggers for this change.

B: When and how is it acceptable to use ICT and when not?

- Notation system documenting the eating habits of each patient (resident) would be acceptable but difficult in practice. It would have to be automated and easy to use

- Difficult to install sensors/cameras in the dining room as there are always a lot of people present – could lead to complications in observing individual eating behaviors

  ➢ Breakfast is usually eaten in the bedroom and would be a good time to obtain information about eating patterns

4) Social interaction

A: What information about her social interaction is important in order to support her?

- Monitoring hearing and vision abilities for early detection of degradation

- Monitoring of attention abilities, moments where patients are less attentive

- Trigger factors for agitated, aggressive and nervous behaviour (behavioural symptoms in general)

- Sources of conflicts and disputes between patients

- When is the best moment to announce to the patient that family will visit?

> This appears to be very difficult for staff members to time - some patients can get very anxious and stressed when they know "too early" about an upcoming appointment or visit

B: When and how is it acceptable to use ICT and when not?

- Audio recording of the noise level in the dining room could help to detect aggressive and agitated behavior

- During family visits it may be inappropriate to record conversations; should recordings be constant or just at set times during the day?

  > Recording during family visits would allow investigation into the impact of family presence on the patients behaviour which could be very useful and important information

5) Outdoor activities

A: What information about her outdoor activities is important in order to support her?

- Patients often get lost outside so it would be helpful to have a device that indicates their location (localization sensors, like a GPS)

- Identifying when a patient begins to experience orientation difficulties; relevant triggers

- Sensors that also indicate the location of staff members (in case of emergencies)

- A device that accompanies the patient during outside activities – regularly reminding them of their location and guiding and reassuring them when they feels disoriented

B: When and how is it acceptable to use them and when not?

- The problem with such localization sensors is that they interfere with the privacy of the patient and staff members may feel monitored

- Such systems should be accepted by everyone in the nursing home. It should be possible to 'switch off' the sensors, for example during break times

Other comments:

- The accumulation of certain objects, mainly food and beverages in the patient's room seems to cause problems because the staff members can't go through the patient's things regularly out of respect of privacy. Therefore, the detection of the accumulation often takes place very late. A kind of object recognition system/device would be helpful to solve this common problem.

- Early detection of loss of objects, like glasses, keys, dental prostheses or hearing aids.

- The impact of certain intervention techniques, the consequences, the change of behaviour in order to evaluate if an intervention was successful or not and worthwhile to repeat or not.

- Importance of immediate feedback to the patient and/or his family has been discussed and should be taken into consideration in terms of integration into the use of the ICT

- Expression of pain; differentiation of types of screaming: pain or nervousness?

  ➢ Some patients lose their language abilities and in order to communicate they scream or become frustrated because they can't express themselves properly.

  ➢ Device that helps them to express their needs and emotions could avoid conflicts between patients

Synthesis of questionnaires:

A: NEEDS

In general, the needs identified by the formal caregiver group include the need to recognise patients' difficulties in executing activities of daily living and the need to identify the possible presence of behavioural symptoms or simple changes in behavioural patterns at the moment they emerge (for example sleeping or eating problems)

In line with those needs, eventual trigger factors for behavioural symptoms have to be identified (for example anxiety, agitation, aggression, irritability, accumulation and storage of objects/food, loss of appetite, sleep disorders) and associated with the different

context/situations: eg. social interactions (visits, group activities, trips,…), ambient environment (noise level, discomfort,…).

Finally, one important need becomes apparent in all covered life domains: the development of devices that could facilitate the patients' understanding and orientation in time and space.

B: ACCEPTABILITY

Basically, everything is acceptable as long as the patients/caregivers give their informed consent. The equipment and the employed technologies should be tolerated by *everyone* and be explained in detail to the patient and their family. If it's appropriate, ICT aimed at restoring lost abilities should be especially considered.

Generally, video recording is not really accepted: it would be preferable to record specific characteristics rather than entire behaviours. However, analysis of video recorded metrics could potentially be valuable when considering the behaviour of persons with dementia. Furthermore, not everyone may be against having their activities recorded visually. It is for this reason that acceptability will be discussed at an individual level, and all efforts will be made to minimise recording to specific characteristics or behaviours, rather than recording the entire body and their every move. This can be illustrated in the case of food preparation; it may only be relevant here to video record the individual's hands, rather than recording their whole body.

Similarly, it seems more acceptable to record information during times when the patient is alone (eg. in their bedroom) rather than times when they are within a group (dining room, living room).

Functional Requirements from Nice focus group with formal carers

1. <u>Hygiene</u> – Is the PwD washing properly? How much time is spent on personal hygiene during the day? How autonomous is the PwD when it comes to personal hygiene? Can PwD differentiate between clean and dirty clothes? Issues surrounding finding and recognising the bathroom; Identify if PwD is accumulating food/beverages in their room (this is often only detected when it starts to smell)

2. <u>Orientation in time and space</u> – verifying whether or not the PwD is orientated correctly; Are they going to sleep and waking up at inappropriate times of the day/night?; Forgetting when they have to go to bed; Going out late at night; phone calls late at night.

3. <u>Social interaction</u> – when is best time to announce to PwD that family will visit? (if notified too early the PwD can become anxious or stressed); identify trigger factors for agitation, aggression, nervous behaviour; Source conflicts and disputes between patients.

4. <u>Outdoor Activities</u> – monitoring PwD location outdoors so they don't get lost; Identify when PwD is starting to become disoriented; identify location of staff members in case of emergencies;

3.2.2   Findings from FG's with informal carers in Nice: executive summary

On 15th of March, 2012, a focus group was held for informal carers in Nice. The aim of the group was to assess the perceived needs of the PwD in an informal care setting as well as the acceptability of a sensorised environment. Eleven participants were included: 9 spouses, 1 son, and 1 professional caregiver. Four Powerpoint presentations were used to elicit views in relation to a PwD named Kurt who lives in his own home with his partner. His behaviour with regard to daily activities was described by the facilitator during each presentation. The first presentation (Appendix 3) addressed outdoor activities, occupation and daily routine activities. Time was then spent discussing Kurt's perceived needs for each specific activity. The second presentation (Appendix 4) described various sensors (such as actigraphy and kinect) which could potentially be used to meet those needs. The views of the focus group on the acceptability of these sensors were recorded. The third presentation (Appendix 5) addressed sleep, eating behaviour and social interaction. Time was then spent discussing Kurt's perceived needs for each specific activity. The fourth presentation (Appendix 6) described various sensors, which could potentially be used to meet those needs. The views of

the focus group on the acceptability of these sensors were recorded. The results are outlined below.

(A) Needs: What information is important?

Generally, the spouses didn't understand the usefulness of proposing different technical devices to obtain information about their partners' behaviour considering they are with them 24/7. Therefore, they didn't understand most of our questions. However, after a discussion, it

seemed that in some activities of daily living they would benefit from obtaining additional information about behaviours they can't always observe and verify themselves.

During the discussion, the need to acquire additional information about three different activities has been expressed by most of the caregivers and therefore appears to be important:

- **Taking medication correctly:** Was the medication taken at the right time and in the correct dosage?
- **Sleep quality:** Acquiring information about sleep quality, the completion of the different sleep cycles and the amount of time slept during the night and during the day.
- **Eating:** Establishing the time meals are eaten, whether or not the meal was finished, and whether or not the meal was eaten in the appropriate manner.

(B) Acceptability

When? Where?

Concerning the acceptability of such technical devices, the spouses share mostly the same opinion: as long as they can be with their partners 24 hours a day they don't accept the idea of 'imposing' sensors. However, if their partners' condition began to deteriorate, they would be more likely to accept them.

With regard to wearable sensors, it seems acceptable for everyone that their close relatives are equipped with them **when they are home alone.**

It remains unacceptable to equip their close relatives with devices **during outdoor activities** such as going to a restaurant or going for a walk. This is in order to protect them from stigmatization and preserve their dignity (they feared making them feel like "rats in a laboratory").

How? Which type of sensors?

The wearable sensors: First of all, the proposed sensors should be accepted by the person who wears them. It seemed that all caregivers agree that the sensors should be small (for example, a small discrete bracelet) so that the patients wouldn't refuse to wear them. Sensors shouldbe very discrete so that the patient doesn't see or feel them, especially when it comes to recording sleep information.

The "ambient" sensors: Generally, sensors are accepted if **the patient's privacy remains preserved**. For example, it would be unacceptable to install cameras or sensors in the bathroom or close to the toilet, but acceptable in the **living room** or kitchen.

3.2.3 Findings from User involvement formal carers dementia care units, Luleå

During the 12th and 18th of April focus group discussions with staff members from two different dementia care units were held in Luleå, Sweden. In both group discussions there were four staff members participating who had all good experience in dementia care. The Interviews were conducted by two nurses while one served as the facilitator of the discussion and the other served as an observer. Totally there were six persons in each discussion group. All staff worked with people with severe dementia who many had behavioural and psychological symptoms of dementia (BPSD). They were used to facilitate their work with different types of sensors available on the market, however, they had no experience of using sensors that were integrated with each other.

Needs

a. Daily routine activities

The staff members had an approach where all information that could help them to better understand and enable them to support the person with dementia was useful. Sensor data that could add information to their own observation was regarded as very useful in potentially improving their understanding and support of the person with dementia. One important aspect discussed was the importance of following the persons stress level while performing daily routines in order to better understand what enhanced or triggered agitation and what made the person calm down. The possibility of getting an early indication through sensors of the need to use the toilet would also be very supportive for the person. In one of the units the staff used a strategy of trying to keep the persons with dementia separated from the others when agitated. It was then important to know what the persons were doing in their rooms without having to disturb them by often entering the room. This was also regarded as a security issue for the staff. It could be important to know the persons position in the room before entering.

b. **Sleep pattern,** This was one area where sensors already were in use, however the one they were using is giving many false alarms and is not entirely reliable. One of the main issue was to know if the person was sleeping or not and to know what the persons were doing in their rooms in the night. Sensors were regarded as very useful since the experience was that persons with dementia often were disturbed when staff entered the room to check on them.

c. **Eating,** Eating was not regarded as an area where sensors could add much new information. The staff kept good control over the eating habits of the persons with dementia through observations. Many times they separated the persons who were agitated from the others and they were then eating in their own rooms. In those situations it was very useful to be able to observe them without having to disturb them and sensors could be useful for some of them.

d. **Social interaction,**

In situations with social interaction and group activities it was often easier for the staff to observe the person with dementia and sensor information was in that sense perceived as less needed. However, several of the staff perceived sensor information on emotional status as useful and the possibility of having systematic information where the person was could be observed over time as useful.

e. *Outdoor activities*

This was an area where all the staff perceived sensors as very useful. Many of the persons with dementia were wanderers and it was a challenge to keep track of them. There was a balance between having control and wanting to let them be free to move around. The more the staff were following the persons with dementia the more hunted they experienced themselves. They welcomed any assistive tool that could facilitate the person with dementia to be more free in movements.

Acceptability:

a. *Daily routine activities*

The staff had generally a positive attitude towards the use of sensors in the daily care of people with dementia. They were also using most available sensors in the market today. A main thread in their way of thinking on acceptability of the use of sensors was that it must have a clear purpose. It could not just be used as a routine for all persons with dementia and be used according to the individual needs of the person. If the use of the sensor could be justified to serve the needs of a person with dementia they could perceive very few limitation. One limitation was the use of sensors in common facilities and rooms where many persons occupied themselves. One concern was, how would they deal with the family members when visiting, and what would they say about the use of sensors for example in the dining room.

b. *Sleep pattern*

Sensors in the private rooms of each person with dementia were already in use and accepted by the staff. There were concerns about using cameras and microphones. To record pictures of what the person was doing or to record speech where it afterward was possible to understand what the person was saying, was not acceptable. It was somehow easier to perceive multiple use of sensors in the private rooms then in common areas, used by all the residents. Another benefit was that the use of sensors in the private rooms could be agreed on with the family.

c. *Eating* There was no special concern about using sensors in the area of eating.

d. *Social interaction* The concern of using sensors in social interaction was about the involvement of many people. Sensors that the persons were warring were of less concern that sensors observing the activity of many people. Another issue raised was the

e. Problem of preventing the persons with dementia of taking the sensors off and throwing them away.

f. *Out door activities*
Concerning the use of sensors for outdoor activities there were very few concerns of acceptability. One important concern was that sensors devices must be very reliable and robust. This is a concern about technical devices in all area of support of people with dementia, but was perceived as especially important in the area of outdoor activities.

4   Dem@Care Scenarios

4.2   Scenario 1: in the 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.

The following population will be included: patients with Mild Cognitive Impairment (n=50), patients with Alzheimer's disease (n=50) and control participants (n=50). Participants will be recruited during a medical consultation at Memory Center of Nice Hospital and Bordeaux Hospital. At first, participants will have a standard consultation with the physician, then they will perform the scenario in an experimental room equipped with daily objects, afterwards they will have a clinician consultation with a neuropsychologist to assess behavioral and psychological disorders from neuropsychiatric scales used in a daily clinical practice.

4.3   Scenario 2: in Home

The aim of the project research and development in the home environment is to use data gathered from a wide range of sensors using either an explicit or ambient approach to support people with early stage diagnosed dementia. The data collection will mainly be in the home of the person with dementia but may include data collected while the person it out in their community, on holiday etc (in particular sensecam data). This support may focus on any of up to five areas of daily life that have been described in the previous sections. The design of the

support provided will be personalised, dependent upon the individual's current status, needs and preferences. The toolbox approach to data collection that we advocate will facilitate this personalisation. While deployment will focus upon persons with early stage dementia, the needs of the individual, rather than formal disease stage, will be the main consideration when designing appropriate deployments. For example, one individual may experience deterioration in sleep latency, and this will be a relevant focus of support for them; this particular issue may not be pertinent for everyone at an early stage of dementia, and conversely, sleep latency may become an issue for a person in a moderate stage of dementia.

 The comprehensiveness of the five chosen priorities will allow for individualisation of the system to cover the needs of the individual with dementia, their next of kin, and their preferences as to what they deem a reasonable amount of technology to have in their home and about their person. In this way the project remains flexible and ethical with respect to the needs of the people affected by dementia. We do not expect that each participant will need or accept each of the areas proposed here but that they can choose the most acceptable for their circumstances.   Emphasis will be on triangulating data from different sensors to contextualise the activity.

As opposed to the testing of short duration and large numbers (as in the Lab work described earlier) this phase will investigate a smaller number of individuals over a longer time period. While the goals of this phase of the research are different it is envisaged that both phases will inform each other. For instance it is envisaged that an explicit approach can be incorporated into the data collection – where PwD are asked to perform certain tasks similar to those completed in the lab.

4.4   Scenario 3: in Nursing Home

This document has highlighted some interesting areas to explore in terms of the needs of people living in residential or nursing care. Some of the learning from scenario 1 and 2 along with a full state of the art review of technologies used in Nursing and Residential Care Facilities will be incorporated into version 2 of the functional requirements (M21).

5   Scenario 1: in the Lab

5.1   Objectives

5.1.1   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 which 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 control participants 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

5.2   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.

5.2.1 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 sensor, fusion microphone.

5.2.2 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.

5.2.3 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.

5.2.4 Executive functions and level of autonomy

Assessment of functional and cognitive abilities during a clinical scenario representing daily life activities.

Cognitive abilities assessment 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.

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 turninh on/off, tea kettle on/off), Galvanic Skin Response Sensor, fusion video camera.

5.2.5 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: audio wearable microphones.

5.2.6 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: wearable microphones.

5.2.7 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: wearable microphones, audio sensors (wearable).

6   Scenario 2: in Home

6.2   Objectives

6.2.1   Diagnosis

Diagnosis is not an explicit goal of this theme as all participants will have diagnosed dementia. However, it is worth noting that the type of data we will collect will be very useful for staging dementia. As dementia is a progressive condition it can generally be regarded as consisting of three stages – early, middle and late (Alzheimer Society of Ireland 2012). These stages are qualitatively very different from each other in terms of managing activities of daily living for both the PwD and their carer. In the early stage there are generally minor changes in the person's abilities or behaviour, for example, loss of memory for recent events. As the dementia progresses to the middle stage these changes become more marked, for instance, the person may become increasingly confused or get lost easily. Late stage dementia is characterised by very pronounced loss of memory and people in this stage often require constant care. The boundaries between these stages are not clearly defined and will vary between individuals. Tools such as the Mattis Dementia Rating Scale (DRS) (Mattis 1976) are widely used in staging dementia. Research suggests however, that looking at performance of activities of daily living in conjunction with DRS scores may improve clinical staging (Shay, et al. 1991). Contextual data such as gisted trends over time in communication patterns, functional levels, sleep patterns etc., will be interesting in terms of assessing the progression of dementia. As theme two is informed by the research in theme one on diagnosis, in turn the detailed real time data gathered during this stage of the research with diagnosed early dementia cases may inform the diagnosis of dementia using sense data.

6.2.2   Support / Enablement

Support or enablement is always limited by the accuracy or extent of information within reach of the clinician. Person centred approaches should be soft touch in that they should not support aspects that are not problematic for the individual. Such assistance where it is not required is likely to orphan *more* skills than no support at all. However, soft touch support

which assists with only the parts of the skill or phenomena that are problematic can encourage maintenance of the whole skill, independence and a better quality of life. In the face of memory problems it is very time consuming to find out which parts of certain phenomena are problematic. Along with interview data collected by a researcher the sensor data can give far greater sophistication to interventions to support or enable a person with dementia.

Support in this phase may also incorporate the needs of the relative for example they may discourage independence because they are concerned about safety issues. Feedback to the relative and reassurance that the PwD is okay may enable them to enjoy time away from the PwD more readily.

6.2.3   Safety

Enabling people with dementia can reduce risks to their wellbeing. For instance it has been argued here that being sedentary is deleterious for the health of individuals. Our system intends to enable people to maintain activity, social connectivity and general independence maintenance. However, with independence comes risk and these will have to be carefully weighed for each individual. All such contingencies that can be predicted will be detailed here. Some of these risks as specific to sleep and exercise are detailed below:

Monitoring and Enablement of Optimal Sleep Patterns

Some portable polysomnogram systems (see Fonareva et al . 2011) that seek to measure EEG, EOG and ECG data require multiple electrodes to be placed on the body in addition to accelerometers attached to the head and upper arm and a respiration belt around the abdomen. Technology such as this may prove physically constraining to the PwD and may increase risk of falls. Readings of sleep patterns may not be accurate due to discomfort levels disturbing sleep and therefore there is a risk that potentially dangerous sleep disorders such as sleep-apnoea will go undiagnosed.

Monitoring and Enablement of Optimal Exercise Habits

Technologies designed to motivate and enable exercise in individuals with dementia may lead to increased risk in terms of safety. For instance, indoor exercise using a treadmill or a

stationary bike may lead to injury if not used correctly. There is a risk of fall as well as the danger of exacerbating conditions such as arthritis which are common in elderly populations. Encouraging outdoor activities such as walking or running also runs the risk of injury due to falls. There is also the additional danger of getting lost due to disorientation.

Monitoring and Enablement of Optimal Social Connectivity

Technologies that encourage accessing the community such as the Opportunity Knocks navigational system may lead to increased risk of accidents or falls. However, due to inbuilt GPS getting lost is unlikely.

Monitoring and Enablement of ADL/IADL

Encouraging independence with regard to daily activities can have several risks. For example cooking may lead to accidents such as fire or burns. Failing to turn off taps may lead to flooding or slips. Failing to cook certain foods correctly could also result in food poisoning. Failure to clean up correctly following meal preparation could lead to an unsanitary living environment.

6.2.4 Support / Feedback

Feedback will be highly personalised based on the assessments made. For instance if there is a problem with reduced social interaction it may be possible that highlighting this to the PwD and giving them encouragement to make contact with people would help them to maintain communication skills. In another individual a system that helps them remember they have already spoken with their relative on the telephone and the main points discussed could be helpful. Feedback could be audio, textual or visual (pictures) and can fall into any of the following categories, reminding, reinforcing, encouraging, motivating or fun based. The target in the feedback could be the relative, formal carer or the PwD.

6.3 Specific targets

The toolbox approach will allow us to incorporate parameters pertaining to the specific targets here listed, as well as taking into account identified needs from the user focus groups (above, section 3.2). Since different users will have different areas that require more or less focus,

maintaining a broad scope of initial parameters will allow for personalisation at the deployment stage.

6.3.1 Sleep

Descriptive

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.

The Dem@Care system shall monitor daily patterns of sleep.

The Dem@Care system shall characterize the daily sleep pattern using the following kinds of parameters (Table 1, Appendix A7):

- 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.)
- Ambient light levels in the home
- Ambient sound levels in the home

Clinician/participant/carer will be involved in setting initial parameters for normal sleep habits. This may also be used to set targets for the participant to attempt to maintain or improve 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

Audio sensors, actigraphy, pressure sensors in mattress, video imaging, 3d modeling of sleeper using kinect, sensecam (daytime activity patterns).

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.

Triangulation

The Dem@Care system shall generate greater contextual information about sleep by relating sleep to physical activity and dietary habits (could the PwD be waking up hungry? Thirsty or needing to use the bathroom because of excessive drinking before bed).

The Dem@Care system shall provide information relating sleep to physical activity by correlating the average sleep length to average physical activity level. This will enable inferences to be drawn about any observed changes in sleep/exercise/diet habits. Follow up clinical assessment may provide information on the relationship between changes in sleep quality and cognitive health.

6.3.2 Exercise/Physical Activity

Descriptive

Research suggests that cognitive degeneration can be reduced by a combination of physical and mental exercise. Monitoring and supporting continued physical activity will be useful for both assessment and enablement goals in the Dem@Care program.

The Dem@Care system shall monitor the daily physical activity of participants. Conversely, the Dem@Care system will monitor lack of activity as a measure of time spent in sedentary

activity. It is expected that inactivity/"sedentariness" will contain unique relationships to other variables that activity measures alone will not capture.

General daily physical activity shall be differentiated from exercise in terms of intensity and duration. 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.

Indoor exercise can include but is not limited to the activities: Treadmill, stationary bike, yoga, dancing etc.

Outdoor exercise can include but is not limited to the activities: Walking, running, cycling, individual sports such as golf, group sports such as bowls, soccer and tennis etc.

The Dem@Care system shall characterize the daily activity/exercise using the following types of parameters (Table 2, Appendix A7):

- Accelerator counts per minute
- Walk speed
- Stride length
- Time taken to stand from sitting position
- Time taken to sit from standing position
- Onset times of exercise
- Exercise duration, intensity
- Distance travelled (as general activity vs exercise where applicable)

- Speed/repetitions (where applicable)
- Intensity through HR monitor etc

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/participant/carer 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.

Suggested technology for Dem@Care monitoring of physical activity:

Actigraphy, GPS data, pedometers, portable heart rate monitors. Participants with greater levels of computer literacy could be encouraged to log their own exercise activities via simple information and communication technology

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

The Dem@Care system shall provide information on the quality of exercise/activity and sedentariness based on the general parameters above.

Triangulation

The Dem@Care system shall relate sleep to physical activity and dietary habits. The Dem@Care system shall provide information relating physical activity to sleep by correlating the average physical activity level to sleep and dietary metrics. This will enable inferences to be drawn about any observed changes in sleep/exercise/diet habits. Follow up clinical assessment may provide information on the relationship between changes exercise habits and cognitive health.

6.3.3 Social Contact

Descriptive

One of the consistently reported areas of perceived need from the perspective of the person with dementia is the area of social interaction. Communication is of great importance in maintaining an individual's sense of self and place in the world and can be protective against cognitive decline. Any observable changes in a person's ability to communicate will be of significant interest to clinicians in terms of both assessment and enablement.

The Dem@Care system shall monitor aspects of the social contact of participants. This monitoring should be content free wherever possible to preserve the privacy of participants and friends/relatives.

The Dem@Care system shall characterize the daily social contact patterns using the following types of parameters (Table 3, Appendix A7):

- Typical social patterns
- Type of social interaction – face to face, telephone, internet etc.
- Number of people encountered per day (camera face recognition?)
- Frequency of speech utterances of participant
- Variety of speech utterances of participant. (Restricted ranges may indicate, low ability to communicate or repetitive questioning)
- Speed of speech (words per minute)
- Cadence of speech
- Speech volume
- Length of sentence
- Number of conversations daily
- Time logging of conversations and communication attempts
- Attending to speakers in proximity (orienting to face nearby speaker)
- Frequency of initiation of communication versus being a recipient

The system should be able to differentiate between meaningful speech and the kind of repetitive questioning that is indicative of poor memory and disorientation. Picking up this kind of behaviour could be a useful point to activate coping strategies like memory boards, calendar reminders and activity schedules etc.

Suggested technologies for Dem@Care monitoring of social contact

Wearable cameras and microphones, mobile and fixed line phone monitoring. Email and text monitoring.

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

- − Daily patterns in comparison to earlier days
- − Weekly patterns in comparison to earlier weeks
- − Monthly patterns in comparison to earlier months

The Dem@Care system shall provide information on the quality of interactions based on the general parameters for speech above.

Triangulation

Multiple sensor data may be used to give greater context to social contact metrics. E.g. GPS metrics indicating that activities like shopping, attending religious services etc are happening should be correlated with high levels of social contact. Home based sensor data can be used to identify when the participant is in proximity to a carer/partner and has the opportunity to communicate. Frequent attempts to gain attention and communicate late at night may indicate distress or disorientation.

Mismatches in this kind of data and changes in long term patterns may indicate worsening dementia symptoms, and be a signal for escalating/changing support plans.

6.3.4 Activities of Daily Life (ADL/IADL)

Descriptive

Dem@Care will investigate the effect of decline in cognitive performance into the way a person can undertake normal Activities of Daily Life (ADL), in order to assess the stage of dementia but also the individual needs for enablement and support. Within the framework of

the project, the most appropriate and technically relevant activities of ADL and IADL will be addressed. A first list of such activities is listed in Table 4, in Appendix A7 and some indicative examples are listed below.

- Eating
- Food/drink preparation
- Housekeeping
- Personal Hygiene
- Telephone Use

More specifically, food and its consumption is an activity central to all of our lives. As well as being the hub of many families social lives, the preparation and consumption of food provides regular activity and structure to ones day as well as the basic nutrients essential for the development and functioning of the brain. Nutrition can play a vital role in maintaining activity in an ageing brain. Therefore the monitoring of as many aspects of food preparation and consumption as possible is of importance to the Dem@Care project. . In a similar way the rest of the ADL and IADL listed above can provide valuable evidence for assessing the current status and identifying specific needs for enablement and support.

The Dem@Care system shall characterize ADL/IADL of the participant using the following types of parameters:

- Identification of process of performing the activities using actigraphy /camera data
- Logging of habits
    - When the activity is performed.

    - How often the activity is performed.
    - How long does the activity last.

- Explore functional abilities for the completion of ADL and the ability to organize with efficiency the different activities.

- Identification of safety issues.
- Identification of decline of the ability to use of technology and devices involved in these activities.

More specific parameters include Is the participant involved in food preparation: Who tends do the following activities?

➢ Opening and closing of refrigerator doors, kitchen presses, kitchen drawers.

➢ Activation and deactivation of devices indicating food preparation: Kettle, oven, electric/gas burners.

➢ Use of sink/dish washer/bins for preparing/tidying/disposal food

Suggested technologies for monitoring aspects of ADL/IADL:

Wearable cameras and microphones, GPS location tracking, fixed cameras in home, in home location monitoring, monitoring of appliance usage, weight of fridge stock and press stock levels

The Dem@Care system shall characterize long term patterns of ADL for the participant habits based on time series data:

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

Triangulation

Multiple sensor data may be used to give greater context to the metrics surrounding the participant's ADL.

For example if eating and drinking activities are detected and the participant has not been observed to be involved in any kind of food preparation, it could be surmised that the participant might be passive in deciding when and what to eat. Changes in long term patterns of this kind of data may indicate changes in the participants' ability to care for themselves.

Changes in patterns between eating/drinking at home vs. going out to cafés /restaurants may be correlated with lessening of social contact or other health indicators like quality of sleep in particular.

6.3.5 Mood

Descriptive

A patient with dementia is affected in different ways as the condition progresses. There may be changes in memory, cognitive ability, and behavior. 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, problems with remembering and thinking can lead to angry outbursts. This can be stressful or even frightening for a caregiver. Aggression is often a reason cited for placing a relative in a care home.

Therefore in a home monitoring system it would be highly useful to attempt to have an element of mood assessment present. This can be used to observe peaks and troughs in a patient's mood and to contribute information as to how and when to design interventions to support mood and activity levels.

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

- Self reported mood through touch screen interface (This is by far the most common method of assessing mood in tele-health systems)
- Tone of voice
- Volume of voice (notable peaks could indicate anger, troughs could indicate low mood)
- Facial expression (Can ambient camera software detect facial expressions?)
- Body posture (e.g. Clenched fists, hunched shoulders.)
- Proximity to carer (e.g. Invading carer's personal space.)

- High restlessness on actigraph (e.g. notable levels of pacing or fidgeting with hands outside of ordinary)

Suggested technologies for mood assessment:

PDA/Tablet interface, audio monitoring, video monitoring and actigraphy.

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

Triangulation

More so than any other variable (As it will never be directly observable.) mood must be assessed with reference to "setting events" the events of the last few minutes/hours that preceded any event of note. Mood can be strongly influenced by fluctuations in diet, exercise, sleep and social interaction. Mood monitoring may require information about all of these other parameters in order to provide useful information for the clinician

7 Conclusions

This deliverable describes application scenarios (T2.2), clinical requirements (T2.1) and user requirements (T2.2), based on which Dem@Care's functional and development specifications will be determined in the individual research and technological WPs (namely WP3-7). The report details how the team arrived at these first set of requirements. It includes a state of the art literature review on assistive technologies for diagnosis and enablement. As evidenced by the literature review, state of the art in assistive technology has been successfully used to enhance the lives of people with dementia and their carers through detecting and compensating for functional decline, delaying the onset of disablement, and postponing movement to residential care. The report also presents findings from two focus groups with professional and informal carers of people with dementia. This comprehensive process has culminated in the description of five sets of functional requirements for the Dem@Care system 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. 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. High-impact, low-involvement personalisation will be made possible at this stage from the toolbox approach used in the data collection, whereby sensors will record an array of potentially applicable parameters.

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, and incorporate them into version 2 of the functional requirements, deliverable D2.6, that is due to month 21.

Next steps include the final definition of the functional requirements and iterative process with technical partners to come up with the ideal range of technology in each setting (Lab, Hoe, Nursing Home) that will be used to provide the foreseen functionalities for the closed loops for the person with dementia and for the clinician.

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9 Appendices

A.1. Gunnel eldercare unit daily activities

Gunnel is 82 years of age and has resided in a dementia care unit for a couple of years.

Daily routine activities

What information about her daily life activities is important in order to support her?

Sleep pattern

What information about her sleep is important in order to support her?

Eating

What information about her eating activities is important in order to support her?

Social interaction

What information about her social interaction activities is important in order to support her?

Out door activities

What information about her outdoor activities is important in order to support her?

A.2. Kurt Private home other areas with sensors

In order to enable Kurt to maintain his abilities in daily life it was decided, following discussions with memory clinic staff, to observe his behaviour for a period of time. Kurt was equipped with wearable sensors, and sensors were also placed around his home.

Sleep

When and how is it acceptable to use sensors and when not?

Eating, planning and performing

When and how is it acceptable to use sensors and when not?

Social interaction

When and how is it acceptable to use sensors and when not?

A.3. Kurt Private home Activities

Kurt is 72 years old and was diagnosed with Alzheimer's disease three years ago.
He lives with his partner Vivianne in their private home.

Outdoor activities

What information about his behavior is important in order to support him?

Occupation

What information about his behavior is important in order to support him?

Daily routine activities
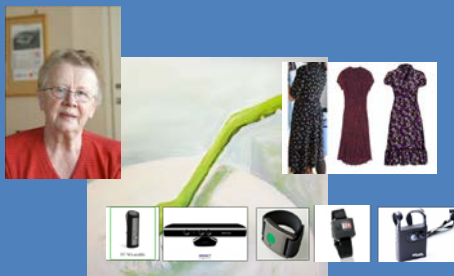
What information about his behavior is important in order to support him?

A.4. Gunnel eldercare unit daily activities with sensors
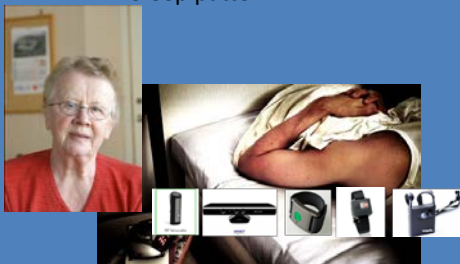
Gunnel has problems with everyday activities. In order to support her a systematic observation of her daily life activities was conducted using wearable sensors and sensors placed in the rooms

Daily routine activities

What information about her daily life activities is important in order to support her?

Sleep pattern

What information about her sleep is important in order to support her?

Eating

What information about her eating activities is important in order to support her?

Social interaction

What information about her social interaction activities is important in order to support her?
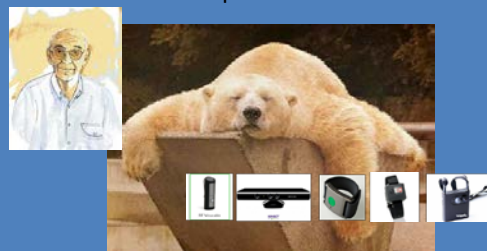
Out door activities

What information about her outdoor activities is important in order to support her?

A.5. Kurt Private home other areas
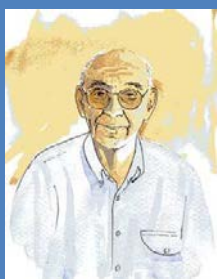
Kurt is 72 years old and was diagnosed with Alzheimer's disease three years ago.
He lives with his partner Vivianne in their private home.
.

Sleep
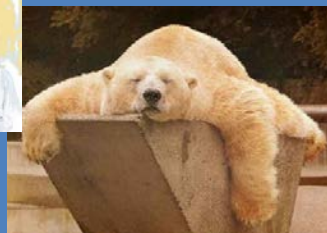
What information about his behavior is important in order to support him?
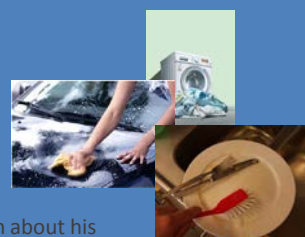
Eating, planning and performing

What information about his behavior is important in order to support him?

Social interaction

What information about his behavior is important in order to support him?

A.6. Kurt Private home Activities with sensors

In order to enable Kurt to maintain his abilities in daily life it was decided, following discussions with memory clinic staff, to observe his behaviour for a period of time. Kurt was equipped with wearable sensors, and sensors were also placed around his home.

Outdoor activities
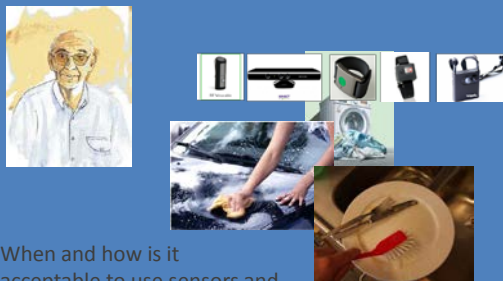
When and how is it acceptable to use sensors and when not?

Occupation

When and how is it acceptable to use sensors and when not?

Daily routine activities

When and how is it acceptable to use sensors and when not?

A.7. Functional Requirements Tables

Table 1: SLEEP

Objective	Description	Parameters	Lab	Home	Nursing Home	User priority	Technical priority	System priority
Assessment	monitoring	Sleep onset time.		✔	✔	H	H	A
		Sleep duration.		✔	✔	H	H	A
		Sleep wake time.		✔	✔	H	H	A
		Number of awakenings.		✔	✔	H	H	A
		Average length of awakenings.		✔	✔	H	H	A
		Minutes slept by location (bedroom – sitting room etc.).		✔	✔	H	H	A
Assessment	Monitoring of environmental parameters.	Ambient light levels in the home.		✔	✔	M	M	A
		Ambient sound levels in the home.		✔	✔	M	M	A
		Temperature in the room of seep.		✔	✔	M	M	A
Assessment		Time spent in bed.		✔	✔	H	H	A
		Amount of movements during the night.		✔	✔	H	H	A
		Amount of times the patient goes to the toilet during the night.		✔	✔	H	H	A
Assessment	Extract long term patterns of sleep. Extraction of trends.	Daily pattern in comparison to earlier days.		✔	✔	H	M	A
		Weekly pattern in comparison to earlier weeks.		✔	✔	H	M	A

		Monthly pattern in comparison to earlier months.		✓	✓	H	M	A
Assessment (Triangulation)	Analysis of trends.	Relate sleep trends of PwD to his/her physical activity, dietary habits , mood and behaviour of the PwD.		✓	✓	H	M	A
Support - Feedback (for the carer & the clinician).	Visualization of results, messages, alerts.	Inform to the carer and the clinician about disturbances in the sleep pattern of the PwD.		✓	✓	H	L	A
Feedback (for the carer and the clinician).	Visualization of results, messages.	Indicating to the carer and the clinician the completion of sleep cycles and amount of time the PwD slept during the night and during the day and any notable deviations in terms of movements, number and length of awakenings.		✓	✓	H	L	A
Feedback (for the PwD and the carer).	Audio content	When waking up, during night-time tell the PwD that it is night, and inform the PwD if the PwD has difficulties to sleep again.			✓	H	L	A
Feedback (for the carer).	Audiovisual content.	Indicate whether PwD is sleeping, and if not if some non-night activity is going on.			✓	H	L	A
Support (for the carer &	Audiovisual content.	Educate the PwD and the carer about		✓	✓	H	L	A

the PwD).		parameters that effect sleep.						
Support (for the carer & the PwD).	Audiovisual content.	Educate the PwD and the carer about the effect of medication and their side effects to sleep.		✓	✓	H	L	A
Support (for the carer & the PwD, personalizati on).	Audiovisual content.	Recommendations to the PwD and the carer for improving the sleep quality of the PwD according his/her profile and preferences.		✓	✓	H	L	A
Support (motivation & rewards).	Messages, visualization of positive progress.	Motivate the PwD, to improve sleep.		✓	✓	H	L	A

Table 2: PHYSICAL ACTIVITY/ EXERCISE

Objective	Description	Parameters	Lab	Home	Nursing Home	User priority	Technical priority	System priority
Assessment of Functional and Cognitive abilities to organise different activities and complete specific activities.		Activity recognition.	✓	✓	✓	H	H	A
		Interaction with objects.	✓	✓	✓	H	H	A
		Completed (yes/no) the activity.	✓	✓	✓	H	H	A
		Period (begins, end) during which the participant has oriented behaviour to do the activity.	✓	✓	✓	H	H	A
		Repetitions of an activity.	✓	✓	✓	H	H	A
		Hands trajectories.	✓	✓		H	H	A
Assessment of motor and the impact of a cognitive activity on gait performance.		Walk speed	✓	✓	✓	H	H	A
		Stride length	✓	✓	✓	H	H	A
		Time taken to stand from sitting position.	✓	✓	✓	H	H	A
		Stopping, displacement during walking.	✓	✓	✓	H	H	A
		Distance travelled.	✓	✓	✓	H	H	A
		Time needed to complete an activity.	✓	✓	✓	H	H	A
		Dynamic balance during the activity.	✓	✓	✓	H	H	A
		Walking speed instantaneous.	✓	✓	✓	H	H	A
Extract long term patterns of physical activity/exercise. Extract trends.		Daily pattern in comparison to earlier days.	✓	✓	✓	H	M	A
		Weekly pattern in comparison to earlier weeks.	✓	✓	✓	H	M	A
		Monthly pattern in comparison to earlier months.	✓	✓	✓	H	M	A
Support (for	Wandering	When PwD leaves a defined			✓	H	L	A

the carer).	Control	near area, the carer(s) would be notified and in case of emergency be able to located the PwD.					
Feedback (for the PwD).	Audiovisual content.	When the PwD cannot decide to which direction to move in the house, guide him/her to go back, by using lighting guidance (night) in addition to verbal instruction.	✓	✓	H	L	A
Assessment (Triangulation).	Analysis of trends.	Relate activity/exercise trends of PwD to his/her mood and behaviour of the PwD.	✓	✓	H	M	A
Feedback (for the PwD).	Audiovisual content.	Reward/Motivate the PwD with positive trends in physical activity/exercise.	✓	✓	H	L	A
EXERCISE (*walking, treadmill, dancing, yoga*)							
Assessment		Onset times of exercise.	✓	✓	H	H	A
		Duration.	✓	✓	H	H	A
		Times stopped during the exercise.	✓	✓	H	H	A
		Speed (running, walking, dancing).	✓	✓	H	H	A
		Balance.	✓	✓	H	H	A
		Repetitions per week/month	✓	✓	H	L	A
		HR during the exercise.	✓	✓	H	H	A
		BR during the exercise.	✓	✓	H	H	A
Safety	Alarm.	Inform the carer & the clinician for abnormal HR and BR values during exercise.	✓	✓	H	L	A
Support (for the PwD).	Reminder. Audiovisual content.	Remind the PwD the exercise sessions in the morning and 30 minute before starting.	✓	✓	H	M	C
Support (for the PwD).	Exercise Guidance. Audiovisual	Guide the PwD to perform the exercise.	✓	✓	H	L	B

	content, simulated presence.							
Support (for the carer & the PwD).	Audiovisual content.	Educate the PwD and the carer about parameters that effect physical activity/exercise.		✓	✓	H	L	A
Support (for the carer & the PwD).	Audiovisual content.	Educate the PwD and the carer about parameters the effect of physical activity/exercise to the heath condition of the PwD.		✓	✓	H	L	A
Support (for the carer & the PwD).	Audiovisual content.	Educate the PwD and the carer about the effect of medication to physical activity/exercise.		✓	✓	H	L	B
Support (motivation & rewards).	Messages, visualization of positive progress.	Motivate the PwD, to perform physical activities and exercise.		✓	✓	H	L	A
Support - Safety		Localization of patient in outdoor activities.		✓	✓	H	H	A

Table 3: SOCIAL CONTACT

Objective	Description	Parameters	Lab	Home	Nursing Home	User priority	Technical priority	System priority
Assessment	Cognitive load.	Speech fluency e.g. pause rate, speech rate, vowel duration.	✓	✓	✓	H	H	A
		Articulation control (e.g. voicing onset time).	✓	✓	✓	H	H	A
Assessment	Explore the time of latency [stimulation, response]	Time of latency between the end of instructions (stimulation) and the beginning of the task (mono & dual) (response).	✓		✓	H	H	A
Assessment	Mutual influence of cognitive activities and motor activities.	Voice features indicative of speech fluency and articulation (obs. period: mono-task cognitive activity and dual task cognitive and motor activity.)	✓		✓	H	H	A
		Correlation between instantaneous walking speed and the vocal features (obs. period: dual task: cognitive and motor activity).	✓		✓	H	H	A
Assessment	Measure impact of the cognitive activity on the gait performance and impact of the motor activity on the	Difference of measurements between mono-task (speech, motor) and dual tasks (speech and motor).	✓		✓	H	H	A

	cognitive performance.							
Assessment	Verbal reaction time and the impact of cognitive load imposed by the sentence recall task on speech fluency.	Verbal reaction time (time interval between the end of assessor's speech and the beginning of participant's speech).	✓		✓	H	H	A
		Voice features indicative of speech fluency e.g. pause rate, speech rate, and vowel duration.	✓		✓	H	H	A
Assessment	Assess the level of the participants' control over the neuromuscular mechanism of speech production.	Diadochokinetic rate (DDK), i.e. the mean number of tokens per second.	✓			H	H	A
		Speech regularity, e.g. similarity between spectral and prosodic features measured at different occurrences of the token.	✓	✓	✓	H	H	A
		Voicing onset time statistics	✓	✓	✓	H	H	A
Assessment		Number of people encountered per day.		✓	✓	H	L	A
Assessment		Frequency of initiation of communication versus being recipient.		✓	✓	H	L	A
Assessment		Monitor attention abilities.		✓	✓	H	H	A
Assessment		Monitor hearing abilities.		✓	✓	H	H	A
Assessment		Monitor vision abilities.		✓	✓	H	H	A
Assessment		Identify sources of conflicts and disputes between PwD.			✓	H	H	A

Support – Feedback (for the PwD)	Reminder. Audiovisual content.	Remind the PwD about meetings, events during the day.		✓	✓	H	L	C
Support - Feedback (for the carer	Alert. Audiovisual content.	Inform the carer about meeting, events the PwD missed, in the day.		✓	✓	H	L	A
Support – Feedback (for the PwD)	Alert. Audiovisual content.	Inform the PwD about visitor(s).			✓	H	M	B
Safety		Registering of the visitors.		✓		H	M	C
Support – Feedback (for the PwD)	Alert. Audiovisual content.	Inform the PwD about incoming call.		✓	✓	H	L	C
Support – Feedback (for the PwD)		Log the calls of the PwD (incoming, outcoming, people talked with, time and date of the calls, duration).		✓	✓	H	L	C
Support – Feedback (for the PwD)	Reminder. Audiovisual content.	Remind the PwD to make calls to people he/she uses to.		✓	✓	H	L	C
Support (for the PwD and the carer)	Audiovisual content.	Educate the PwD and the carer about the effect of social contact to dementia.		✓	✓	H	L	A
Support (for the PwD and the carer)	Audiovisual content.	Recommend the PwD and the carer for ways to social contact for the PwD, according to his/her preferences and condition.		✓	✓	H	L	A
Assessment	Characterize long term patterns of social contact. Exract trends	Daily pattern in comparison to earlier days.		✓	✓	H	M	A
		Weekly pattern in comparison to earlier weeks.		✓	✓	H	M	A
		Monthly pattern in comparison to earlier months.		✓	✓	H	M	A
Assessment (Triangulation	Analysis of trends.	Relate social condact trends of PwD to his/her mood and		✓	✓	H	L	A

)		behaviour of the PwD.						
Feedback (for PwD)	Audiovisual content.	Inform the carer about negative trends in social contact.		✓	✓	H	L	A
Support (motivation & rewards).	Messages, visualization of positive progress.	Motivate the PwD to socialise.		✓	✓	H	L	A

Table 4: ACTIVITIES OF DAILY LIFE (ADL/IADL)

Objective	Description	Parameters	Lab	Home	Nursing Home	User priority	Technical priority	System priority
Assessment Diagnosis.	Eating	Identification of process of eating and drinking.		✓	✓	H	H	A
		Start time & end time of eating activity.		✓	✓	H	H	A
		Length of eating/drinking.		✓	✓	H	H	A
		When is food/drink consumed.		✓	✓	H	H	A
		How often does participant eat/drink?		✓	✓	H	H	A
		Food/drink consumed (quality & quantity).		✓	✓	H	H	A
		Identify difficulties to use cutlery correctly.		✓	✓	H	H	A
		Identify changes in eating habits (food preferences, time of meals, quantity of food).		✓	✓	H	H	A
		Food/drink consumed outside home: carer/relatives home, café, restaurant, bar, hospital, etc.		✓		H	H	C
Feedback (for the PwD)..		Remind the meals to the PwD.			✓	H	L	B
Feedback (for the carer). Alert.		Indicate when PwD starts to have difficulties with using the cutlery correctly.		✓	✓	H	L	A
Feedback		Indicate when PwD starts to		✓	✓	H	L	A

(for the carer). Alert		have different eating habits (food preferences, time of meals, quantity of food).					
Feedback (for the carer). Alert.		Indicate when PwD has missed a meal.		✓	✓	H	L	A
Feedback (for the carer)		Indicate when PwD starts to have meals in different places in the house.		✓	✓	H	L	A
Assessment Diagnosis.	Food /drink preparation	Food/drink: place consumed. (home /kitchen/dining room/living room/bed).		✓	✓	H	H	A
		Identification of opening/closing refrigerator doors, kitchen presses, kitchen drawers.		✓	✓	H	H	A
		Activate and de-activate devices for food/drink preparation.	✓	✓		H	H	A
Assessment Diagnosis.		Use of sink/dishwasher/bins for preparing/tidying/disposal food.		✓		H	H	A
		Sequence of activities for food/drink preparation.	✓	✓		H	M	A
Enablement		Log food stock (in the fridge, in the kitchen cupboard).		✓		H	M	B

Feedback (for thePwD and the carer).		Inform the PwD and the carer if need to make shopping for food.		✓		H	L	B
Support - Feedback (for the carer & the clinician).		Inform the carer and the clinician when the PwD has an accident in the kitchen with the use of devices.		✓		H	L	A
Feedback (for the PwD).		Remind the PwD that is time to prepare a meal.		✓		H	L	B
Support (for the carer & the PwD, personalizatio n).		Recommendations to the PwD for meals according his/her preferences and the past meals.		✓		H	L	C
Assessment Diagnosis	Housekeeping	Water the plant/gardening.	✓			H	H	A
		Activities for cleaning the house (the floor and dirty surfaces).		✓		H	H	A
		Identify changes regarding disposing of rubbish.		✓		H	H	A
		Identify difficulties of the PwD with llaundry.		✓		H	H	A
		Identify if PwD is accumulating food/beverages in his/her room.			✓	H	H	A
Assessment Feedback (for the carer)		Detect if doors or items are left in undesired state for a period of time and inform the carer.	✓	✓		H	M	A
Support Feeback (for the carer) Alarm.		Inform the carer when the PwD is not in the house, but the doors are open.		✓		H	L	C
Feedback		Inform the carer about rising		✓		H	L	A

(for the carer). Alert.		difficulties regarding Housekeeping activities.						
Support - Enablement		Enable/Guide the PwD to manage the room temperature.		✓	✓	H	M	B
Assessment	Personal Hygiene	Time the PwD spends in personal hygiene during the day.			✓	H	H	A
		Detect changes regarding the autonomy of the PwD with personal hygiene.			✓	H	H	A
Support (for the carer & the PwD).		Inform the carer about identified changes in the autonomy of the PwD with personal hygiene.			✓	H	L	A
Assessment	Telephone use	Identify when the PwD starts having difficulties to operate telephone on his/her own (to looks up and dial numbers).	✓	✓	✓	H	L	A
		Picture Schedules to aid dialing without having to remember numbers.		✓	✓	H	L	C
Assessment Feedback (for the carer)	Care of Pets	Identify if the PwD forgets to take out the dog for a walk for a period. Inform the carer.		✓	✓	H	L	B
Feedback (for thePwD)		Remind the PwD vet appointment.		✓	✓	H	L	C
Feedback (for PwD)		Remind the PwD to take the dog out for a walk, if last time he/she didn't.		✓	✓	H	L	B
Assessment	Financial Management	Identify if the PwD has difficulties to handle bills and write a check.	✓	✓	✓	H	L	B

Feedback (for the carer)		Inform the carer about the rising difficulties in handling money.		✓	✓	H	L	B
Feedback (for the PwD)		Guide the PwD to handle bills.		✓		H	L	B
Safety	Medication & Health Management.	Detect Medication adherence.		✓	✓	H	M	B
		Identify that the PwD takes the right medication, and the right dose.	✓	✓	✓	H	M	B
Feedback (for the carer). Alert.		Inform the carer about the effect of medication in-compliance.		✓	✓	H	L	B
Feedback (for the carer). Alert.		Inform the carer about difficulties on medication intake.		✓	✓	H	L	B
Safety		Identify other health problems		✓	✓	H	L	A
Feedback (for the PwD).		Remind the PwD appointments with the doctor.		✓	✓	H	L	C
Feedback (for the carer). Alert.		Inform the carer about other health problems.		✓	✓	H	L	A
Assessment	Technology use	Identify if the PwD starts to have difficulties with the use of technology (TV, PC, radio, CD player).	✓	✓	✓	H	H	A
Feedback (for the carer). Alert.		Inform the carer about the rising difficulties with the use of technology (TV, PC, radio, CD player).		✓	✓	H	L	A

Feedback (for the PwD).		Guide the PwD to use of technology (TV, PC, radio, CD player).		✓	✓	H	L	A
Assessment	Transportation.	Identify if the PwD has difficulties to arrange transportation.	✓	✓		H	H	A
Feedback (for the PwD)		Guide the PwD to arrange transportation.		✓		H	L	A
Feedback (for the PwD and the carer).	Alert.	Inform the the carer and the clinician if the PwD performs ADL in a wrong sequence, or if it takes too much time to complete the activity.		✓		H	L	A
Safety	Alarms	Detect flood in the bathroom.		✓	✓	H	M	B
		Detect gas leak.		✓	✓	H	M	B
Support - Enablement		Help the PwD to find lost objects.		✓	✓	H	H	A
Assessment	Dressing	Detection of difficulties on dressing and choosing the clothes.		✓	✓	H	H	A
		Detection of difficulties to differentiate clean from dirty clothes.		✓	✓	H	H	A
Assessment	Fall prevention/detection	Positioning and posture while lying down to rising transition		✓	✓	H	H	A
		Fall detection.	✓	✓	✓	H	H	A
Feedback (for PwD).	Audiovisual content.	Reward the PwD for the completion of activities.		✓	✓	H	L	A
Feedback (for the PwD).	Activity deviations. Audiovisual content.	Inform the PwD when deviates from the expected activity, or negative trend detected. Encourage the PwD to follow			✓	H	L	A

		the predefined agenda of the day.					
Support(for the PwD)	Calendar. Audiovisual content.	Provide the PwD a calendar and a day plan according to his/her preferences.	✓	✓	H	L	C
Support – Feedback (for the PwD)	Activity Indication. Audiovisual content.	Indicate (time, description) the activities recently done and remind about the ones that are in the very near future.	✓	✓	H	L	B
Assessment	Characterize long term patterns of ADL. Extract trends.	Daily pattern in comparison to earlier days.	✓	✓	H	M	A
		Weekly pattern in comparison to earlier weeks.	✓	✓	H	M	A
		Monthly pattern in comparison to earlier months.	✓	✓	H	M	A
Assessment (triangulation).	Analysis of trends.	Relate the extracted trends of ADL with trends of mood.	✓	✓	H	M	A
Enablement – Support (for the PwD).	Audiovisual content.	Guide the PwD to perform ADL.	✓		H	H	C
Support (for the carer & the PwD).	Audiovisual content.	Educate the PwD and the carer about the effect of proper diet.	✓	✓	H	L	A
Support/Feed back (for PwD).	Audiovisual content	Reinforcement: inform PwD when they have appropriately completed a task.	✓	✓	H	L	H

Table 5: MOOD

Objective	Description	Parameters	Lab	Home	Nursing Home	User priority	Technical priority	System priority
Assessment	Verbal fluency and mood (Apathy) assessment.	Verbal reaction spontaneity (time between the end of assessor's speech and the beginning of participant's speech).	✓	✓	✓	H	H	A
		Involvement in the discussion (speech rate & total time of participant's speech).	✓	✓	✓	H	H	A
		Speech fluency (pause rate, vowel duration).	✓	✓	✓	H	H	A
		Mood: active vs. passive (prosodic features, i.e. pitch contour statistics, energy statistics).	✓	✓	✓	H	H	A
Assessment	Stress.	Stress level.	✓	✓	✓	H	H	A
Assessment	Characterize long term patterns of mood. Extract trends.	Daily pattern of mood in comparison to earlier days.		✓	✓	H	M	A
		Weekly pattern of mood in comparison to earlier weeks.		✓	✓	H	M	A
		Monthly pattern of mood in comparison to earlier months.		✓	✓	H	M	A
Support (for the carer and the PwD).		Inform the carer and the clinician about the detection negative mood trends.		✓	✓	H	L	A
Support (for the carer and the PwD).	Audiovisual content.	Educate the PwD and the carer about the parameters that affect mood.		✓	✓	H	L	A

Support (for the carer and the PwD).	Audiovisual content.	Educate the PwD and the carer about the effects of medication incompliance to behavior and mood.		✓	✓	H	L	A
Assessment (Triangulation)		Identify trigger factors for agitation, aggression, nervous behaviour.		✓	✓	H	M	B
Support (for the carer and the PwD).		Inform the carer about identified factors for agitation, aggression, nervous behaviour.		✓	✓	H	L	A
Assessment		Correlate mood parameters with medication adherence.		✓	✓	H	L	A
Assessment		Correlate mood parameters with sleep parameters.		✓	✓	H	L	A