THE IMPACT AND BENEFITS OF INNOVATIVE, INTELLIGENT ASSISTIVE LIGHTENING FOR THE COGNITIVE DECLINE OF THE MCI INDEPENDENT SENIORS

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WHY MILD COGNITIVE IMPAIRMENT (MCI)?

MCI is an intermediate stage of cognitive deficit, which is often, but not always, a transitional stage between changes occurring during aging and dementia.

**MCI Progression to Dementia**

20-40%
(10-15% per year)

**Risk Factors**
- The degree of functional impairment
- Severity of neuropsychological test scores
- Presence of neuropsychiatric behaviours at the time of MCI diagnosis
- Abnormalities in structural magnetic resonance imaging (e.g. hippocampal atrophy, volumetric brain changes) and magnetic resonance spectroscopy of the brain
MCI ETIOLOGY AND CLASSIFICATION

Considering impairment in the memory domain as well as in a single domain or multiple ones, MCI can be classified in 4 major subtypes – amnestic MCI (aMCI) and non amnestic MCI (naMCI), single or multiple domain as follows:

- **aMCI – single domain** (impairment only in memory),
- **aMCI – multiple domain** (impairment in memory and other cognitive domain),
- **naMCI – single domain** (impairment in a single cognitive domain, but not memory),
- **naMCI – multiple domain** (impairment in at least two cognitive domains, but not memory).
INNOVATIVE & INTELLIGENT ASSISTIVE LIGHTING
NON VISUAL LIGHT EFFECTS

Regulation of sleep-wake cycle
Regulation of appetite
Impact on mood
Impact on activity-rest-pattern
Impact on behaviour

Light exposure at the right time → positive effects
Light exposure at the wrong time → negative effects
NON VISUAL LIGHT EFFECTS

Short Term Effects

Physiological level
• Melatonin suppression
• Heart rate
• Cortical activity

Subjective level
• Wake state -> alertness/sleepiness

Cognitive Level
• Memory
• Attention

(Gaggioni, 2014)
NON VISUAL LIGHT EFFECTS

Long Term Effects

**Chronodisruption**
(disturbing chronobiological rhythms)

Statement (published 2007)
PHOTOMETRIC FACTORS
(Triggers of the non-visual effects)

1. Light Intensity
2. Light Spectrum - colour temperature
3. Time of exposure
4. Duration of Exposure
5. Light History
ACTION & REACTION

Action
• We stay 90% of the time of the day in bad lit indoors
• We spend a lot of our night-time using lights and displays
• EU average (2010): 17.2% with night shift work with at least 1 shift/month

Reaction
• Weakness of Zeitgeber strength (A zeitgeber is any external or environmental cue that entrains or synchronizes an organism’s biological rhythms to the Earth’s 24-hour light/dark cycle and 12-month cycle)
• Chronodisruption
WHAT ?


PETAL
~PERSONALIZABLE ASSISTIVE AMBIENT MONITORING AND LIGHTING~
AIM

Objectifying the effect of environment personalisation and lighting assistance on:

- Spatial and Temporal Orientation
- Sleep-wake cycle
- Quality of Life
- Daily Activities
- Attention
- Cognitive decline

Quality of Life
The PETAL Platform is designed to address the needs of older adults, particularly those with mild cognitive impairments, by providing personalized support. It includes a Personalisation Rule Editor to set functionalities of technological support for controlling lights and other digital devices based on relevant events. The platform monitors the environment and user behavior, controll applications and devices.

**What does the platform perform?**
- Monitoring environment and user's behavior
- Controlling applications and devices

**What can the users do?**
- Setting the functionalities of technological support to control lights and other digital devices when relevant events occur.

**Older Adults**
Problems:
- Mild cognitive impairments
- Cognitive issues, e.g., tendency to forget tasks/events...
- Other issues, e.g., cardiovascular issues, reduced sight, irregular eating habits, ...
- Increased risk of social isolation, and depression

**How does the platform respond?**
- Personalized control of lights and other digital appliances
- Personalised warning messages issued in risky situations
- Persuasive messages to stimulate the elderly in more healthy habits (e.g., do more physical activity)
HUMAN CENTRIC LIGHTING (HCL)

• Lighting that induces positive health effects in human beings
• This term was implemented in 2013 into the lighting industry and describes all kinds of lighting that positively affect human beings’ mood, alertness, performance, health and well-being
• Usually the following components are considered:
  1) use of daylight
  2) high-quality artificial light supplementing daylight whenever it is missing,
  3) use of sensors to optimize light usage
  4) easy-to-use light-control schemes.
PETAL LIGHTING CONCEPT

Daylight
- Improve sleep-wake-rhythm
- Direct attention in a timely manner
- Support structure of daily activities
- Support spatio-temporal orientation

Artificial light
- Improve sleep-wake-rhythm
- Direct attention in a timely manner
- Support structure of daily activities
- Support spatio-temporal orientation

Night light (Melatonin light)
- Improve sleep-wake-rhythm

Orientation light
- Direct attention in a timely manner
- Support spatio-temporal orientation

Wake up light
- Improve sleep-wake-rhythm
- Support structure of daily activities
- Support spatio-temporal orientation

Signal light
- Direct attention in a timely manner
CRUCIAL REQUIREMENTS FOR THE LIGHTING SYSTEM IN PETAL PROJECT:

1) All components must be available at the market
2) All components must be easily installable
3) Each component must have an internet connection to connect it with the PETAL platform
4) The whole PETAL system must cost below 4,000 EUR.
PETAL LIGHTING CONCEPT
The GREAT Luminaire

vertical illuminance levels reaching an observers’ eye
The GREAT-Luminaire comes with special light scenes that were developed to have an influence on the acute affective state of an observer. The user can choose between an activating light cue, a relaxing light cue and a “TV”-scene:

- “TV”-scene: a relaxing ambient light setting for activities with low visual demands e.g. while listening to music or watching TV.

- Activating light cue: studies showed that light with specific color temperature and intensity can be used for acute alerting effects (Yang et al., 2018).

- Relaxing light cue: a reduction in light intensity and color temperature directly lead to a feeling of comfort and relaxation.
PETAL LIGHTING CONCEPT
Light effects of the GREAT concept

- Fulfills visual requirements
- Enhances motivation
- Promotes mobility
- Avoids falls due to visual conditions
- Fulfils need for safety
- Biodynamic lighting combined with light-therapy-approach
- High-quality light for higher visual requirements in elderly
- Ambient light cues for activation and relaxation and light scenes
- Support sleep-wake-rhythm
- Stabilizes melatonine rhythm
- Supports leading an active and healthy life
- Activates
- Relaxate
- Creates comfortable ambience
## PETAL LIGHTING CONCEPT

Examples of rules using light

<table>
<thead>
<tr>
<th>Rule no.</th>
<th>Rule name</th>
<th>Trigger</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use daylight outside</td>
<td>IF there is bright daylight</td>
<td>THEN remember person to go outside</td>
</tr>
<tr>
<td>2</td>
<td>Use daylight inside</td>
<td>IF daylight is insufficient at the most common place (e.g. couch)</td>
<td>THEN remember person to go to brighter areas in the flat</td>
</tr>
<tr>
<td>3</td>
<td>Use artificial bright light</td>
<td>IF there is not enough daylight in the flat</td>
<td>THEN artificial light should turn on</td>
</tr>
<tr>
<td>5</td>
<td>Wake up smoothly with light</td>
<td>IF the person should be waked up</td>
<td>THEN the wake-up light turns on</td>
</tr>
<tr>
<td>6</td>
<td>Use alarm light for oven</td>
<td>IF the oven has left on after leaving the kitchen</td>
<td>THEN the signal light should turn on (red alarm)</td>
</tr>
<tr>
<td>7</td>
<td>Inform caregiver in emergency case</td>
<td>IF there is light in the bathroom during the night for more than 2 hours</td>
<td>THEN give an alert message to his/her caregiver/relative</td>
</tr>
<tr>
<td>8</td>
<td>Prevent falling at night</td>
<td>IF the person stands up during the night</td>
<td>THEN the orientation light turns on guiding the way to the bathroom</td>
</tr>
<tr>
<td>9</td>
<td>Healthy biodynamic light</td>
<td>IF the person is inside the flat</td>
<td>THEN biodynamic light will be used in all occupied rooms</td>
</tr>
</tbody>
</table>
PETAL LIGHTING CONCEPT
Prototype flat equipment
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