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D1.1: User requirements and system specifications

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[1] L = Legal agreement, O = Other, P = Plan, PR = Prototype, R = Report, U = User scenario

[2] PU = Public, PP = Restricted to other programme participants (including the Commission Services), RE = Restricted to a group specified by the consortium (including the Commission Services), CO = Confidential, only for members of the consortium (including the Commission Services)

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List of abbreviations (alphabetically)

Abbreviation	Full name
LSI	Loneliness and Social Isolation
MCI	Mild Cognitive Impairment
UML	Unified Modelling Language

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About this document

This deliverable provides in the first part a definition of our 4 targets end-users (older adults, caregivers, healthcare professionals and commercial stakeholders) with a focus on their life routines, demands and struggles in everyday life. After this overview the focus will specifically flow into requirements and needs targeted on each end-user. In particular a) needs of older adults and people with mild cognitive impairment (MCI) in respect to maintaining their physical and cognitive health status; b) family members' needs in order to properly care and sustain their elderly person; c) commercial stakeholders' requirements in terms of sufficiently answering to demands of the 4 target groups and finally d) technological needs of the 4 target groups based on their knowledge and literacy. The third part of this deliverable will focus on dissemination channels and messages appropriate for all target groups and how the ReMember-Me should meet these requirements. The last part will include a brief description of use cases.

The present deliverable is closely related to T1.1Mock-up design for the Co-creation and T2.1 Co-creation phase and innovation approach.

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1 Brief overview on targeted user groups

In a first step during the kick-off workshop the entire consortium identified the specific end users' groups as to tailor the ReMember-Me system specifications on users' requirements. According to their level of interaction with the ReMember-Me system, users have been divided into primary, secondary, tertiary and quaternary end-users and will be described in the following part in an exhaustive manner.

1.1 Primary end-users

Primary users (daily using the full system) will be older adults aged at least 65 years old with or without impairments (motor, perception, cognition) and with or without a little familiarity with technology. The elderlies are the core end-user group of the Re-Member-Me system, which is conceptualized to address their needs and requirements. Most developed world countries have accepted the chronological age of 65 years as a tentative definition of "elderly" or older person. Lacking an accepted and acceptable classification, in many instances the age at which a person became eligible for statutory and occupational retirement pensions has become the default definition [1]. However, there is no "typical" older person and the resulting diversity in the capacities and health needs of older people is not random, but rooted in events throughout the life course that can often be modified. The general picture of changes to the ageing body is indeed, a complex one, implying subtle declines of cognitive performing and of psychological well-being, motor abilities and nutritional habits. Specifically, these changes regard: (i) sensory changes, especially deflection in hearing and vision systems, which in turn, may mediate age-related changes in cognitive functioning; (ii) progressive physical inactivity or motor hypo-mobility; (iii) deterioration of several cognitive functions, such as episodic and working memory, processing speed, attention, and executive functions; (iv) psychopathological symptoms, with deflected mood, low satisfaction and lack of motivation. Moreover, sub-threshold depressive symptoms and persistent motivation disorders like apathy [2] are independently associated with incident dementia in community-dwelling older people in different settings and countries [3]. As older people with apathy are a highly vulnerable group that tends to withdraw from care and

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social interactions, with a diminution in cognitive stimulation, apathy and sub-threshold depression may potentially lead to greater vulnerability to age-related neuropathological changes and cognitive decline [4]. Additionally, the frailty syndrome, is a highly prevalent state in old age characterized by "*decreased reserve and resistance to stressors, resulting from cumulative declines across multiple physiologic systems and causing vulnerability to adverse outcomes*" [5]. Mental or cognitive fatigue, which are core features of the frailty syndrome and the most common reason for mildly impaired cognitive function in older adults [6], may cause multiple negative outcomes in the elderly, including hospitalizations, increased use of healthcare services, incident disability, and mortality [7].

Concurrently, there is increasing evidence that some forms of cognitive impairment in normal ageing are recognizable as an early manifestation of dementia [8]. The stage between the expected cognitive decline of normal aging and the more serious decline of dementia is termed Mild Cognitive Impairment (MCI) [9]. MCI is a heterogeneous and still controversial syndrome; however, the usefulness of this paradigm is the recognition that dementia is not a dichotomous state, while the strongest risk factor for MCI is increasing age. In order to be diagnosed as a patient with MCI there must be a measurable deficit in cognition in at least one cognitive domain, subjective cognitive complaint confirmed by a clinician/caregiver and no functional impairment in activities of daily living [9]. There are different subgroups of MCIs, in order to include all aspects of cognitive deficits: in particular a first distinction is between the presence/absence of memory deficits; thus, the dichotomy is non-amnestic or amnestic MCI. Then, another distinction depends on how many cognitive domains are impaired in addition to memory: for example, when the elder is impaired in memory and also in other cognitive domain (language, executive function, praxis etc.) it is defined as an amnestic-MCI multiple domain while when the elder is not impaired in memory, but in one or more cognitive domain it is respectively defined non amnestic-MCI single or multiple domain.

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1.2 Secondary end-users

Due to aging-related disabilities, elderly individuals could require support and assistance in either basic or instrumental activities of daily living. In light of this, the secondary users are the elderlies' "informal caregivers", i.e. any relative, partner, friend or neighbour who has a significant personal relationship with, and provides a broad range of assistance for, an older person or an adult with a chronic or disabling condition. In some cases, the term "informal caregiver" is used interchangeably with "family caregiver". Again, there is a lack of consensus in how informal caregivers are defined [10]. Definitions range from restrictive to broad, and influence who is included in basic and translational caregiving research. More restrictive definitions limit caregiver inclusion criteria to those who meet thresholds related to the extent of assistance they provide (hours of care provided and number of times a week) [11] and/or assistance with daily care tasks. For example, some studies require a minimum amount of care to be provided by a family member (e.g., 4 hours per day or help with at least one activity of daily living). Other studies restrict participation to those who are the "primary" caregiver. Broader definitions simply require some level of impairment on the part of the care-recipient (e.g. having two impairments in instrumental activities of daily living).

Further, there may be discrepancies between subjective and objective reports of caregiving status. Some people report providing instrumental, tangible, and emotional help to another person, but do not identify with the term "caregiver". Others identify with the term "caregiver" but report not providing these types of assistance. Therefore, to most accurately identify caregivers, it may be beneficial to measure caregiving status both objectively (i.e. hours of care provided) and subjectively. Caregivers are often responsible for providing physical and emotional support to elderlies' family members, which can limit their ability to work and to participate in regular social activities, consequently decreasing their perceived well-being. However, to avoid this, it's important to support the family caregivers in the community (e.g. have informational, emotional and instrumental resources). Only in this way it's guaranteed a higher quality care and better functional recovery and community reintegration of the elderly.

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Conversely, when this condition is not met, caregivers experience greater financial, physical and psychosocial costs [12], with worsened quality of the care they are able to provide. Many studies have demonstrated that caregivers' physical health, emotional state and psychological well-being are all affected by the caregiving role [13][14]. Moreover, less stressed caregivers will also be healthier carers and less likely to seek help from the health care system.

1.3 Tertiary end-users

This group includes medical and healthcare professionals, such as neurologists, cognitive psychologists, neuropsychologists who are responsible for the professional monitoring and treatment of older adults. Their challenge regards offering meaningful exercises for brain stimulation and training, in order to slow down the elderly's cognitive decline. Their activities need a constant updating to provide adequate care, as greater availability and reliability of information for specialists will impact actual knowledge on factors influencing people's adjustment to living with age-related cognitive decline. They also need improved working methods as to achieve greater effectiveness and faster, more informed, decision-making. Indeed, improved efficiency and increased productivity of health and care systems for the elderlies is crucial as added value can be created through better outcomes for older people and increased work satisfaction of health professionals and care personnel, as well as better quality of life and financial security of informal/family careers.

The development of internet-delivered programs for preventing or delaying the onset of cognitive decline in the elderlies is the object of intensive research activity, as this would increase the scalability and reach of these interventions. Actually, remote care service delivery for the elderlies has the potentiality to overcome barriers such as long waiting lists, which extend time of intervention, and distances, in order to reach rural areas as well. The recent experience of Covid-19 pandemic highlighted how information and communication technologies can provide useful solutions for remote care in order

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to avoid the consequences of the suppression of medical visits and the availability of the health system due to measures of social distancing [15].

Furthermore, used in an adequate manner, technology can also empower human interaction and reduce distance between elderlies and community. ReMember-Me promotes communication and allows older adults to share their biographical memories with an interested interlocutor (e.g. university students). This is an ideal way to connect seniors with young generations, stimulate elderly's memory and self-esteem but also enchase students' interest on historical events and improve their learning experience.

1.4 Quaternary end-users

The quaternary end-users consist of the main target group for the commercialization of the ReMember-Me system. This group of people includes commercial stakeholders who can be care units, health insurance companies, healthcare product vendors, telecare companies, academic institutions and researchers who will indirectly benefit from the usage of the ReMember-Me system. Commercial stakeholders are looking for innovative systems, which could assist them to enhance their reputation, help them differentiate from the competitors, increase number of existing customers and revenues, range of products, as well as, make their services more cost-effective and time-efficient. Academic institutions could benefit from the data collected from ReMember-Me system. Users can give authorisation for some of their data to be collected and used by researchers to further explore research hypothesis, in relevant scientific activities. Care units could differentiate themselves from competition, if they offer the system as part of their services then family members and healthcare professionals who want to monitor the primary users' well-being and cognitive function will find value to these care units. Health insurance companies can use the ReMember-Me platform to monitor the cognitive function of their customers and adjust their funding schemes. Universities are considered part of the quaternary users because offering to the students' organizations the access to the platform as an additional educational source differentiated them from other universities that provide less educational.

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Finally, it is crucial to understand the healthcare ecosystem. It embraces multiple levels of consideration (societal, organizational and on individual level) and the relationships between key stakeholders. The interactions among the stakeholders could be complex and multi-dimensional [16] . Usually, older adults are hesitant towards integrating into their daily lives any innovative technological advancements. Negash et al (2018) highlight the influential role of healthcare professionals to the informal caregiver and then the older adults for adopting a new healthcare product in their daily life. However, the relationship between the commercial stakeholders (care units, healthcare insurance brokers) and healthcare professionals regarding implementing innovative solutions, do not operate in hierarchy but as exchange knowledge between them [17]. Despite the struggles and challenges, it's important to formulate products that meet buyers' expectations, and in this case, primary, secondary and tertiary users.

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2 User requirements and expectations

This chapter shows users' requirements related to the ReMember-Me system as a whole, and are inferred from relevant literature on needs of recipients of this project.

2.1 Older adults and MCI requirements

Although a universal description for healthy aging is not available, and it may differ depending on the purpose of the definition and/or the questions raised, from a biological perspective, active ageing is the effort to delay or slowing down the progressive, generalized impairment of function that occur as people grow older. The concept includes survival to old age, delay in the onset of non-communicable diseases (including cardiovascular disease, neurodegenerative diseases, dementia and mild cognitive impairment) and optimal functioning for the maximal period at individual levels (physical and cognitive capability), body systems and cells. According to the last World Health Organization guidelines [18], successful and healthy ageing is defined as the process of optimizing opportunities for contrasting functional decline and support of older adults' participation in society without discrimination. In this sense, healthy aging does not simply refer to "the absence of infirmity or disease" in older age, but embraces a wider definition of well-being, encompassing physical, mental and cognitive individual functioning. Thus, in order to preserve optimal functioning and independence, older adults need to: 1) take care of physical health; 2) be physically active; 3) keep mind active; 4) stay connected with social activities and 5) reduce risk to cognitive health [19].

Regarding the older adults' need to maintain cognitive and physical health, previous evidence demonstrated that the cognitive performance of older adults can be improved through systematic training focused on cognitive skills [20] and that cognitive functioning is crucial for performing activities of daily living [21], [22] and for maintaining health related quality of life among older adults [23]. Specifically, performance on definite abilities (memory, reasoning, and visual speed of processing) is

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associated with performance of cognitively demanding instrumental activities of daily living critical for independent living [24]. Thus, improvement in cognitive ability should result in maintenance of functional independence. In turn, maintained functional independence determines a positive cascade of effects including improvements in quality of life, mobility, and health service utilization. Moreover, multidomain interventions (diet, exercise, cognitive training, vascular risk monitoring) aimed at addressing the elderlies' crucial need to be physically and cognitively active, and to maintain physical health also reducing risks to cognitive health, have proved effective in improving or maintaining cognitive functioning in at-risk elderly people from the general population [25], [26]. Proponents of cognitive training have argued that computer-based interventions can improve underlying cognitive processes, as evidenced by transfer to improved performance on tasks different from training, but which measure abilities in the same cognitive constructs [20]. Moreover, preliminary evidence demonstrates that a limited dose (35 hours of total program usage) of home-based computerized intervention can drive cognitive improvements as measured with neuropsychological test battery, suggesting potential cognitive health maintenance implications for cognitively normal older adults [27]. Indeed, there is much interest in brain computerized trainings and apps, and both naïve participants as well as application-exposed participants show a positive perception of brain training, suggesting that people expect to improve with their use [28]. In particular, older adults are willing to invest significant amounts of time in game-based cognitive training to gain prolonged functional independence. The best predictors of willingness to spend time in training are belief in cognitive training efficacy, followed by openness to experience, and participants' self-perceived cognitive deficit [29]. Such results are consistent with both the Health Belief Model [30], assuming that health related behaviours are shaped by a belief that a threat would be reduced by following a health recommendation, and the Protection-Motivation Theory [31], positing that health behaviours are shaped by the belief that a recommended response is effective.

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As for the need to be involved in social activities, 50% of individuals aged over 60 are at risk of social isolation and one-third will experience some degree of loneliness later in life. Moreover, minor depression, lack of motivation and effort, and loss of interests in once enjoyed activities, which are very common symptoms in old age and related over time to a change in cognitive status from not cognitively impaired to a classification of MCI [32], lead to social withdrawal and progressive disinterest in socialising, potentially determining loneliness and social isolation (LSI). Studies demonstrated an inverse association between dementia risk and number of close relationships [4].While LSI are known to be related to depression that is itself linked to incident cognitive decline, the association of depressive symptoms and apathy in individuals at risk for developing dementia (for example those perceiving some cognitive changes as they age) can determine a circular-causal relationship and increase the odds of progressing to cognitive deterioration. Additionally, LSI have been associated with the combination of reduced physical activity and smoking among older people [33], factors that contribute to cardiovascular disease risk, increasing the risk of developing dementia [34]. Impoverished social relationships lead to a diminution in cognitive stimulation, thus eroding the cognitive reserve, and raising the odds for cognitive deterioration in cognitively unimpaired older at-risk subjects [35]. Interventions designed to alleviate loneliness and enhance social engagement in subjects at increased risk for developing dementia should therefore have a consistent effect on cognitive function, and effectively delay or prevent the onset of cognitive deterioration. A very recent review of reviews [36] concluded that the individuality of the experience of loneliness and isolation may cause difficulty in the delivery of standardised interventions. As there is no one-size-fits-all approach to addressing LSI, interventions need to be tailored as to suit the needs of individuals, specific groups or the degree of loneliness experienced. Concurrently, artificial agents, such as robots, embodied conversational agents, and chatbots, present an innovation in care delivery, and have been shown to reduce patient loneliness by providing social support. Conversational agents have demonstrated benefits for mental health, such as reduced depression and anxiety symptoms [37], [38], and other forms of artificial companionship are being

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explored in the context of health, including Alexa (a virtual voice assistant made by Amazon) [39]. When questioned about willingness to use proactive voice assistants more than 40% of elderlies (>55 yrs) in the UK and USA reported that either had or would like to buy a smart-home assistant. Interestingly, people that reported they were lonely and socially isolated were willing to spend on average 167 USD for a smart-home assistant, while the ones not reporting this - only 96 USD.

Regarding the frail elderlies [40] physical and cognitive trainings aimed at increasing energy availability and enhancing attentional control and monitoring abilities should be effective in counteracting fatigue (one of the most prominent symptom in the frailty syndrome). However, while the positive effect of physical trainings on fatigue is fairly well established, only prosiming evidence has suggested that cognitive interventions are effective in improving psycho-physical strenght, and in reducing falling risks in older adults and demented or parkinsonian patients [41].

As for patients diagnosed with MCI, the premise of neuroplasticity on enhancing cognitive functioning among healthy as well as cognitively impaired individuals across the lifespan, and the potential of harnessing these processes to prevent cognitive decline has attracted substantial scientific interest. Considerable research and clinical efforts have been directed toward finding disease-modifying interventions that may prevent or delay progression from MCI to clinical dementia. Nevertheless, currently available evidence does not allow to determine whether or not computerised cognitive training will prevent clinical dementia [42], although it does improve cognitive function in older people with MCI [43]. Computerised cognitive training programmes are associated with high satisfaction levels in MCI also, with equal or better adherence rates when compared with traditional cognitive training [44]. However, the long-term transfer of these improvements and the potential to reduce dementia prevalence remains unknown.

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2.2 Family members needs for caregiving

Caregiving affects everyone: throughout the span of a lifetime, the vast majority of the people will be or need a caregiver [45]. A large proportion of caregivers experience positive aspect, such as the rewards or satisfaction derived from the caregiving relationship [46], which may buffer the negative aspects of caregiving. Several caregiver- and patient-related factors make these positive experiences more likely: a good relationship between family member and patient before the illness, being a caregiver voluntary, maintaining own leisure time and not working outside. Also it's noteworthy that often the caregiver is a relative with almost the same age of the elder (for example the spouse or a brother) or anyway an older adult (in case of child). For this reason, for some aspects their needs are comparable to those of the elderly, since they share roughly the same age group. However, for other aspects, they have specific needs derived from their condition of caregiver, in particular: 1) to learn how to become competent, safe volunteer workers who can better protect their family members (i.e., the care recipients) [47]; 2) to be informed about her/his condition (for example with clinician support); and 3) to maintain their leisure time in order to not feel burden [45]. They also need 4) connections with resources to get their questions answered, to know where they can obtain needed information and where they can receive support and encouragement to carry on what in many cases is a daunting task.

Indeed, family caregivers often feel unprepared to provide care, have inadequate knowledge to deliver proper care, and receive little guidance from the formal health care providers [48]. Due to inadequate knowledge and skill, caregivers may be unfamiliar with the type of care they must provide, or the amount of care needed, and they may not know how to access and best utilize available resources. As a result, caregivers often neglect their own health care needs in order to assist their family member, causing deterioration in the caregiver's health and well-being [49]. Despite the importance of information to help caregivers, a research focus on the family as a part of the patient's therapeutic plan of care is largely absent from interventional research and from general clinical practice as well. Few randomized clinical trials of educational interventions

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directed toward family caregivers have been conducted or published, and there is limited research on skills training for caregivers. However, strengthening caregivers' competence and confidence improves their mastery, and caregivers with higher levels of mastery of the care situation have more positive responses to providing care, because they perceive themselves as able to meet care demands [50]. Caregiver mastery can reduce caregiver distress [51] and is associated to more positive health-related behaviours among caregivers. For example, a psycho-educational intervention to teach management of behavioural problems and basic activities of daily living reduced caregivers' anxiety as they felt more capable of managing difficult behaviours [50]. Similar findings were demonstrated for a portable CD-ROM training program for caregivers of people with dementia [52]. Indeed, increasing request for individual and group psychological support [53], [54] comes from caregivers experiencing burnout as lack of awareness for memory and functional impairment emerges with dementia progression rendering patient's management more difficult. Also interventions to build problem-solving abilities and skills help caregivers of persons with dementia by decreasing negative behaviour in those they care for [55]. Finally, programs to increase caregivers' knowledge about community services and how to access them additionally increase their sense of competence and reduce depression [56]. An additional area of research concerns ambient assisted living, which is increasingly emerging within the field of information and communications technology. These technologies combine ubiquitous information, communication, and entertainment, with enhanced personalization, natural interaction and intelligence. The capability of these technologies can range from simple push-button emergency call systems to complexly crafted systems that enable individuals to maintain their independence and live alone, to prevent wandering, or "smart homes" to monitor individuals' physical and medical safety. As these technologies are developed, it is beneficial to understand how they can supplement caregivers, so they can also maintain their independence; provide better long-term support; and maintain their own physical, social, and emotional wellness.

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2.3 Commercial stakeholders' needs

As said before commercial stakeholders could include care units, healthcare product vendors, tele-health care companies and insurance brokers. Their needs are in terms of ability to treat data collected locally or remotely, cost efficiency, iterative tools for updating the system to the mental conditions of the patients, remote access and management and reusability of the product expectations.

Pseudonymisation is a procedure by which identifying data with a certain algorithm is replaced by encrypted data (the pseudonym). The algorithm can always determine the same pseudonym for an individual, allowing information about the individual, including from different sources, to be combined. Pseudonymisation is reversible and as such it is still personal data that falls under the GDPR. Pseudonymisation does reduce the risk of data misuse in the event of a data breach, because you need to know how the algorithm works. Anonymisation is an irreversible processing in which personal data are replaced by anonymous data.

To date there are different tools in the market that allow to pseudonymize, but also anonymise personal data. Among others, Ordina Data Migratie Straat (ODMS) is a tool set up by Ordina for data migrations. ODMS is independent of the source technology so that it can be used on all databases. This future-proof solution is ISO-27001 certified and is offered to various customers as a service. ODMS is supplemented with algorithms for (homomorphic) encryption developed by COSIC. Since both tools use the same algorithms, reference integrity can be guaranteed. The cryptographic library of the research group COSIC contains encryption, hashing and MAC algorithms and FPE (format preserving encryption) and randomization tools. These types of technologies ensure the right way to use the gathered data from the Remember-Me system in various ways and make it commercially liable to support other research about the various types of the dementia disease and their evolution in time. The technical partners within the consortium (AOI, EP, TUC) will define selection parameters (i.e. data protection level and the entity of pseudonymisation wishes to reach) that will guide the choice for ReMember-Me. Once the tools that respect these parameters are selected, they will be

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presented to the rest of the consortium and all, unanimously, will choose the most suitable tool for ReMember-me and its end-users needs. In addition, Remember-Me can be a household system to be used as a reference guide how to deal with the end-user during the process of dementia.

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3 System specification

3.1 System requirements for all users

Because many cognitive training programs are technology-based (delivered by computer or mobile device), the Senior Technology Acceptance Model [57] is especially relevant when systems requirements have to be defined as to maximize willingness to spend time in training in the elderlies. This model predicts that attitudes toward using technology are primarily influenced in older adults, by the perceived usefulness and perceived ease of use of the technology. Perceived usefulness was described as 'the degree to which a person believes that using the particular technology would enhance his/her job performance' [58]. Perceived ease of use is 'the extent to which a person believes that using a technology is free of effort' [58]. These two factors jointly determine attitude towards using behaviour, and perceived usefulness also mediates the effect of perceived ease of use on attitude. Perceived usefulness and attitude toward using behaviour predict the behavioural intention to use, which directly affects actual usage behaviour. Other external factors, such as self-efficacy, health, physical functioning, and cognitive ability, influence perceived usefulness and ease of use. More specifically, three direct determinants of intention of usage (performance expectancy, effort expectancy and social influence), two direct determinants of usage behaviour (behavioural intention and facilitating conditions), and four moderators (gender, age, experience and voluntariness of use) [59] are strong predictors of usage in different technological, research and participant settings [60].

These concepts, if applicable to the domain of cognitive training, predict that older adults' perceptions that cognitive decline is a threat to them will increase their likelihood of adopting cognitive training, especially if they already have negative perceptions of their own cognition. The same need to maintain optimal cognitive capability and functional independence determines willingness to include more cognitively stimulating activities into their daily routines also in adults reporting higher, rather than lower, cognitive functioning and well-being. Indeed, a recent survey found that the latters had a great desire to do more to improve their cognitive health and

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engage in cognitively stimulating activities [61]. Thus, in order to ensure that the products, services or environments for cognitive stimulation are appropriate to be used by the elderlies with no limitation, the major determinants of intention of usage and usage behaviour need to be addressed. As for performance expectancy, i.e. the degree to which a person believes that using the technology will help him/her to better perform tasks, the concept is superimposable to perceived usefulness. Therefore, one of the influencing attributes of the technology and product characteristics that maximises user's attitude toward usage and behavioural intention to adopt technology-based cognitive interventions will be the availability of performance analytics as to inform patients and caregivers on the potential improvement in cognitive capability derived from the intervention. This feature will increase participants' awareness of cognitive decline (which is one crucial predictor of willingness to spend time in training) [29] and will meet the caregivers' need to be informed about the patient's condition. It will also provide to tertiary end-users reliable information on the participants' cognitive status, thus responding to the need of promptly detecting an incipient cognitive decline. For example, some technology-based cognitive interventions (eg. BrainHQ from Posit Science) compare the individual actual performance to internal norms, and score it according to age-expected performance and percentile ranks. In some cases, they also show the average time spent by users on a definite exercise or daily training hours thus impinging on intention to use through the social influence effect (the perception that others consider technology usage important and valuable for cognitive health).

The other determinant of intention of usage, i.e. effort expectancy, is the degree of ease associated with using the technology [59]. It is known that with ageing come related changes in physiological and psychological abilities, which will inevitably influence the needs of older people and their capability to use technology or technical device [62]. For instance, age-related visual and hearing impairments may influence the ease of use of devices, which rely primarily on graphical/text-based or sound-based user interfaces to present information [63]. Due to the declines in touch sensitivity and psychomotor performance, old people may have difficulty in performing accurate and discrete movements –like tapping very small targets, pressing small buttons or writing with a

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stylus– as required by many technological devices. Moreover, use of new technologies requires learning new skills, so, given that they experience declines in cognitive abilities such as selective attention and working memory, older adults may have more difficulty in understanding and learning, and are slower in acquiring new skills than younger adults. Thus, in order to overcome the reported changes in elderlies' physiological and psychological abilities and to increase the degree of ease, technology-based training programs should be intuitive and extremely easy to use. The interface should be basic, with the possibility to add functionalities, and interaction steps should be minimized with a minimal amount of pages and information (see for example AAL Elders Up! (2013) D2.3 User requirements and specification of user groups). The system should also provide clear and understandable symbols, big fonts, buttons and high contrasts. All buttons should be large and easy to tap, surrounded with clear boundaries and not smaller than the size of the thumb. As to minimize learning demands, the user interface should be consistent and display common tasks (help, search information) always at the same place. Also, the possibility to receive reminders and alerts such that the system actively reach out and engage users through e.g. e-mail, rather than passively wait for the user to log in, will have a positive impact on effort expectancy as it will compensate for potential prospective memory problems or motivation disorders.

Other facilitating conditions that will positively affect behavioural intention of technology usage [59] include fluency and predictability of interactions, and the potentiality of receiving online support. Indeed, facilitating conditions are the degree to which a person believes that will be technical support for the use of the technology. For example, the introduction of a progress bar or other relevant information in case an action takes more than one second, will reassure users that the system is properly working and no external support is needed. The potentiality for system recovering from errors (and notifying users) will also further facilitate the use of technology. These facilitating conditions will also meet the caregivers' need to increase competence, confidence and mastery of the care situation, as their interaction with the cognitive stimulation system will be backed-up by the possibility to receive online support. They

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will also respond to the need of tertiary and quaternary users for a predictable and reliable system.

Lastly, a paper manual explaining the system main functionalities, a demo showing the use of the ReMember-Me platform, and the possibility to call/chat with a help desk (see AAL Elders Up! (2013) D2.3 User requirements and specification of user groups) will meet the four target groups' need for a reliable and predictable system.

4 Dissemination channel and appropriate messages

The dissemination of the results of ReMember - Me will take several forms and use a variety of media. Some activities are expected to have a greater impact than others, and thus, their value in relation to the aims of the project may be different. Nevertheless, all dissemination activities will be aligned to the Dissemination Plan aim to promote commercial exploitation of the project's results and the widest dissemination of knowledge from the project.

Therefore, a strong online presence is a crucial component of our dissemination plan, since most consumer use the web to search for local business. The project website is one of the main sources of information about the project available to most stakeholders.

On the other hand, online social networks are another potentially useful dissemination tool and channel. The project will take advantage of the well-established social media channels such as twitter, which is a particularly useful way at engaging participants at events and in increasing the impact and visibility of such events, and also it easily helps to promote ReMember-Me's research and outcomes, reaching a large number of people quickly as well as new audiences. Other social networks that we will use within the project are:

- Facebook: Facebook is one of the most popular platforms, not only for personal use but business as well. For businesses, Facebook is a place to share photos, updates, and general news with those who follow or "like" you.

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- LinkedIn: LinkedIn can help ReMember-Me build a brand, build new networks, relationships with mutual connections, being one othe most powerful professional tools.

- Instagram: finally, ReMember-Me will use Instagram as a key social network, with massive audience and most powerful influence on shopping habits. As reported by "Visual Capitalist", 72% of Instagram users report making purchase decisions based on something that they saw on the site.

Blogs will also help to publicise project effort and results and may be particularly effective in reaching formal and informal carers.

Workshops are an essential knowledge dissemination means. Consortium partners will use workshops to discuss, present and deliberate project related matters and findings with the different target end users identified within the project.

Lastly, another contribution for dissemination will come from external conferences and scientific publication, through which we will share our project findings and outcomes.

5. How will ReMember-Me tangle end-users needs?

To address the Remember-Me end-user needs and to increase system acceptance by the older adults and target users, in general, the following technological aspects need be addressed.

From the technological perspective, the nowadays older adults' assistive services are shifting towards the use of objective monitoring using IoT (Internet of Things) sensors and sensors networks being driven by a strong need of objective monitoring of older adult's health and care state. Most of today's care process assessment is still relying on self-reporting of "perceived behaviours or state", but this kind of models are proven not to be viable in the case of elders who mostly deals with problems such as forgetfulness and confusion and chaining mood and behaviour. Recent IoT advancements and the development of miniaturized sensors have the potential of changing this situation, by enabling the remote and daily monitoring of important care aspects such as physical

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activity and sleep patterns. Thus, for the development of the Remember-Me system we have addressed this issue by using combination of sensors-based monitoring of important features such as sleep patterns and activity with the self-assessment of cognitive state by using questioners.

In terms of monitoring solutions related to Remember-Me system objectives the state of the art monitoring infrastructures integrate the following types of non-wearable heterogeneous sensing units installed in the older adult's houses: (i) movement sensors, (ii) electronics and electrical devices monitoring sensors placed on the electrical and electronic appliances, (iii) toilet sensors, (iv) contact sensors to monitor the opening/ closing of a door, office desk or and self-grooming table and (v) force sensors placed on sofa /bed/ armchair to monitor the sleeping or sitting activities. Wearable sensors can be combined with ambient sensors in complex monitoring infrastructures that can be used to obtain more accurate results in monitoring the heath/well-being status or sleep quality. Sleep quality is an important factor for a person's stage of health because it reduces the risk of developing chronic diseases and mental disorders. Most state-of-the-art approaches for monitoring sleep quality focus on comparative analyses and evaluation of the commercial devices available on the market [64]–[66], while only some of them present academic research solutions [67]–[69]. Authors [65] evaluate five wearable devices for recording the sleep quality, namely the Basis Health Tracker, the Misfit Shine, the Fitbit Flex, the Withings Pulse O2 and the Actiwatch Spectrum actigraph. The Basis Health Tracker is an actigraph embedded in a wristwatch, while the Misfit Shine is a sleep-tracking device provided with a strap to be worn on the hand. The Withings Pulse O2 is also a sleep-tracking device worn on the wrist, while the Actiwatch Spectrum is a wristwatch with an embedded accelerometer. Smart beds as well as cameras are an alternative to the wearable commercial devices for monitoring the sleep quality, beside the polysomnography and the videosomnography that can be used in clinical evaluations. Solutions such as [70] propose a non-intrusive monitoring infrastructure consisting of pressure sensors embedded in bed which is used for detecting sleep quality. The sleep quality is assessed based on the sleep position and the

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sleep stages. Similarly, in [71] a microbend fiber optic mat embedded in the mattress of the bed is used to monitor the sleep quality. The sleep quality is evaluated based on the following types of data acquired from sensor: sleep duration, movements during the sleep, heart rate, awake stage duration, time spend in bed as well as the respiration rate. The benefits of assistive technologies come from their core analytics components that use advanced machine learning techniques for taking decisions, alerting or providing support for doctors and caregivers. The user acceptance for these technologies relates to their understanding of the brought benefits and potential improvement for their quality of life. In general, older adults, doctors and caregivers agree and seem to be comfortable to us AI/ML technologies for assisting and improving the care process [72], [73]. They are usually adapted to particularities of older adult's health status such as mild dementia [74], medication and polypharmacy [75], cardiovascular problems [76] or physical activity [77]. However, the acceptance of such technology is usually influenced by factors such as age and education [78], while the adoption of intelligent technologies is corelated with the older adult loneliness and with the support provided by caregivers [79]. The Remember-Me system may benefit on such techniques for implementing the baseline assessment to assess their current cognitive, emotional and physical status which will be done on top of the monitored data. Also, the availability of performance analytics as to inform patients and caregivers on the potential improvement in cognitive capability derived from the intervention is important for increasing the user acceptance.

The use of social robots for older people care is a new technological trend for supporting the intervention and will increase the motivation and end-user adherence with the RememberMe system. Existing studies for the social robots' acceptance are relatively new and conclude that further research is required for assessing acceptance rate but in the same time clearly identify the care areas where the robots can be successfully used as physical assistance, safety/monitoring, and social companionship for an older adult [73], [80]. Other surveys show that older adults have positive thoughts regarding the usefulness, utility, safety, and trust of a social robot, while doctors and caregivers consider that the robot is a useful tool for rehabilitation [81]. Remember-Me

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system will use the robot as an intervention tool allowing the delivery of recommendations on several health-related aspects deemed important for a healthy brain according to recent literature, such as hydration, nutrition, sleep, etc. In general, more positive acceptance is found after the users interact with the robot after a period, while the acceptance level is directly influenced by the robot's social capabilities [82]. Other authors pinpoint that usefulness, adaptability, enjoyment, sociability, companionship, and perceived behavioural control are important for the high acceptance rate of social robots [83]. One specific factor for accepting the social robot as a care companion is loneliness, the social robots may offer support and companionship especially at home [84]. Thus, in Remember-Me system the robot will used as a facilitator of the interaction with healthcare professionals and family members/informal caregivers as well as new people. For example, recent study has shown that PARO can be very useful for improving quality of life of older adults with dementia and Alzheimer, affection and social interaction, reducing depression and anxiety—even for reducing pain medication usage [85]. The Nao robot is also reported in several approaches as useful coaching assistant [86]. In [87] a particular use case for Nao is presented as an illustrative scenario for social robot driven intervention, an autonomous exercise tutor. The robot is capable to learn from a human, to generate feedback situations such as speed and amplitude adjustment, mirroring detection and no motion. For the specific use–case of older adult care, Pepper was successfully used in healthcare and older adult-care facilities mainly as narrative-memory-based human–robot companionship [88] and medicine taking reminding, encouraging older adults to keep active and helping them keep in touch with family and friends (see: Culture Aware Robots and Environmental Sensor Systems for Elderly Support. Available online: http://caressesrobot.org/en/). There are several other social robots that are reported in the literature as potential solution for older adult care intervention. Zora and James are examples of robots that can be used in interventions for the care personnel and for the older adult-care institutions [89].

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6. Use cases

A use case is a series of related interactions between a user (or more generally, an "actor") and a system that enables the user to achieve a goal. Each use case is represented as a sequence of simple steps, beginnings with a user's goal and ending when that goal is fulfilled. The development of the use cases for ReMember – Me system has been done interactively with the initial compilation of the requirements. Use cases are comprised of several parts all aiming to define the flow/list of actions an actor performs with a system to achieve a goal as well as other parameters associated with those actions, including ethical aspects, restrictions, environmental implications, etc. The Use Case is frequently accompanied by Unified Modelling Language (UML) used in the field of software engineering to model actor-system interactions in a schematic way. Based on the user categories involved in this project, the use cases created are primary, secondary, tertiary and quaternary user-oriented.

In general, the following parts compose a use case: ID, name, PILOT, actors, description, stakeholders and interests, trigger, preconditions, post-conditions, normal flow, alternative flows, exceptions, include relationship, frequency of use, special requirements, assumption and notes. Not all these elements must be completed for a specific use case. Only those elements useful for the description of requirements and/or for the definition of the situations to be tested at the pilots will be fulfilled. Nevertheless, all use cases will include the basic elements: name, pilot, priority, actors, description and normal flow.

Here some examples of primary, secondary and tertiary oriented use case in ReMember - Me:

UC.PU2: Older adult performs daily short detection exercises

General description	
Use case name	UC.PU2: Older adult performs daily short detection exercises
Version (updated)	V0.1 (May, 2020)
Authors	MAT
Description	Older adult is prompted to perform short detection exercises (see action) on regular intervals throughout the day and week. The results are stored in the system and conveyed in three target groups in different ways. Alerts are sent when a significant drop-in activity or decline in performance is detected.
Pre-conditions	∇ Detection exercises must be appropriate and adapted to the level of function of the user (Category A, B, C) ∇ Detection exercises are dynamically adapted according to user performance ∇ Detection exercises may be prompted by the robot but must be performed on the tablet screen to ensure reliable registration of user input ∇ Detection exercises are performed in all cognitive domains and are alternating daily
Goal	Assess users' emotional and cognitive function in regular intervals in order to detect emotional or cognitive difficulties early on and adapt the exercise plan accordingly.
Post-conditions	After the completion of each short detection exercise, users' receive an encouraging quote by the robot
Involved actors	Older adult
Use-case initiation	Use case is initiated automatically according to the user's waking and sleeping pattern or manually if the user presses the appropriate button
Main flow	1. System detects time of day and automatically generates a detection exercise 2. System generates a detection exercise when prompted by user 3. User performs detection exercise 4. System generates encouraging message 5. Data is stored on Progress Dashboard
Related to	UC.PU1
Specific description	
Privacy & Regulation restrictions	∇ Results will be visible in an appropriate language and manner for different target groups with respect to their knowledge and characteristics ∇ User should receive feedback and encouragement after completion of each exercise independent of their performance ∇ Notifications must be adapted to users' life and preferences in order to not be tiring or annoying
Environmental restrictions	n/a
References	n/a
Notes (optional)	n/a
UML Sequence Diagram	

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UC.SU1: Family member/informal caregiver connects with older adult and inserts background information

General description	
Use case name	UC.SU1: Family member/informal caregiver connects with older adult and inserts background information
Version (updated)	V0.1 (May, 2020)
Authors	MAT
Description	During the initial usage of the ReMember-Me system the family member has to create an account in the ReMember-Me system and connect with the older adult and get their authorization in order to view data related to them or connect through the Meet People platform. After the registration and connection, the family member is prompted to add some baseline information regarding the user (health-related data).
Pre-conditions	∇ Connection to the internet ∇ Installation of the ReMember-Me app for caregivers ∇ Their relative (older adult) has obtained and registered in the ReMember-Me system for older adults ∇ Their relative authorizes them to view their data
Goal	Connect with older adults in order to monitor their progress and engage in brain stimulating activities with them.
Post-conditions	After completion of connection and background information entry, a system pop-up notifies the user that everything is set and they can start using the system.
Involved actors	Family member/informal caregiver; Older adult
Use-case initiation	Initiated when the family member creates an account in the ReMember-Me app for caregivers and connects with a user
Main flow	1. App prompts user to register 2. App prompts user to connect with a relative (older adult) 3. Connection is approved by older adult 4. User is prompted to enter some background information 5. User receives a message that everything is set
Related to	UC.PU1
Specific description	
Privacy & Regulation restrictions	∇ User must be approved by older adults in order to view their data ∇ Older adult may revoke his/her access at any time point ∇ User must see a disclaimer upon enrolling in the app that the system is not a medical instrument but only a complementary tool and regarding data protection policies
Environmental restrictions	n/a
References	n/a
Notes (optional)	n/a
UML Sequence Diagram	

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UC.TU1: Healthcare professional views patient's progress

General description	
Use case name	UC.TU1: Healthcare professional views patient's progress
Version (updated)	V0.1 (May, 2020)
Authors	MAT
Description	Healthcare professional can view the older adults progress and performance trends on the Dashboard. In detail, they may view: ∇ Charts on progress per domain (cognitive included sub-domains, physical, emotional, social) ∇ Alerts on affected domains in which decline is detected ∇ The suggested rehabilitation plan ∇ Other notifications
Pre-conditions	∇ Connection to the internet ∇ Installation of the ReMember-Me app for healthcare professionals ∇ Their patient (older adult) has obtained and registered in the ReMember-Me system for older adults ∇ The older adult has authorized them as a trusted contact ∇ Their patient has performed the baseline assessment, short detection exercises and games
Goal	To assist healthcare professionals in monitoring their patients' progress and health status, in order to intervene early on.
Post-conditions	n/a
Involved actors	Healthcare professionals
Use-case initiation	The use case is initiated every time the healthcare professional views the dashboard or automatically receives a system-generated alert.
Main flow	1. (optional) Healthcare professional receives an alert 2. Healthcare professional visits Dashboard
Related to	UC.PU1, UC.PU2, UC.PU3, UC.PU7
Specific description	
Privacy & Regulation restrictions	∇ Results are conveyed in appropriate language and manner for healthcare professionals ∇ User must see a disclaimer accompanying the results regarding the reliability of data
Environmental restrictions	n/a
References	n/a
Notes (optional)	n/a
UML Sequence Diagram	

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7 Conclusions

In this deliverable, the user requirements for the ReMember – Me system have been specified. The requirements are based on the analysis of the literature and consider the needs of the users to be developed in the different prototype versions in function of their priority. The literature research evidenced that, even if elderlies and caregivers requirements overlap some levels of system use, it is important to specify the specific need of each group. According to the recent literature, it is clear that multidomain interventions (physical, cognitive, social) could increase elderlies' quality of life and their independence in daily living. Furthermore, our review of previous works highlighted that empower caregivers' knowledge regarding the disease and its evolution may enchase their mastery and reduce stress level. The intelligent platform will consider data protection, cost efficiency, interactive and intuitive tools, remote access and management of the system. ReMember-Me will guarantee full anonymity of personal data and the protection of online and offline data via full compliance with GDPR and other European legislations (GDPR Regulation 2016/679, Directive 2016/680, Directive 2002/58/EC). A comprehensive overview of the technological aspects that must be addressed for the project goals was explored in section 5 while examples of primary, secondary and tertiary use cases in ReMember - Me lead to the closure of the document.

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