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# DEVELOPMENT OF ASSISTIVE TECHNOLOGIES TO ADDRESS THE NEEDS OF INDIVIDUALS WITH MILD COGNITIVE IMPAIRMENT IN THE PURSUIT OF INDEPENDENT LIVING

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## ABSTRACT
Mild Cognitive Impairment affects significant numbers of people aged over 65. It is growing in prevalence and poses many challenges to independent living. This project examines the case of a multidisciplinary group of subject matter experts engaging graduate design students to investigate and solve specific challenges in this area. Goals included exploration of new solutions and enhanced training of the student participants. Results highlight the importance of end user involvement in development and training.

*Keywords: Mild cognitive impairment, assistive technologies, industrial design, independent living, iterative design process*

## 1 BACKGROUND
Mild Cognitive Impairment (MCI) is a clinical condition characterized by subtle cognitive decline in one or more domains of cognition (e.g., memory, executive function, etc.) without significant functional impairment [1]. While people with MCI retain the ability to take care of their basic needs, studies have found that there is a noticeable decline in their abilities to perform Instrumental Activities of Daily Living (IADLs) [2]. IADLs are activities that require multiple steps and tap into executive functioning, so they are the first activities impacted by cognitive declines. Examples of IADLs include shopping, managing finances, maintaining appointments, and keeping track of objects. Most often, an MCI diagnosis is applied when an individual has a suspected or confirmed underlying neurodegenerative disorder (e.g., Alzheimer's disease), and MCI represents an intermediate stage between the expected cognitive decline of normal aging and dementia. MCI affects 15-20% of people over the age of 65 [3] and is growing in prevalence. Of those diagnosed with MCI, 14.9% will go on to develop dementia in 2 years and relative risk of dementia 2-5 years after MCI diagnosis was 3.3x that of those without MCI [4].
Although there is no cure for MCI, current treatments focus on longitudinal monitoring of cognition and functional status, reduction of modifiable risk factors (e.g., cerebrovascular risk factors, depressed mood, and medication effects), and engagement in lifestyle behaviours that support cognitive functioning [5-8]. Specifically, healthcare professionals are encouraged to counsel individuals with MCI to engage in regular exercise and cognitive stimulation [4, 9, 10] and growing evidence supports the use of comprehensive behavioural interventions, such as that offered at Cognitive Empowerment Program (CEP), to provide maximal benefit.
The Cognitive Empowerment Program (CEP) at Emory University educates members and caregivers on strategies to compensate for cognitive decline. The CEP is exploring how technology can further this training and support for members during everyday activities at home. As specific areas of design needs are identified, they present opportunities to further define the background and basic design requirements for project briefs that may then be presented to student design courses [11].This project is a collaboration between the CEP, the Wireless Inclusive Technologies Rehabilitation Engineering Research Center

(Wireless RERC) and the Georgia Tech Aware Home Research Initiative (AHRI). The goal was for subject matter experts to define design requirements & opportunities to engage students.

## 2 METHOD

The student design project was conducted within a graduate design studio class in the School of Industrial Design at Georgia Tech. This particular studio was comprised of first year graduate students who come from non-design backgrounds and were completing a foundational training year of study in design. The multidisciplinary team comprised of subject matter experts from AHRI and CEP provided problem briefs detailing specific challenges experienced by individuals with mild cognitive impairment (MCI) in living independently. Two student design teams of three members (6 total students) were formed to address the two major issues outlined in the following briefs "Item Tracker Pad" and "Ambient Alerting/Cueing":

### 2.1 Item Tracker Pad Brief:

*Individuals with MCI frequently lose items due to memory difficulties. This can be a huge source of frustration for the individual with MCI as well as their care partners, who may need to assist with finding the objects. In cognitive rehabilitation, individuals are trained to keep important items in a single location that is located near a site where the item will be used (e.g., keeping keys near the door) in such a manner that it is difficult to miss or overlook (out in the open, often a bright colour). The most frequent example of this is creating a spot near the door where an individual keeps the items they need when leaving the house – this could include some combination of a purse/wallet, keys, cell phone, calendar/schedule, eyeglasses, and hearing aids.*

### 2.2 Ambient Alerting / Cueing Brief:

*Individuals with MCI often have difficulties keeping up with everyday activities at home due to the cognitive difficulties they experience, including things like forgetting, declines in problem solving, and trouble completing complex tasks that require multiple steps. Moreover, some individuals with MCI experience depression or other mood difficulties, which can interfere with task initiation and follow through. For example, individuals with MCI may forget to take medications without assistance, neglect household chores or complete them incorrectly, and even may struggle to complete safety-related tasks like turning off the stove or locking the doors without reminders. Many of these activities are difficult to track and do not have built-in feedback about whether the individual completing the task did so correctly, which presents a problem for both individuals with MCI and their spouses or care partners. Presently, many care partners report that they are either the ones to complete these types of activities (e.g., they are the only ones who cook or will administer medications to the individual with MCI) or that they must always check to ensure the tasks have been completed. This can result in a decrease in feelings of autonomy and empowerment for the individual with MCI, can lead to reduced peace of mind for the care partner, and can cause tension in their relationship.*

The assigned goal for each team was to conduct sufficient background research (through literature and interaction with subject matter experts) in order to adequately understand the problem, the needs of the users, the state of the art of current solutions and related technologies that might be leveraged to develop proposed solutions to address the needs of users. Due to COVID 19 restrictions and time constraints, it was recognized that any design solutions resulting from this study would be conceptual in nature, being presented digitally without physical prototypes needed for subsequent testing/validation.

Once the teams sufficiently understood the needs of their users, they developed basic problem statements and objectives to guide subsequent design efforts. Both teams presented their background research, problem statements and design goals to the class and project sponsors who provided feedback and further guidance. The teams then undertook an iterative design process to develop solution proposals. The final design proposals were then presented and evaluated by subject matter experts (3 in total).

Two surveys were distributed after the project: one to students and one to the expert evaluators. The goal of the student survey was to understand their background and previous experience with the topic, learn how the design was executed and tested, determine what was learned, and find out how students rated their designs. The expert survey was aimed at more objectively assessing the designs and to learn more about the stronger or weaker aspects of the final designs and to compare the perceived outcomes between the two groups.

## 3 RESULTS & DISCUSSION

A total of 6 students and 3 expert reviewers participated in the project. The students were divided into two teams: "Ambient Alerting" and "Lost Item Tracking". Each team developed a proposed design solution to the objectives outlined in the project briefs – as illustrated in Figures 1 and 2:

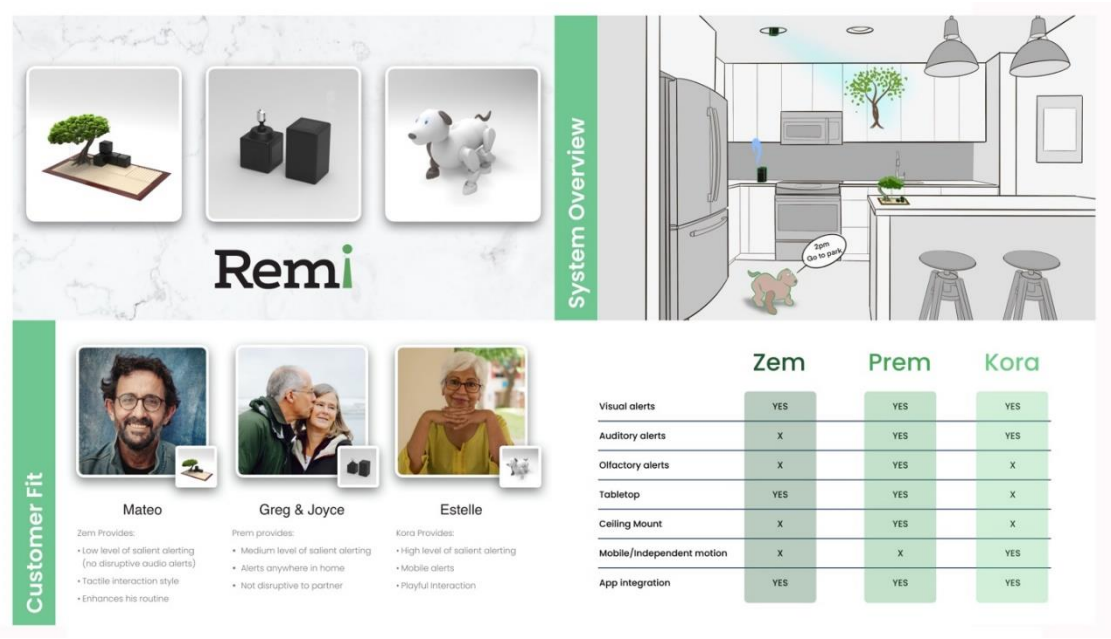


*Figure 1. Final design solution developed by "Ambient Alerting" team*


*Figure 2. Final design solution developed by "Lost Item Tracking" team*

Four students (two from each team) completed a post-project survey. As a part of this survey students were queried as to whether they felt they had increased their knowledge of the needs of individuals with MCI, what methods they had used in an attempt to understand the needs of individuals with MCI, and how students perceived the effectiveness of their designs. Questions were multiple choice where answers were on scales of: (a) yes/no; (b) A lot/some/none; (c) completely/mostly/somewhat/not at all.

The 3 subject matter experts involved with the project also assessed the output of each of the two student teams. The expert survey contained 3 questions mirroring the last three on the student survey in order to contrast the student perception with those of practitioners, compare how well the design objectives were met, and to gauge the actual level of student learning. The subject matter experts also provided written assessments of each team's design.

*Table 1. Results of post project survey*

| **Question:** | **Team:** | | | |
|---|---|---|---|---|
| | Lost Item Tracking Team | | Ambient Alerting Team | |
| | Student (n=2): | Expert (n=3): | Student (n=2): | Expert (n=3): |
| Ever known or provided care for someone with MCI? | 1 with experience | | None | |
| Simulation strategies or devices employed during design process? | No | | No | |
| Did you speak directly to persons with MCI? | During initial research & design | | No | |
| Overall knowledge of MCI needs BEFORE project? | 2-Knew a little bit | | None | |
| Overall knowledge of MCI needs AFTER project? | 2-Knew a little bit | | 2-Knew a little bit | |
| Do you feel better equipped to discover needs for very different user groups after project? | Mostly, Aware of need to learn more | | Mostly, Aware of need to learn more | |
| Methods used to understand MCI user needs during project? | Literature research, SME interviews, MCI user survey & interviews | | Literature research, SME interviews | |
| Were observation, surveys or other methods used to understand user needs? | No | | No | |
| How effective does solution meet project brief objectives? | Mostly | 1-Completely<br>2-Mostly | Mostly & Somewhat | 1-Mostly<br>2-Somewhat |
| How effective does solution meet MCI user needs? | Mostly | 3-Mostly | Mostly | 2-Mostly<br>1-Somewhat |
| How practical is the design for MCI users to integrate into their lives? | Somewhat | 2-Completely<br>1-Mostly | Mostly & Somewhat | 1-Not practical<br>2-Somewhat |

The expert reviewers rated the "Lost Item Tracking" team's designs more highly in general with respect to meeting original project objectives, meeting user needs, and practicality. Interestingly the students on this team rated their own performance in these areas somewhat lower than the experts. This team included a member with a friend/family member with MCI. This was also the team that engaged users with MCI during concept development. One or both of these factors may have contributed to the improved design. Deeper engagement with real user issues may also have contributed to the student perception that their design could be better because they were able to uncover more detailed and nuanced problems.

The "Ambient Alerting" team rated their design effectiveness somewhat higher than the expert reviewers. This team had no prior experience with MCI and did not engage users directly. Their lack of prior personal experience may have contributed to a perception that direct user engagement was not as necessary to discover needs and issues faced by individuals with MCI. By not engaging users, it likely prevented the team from discovering detailed or non-obvious needs, reducing the effectiveness of their design and the perception that their final solution was better than it was.

It was also suggested by the expert reviewers that, since the range of MCI limitations varies significantly, a more meaningful survey of student learning and design effectiveness should assess specific user capabilities or pose a series of questions focusing on the needs of MCI sufferers of different limitations.

# 4 CONCLUSIONS & RECOMMENDATIONS

One of the biggest distinctions between the teams' outcomes was the engagement of users with MCI. The team that did (Lost Item Tracking) minimized their assessment of outcomes (meeting objectives, effectiveness of the solution, and practicality). Experts evaluated this team's output the same or higher. The team that did not engage users (Ambient Alerting) tended to give higher self-evaluations of their outcomes compared to expert reviewers. There is much which can be learned through experience, background research and second-hand observation. This can still be insufficient to expose the nuance of a use case and lead to expectations that a design solution is better than it actually is. This was supported through the expert reviewer feedback to both teams:

*The design solutions from both teams demonstrated an appreciation for the delicacy needed to support people with cognitive challenges while respecting their knowledge and intelligence. As a person with MCI noted, the solutions were not 'punitive'. Design solutions from both teams maintained a high degree of flexibility for users, which is especially important for integration in their lives. Both teams did a remarkable job developing solutions that were respectful of the intended users and addressed the challenges experienced by people with mild cognitive impairment, especially considering limitations on interactions with stakeholders due to COVID precautions preventing face-face interaction and making it more difficult to grasp the impact of MCI as well as to solicit input and feedback on ideas. (In similar class projects done prior to COVID, students were able to meet with people living with MCI and their care partners and were often invited to visit their homes. Within the scope of this project, teams were not able to meet with people face-to-face and that certainly made.*

*While the "Lost Item Tracking" team's "Colour Block" concept (Figure 2) benefited from its simplicity, the integration of technology was "somewhat forced" and "unclear". Individuals with MCI typically prefer the opportunity to customize product(s) to a greater degree to fit with the existing aesthetics of their homes. Additional technical work is needed on the "Colour Block" product to develop the interactivity needed to encourage the user to pull out a cubby to retrieve an item and to push it in once an item is returned. Through user testing and greater automation of cubby components, it may be possible to identify a mechanism which removes the need for people with MCI to remember to move blocks when an item is taken or replaced. Working with users could help determine how the audio reminders would work (what would trigger it, the content of message(s), and if it would change (depending on the status of objects). Overall, this design was extremely responsive to the needs with people with MCI and would be easy to integrate into the lives of individuals with MCI and provides a great basis for supporting compensatory strategy training focused on use of the colour block. With further design development, this is a viable product for people with MCI.*

*The Ambient Alerting team's solution "Remi" (Figure 1) product system is further from completion, requiring substantial design & engineering development. While the range of products would allow for expansion as the needs and abilities of users with MCI change and the product suite could be helpful for keeping track of appointments, it does not address the issue of alerting people to risks around the house.* (Note from authors: the team assumed the use of IOT enabled appliances, integrated with the system to provide such alerting). *This team would benefit from more input from potential users to fully understand the problem space. People with MCI should be asked to provide examples of types of things they want to be reminded about and what kind of systems, both paper-based and electronic, that they are already using to keep track of appointments, if that is what they want to be reminded about. Similarly, the Remi system will need to identify the role that the care partners will play in the reminder system and adjust designs accordingly. Overall, this design was mildly responsive to the specific needs of people with MCI and would likely be somewhat difficult for many people with MCI to integrate into their daily life. The design relied heavily on interfacing with technology (e.g., entering digital appointments), which many older adults find challenging. Given this, the care partners of people with MCI would likely be interacting with these technologies more often than the people with MCI. Although this can support autonomy and daily function, this design would benefit from simplification so dyads can determine the extent to which interaction depends on the member versus the care partner and to provide greater autonomy for high functioning individuals diagnosed with MCI.*

Suggestions for future projects of this nature include additional instruction on the needs and issues faced by individuals suffering with MCI. Further efforts should facilitate direct communication between students and individuals with MCI to better understand relevant design parameters and to facilitate input and feedback within an iterative design process. A longer project duration that allows prototype

fabrication for usability testing would be ideal. While 2D representations are helpful, they do not replace what can be learned through prototype-based testing.

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