

Original Research

Using a Gamification Approach to Enhance Continued Use of Assistive Technology Intervention in Persons Living with Dementia

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Abstract

Assistive technology (AT) interventions have shown promising results in supporting cognitive, social, and physical activities in persons living with dementia (PLWD) and their caregivers. Despite strong evidence of the effectiveness of AT, PLWD and their caregivers can disengage with the technology after it is used for a time – i.e., the “stickiness challenge”. Diminished use of AT reduces the opportunity for it to have optimal impact. We asked whether the opportunity to engage in cognitive games may enhance continued use of AT in PLWD and their caregivers. We investigated whether gamification used in conjunction with a well-established AT commercial product, the MapHabit System (MHS), enhanced stickiness of the intervention. The MHS uses a series of visual maps incorporating step-by-step images and videos to help PLWD and their caregivers complete activities of daily living. Using a randomized control trial (RCT), we determined the number of visual maps accessed daily by a group of PLWD using the MHS with gamification in comparison to a control group using the MHS plus viewing health-



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related informational videos. The study lasted six months, with changes-in-quality-of-life and net-promoter questionnaires being administered at the end. We found no differences in scores between the two groups with respect to the number of maps accessed nor duration-of-use of the MHS. Notably, both groups reported scores reflecting improved quality of life as well as high user-satisfaction ratings. The findings here report the first RCT study in PLWD using a “stickiness” approach to enhance AT engagement. Our findings suggest that it is likely that gamification used as an adjunct, as we did here, has little impact on “stickiness”. A more promising approach may be to use gamification conditionally as an incentive reward for continually using an AT intervention. Between-group imbalances in gender and ethnicity could also have contributed to outcomes. This study sets the stage for exploring all these possibilities as AT becomes more integrated into healthcare practice and research.

Keywords

Dementia; Alzheimer’s disease; caregiving; assistive technology; stickiness; gamification; caregiver burden; quality of life; activities of daily living; habits

1. Introduction

Persons living with dementia (PLWD) face many quality-of-life challenges, such as difficulty remembering and independently completing various tasks, shorter attention spans, changes in communication ability, and other functional barriers [1, 2]. During the last several years, the use of assistive technology (AT) in the service of PLWD has shown strong evidence of aiding in the preservation of cognitive, social, and physical functions, as well as ability to complete activities of daily living (ADLs), maintain their independence, and enhance overall quality of life (QOL) [3-6]. Moreover, AT can play a multidimensional role in caregiving. In addition to its positive impact on cognitive abilities, it serves to alleviate strains on PLWD, their families, and their caregivers as well as reducing the need for formal services, and hospital visits, all of which are significant contributors to economic and personal burdens associated with dementia [7].

Despite strong evidence of the effectiveness of AT, PLWD and their caregivers can lose interest or disengage with the technology after it is used for a time, thereby reducing the opportunity for AT to have optimal impact. Thus, effective methods in retaining and fostering engagement with the technology becomes integral. The challenge of helping users re-engage with assistive devices as they begin to lose interest is often referred to as the “stickiness challenge”, a term adopted from the business industry and refers to the ability of an idea or product to stay in the minds of customers and maintain their engagement. Particularly, the stickiness challenge has been a key interest amongst technology-focused disciplines that seek to understand mechanisms that catalyze motivation and positive patterns in technology engagement [8]. A notable endeavor in achieving stickiness is seen in the adoption of gamification throughout various industries. This approach involves the integration of game design fundamentals into non-game environments in order to cultivate reward-seeking, motivational processes from participants that ultimately result in higher engagement and prolongation of a product, service, or technology [9, 10]. Gamification and its efficacy is presenting to be integrative throughout various contexts, its versatility extending to

promising potential within dementia care. Initial literature suggests elements of gamification are efficacious in improving social connection, rehabilitation, creativity, ADLs, and cognition [11-13]. Moreover, the implementation of gamification in dementia care shows evidence of increase in participant engagement [14].

One approach to gamification that has risen in dementia research is the use of serious games, defined as games that have the primary purpose of learning or problem-solving rather than of entertainment [15]. Recent studies have suggested that the opportunity to play these cognitively-engaging games in conjunction with the use of assistive technologies may be an effective approach in reducing the risk of disengagement [16-18], pointing to the sticky effects of gamification. In tandem, cognitively-stimulating games show evidence of improved emotional, cognitive, and behavioral well-being of PLWD [15, 19, 20]. Together, the integration of cognitive games into AT as a form of gamified stickiness becomes a promising investigation in exploring approaches to retaining PLWD's engagement with AT.

Here we describe findings from a study involving PLWD and their caregivers who used a well-known, commercially available assistive technology system, the MapHabit System (MHS). The question of interest was whether adding the opportunity to play engaging cognitive games to the MHS motivated a group of users to access the MHS more frequently or for a longer duration than a control group who used the MHS and had the opportunity to watch non-interactive educational videos. Simply put, did the use of gamification reduce the risk of disengagement? We used a randomized control trial (RCT) paradigm and collected use-data for six months. At the end of the 6-month study, we administered two questionnaires to participants, one which asked about changes in quality of life between the start and end of the study, and the other asked about participants' satisfaction in progress made during the six months using the MHS.

2. Materials and Methods

2.1 The MapHabit System (MHS)

The MapHabit System (MHS), is a commercially available visual mapping software application made resident on a user's encrypted smart tablet. It has been described in several previous publications (indicated below). Briefly, the MHS mechanism depends on the so-called "habit regions" of the brain, which includes the neostriatum that, unlike the hippocampus, are often unaffected by ADRD. This region of the striatum supports the development and the utilization of habit-forming behaviors and importantly, unlike the hippocampus, does not require conscious awareness of the learning experiences for the behaviors to be satisfactorily carried out [21-23]. The MHS utilizes visual, audio, and text media to create step-by-step guides, called maps, to facilitate participants and their caregivers in structuring and accomplishing ADLs [24]. Use of the MHS across a period of several months has successfully assisted caregivers and individuals living with dementia in creating routines and habits in their daily lives, in turn allowing them to enhance their ability to carry out ADLs and continue maintaining their quality of life and independence [5, 6, 25, 26].

2.2 Recruitment, Enrollment, and Consent

This study was carried out in partnership between the Aging & Health division at a community development organization (Atlanta Regional Commission, Atlanta, GA); a faith-based educational

and dementia caregiver organization (The Alter program, Atlanta, GA); a non-profit, community-based adult day care (Royal Adult Day Services, Stone Mountain, GA); and a healthcare AT company (MapHabit, Inc, Atlanta, GA). Through their social media posts, community events, informational sessions with caregivers, and other outreach efforts, these organizations recruited interested ADRD families to the study. Interested families were enrolled by clinical coordinators who worked with the care partners and their PLWD for the duration of the study.

2.2.1 Ethics Statement

Advarra Institutional Review Board (IRB) served as the multi-site protocol to evaluate the feasibility of collecting user interaction data in participants using MapHabit software (Pro00039611). The study was registered as a clinical trial with ClinicalTrials.gov (NCT05422339), a registry that meets the requirements of the International Committee of Medical Journal Editors (ICMJE). The study complies with the Declaration of Helsinki regarding the ethical principles of research involving human participants. Electronic informed consent was obtained from the primary care partner (the legally authorized representative of the PLWD) via REDCap, a secure web application database, before study commencement. PLWD hereafter will be referred to as participants.

2.2.2 Participants

Each participant enrolled together with their primary care partner, who completed the assessment forms administered at the end of the six-month study. Participants were individuals with mild cognitive impairment (MCI) or in the mild-to-moderate stage of ADRD. The diagnosis of the participant was derived from interviews with the care partner. Care partners and participants were required to be proficient in English and have internet access. Participating care partners needed to be in a direct care partner relationship with the participant, defined as a care partner who spends at least eight hours per week with the participant. Table 1 shows demographic characteristics of the caregivers and their care-recipient participants. Participants used the MHS under the supervision of their care partners.

Table 1 Person Living with Dementia Participant Demographics.

Variable	Control Group (n = 15)	Experimental Group (n = 13)
Age (%)		
31-40	1 (7)	
41-50	1 (7)	1 (8)
51-60	1 (7)	2 (15)
61-70	2 (13)	1 (8)
71-80	4 (26)	5 (38)
81-90	4 (26)	4 (31)
91-100	2 (13)	-
Gender (%)		
Female	8 (53)	8 (62)
Male	7 (47)	5 (38)
Race (%)		

White	8 (53)	9 (69)
Black or African American	7 (47)	3 (23)
Hispanic/Latinx	-	-
Other	-	1 (8)

2.3 Tablet Training and Coaching Calls

At the beginning of the study, a clinical coordinator met with each dyad to complete their pre-assessment battery. After completing their pre-assessments, both study groups were trained to access a library of dementia education maps focused on Alzheimer’s disease, dementia care, and care partner support. They were also shown how to access maps that guide the user in completing ADLs, with the ability to customize them to fit the specific ADL needs of their care recipients. After 6 months of using the MHS under their respective conditions, the clinical coordinator met with each dyad for a final session to administer two assessment questionnaires. All dyads had the opportunity for coaching calls via Zoom with one of the clinical coordinators throughout the study. These calls were weekly for the first month and bi-weekly for the second month. Most dyads had shifted to monthly calls by the time they reached the final month of the study.

2.4 Interventions and Assessments

The two dyad Groups: The Experimental (cognitive games) Group (n = 13), and the Control (video viewing) Group (n = 15) used the MHS for six months. The “sticky” activity in the Experimental Group involved receiving four new cognitive games – in the form of maps – each month that consisted of variations of Word Scramble, Iconic Landmarks, Rebus Puzzles, Analogies, etc. (see Figure 1 for an example of a cognitive game map). The cognitive games that were chosen for the current study followed game types observed to be prevalent in literature centered on serious games within dementia research [15, 27, 28]. Games in this classification fundamentally aim for cognitive stimulation as the primary mechanism of slowing down symptom acuity. Game content that were provided to the Experimental Group were curated in collaboration with professional dementia care clinicians. Game design elements of positive reinforcement, problem-solving, progression, and visual-auditory cues were implemented into game content and software. The dyad caregiver engaged the participant using these gamified maps. The Control Group watched several 40–55-minute educational videos that were transmitted to the care partners’ MHS device each month. The content involved topics such as Happiness, Memory, Nutrition/Diet, and Mindfulness (see Figure 2 for title frame of a typical video). The intent was to have the two groups engaged for about equal lengths of time in each of their respective interventions.

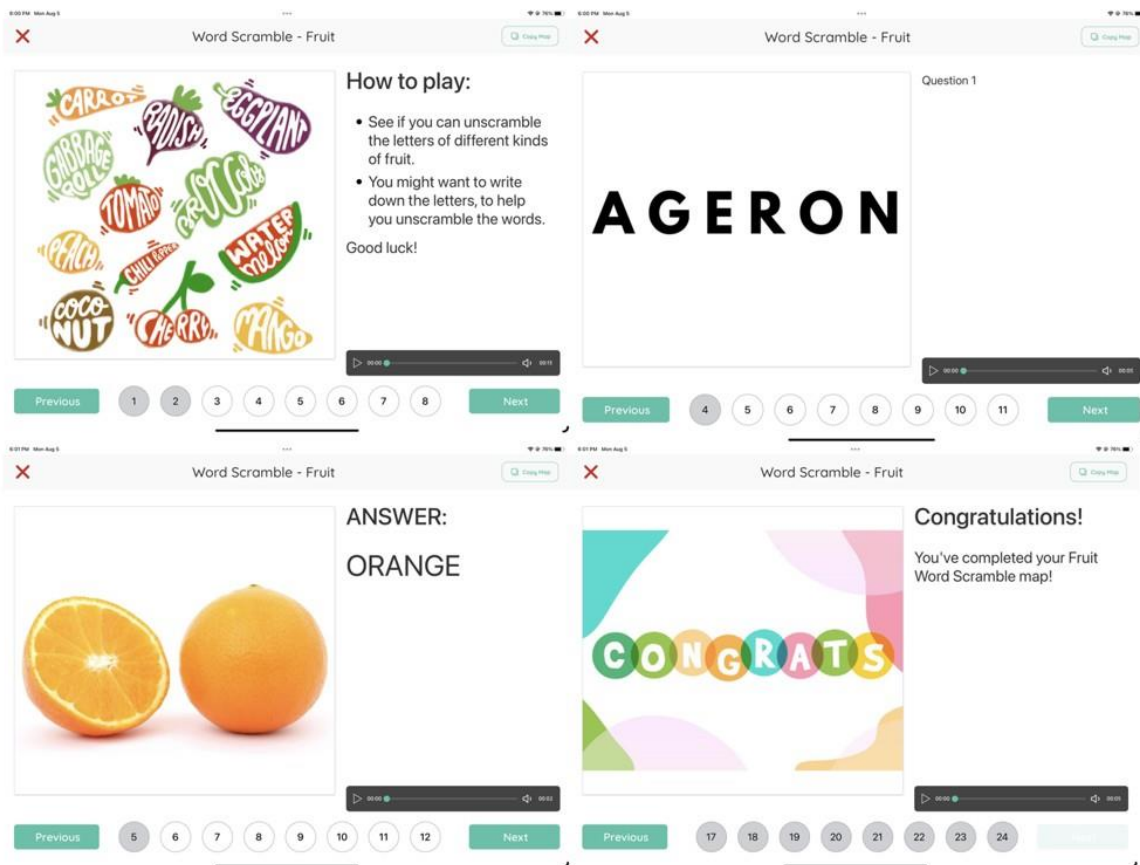


Figure 1 Example of a cognitive game map in the MHS (order of progression is top left, top right, bottom left, bottom right).



Figure 2 Example of a title frame of an educational video.

At the completion of the study, two self-report questionnaires were administered to both groups. Firstly, the Quality of Life–18 (QOL-18) asked participants to compare their quality of life across several dimensions (independence, engagement, etc.) at the six-month time-point versus the start of the study [5]. The QOL-18 used a Likert scale for each question ranging from 1 (much worse), 3 (no change), and 5 (much better). A second questionnaire measured participant satisfaction and content preference and asked two questions to query the participants' overall satisfaction with the MHS: How satisfied were you with your participant's progress? How much better do you feel that your participant is now, compared to the start of the study? An ordinal scale of 1-10 was provided for each answer, with 10 being most favorable or positive, 1 being least favorable or positive. Analysis involved descriptive statistics: the number of participants in each group that responded with scores of 7 or above for each question.

2.5 Data Analyses

Map utilization data was electronically collected by the MHS and consisted of cumulating the numbers of maps accessed by each dyad during the six-month course of the study. We standardized time scales to account for dyads that enrolled and started at different times during the study. Specifically, all dyads' time axes were rescaled so that Day 1 corresponded to the first use-day of the application, regardless of a dyad's onboarding date. Python Pandas open-source tool was utilized for data analyses. GraphPad Prism, v10.2.2, was used to analyze baseline characteristics of care partners and care recipients using descriptive statistics. QOL-18 used a Likert scale, and a 1-sample t-test was used to evaluate the difference of the group mean score compared to the null score (3 – no change) of the Likert scale. Analyses of participant satisfaction used descriptive statistics and comparisons of group means involved unpaired comparison t-tests.

3. Results

3.1 Person Living with Dementia Characteristics

Twenty-eight dyads participated in the study (Experimental Group, $n = 13$; Control Group, $n = 15$). PLWD demographics are shown in Table 1.

3.2 Map Usage and Map Preferences

Figure 3 shows the frequency of map-use by the Experimental group and Control group. There was a trend during the first month in which the Control group accessed more maps than the Experimental group on average (Control: mean of maps accessed = 83, median = 60; Experimental: mean of maps accessed = 35, median = 32). That trend carried into the second month (Control: mean = 62, median = 36; Experimental: mean = 21, median = 7). However, none of the group differences in scores reached significance, as analyzed by parametric t-tests or non-parametric Mann-Whitney U-tests (all $ps > 0.089$). Closer analyses of the data revealed that during the first two months of the study, two participants in the Control group accessed on average 170–253 maps per month (compared to the other subjects in the Control group who averaged 50–57 maps per month in the same timeframe). We have no evidence that the two participants in the Control Group had any different instructions or coaxing than the other participants in the study; they simply may have been more engaged initially in the technology than the other participants. We re-analyzed the 6-month

data using median group scores to reduce the impact of the two outlier scores, and the p -value outcomes were again not significant (p s > 0.05). In additional analyses, we deleted these two participants from the Control group data– for example, month-1 mean maps scores (Control = 57, Experimental = 35) and median scores (Control = 54, Experimental = 25) – and no comparisons were significant (all p s > 0.05). The remaining four months of the study evidenced progressive decline in frequency of map use by both groups, with no significant differences between the groups either in frequency nor duration of map use (all p s > 0.05).

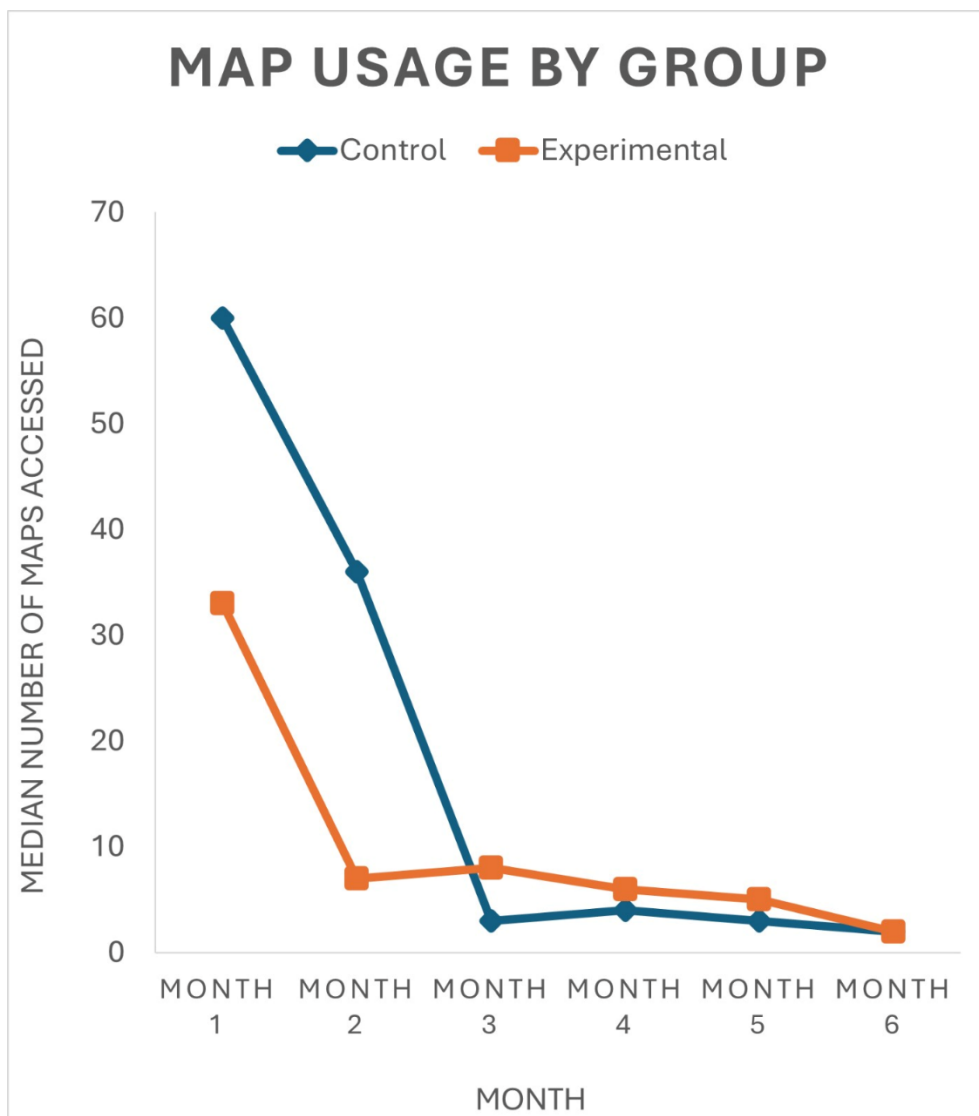


Figure 3 Median number of maps used by group.

3.3 Post-Study Questionnaires

3.3.1 QOL-18

The questionnaire was administered at the completion of study. Using a one-sample t-test (to a specified mean of 3, the middle score in the Likert scale), the Control group averaged an overall score of 3.6 (p < 0.01), and the Experimental group averaged an overall score of 3.3 (p = 0.07). Both groups had several individual items in the QOL assessment that showed significant increases in

scores at the six-month time point compared to the start of the study. For example, the Control group, the areas with the most significant positive changes were Positive Moments, Mood, Anxiety, Coping Ability, Overall Quality of Life, Expression of Appreciation, and Cooperation (all p s < 0.01). In the Experimental group, areas that showed positive changes included Ability to Carry Out Activities of Daily Living, Positive Moments, Expression of Appreciation (all p s < 0.01), and Mood (p < 0.05). Other areas also changed positively for both groups, but they did not reach statistical significance. There were no significant negative changes reported for either group.

3.3.2 User Satisfaction

There were similar findings for both groups on the two-item questionnaire in rating their satisfaction with their participants' progress using the MHS, 60% of the Control Group care partners endorsed a score of 7 or above (range of 1–10). In rating their sense of whether their participant was now better or worse than at the start of the study, 67% of Control Group caregivers endorsed a score of 7 or above (better). For the Experimental Group, caregivers reported scores that were numerically a bit lower than the Control Group scores for both questions: With respect to participants' progress, 46% endorsed a score of 7 or above, while for doing better or worse by the end of the study, 54% endorsed a score of 7 or above.

4. Discussion

4.1 General Observations

Using an RCT paradigm, we determined that the addition of gamification to the MHS did not enhance the frequency or the duration of the use of the MHS assistive technology. Specifically, for each month of the six-month study, the Experimental Group and the Control Group evidenced monthly comparable overall scores on each of the two usage-related measures (Figure 3). In the first months of the study, it appeared that the Control Group trended to a higher frequency of map use than the Experimental Group; however, the differences did not reach statistical significance (all p 's > 0.075). As described in the Results, Figure 3, the statistical trend was due to instances of unusually high initial map-use scores during the first two months in two Control group participants. Analyses using group median scores instead of mean scores, and/or analyses that did not include the two outlier participants, showed that the two groups were close in scores at all time points and did not differ in either frequency or duration of map-use (all p 's > 0.10).

By the end of the six-month study, both groups showed similar patterns of progressive declines in accessing MHS maps. During the last months of the study, with few exceptions in each group, most users evidenced daily map-use scores of zero. These findings should not be interpreted as necessarily negative. In fact, they are consistent with findings from previous studies using the MHS: As the ability to accomplish ADLs becomes more habit-like and successful, the need to access such maps progressively declines, underscoring the effectiveness of this intervention.

Consistent with the previous point are the findings from the QOL questionnaire, where there were many endorsements of significantly improved QOL aspects in both the Experimental and Control groups, and in the user satisfaction questionnaire where about half the dyads in each group endorsed scores of 7 or above. In the latter case, while not a majority outcome, the fact that half of the participants in both groups endorsed higher-end scores reflects participants' satisfaction and a

sense of forward progress having been achieved. Additionally, this finding is a promising outcome in support of the overall utility of using AT with populations of individuals living with neuro-cognitive impairments.

4.2 Study Limitations

Several limitations of our experimental design and procedures came to light during the exploration of analytics of the study. Although participants were randomly assigned to the two groups as they enrolled in the RCT, the study had a small number of participants overall. Accordingly, while adjusting group membership to match age and education, there were some imbalances in terms of gender and ethnicity (Table 1). It is conceivable that the imbalance of gender in the groups could have had an influence on the careful balance between intrinsic and extrinsic motivation [16, 17] and how much users re-engaged with assistive devices when they began to lose interest [27]. A similar question could be asked about the role of ethnicity, but the small number of subjects available for the study meant we were underpowered to meaningfully explore either of those interesting possibilities. The limitations of undertaking a relatively small-n study, including, in the present case, inability to explore or generalize about the impact on the results of variables like gender and ethnicity, underscore the need for future studies to enroll sufficient numbers of subjects to be adequately powered and designed to effectively address these and other questions. Efforts were made to equilibrate the amount of time during which the two groups engaged in their respective adjunct activities (working on cognitive game maps or watching videos). In particular, while the videos were time-locked, we could not determine how engaged the participants were during viewing. Nevertheless, reports of time durations obtained periodically from the caregivers, although admittedly rough estimates, did tend toward similar outcomes for both groups. This finding underscores that relying wholly on caregiver-reporting does introduce some amount of subjectivity in the reporting. It would be useful in future studies to incorporate some forms of objective measures, independent of caregiver-reporting, e.g. periodic video sampling showing whether the participant is engaged. Because of a technology glitch, the data collected on the use of the Experimental Group's cognitive games, and the extent to which that use might have correlated with MHS map-use, was not able to be analyzed. All these limitations are addressable, and they should be considered as important variables to explore and to manage in future studies.

5. Conclusions

To our knowledge, the findings reported here involve the first randomized control trial in PLWD using a "stickiness" approach to enhance AT engagement. A clear outcome to consider is that the use of gamification should be explored not just as an adjunct or an add-on to AT (as was the case in the present study), but instead as reward-incentive for continuing to use AT, e.g., requiring that certain daily levels of AT-use be completed in order to access gamification activities. In that regard, the present study provided preliminary evidence that participants liked the gamification activities, and they spent considerable time engaging with them. Moreover, these findings are consistent with the findings from others [16] that gamification has the potential to help reduce the risk of disengagement by creating interactive, enjoyable experiences that motivate users to continue using assistive technologies. It is clear that the utility of "stickiness" can be rigorously explored in the

context of ATs, and the present study has set the stage for this challenge as ATs become recognized as integral to healthcare standards of practice.

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Author Contributions

Brittany Montgomery: Conceptualization, study design, methodology, study execution – recruitment of subjects, testing of subjects, establishing REDCap data files and storage, writing – original draft, formal analysis, writing – review and editing. Calvin Mammen: Conceptualization, methodology, software, statistical analyses, writing –review and editing. Matt Golden: Conceptualization, study design, methodology, writing – review and editing. All authors have read and approved the published version of the manuscript.

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Competing Interests

We have read the journal's policy, and the authors of this manuscript have the following competing interests: Author Brittany Montgomery, MS was the full-time Clinical Lead at MapHabit, Inc., the company that develops the assistive technology (the MapHabit System) that was used in this study. Ms. Montgomery received compensation from MapHabit, Inc. Author Calvin Mammen, MS is the full-time software engineer at MapHabit, Inc. Mr. Mammen received compensation from MapHabit, Inc. Author Matt Golden, BBA is the full-time Chief Executive Officer at MapHabit, Inc. Mr. Golden received compensation from MapHabit, Inc. We have fully disclosed any and all interests to LIDSEN.

Data Availability Statement

All the individual participant data (IPD) collected during the trial that were collected and analyzed – including demographic characteristics, post-study questionnaires, and software usage – will be available after deidentification. Supporting information including Study Protocol, statistical Analysis Plan (SAP), Informed Consent Form (ICF), Clinical Study Report (CSR), and analytic code will be made available immediately following publication. To access such IPD, researchers must provide a methodologically sound proposal directed to shan@maphabit.com. To gain access, data requestors will need to sign a data access agreement.

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