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Mild Cognitive Impairment User Requirements

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1 INTRODUCTION AND GOALS

Nowadays European society is increasingly facing many challenges connected with current significant social and demographic trends. Indeed, the ageing of populations, the change of lifestyles towards growing individualization, a strive for lifelong personal independence and the growth of single households are trends currently occurring together with a progressive and increasing digitalization of both private and professional lives. In this context, it is not by chance that the PETAL consortium decided targeting the elderly population, a group of people, which is expected to highly increase in the next future. In particular, while the original plan of the project was to target elderly people affected by mild dementia, the PETAL consortium in the initial phases of the project has decided moving the focus to elderly affected by Mild Cognitive Impairment (MCI).

MCI is a quite frequent condition in the elderly population. It is generally characterized by an initial deterioration in a single or multiple cognitive domains such as memory, executive functioning, attention, or visuospatial abilities while generally global cognition and basic activities of daily living are mostly fine. However, many studies have suggested that persons with mild cognitive impairment are at increased risk of progressing to dementia. Preventive interventions and appropriate treatments should be able to improve cognitive performance and retard or prevent progressive deficits, thus it is crucial to intervene as soon as possible with those persons. In older adults with MCI, even subtle declines in cognitive abilities or everyday functioning are associated with e.g. decreased independence and safety, additional burden for caregivers, reduced chance of reverting to normal cognitive status, and, as said before, increased likelihood of developing dementia. The PETAL project takes on with these challenges and developments: based on an innovative technological solution, it aims to assist elderly people with MCI in order to satisfy their unique requirements for managing an active and independent life at home, while increasing awareness and control of their current lifestyle. This will be achieved through an intelligent platform able to monitor users' behaviour (movements, interactions) and support personalized control of lights and appliances in their environment, as well as providing them with relevant and tailored information in an intuitive and natural manner.

Thus, the reasons why the PETAL consortium decided addressing people with MCI instead of those affected by mild dementia (as originally planned) are rooted in a more in-depth consideration of the type of solution that PETAL aims to provide to its target users. Indeed, giving the technological connotation of the proposed solution and the intended active involvement of end users (caregivers and even elderly having some familiarity with technology) in using the developed platform for personalization purposes, we preferred considering a class of elderly with reduced impairments in judgments/reasoning, less difficulties with everyday activities, with a more autonomous lifestyle, and with less needs in terms of care management, also considering that patients in greatest need of chronic care management are those least likely to engage with technology. Indeed, elderly with MCI have a stronger potential to learn to use new technologies than those with dementia, and introducing systems for people with MCI when they are more able to adapt and interact with the technology may have more potential.

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As such, in order to ensure that the PETAL platform will properly support the needs of MCI older adults, the specific lifestyles, capabilities, living environments and ambitions of MCI elderly people must be taken into account in order to find adequate concepts and solutions for the purpose of promoting their independence. Accordingly, the present deliverable sheds light on the requirements of MCI older adults in their role of beneficiaries from care services and consumers, with their own specific, age-related interests, needs and requirements.

These requirements should be read in conjunction with the social, technical and regulatory environments as well as the needs and requirements of informal and formal caregivers (as dealt with in deliverable D1.2.) and be taken as a basis for the upcoming development process and system design. In view of that, the present analysis pursues the objective to identify relevant issues allowing choices between potential features, modes of interaction and designs the PETAL system will adopt. In particular, this deliverable is structured into the following parts: we first introduce the characteristics of the target population, next we describe the method followed to gather users' requirements, then we describe and analyse the collected data, lastly some concluding indications and remarks are provided.

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2 TARGET GROUP CHARACTERIZATION (MCI ELDERLY)

2.1 Introduction

In the last decade, the field of ageing and dementia has become of a high interest, especially when it comes to the early diagnoses and intervention, the main goal being to identify clinical symptoms and biomarkers. The term Mild Cognitive Impairment (MCI), as a clinical entity, was introduced more than 20 years ago - since then, patients have been investigated from different perspectives such as clinical, imagistic, genetic, morpho pathological and epidemiological.

The prevalence of MCI varies according to the population on which this pathology has been studied. Using the diagnostic criteria proposed by Winblad in 2004, the prevalence of MCI was 42% in France (Artero et al 2008), 28.3% in the US (Manly et al 2005), 24.3% in Austria (Fischer et al 2007) and 16.1% in Italy (Di Carlo et al. 2007). In a study of 2364 patients of various entities, the rate of pathological reversibility was examined - the result showed no alteration for 47%. However, 31% showed a regression of the pathological process on period of 4.7 years (Manly et al 2008). Moreover, the mortality raised by 50% to 150% among MCI patients compared with the healthy subjects (Guehne, Luck, Busse, Angermeyer, Riedel & Heyer 2007; Hudenrfund 2006; Wilson 2009).

2.2 Classification

The concept of MCI defines a pathology wider than just a prodromal phase of Alzheimer's Disease (AD). The heterogeneity of MCI aetiology is reflected by the numerous studies conducted so far. MCI patients, followed during a period of time, either progress to AD, maintain their cognitive status or show an improvement and sometimes a full clinical recovery of their cognitive functions. What is more, the MCI heterogeneity is reflected in the clinical manifestations as well, hence its classification under 4 subtypes (the classification is based on whether the memory domain is affected or not as well as if there are any other cognitive domains are altered such as language, executive functions, visual and temporal orientation):

- amnesic MCI (aMCI) - the memory is affected
 - o single domain aMCI - only memory is affected
 - o multiple domain aMCI - there are other cognitive domains affected, besides memory
- non-amnesic (naMCI) - the memory is not affected
 - o single domain naMCI - one cognitive domain is affected, the memory being unaffected
 - o multiple domain naMCI - more than one cognitive domain is affected, the memory being unaffected.

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2.3 Aetiology and Risk Factors

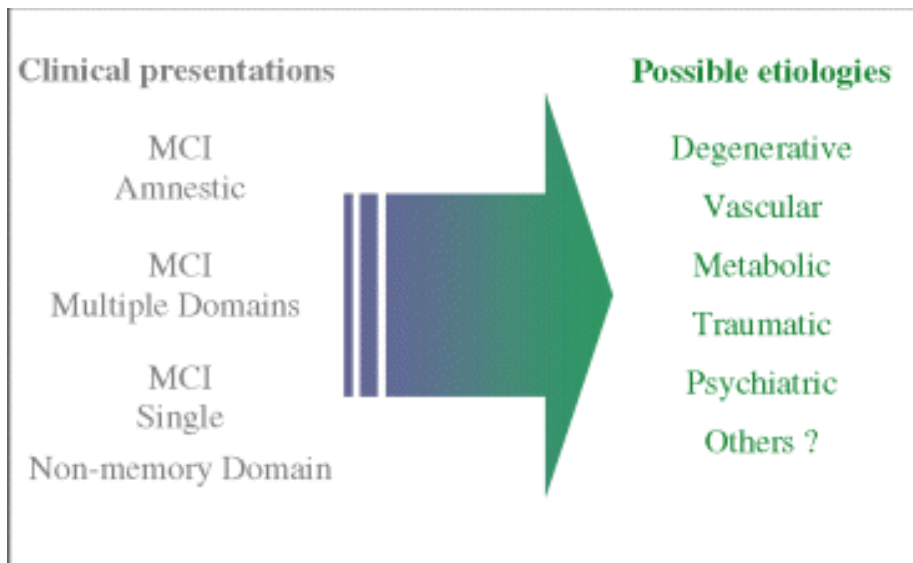


Figure1 – Multiple aetiologies and the heterogenous clinical presentation of MCI

Each and every one of this subtypes may have several underlying aetiologies - Figure 1 and Figure 2. In particular, although the neurodegenerative processes might be the cause for aMCI, there are also other possible pathological process responsible for this - Ischemia, trauma, metabolic imbalances, psychiatric pathologies (depression or Burnout Syndrome) or other somatic causes (e.g. cardiovascular diseases).

In terms of risk factors, their role in the development as well as MCI progression is yet to be determined. Old age, low education, male gender and genetic mutations - the presence of ε4 allele on the APOE gene are associated with MCI.

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		Aetiology			
		Degenerative	Vascular	Psychiatric	Trauma
Clinical classification	MCI Amnestic	AD		Depr	
	MCI + Amn	AD	VaD	Depr	
	Multiple Domain - Amn	DLB	VaD		
	MCI single Nonmemory Domain	FTD			
		DLB			

Figure2 – MCI Classification and the possible aetiologies

2.4 Clinical Symptoms

As a starting point for the clinical symptoms’ descriptions, MCI patients presents alterations of the cognitive functions which cannot fit into the criteria that define dementia. These patients often have difficulties in performing daily tasks or sometimes need more time than healthy subject in order to finish their tasks - driving, the use od digital devices, finding and organising their personal belongings, shopping, following their treatment at home, moving or visual and spatial orientation. In most of the time, these patients are independent, living alone or with family, spouse, etc, maintaining their abilities to maintain social interactions and engage in the activities required at the workplace. One of the most common problems these patients seem to encounter is difficulty in falling asleep as well as sudden wake ups during the night.

From an objective point of view, MCI is defined as a decrease of the cognitive performance measured by applying a series of neuropathological tests. There is no gold-standard when it comes to this type of tests, the aim is that they cover the main cognitive domains - executive functions, attention, language, memory, visual and temporal orientation. The degree of independence is measured through interviews conducted with these patients and/or evaluation scales for the activities of daily living (ADL and iADL).

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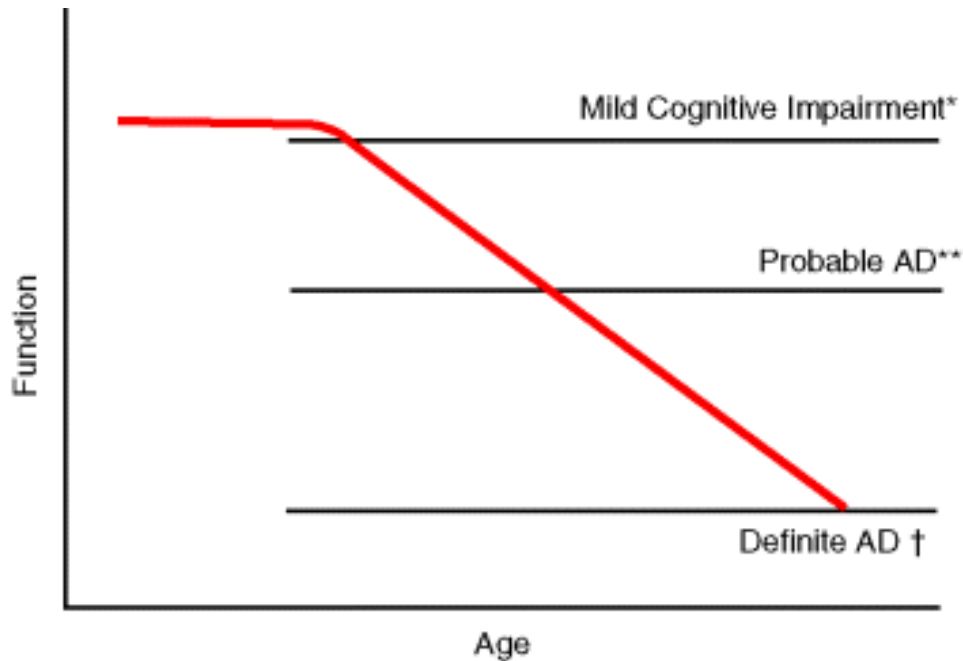



Figure3 – Hypothetic alterations of the cognitive functions to the point of developing AD.

In this scheme (Figure3), we used the premise that subjects maintain their cognitive functions as getting older as a starting point. The diagnoses of AD is confirmed after a significant deterioration in this functions, so the MCI criteria aim to discover the slight clinical changes that this patients encounter.

2.5 Clinical Diagnoses

The first clinical diagnostic criteria were proposed by a group of researchers from Mayo Clinic in the late 90's. The criteria were developed as a result of clinical changes observed in a longitudinal study that focussed on the clinical alterations present in dementia patients. The latest criteria on MCI, DSM-5 (Diagnostic and Statistical Manual for Mental Disorders), proposed by the American Association of Psychiatry are currently in use and focus on the following:

- objective as well as subjective symptoms related by the patients
- alterations of the cognitive functions, on single or multiple domains
- patients maintain their independence
- all the above mentioned not fitting the diagnostic criteria for dementia.

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	Mayo Clinic	Key-Symposium	NIA-AA	DSM-5
Criteria				
Subjective memory alterations (related by the patient or caregivers)	X			
Subjective alterations of the cognitive functions (related by the patient or caregivers)		X	X	X
Objective alterations of the memory	X			
Objective alterations of the cognitive functions		X	X	X
Cognitive functions between normal parameters	X			
Maintaining their independence	X	X	X	X
No dementia	X	X	X	X

Tabella 1 – Clinical criteria of MCI; NIA-AA = National Institute on Aging-Alzheimer’s Association workgroup. DSM – 5 = fifth edition of Diagnostic and Statistical Manual of Mental Disorders

Taking all of this into consideration, we might suggest that a typical profile of an MCI patient is comprised of

- their independence is maintained
- the most frequent symptoms are
 - the difficulties in falling asleep
 - sudden wake ups during the night
 - short periods of spatial and temporal disorientation
 - reduced physical activity
 - reduced social interaction
 - psychiatric symptoms - depression, anxiety, loneliness
- they need more time to accomplish their daily tasks
- neuropsychiatric tests objectify these aforementioned alterations

The diagnostic algorithm shown in Figure 4 is based on the clinical symptoms, biomarkers and genetic tests, imagistic and neuro-imaging investigations. The most frequently used neuropsychological tests are MMSE (Mini Mental State Examination), Verbal Fluency Test, Rey's

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Figure and Grober-Buschke Test. The quality of life is measured through some standardized questionnaires, daily activities as well, using ADL (Activities of Daily Living) and iADL (Instrumental Activities of Daily Living) questionnaires.

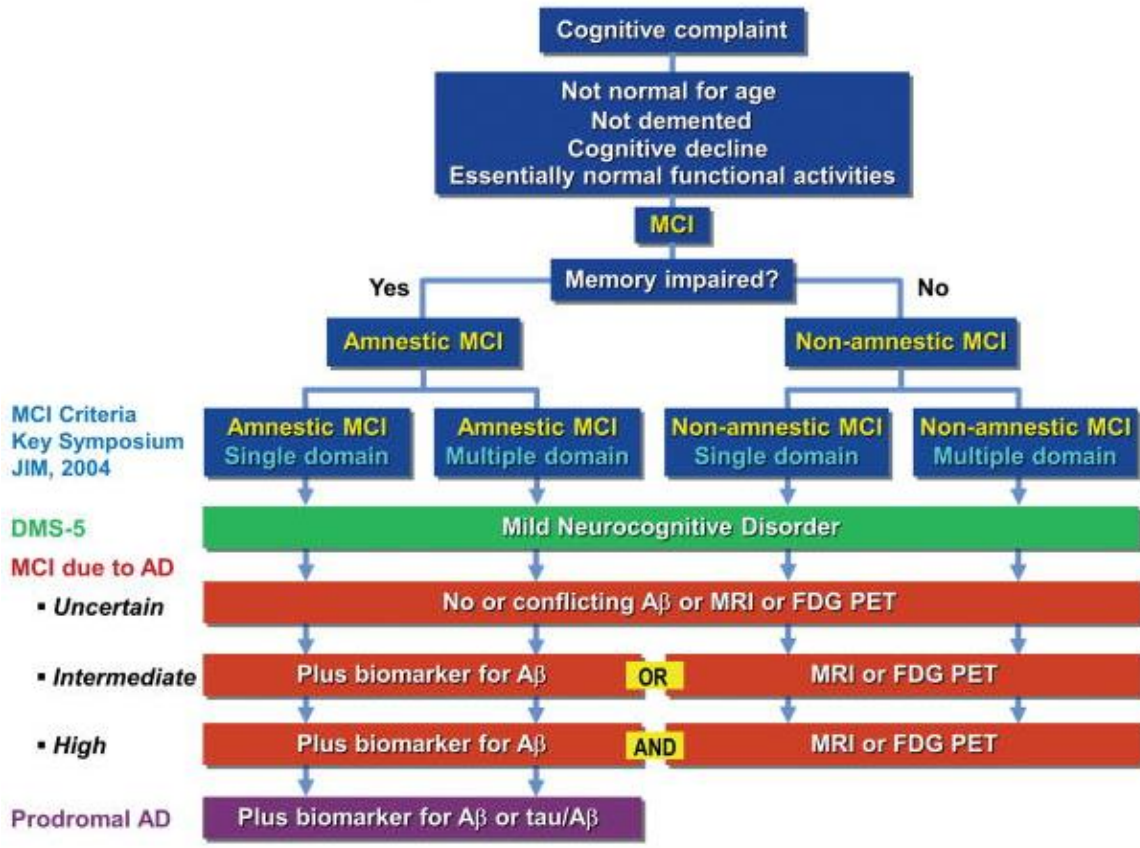


Figure4 – Diagnostic algorithm of MCI

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3 ANALYSIS OF THE CURRENT SITUATION

This section aims to emphasize the current situation regarding the ongoing interventions which focus on the MCI patients as well as the technological literacy among them. The information applies to both Europe and international and represents the starting point for this project.

3.1 Practices, Services, Policies and Interventions Currently Used for Supporting MCI Elderly

Interventions for MCI have been proposed in order to prevent, slow down and even reverse the progression to Alzheimer's disease. Proposed interventions can be grouped into the following categories: pharmacological (medication), physical training/exercise, cognitive intervention and psychotherapy.

In general, recommendations focus on non-pharmacological interventions, such as physical or cognitive training, that rarely produce adverse events (Daviglus et al., 2010).

Pharmacological

In the present moment there exists no approved pharmacological treatment for MCI.

Cerebral enhancing agents such as cholinesterase inhibitors and N-methyl-D-aspartate glutamate receptor antagonists are approved for use in patients with dementia aiming to slow down cognitive and functional decline. Cerebral protecting agents - antioxidants and omega 3 fatty acids - might increase neurotransmitters, hormones and cerebral bloodflow as well as slow or halt pathological processes. B vitamins, ginseng, ginko biloba and acetyl-L-carnitine may have benefits from both worlds, acting as both cerebral protecting and enhancing agents. Hormonal therapies including estrogen, testosterone and dehydroepiandrosterone have also been tested but with no conclusive results of the randomised control trials conducted upon this therapies related to an improvement of memory-related outcomes. Furthermore, statins, previously considered to be cerebral protective, were reported by the FDA to increase the risk of cognitive impairment (Rojas-Fernandez & Cameron 2012).

Physical training

Research on physical training/exercise programs targeting persons with MCI are rare. Moderate intensity physical training programs - walking for instance - may improve cognitive functions (e.g. executive function, memory) two topical reviews summarizing five clinical trials of physical training programs targeting persons with MCI have concluded (Lautenschlager, Cox, & Kurz, 2010; Teixeira et al., 2011). Women seemed to benefit more from physical exercise than men, especially due to higher attendance and adherence rates in the programs that predicted more improvement on cognitive outcomes (Lautenschlager et al., 2010; Teixeira et al., 2011).

Nevertheless, without undermining its benefits, standardizing physical activity interventions for older adults would highly help clinicians translate the research findings to community settings (Elsawy & Higgins, 2010). Additionally, further research is needed to clarify which cognitive domain(s) benefit from physical exercise, the underlying neuronal- or vascular-protective mechanisms that occur due to physical exercise, the comparability of different types of physical exercise, and whether combining physical exercise with other types of non-pharmacological interventions is more effective than exercise alone in persons with MCI.

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Cognitive interventions

These types of interventions are probably the ones in which researchers invest most of their time and resources. Cognitive interventions are based on the neuroplasticity theory and there are two main approaches that have been applied: processing efficiency training (e.g., speed of processing training, dual tasks) aims to improve the broad capacity for fluid mental processing, whereas teaching cognitive strategies (e.g., teaching reasoning strategies, mnemonics) aims to compensate for the loss of specific higher order cognitive abilities. However, a truly successful cognitive intervention must also show transferrable (improvements from a particular training domain are generalizable to other untrained domains and daily functions) and sustainable (training effects last beyond the proximal post-training period) effects (Lovden et al. 2011). According to the most recent systematic review of 15 group- or individual-based cognitive interventions targeting patients with amnesic MCI (sample sizes ranged from 1 to 193), 44% of the objective measures of memory and 49% of the subjective measures of memory, quality of life, or mood significantly improved after interventions, while only 19% of objective measures of cognition other than memory improved (Jean, Bergeron, Thivierge, & Simard, 2010).

Other cognitive training studies might benefit from moving to a real-world context, such as managing finances and medication, driving, and grocery shopping. The Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study of 2,802 participants (Mage = 74) used this approach. One of the treatment arms in the ACTIVE, reasoning training, added content such as learning how to identify patterns related to real life situations, including identifying medication dosing patterns and filling a pill reminder case. The group that received reasoning training reported significantly less difficulty in overall IADLs than the control group, and the subgroup of MCI participants also benefited from this training (Unverzagt et al., 2009).

in this area of cognitive training, technology can provide valuable support. Exercises can be delivered on a technical platform, personalized and adapted to the patient's level and the software can provide automatic feedback. Technique can of course also remind the patients that the exercises should be done now, or point out that they were not made at the scheduled time.

To do their exercises regularly, MCI patients need a strong stimulus and, above all, praise. Both must not be merely done automatically by software, but the human component is crucial and indispensable. Moreover, one should not leave everything to the informal caregivers – normally family members – but one should also have a supervision from external, professional forces, a kind of dementia care manager. It is very important to focus on positive reinforcement whereas interventions that could be interpreted as punishment have to be strictly avoided.

Psychotherapy

Psychotherapy interventions have been tested for their impact on coping with a diagnosis in MCI patients and caregivers which may prove in a real challenge. A comparison in terms of acceptance was made between patients with MCI that received information about their diagnosis without receiving any previous therapy and patients which benefited from therapy prior to their diagnosis announcement.

One single-group study of cognitive-behavioral therapy of 22 participants with MCI and their caregivers found a significant effect on the patients' levels of acceptance of their diagnosis (Joosten-Weyn Banningh, Kessels, Olde Rikkert, GeleijnsLanting, & Kraaimaat, 2008). In another study of 93 persons with MCI that included a waitlist control group, MCI patients that received therapy had significantly greater acceptance of their diagnosis and better management

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of memory problems, but overall levels of psychological distress and well-being did not differ between the groups (Joosten-Weyn Banningh, et al., 2010).

Around 35% to 85% of persons with MCI have neuropsychiatric symptoms, and the most common ones are depression, anxiety, and irritability (Monastero et al., 2009). There are relatively few psychotherapies trials targeting persons with MCI. The role of psychotherapy for MCI symptoms and adaptation should be studied because it has potential to help improve awareness of and confidence in using cognitive strategies and also possibly improve social connections and overall well-being in persons with MCI. This approach also holds the potential to help persons with cognitive decline effectively manage their non-cognitive symptoms, such as depression or anxiety, and improve the communication between patients and their caregivers. Moreover, as found in a previous study of older cancer survivors (Campbell et al., 2009), psychotherapy may also improve motivation in older adults with MCI to engage in healthy lifestyles which may also have a positive effect on the underlying neurobiology of cognition.

3.2 Use of Digital Devices and Internet Services by Elderly

Technology provides the opportunity for older people to renew or develop social contacts and engage actively in their own community. It can prevent social isolation of the elderly and the feeling of loneliness arising from changes in life such as retirement, health damage, etc. and can help those who are socially isolated to escape their situation. We live in an era where technology offers fast and relatively inexpensive contacts with colleagues and friends, thus promoting the participation of elderly people in society, with the effect of reducing their social isolation in the community.

However, elderly people have a difficult relationship with technology, especially because hardware and software have not been designed to fit for them. For a large part of the elderly, the technology is unfamiliar and "foreign" and even if the elderly realise the potential of technology, it considers the investment of personal resources necessary to use this new "artefact". The language of technology is unfamiliar to older people because it depends on a number of elements that are outside of their own culture.

In 2001 the Organisation for Economic Co-operation and Development (OECD) defined the term 'Digital Divide' as 'the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies (ICT) and to their use of the internet for a wide variety of activities'. Accordingly, there are two aspects to the Digital Divide: the first gap considers mainly the division between those who have access to ICT such as computers and the internet and those who do not. This type of scope often refers to the urban-rural divide, the latter having slower internet speeds, prices, and technological choice. The second gap refers to different types and levels of internet use, motivation and skills: looking at what uses and benefits people enjoy, once they have access to the internet. This also includes looking at the type of content and services accessed online (i.e. eHealth, eGovernment), as well as whether these comply with international web accessibility standards to make their content accessible to all, including people with disabilities (according to the European Commission only about one third of public services websites were accessible to these groups).

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The concept of the digital divide keeps evolving and broadening with new technological developments: some studies have looked into further digital divides emerging among internet users¹ who use multiple mobile devices like tablets and smartphones to access the internet. Increasingly mobile devices complement the way we access and use the internet: the number of EU citizens using mobile devices such as tablets and mobile phones to access the internet has increased from 36% in 2012 to 51% in 2014. Therefore, as digital technologies continue developing, some users embrace them and enhance their online experiences, while others have a limited internet use or do not use the technology at all. Given its dynamic nature, the digital divide will not disappear, and some argue that it will never close as long as other inequalities exist in society.

According to statistics, 30% of EU homes still do not have a subscription to fixed broadband, in spite of its availability ('Broadband for all by 2013' project aimed that every household in the EU can access basic broadband speeds of at least 144kbps). According to Eurostat, the most significant reasons for households not having internet access are: that it is unnecessary (45%); lack of skills (41%); and because equipment (27%), and access (24%), is too expensive. When considering broadband take-up progress by country, it is clear that wide disparities remain in the EU mainly along a North-South divide: the Netherlands, Luxembourg, Finland, the United Kingdom, Sweden and Germany registered the highest broadband penetration figures in 2014, while Bulgaria, Romania, Portugal and Greece have the lowest take-up rates in both rural and urban areas. When it comes to fast and ultra fast broadband the numbers are even lower - fast speed broadband is available to 68% of the EU population, but mainly in urban areas (only 25% in rural areas). In terms of take-up, only 31% of all broadband subscriptions are at least 30 Mbps and only 9% of EU households subscribe to 'ultra-fast broadband' (>100 Mbps).

In terms of internet regular users, their number in the EU increased substantially over the last decade from 43% in 2005 to 75% in 2014 (see Figure 2). Usage is also more frequent, with 43% of the population (i.e. 77% of regular users) now using the internet almost every day, compared to 29% in 2005. Likewise, the number of non-users (16-74 years old) has more than halved over the period, from 43% in 2005 to 18% in 2014 (close to the Digital Agenda target of 15% non-users by 2015). This means that about 58 million European citizens do not use the internet. According to the European Disability Forum (EDF), non-users are mainly the elderly and people with disabilities; as one in three persons with disabilities has never used the internet, representing 54% of those who have never been online. Furthermore, over 69% of people who lack basic digital skills are aged over 55 years.

When it comes to Romanian population, The Romanian National Institute of Statistics (INSSE) stated that "Romania is already facing complex economic and social consequences of a population undergoing a slow but continuous demographic aging.". In addition, a statistical portrait of the European Union 2012 showed that "Romania is one of the most affected country by the phenomenon of ageing. In 2010, the Romanian population median age was 38.3 years, close to the EU average estimated at 40.9 years.". Translated into numbers, according to INSSE report on 2013, PC is used by more than half (54.0%) of the individuals aged 45-54 years, by 38.2% of people aged 55-64 years and only by 16.8% of individuals aged 65-74 years. During 2006 - 2012 period, the percentage of households with Internet access increased in Romania from 14 to 54%. Furthermore, Eurostat Statistics in 2012 shows that in Romania, 73% of users access the internet to read the news and newspapers online, 8% use internet banking services, 48% post messages on social networks, 24% use services related to travel and 9% need internet to create a website or a blog. In terms of devices, in 2013, the most commonly used

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devices for Internet accessing were mobile or smartphones - 61.8%, followed by notebooks with a 47.5%. The share of men who have accessed the Internet via mobile phone or smartphone was slightly higher than women (64.0% vs. 59.3%) and among those who have used the notebook, the most commonly type of network technology was Wireless (62.5%).

3.3 Use of Lights in People with Dementia

Introduction

Although an enormous amount of studies has already focused on light treatments in elderly to improve health, mood, behaviour and cognition, light effects in people with dementia are not sufficiently studied. Furthermore, most light studies in people with dementia focus on people with moderately to severe dementia but not on mildly demented persons or persons with MCI. This means, that there is a lack of knowledge in this field, that makes our research within the project PETAL even more important.

There are different kinds of light treatments, that can be distinguished. The most commonly used approach is light with high illuminances reaching the eye of an observer (bright light approach or so called light therapy). Intensities can vary but usually bright light therapy uses vertical illuminances (at the eye level of an observer) of 2,500 Lux applied for 2 hours or 10,000 Lux applied for 30 minutes. Other approaches focus on variations of correlated colour temperature (CCT), expecting different reactions on sleep, behaviour, mood and cognition if high or low colour temperatures of white light are applied during the day. The correlated colour temperature is used for categorizing white light in the range of warm white light that appears orange-yellowish (low CCT) to cold white light that appears bluish (high CCT). Colour temperatures below 3000 Kelvin are classified as "low" while colour temperatures higher than 3000 Kelvin are classified as "high". Studies with healthy participants showed different physiological reactions (heart rate variability, endocrine system e.g. melatonin release) in dependence of applied CCT. Another approach focus on variations of light illuminances in the morning and evening, simulating natural light conditions provided during dawn and dusk. Dawn-dusk-simulations start to intensify light levels in the early morning from a very low level to awake a sleeping person smoothly, avoiding sleep inertia, and end the day in the evening with a reduction in light levels to prepare a person for going to bed. Bartenbach developed a more complex and advanced kind of this approach to simulate natural processes of the sun, called biodynamic lighting. Here, the intensity of the light and the colour temperature vary during a 24 hours-cycle. This is a more natural approach, that has not investigated in the found studies.

The following part gives an overview of the state of the art concerning light effects in people with dementia. The studies assessed the effects of bright light, variations of colour temperature and dawn-dusk-simulations on sleep / circadian rhythms, aberrant behaviour / agitation, mood / depression and cognition in persons with dementia, assuming some similar effects in people with MCI. One study was included using infrared-light to stimulate cognitive processes.

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State of the art

Bartenbach conducted a literature search concluding studies from 1988 (earliest study) to April 2017, which resulted in a total of 19 articles assessing light effects in people with different stages of dementia. Most of them addressed sleep or circadian rhythmicity (11 studies) and/or behaviour (7 studies), mostly agitation. Few studies focused on mood/depression (4 studies) or on cognitive functions (4 studies).

Overall the studies showed, that bright light treatments with at least 1800 Lux (most studies prefer 2500 Lux applied for 2 hours) and possibly dawn-dusk simulation (changing light intensities in the early morning and evening) seem to be efficient in treating disruptions of sleep and circadian rhythm in persons with dementia.

Bright light and near-infra red light may be used as additional treatment for cognitive decline in persons with dementia, but it has to be considered that research fundament is sparse and not sufficiently evaluated to give clear recommendations.

There are inconsistent results concerning light interventions to treat behavioural problems like agitation. It should be considered, that bright light potentially exacerbates aberrant behaviour in persons with dementia if applied in a wrong way or at a wrong time. Especially new approaches focusing on influencing the immediate behaviour e.g. through light scenes or cues were not investigated in the past at all. Bartenbach is currently running a study in people with dementia to stimulate the immediate affective state and the alertness level of people with dementia via light stimuli. Such alerting effects were already shown in healthy young people and different light ambiances were used in a trial to activate or calm down healthy elderly but such light effects were not investigated in elderly with dementia at all.

Inconsistent results were also found in treating mood/depression with light interventions in persons with dementia. This fact is quite interesting because light therapy is a commonly and successfully used treatment of seasonal affective disorders (SAD). More studies are necessary to evaluate which kind of lighting can be used for treating mood disturbances in elderly with MCI or dementia.

In summary, light seems to be quite effective to treat long-term effects like an improvement of sleep and a stabilization of the circadian rhythm, while short-term effects are not sufficiently studied in people with cognitive declines right now.

Lighting for vision

Beside physiological effects, the traditional reason for using lights should not be neglected. Light is generally used to enable vision, which is not only important in general but plays a very important role when talking about elderly people who show limited visionary abilities because of the aging eye. Therefore, the traditional use of light can be adapted to the higher requirements elderly people show. This means to use higher illuminance levels, spot-lighting, night-lights or guiding lights in task areas and ambience to avoid falls, enable a person to securely move around and use this higher light level for performing reading, paper-pencil tasks e.g. crosswords, etc. People who can see well are more motivated to perform tasks and they are more self-confident in their movement. Cognitive work and higher activity rates lead to a better health status and therefore light should also focus on these aspects in the daily lives of elderly with cognitive impairments.

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4 MCI Patients Requirements – Summary

As previously mentioned in this document, MCI is a vast pathology that is based on symptoms which are not always perceived nor by the patients or their relative and caregivers. In this respect, we composed a questionnaire that aims to offer us a better understanding regarding the patients, their needs and environment, as well as the aspects of their lives that needs to be improved. The questions are as follows:

<p>Technological Literacy</p> <ul style="list-style-type: none"> • Which devices do you use? • What is the most frequent purpose of using such technological devices? • What type of communication tool do you prefer to contact your relatives or caregivers? • How do you prefer to receive reminders/alarms from relatives or caregivers? • Are you already using devices with relatives or caregivers? If so, which ones? For which purposes? 	<p>Relatives and Caregivers</p> <ul style="list-style-type: none"> • Do you live alone in your apartment or with someone else? • Who does help you regularly? • What kind of care do you receive from relatives/caregivers? • How often does somebody come to your place to help you? <p>Socio-demographics</p> <ul style="list-style-type: none"> • Year of birth • Gender • Which is your highest education degree? • Where do you come from?
<p>Sensors, devices and lights</p> <ul style="list-style-type: none"> • In which situations do you feel the need of a specific aid? • Would you like to have other or better lights in your home? If yes, which parts of your home should be lighted better • Is your current lighting appropriate for your visual requirements? If not, why? • Do you think that lighting system could help you in your daily activities (e.g. using automatic switch on/switch off of lights or using coloured lights to remind you on different things) • Did you ever fall at home due to poor lighting during the night? If yes, do you think that the use of specific colored lights in each room could help you to avoid falling? • Do you have difficulties falling asleep? If it happens, do you think that a gradual reduction in light intensity in the evenings can help you sleep better? 	<p>Additional questions</p> <ul style="list-style-type: none"> • How your typical day is structured? • Are there any aspects/behaviour in your lifestyle you would be willing to change/improve? If yes, which ones? • Do you use reminders? If yes, for which purposes (e.g. to remember medical appointment, for medicine adherence, to remember doing exercises, to remember the starting time of some events, etc.)? • In which manner do you set up such reminders (e.g. by using which device?) Do you feel that notifications/reminders should be better “personalised”? How?

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<ul style="list-style-type: none"> Do you wake up during the night and do not know where you are? If it happens, do you think that using colored nightlights can help you recognize where you are? 	
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4.1 ANA

Our first patient is an independent woman, age 67, who has been recently diagnosed with MCI. She does not have a higher education degree, completing only high school, and she is currently living in Bucharest with her husband and his son's family who actually live in an apartment just above hers. From what she relates, the patient is well accustomed to technology and modern devices - she uses the laptop and her smartphone daily in order to socialise and communicate with her friends and relatives. She is more fond of her smartphone that she is mostly using to communicate with the close ones.

As previously mentioned, she is an independent patient so she does not require any special caring. However, her husband often helps her with the housework or for shopping. In terms of lighting, she is of the opinion that her current lighting system, generating mostly warm white light, suits her needs well. Moreover, the apartment is well lid with natural light and there is no need for orientation light during the night as there is enough light coming from outside. On the other hand, when presented the project and the principle on which it is based on, the patient was enthusiastic and expressed her whole collaboration and support, believing that our solution might increase her quality of life - in particular by having a more active life and social interactions. One aspect worth mentioning is that she had several falls in the past, but none of them due to a neurological issue or poor lighting. In addition, she does encounter some issues in falling asleep, but does not experience sudden wake ups during the night. The patient did not report any episode of memory loss or disorientation so far.

Her daily routine starts at 7-8 am when she wakes up. She does her housework until 4pm when she goes to her son's apartment in order to look after her grandchildren. When the son and his wife return home, they occasionally have dinner together. In the late evenings, she spends approximately 3 hours browsing the internet and social media platforms. The most significant improvements the patients expect after the field trials are an improvement in terms of social life, easily falling asleep as well as being more active.

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4.2 APPOLIS

Elderly 1

Sociodemographics

Test person 1 is a man born in 1938 (81 years old) in Italy, he has been living for five years in an apartment for the elderly run by the Griesfeld Foundation of Egna.

Qualification: Diploma from a school of commerce (10-11 years of school education).

Before retiring, he worked as a representative for heating and sanitary installations in the area of Bolzano-Bozen.

He said that his passion was going to the mountains for walking and climbing. Even today he still goes out every day to take long walks around Egna.

He doesn't have any family nearby. Once a day, a nurse (professional caregiver) comes by to see if everything is all right and once a week, a person comes to clean the apartment.

The man cooks for himself: he prepares a healthy breakfast around 10 a.m., then goes out for a walk and in the late afternoon prepares dinner. He says he doesn't need lunch, with these two meals a day it's enough.

The state of health seems quite good, nevertheless he takes several medicines (to be investigated for what kind of disease). The gentleman said that until recently he had a blood pressure monitor, after it got out of use he has not bought another one.

In general, he is interested in the Petal project because he is happy to give his opinion on the use of new technologies that can help older people like him and for society. He declares open towards new technologies.

Technological literacy

The technological devices used by the gentleman are television and mobile phone (not smartphone). The mobile phone is used only to call, to be called and occasionally to send text messages. The mobile phone is the only electronic device used. Sporadically it makes crosswords on paper. In this professional life he never used computers, neither privately.

Sensors, devices and lights

The gentleman considers himself rather autonomous in the management of his daily life. The neighbour complains about the excessive volume of the TV in the evening, so it is useful to have a sensor / warning light that alerts him if the sound exceeds a certain threshold.

The gentleman wants to change the layout of the living room/kitchen furniture, he would also like to have better lighting in general; he considers the lighting in the bathroom to be insufficient.

He also believes that a light signal can help him remember certain things, such as taking medication or turning off the stove. The automatic switching on of lights does not seem to him to be a great help. He has never fallen at night due to poor lighting and can't imagine having coloured light in his house.

The gentleman suffers quite often from insomnia, has difficulty falling asleep, says that the reason why he does not sleep are the thoughts that afflict him at night. He does not believe that adequate light during the day will help him sleep better at night.

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Relatives and Caregivers

The gentleman lives alone, a nurse from the Griesfeld Foundation comes by every day to check on his condition. He has no relatives in the neighbourhood to visit or help him.

Interview conducted on 30.01.2019 at the apartment of the elderly, Griesfeld Foundation, Egna-Neumarkt. Participants: Elena Vanzo, Hermann Atz (apollis), senior citizen

Elderly 2

Sociodemographics

Test person 2 is a man born in 1936 (83 years old) in Italy, living alone in a Griesfeld Foundation seniors' apartment (since two weeks).

Qualification: elementary school.

The gentleman lived and worked for more than fifty years in Germany as a truck driver for a supermarket chain, his passion was and still is cars and he regrets profoundly having lost the opportunity to drive a car (his license was withdrawn following an accident caused by a stroke of sleep). His wife died about 15 years ago.

He returned to South Tyrol about 5 years ago following a worsening of his health. He was in the intensive care unit for a long time, and after recovering he went to live with relatives in a mountain village not far from Egna-Neumarkt. In this village he felt alone. He has been moving into this old people's apartment only about two weeks ago and his first impressions are very positive, he likes to see new people.

He prepares his own breakfast (a coffee) and then walks alone to the canteen of the old people's home Griesfeld for lunch and dinner. A niece is the nearest relative, she has the power to sign for him official documents and sometimes calls him on the phone. But she is very busy in her work (manager and cook of a small hotel).

As for the state of health, the gentleman has diabetes, has difficulty walking (he walks with a stick) and takes many medicines.

The gentleman participates with interest in the Petal project, he says to be only worried about the use of the tablet (he doubts to be able to use it, but we assured him that we will explain well how to use it).

Technological literacy

The technological devices used by the gentleman are television and mobile phone (not smartphone). The mobile phone is used to call and to be called, not to send messages.

Sensors, devices and lights

The elderly person considers the lighting in the apartment to be adequate, but is nevertheless curious to try out a new type of lighting. He would like to have an automatic light in the bathroom, both the light on the ceiling and the light above the mirror. Some time ago he had fallen inside the house, he says because of the strong medicines he took at that time. The gentleman suffers sometimes from insomnia and has difficulty falling asleep.

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Relatives and Caregiver

The gentleman lives alone, a nurse (professional caregiver) from the Griesfeld Foundation comes by every day to check on his condition. She has some relatives nearby, a brother, a niece, but he doesn't hear them and doesn't see them often, only sporadically. The main help he gets is from the nurse in the nursing home, who visits him every day to check on his condition.

Interview conducted on 30.01.2019 at the apartment of the elderly, Griesfeld

4.3 FSL

First Subject

Brief description: L.C. is a 80 years old woman, who has been living alone for 5 months, when her only son went to live with his partner. Her husband died years ago but, even today, she feels sad when she remind him. From the end of last summer, she has noted some defaillance in cognitive domains, expecially short-term memory and prolonged attention. For this reason she has decided to schedule and appointment at the Memory Clinic at Fondazione Santa Lucia. After all the specific assessment, she received a diagnosis of MCI.

Interview: Regarding her daily routine, she usually wakes up early in the morning, around 7.30 a.m., and go out to run some errands. It's unusuall that she spends the morning completely at home. Usually, in fact she goes out to go to the post office or bank, or from the beautician or the hairdresser. She is enrolled in the gym to do the gymnastics two afternoons a week at 4 pm, but since she signed up she didn't go there because in winter it gets dark early and she feels afraid to go out alone. During the morning stay out for a couple of hours and she eats at pizzeria cut. Alternatively, if she comes home on time, she prepares a light meal. Orientatively she has dinner around 19-20 in the afternoon.

L.C. loves a lot her home and for this reason she has a cleaning lady for three days morning a week. In the remaining days she takes care of keeping in order, but also states that being alone there is little disorder and it is easy to deal with it.

Twice a month, her son with his two children comes to visit her in the weekend. Her grandchildren have their own rooms in the house, while her son has an attic upstairs. When they go to see her, she likes to cook for them and spend time with them.

When she is alone and feels sad, she prefers to call her friends or she visits them. She likes reading the newspaper, watching television (preferably in her bedroom where she has a very large television).

His house has two exposures, but the brightest room remains the living room; according to her, installing the PETAL luminaries could help her especially on rainy days.

Also, about the possibility to improve her cognitive abilities she feels very excited and it represents another reason to participate to PETAL project. Finally, in the last period it is difficult to sleep with frequent nocturnal awakenings.

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Second Subject

Brief description: L.D.G. is a 78 years old MCI who live alone. She has two sons who live far from her neighborhood. In April 2018 her primary care physician request a specialistic visit since the patient experiences problems with short-term memory, attention, planning of activities of daily life. She underwent a screening assessment of cognitive functions in May 2018 at the Memory Clinic of Fondazione Santa Lucia. Subsequently, a diagnosis of MCI was diagnosed.

Interview: L.D.G. start by thanking for the opportunity to be included in the PETAL project. Initially, she preferred to keep the evaluation report for herself and now, thanks to PETAL, she decided to spoke with her two sons.

During the interview the patient claims to use mainly the smartphone on which she has internet, and uses it to communicate with her son (both via phone calls and instant messages). Also, she has a personal profile on one of the most famous social networks. She hasn't a personal computer. She report to be autonomous for carrying out daily activities. Anyway, the caregiver contacts her daily and help her only when she need to be accompanied to the doctor or to a far area of the city. Once a week a payed woman helps her in housecleaning.

She has sleeping disorders (insomnia) and she sometimes feels sad. She loves painting and once she liked to read; she thinks that a device that read aloud a book could help her to restore this hobby. Moreover, she also likes to take long walks and see her friends both at her home and theirs.

About her flat, it has a good lighting system she thinks that the implementation is unnecessary. Coloured lights could help her to remind medicine or if her meal is on the stove; however she doesn't need courtesy lights, she leaves the TV on all night to feel not alone and and so it works as assistance light to go to the bathroom.

Finally, about memory training she hopes that it could help her to improve her cognitive functions and for this reason she involves a lot of expectation on the PETAL projet.

4.4 Bartenbach

The first MCI patient in the field trials of Austria is a 64years old man, living with his wife and his 15years old daughter as well as with 2 cats in a flat with five rooms and a small corridor. He is technically very affine, has a computer with internet as well as WIFI in all rooms, has a smartphone and uses apps, TV and radio and wears a smartwatch to get some information about his fitness level and he uses it to play "Pokemon Go". He likes to play chess on his computer, uses different apps on his smartphone, also writes e-mails and for communication reasons he usually uses his smartphone to make phone calls. The best way to remind him about things or to receive alerts is via SMS. His wife also uses a smartphone and sometimes the computer. Their daughter has a laptop and has a good technical knowledge.

The patient argued that the most common situation where he needs help is to remind him about appointments that he inserts in a calendar. About the lighting he explained that the flat is very dark although they tried to make it brighter. They use traditional bulbs in all rooms, but they wish to have better lights and a brighter flat, because the patient and his wife feel

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depressed in the winter month because of the bad lighting. Especially the activating and relaxing light is interesting for them and they would like to have a wake-up light. During the night they do not use a lot of light and usually don't need it to find the way to the bathroom. Thus, sometimes they hit something while moving around in the dark, but the patient has never fallen because of that. The patient also likes to wear the new smartwatch to get some more information about his health status and to receive reminders when his activity level is too low, etc. The patient never woke up during the night and was irritated, but he has some short irritations because he lost his orientation while driving in familiar environments. His sleep is quite good. But the sleep of his wife is often disturbed (waking up during the night and cannot falling asleep again, waking up very early).

In terms of daily activities his wife structures their day mainly, but they get up very early during the week because the patient drives their daughter to school. They do not have fixed times for their meals in the morning or midday, but they have a meal together in the evening at the same time usually. At weekends the patient likes to sleep longer, therefore a wake-up light should be adjustable for weekdays and weekends. Overall, the patient and his wife are very happy to take part of the project and they are looking forward to getting familiar with the PETALsystem.

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5 Summary of Patients Characteristics

The sample of seniors with mild cognitive impairment interviewed in three different countries (Italy, Romania, Austria) seems to be representative with regard to the composition by age, sex and type of household.

The majority of the patients leave by themselves which represents the ideal situation for maximising the benefits of the PETAL System. However, the heterogeneity of also enrolling patients that do not live alone represents a chance for this system to prove its versatility in all kinds of environments.

The technological literacy is at a relatively high level among the recruited patients, most of them being able to use both a computer and a smartphone. Internet connection will be in all cases with enough bandwidth speed for the platform to run smoothly. In this respect, getting accustomed with the devices involved in our project will not represent a major issue.

Their current lighting system is unanimously accepted by the patients as appropriate to their needs - the reasons behind this fact can be numerous: either they never thought about the importance and effects of coloured and assisted lighting, nobody brought this matter to their attention or they didn't believe it is science based. Altogether, they were all enthusiastic about the system and truly believe that it will improve their quality of life. They all agreed with installing the PETAL system and are looking forward to seeing for real all the equipment at work.

The health status evaluated for each patient showed some mutual results. Firstly, although some of them have formal caregivers or relatives with whom they stay in contact, all the patients are independent and does not require medical assistance. Taking all the medical issues into account the clinical symptoms gathered from the subjects accurately characterize MCI - some patients are having episodes of temporal and spatial disorientation, others have troubles falling asleep or encounters difficulties in performing their daily tasks. Thus, using the PETAL System we can address each and every aspect of the MCI pathology and compare the final results to see which areas have the highest improvement and which have the lowest. All in all, they seem to be still rather autonomous. Support from outside the household refers mainly to home care and less to personal assistance and is more frequent for the patients leaving on their own.

Another aspect worth mentioning is the social interaction which has lower levels among the patients leaving alone. Loneliness is often correlated with anxiety and depression which further leads to isolation. PETAL aims to balance their hormonal levels by providing an assisted, personalized and more relaxed environment which will eventually trigger their will to start engaging more with other people.

The questionnaire answered by the patients showed specific aspects and areas that PETAL system should address: insomnia, difficulties falling asleep as well as sudden awakening are by far the most frequently encountered issues among our patients. What is more, the majority suggested that using the system for reminders would really prove useful for their daily activities. Additionally, although the current lighting system was fairly rated by them its improvement should not be neglected at all. Adjusting the colour temperature according to the circadian rhythm should improve anxiety and depression symptoms which are mentioned by

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some of the MCI patients and by adding the motion sensors, turning on the lights when they enter a room is an area we also have to take into consideration.

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6 Conclusions

In the last decade, the Aging and Dementia field presented an increasingly higher interest, especially from the point of view of early diagnoses and prevention by establishing a set of clinical signs as well as developing predictive biomarkers. The concept of MCI is still under an intense debate due to the diagnostic criteria as well as clinical manifestation. However, this project aims to add light therapy to the non-pharmacological methods of slowing the cognitive decline in this type of patients.

When it comes to the patients involved in our project, there are certain aspects and requirements that PETAL system has to meet, particularly regarding sleep issues (difficulties falling asleep, sudden awakenings or insomnia), reminders and inappropriate lighting.

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