Self-guided Immersive VR Cognitive Training

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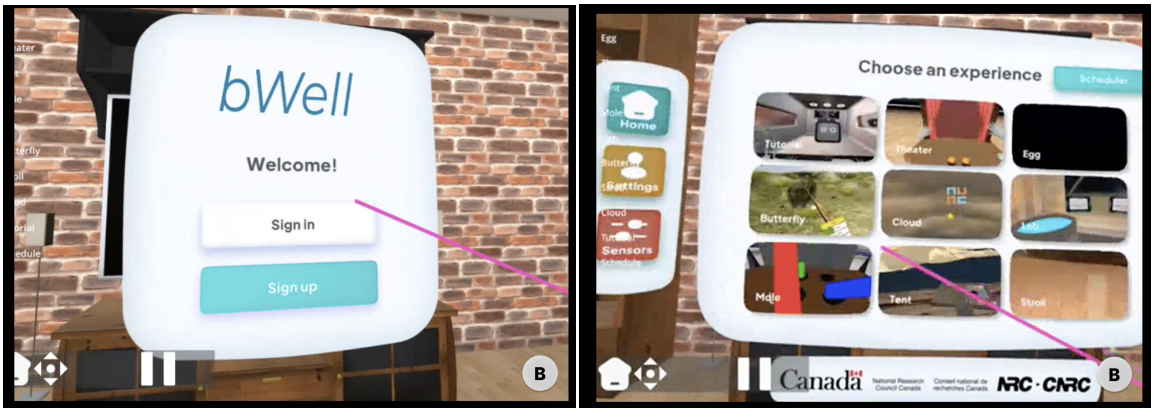

Fig. 1. Welcome Page (Left) and Main Page (Right) of bWell Application

Virtual reality (VR) technology has emerged as a promising alternative to traditional pen-and-paper approaches for cognitive rehabilitation in mental health disorders. In this context, the Cognitive Health Technologies (CHT) team at the National Research Council Canada (NRC) has developed bWell, a state-of-the-art VR application specifically designed to improve cognitive capabilities in patients with depression. bWell provides a suite of eight immersive cognitive exercises that target different cognitive domains. Following the initial validation of the prototype, the CHT team transformed it into a self-administrative mode, with the intention of exploring the potential for patients to use it at home independently. In this study, we evaluate the usability of bWell through a three-phase process, including Cognitive Walkthrough, Expert Heuristic Evaluation, and Usability Testing sessions. The results shed light on users' demands and habits regarding VR-based self-administrative cognitive applications and inform the design of future interventions.

CCS Concepts: • **Human-Computer Interaction (HCI)**; • **Interaction Design**;

Additional Key Words and Phrases: Virtual Reality, Cognitive Rehabilitation, Mental Health, Usability Testing, VR Heuristic Evaluation

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1 INTRODUCTION

The increasing prevalence of mental health disorders is a global concern. According to Trautmann [12], almost half of the population in the middle- and high-income countries is affected, causing a range of impacts on their daily lives. To address this challenge, numerous studies have suggested immersive virtual reality (VR) technologies as a potential supplement or alternative to traditional pen-and-paper approaches in evaluating and treating mental health disorders across domains. These technologies offer several benefits, such as enabling clinicians to deliver and regulate stimuli while capturing responses with high-fidelity assessment tests, resulting in clinical care that accurately reflects real-world deficits in cognitive functioning. Additionally, they provide reliable predictions about their patients' real-life conditions. Furthermore, studies have indicated that configurable exercises combining standardized assessments with adaptive and gamified variants for therapy can improve specific cognitive domains and transfer these improvements to real-world functioning through regular practice. This feature makes them ideal for cognitive rehabilitation and remediation.

The Cognitive Health Technologies (CHT) team at the National Research Council Canada (NRC) has created bWell, a state-of-the-art cognitive care platform designed to offer multisensory cognitive tasks for treatment providers. The bWell platform provides an immersive 3D environment for cognitive assessment and treatment, featuring eight exercises that target different cognitive domains. The CHT team initially validated the prototype by testing it on healthy adults in a laboratory environment, receiving feedback from the cognitive care network throughout the development process [4]. Building on this work, the team developed bWell-D, a program specifically designed for patients with major depressive disorder (MDD). The program was developed through a co-design process involving patient end-users and clinicians to ensure its effectiveness and suitability [5]. To address the challenges of determining the effective components and clinical relevance of digital interventions, the CHT team co-designed the content and incorporated theory-based gamification techniques to enhance the effectiveness of digital interventions.

Improving beyond bWell-D, the CHT team transformed the prototype from a professional-supervisory mode to a self-administrative mode, intending to explore the potential for patients to use bWell at home independently, in collaboration with DFP@UBC. To achieve this objective, we must first gain an understanding of users' general demands for self-administrative mental health applications and their habits with cognitive training and VR technologies. Additionally, we need to evaluate the usability of the current bWell interfaces and adjust them to meet the needs of patients with little or no previous experience with VR technologies. Finally, to ensure continuous use of bWell at home, we need to explore and integrate designs that enhance long-term engagement into the current platform.

A three-phase study was designed and conducted over four months better to understand user demands for a VR-based self-administrative cognitive application and evaluate the usability of the bWell prototype. The study included a Cognitive Walkthrough session, an Expert Heuristic Evaluation session, and a Usability Testing session. The results from each session are analyzed and summarized in **Section 4 Results** covering identified room for improvement in the user experience and for long-term engagement, followed by a further **Discussion & Design Suggestions** of the findings and design recommendations and **Limitations**.

2 RELATED WORKS

2.1 Self-Administrative Cognitive Exercise

Computer-based programs, including virtual reality (VR), are increasingly important in neurorehabilitation [1], specifically in cognitive training (CT) for individuals with mental health or neurological disorders. CT includes both compensatory, aiming to facilitate the development of new strategies to cope with cognitive impairments, and restorative

techniques, which focus on restoring impaired cognitive functions through methods[10]. Studies showed that engaging in cognitive training exercises leads to improvement in individuals' cognitive function and better quality of life [10]. Recent technological advancements have enabled computer-assisted cognitive rehabilitation [10] to offer personalized, adaptable, and cost-effective programs with instant feedback, utilizing technologies such as wearable systems and non-invasive brain stimulation [10]. Notably, virtual reality (VR) technology holds enormous potential and exciting prospects for neurorehabilitation, such as rehabilitation for depression and anxiety [13]. Kinne et al. [7] conducted a systematic review to evaluate the effectiveness of home-based virtual reality systems on vestibular rehabilitation and suggested that home-based VR rehabilitation is just as effective as a conventional vestibular rehabilitation program. In addition, several studies [8, 11] have shown the efficacy of home-based VR rehabilitation and VR games for individuals who have experienced a stroke. However, Miller et al. and Lin et al. also highlighted the need for rigorous methods and standards for developing this technology for home usage [8, 9].

2.2 Usability of VR Products

Since VR development practices have a diverse set of practices compared to traditional software development, the evaluation processes, including usability evaluation, are also different and executed unconventionally by industrial practitioners today. Our study relied heavily on a recent systematic literature review of the usability evaluation methods practiced by industrial researchers while building VR products after 2000 [6]. According to the study, controlled experiments are the most widely used usability evaluation approach, while other focused approaches, like Pluralistic Walk-through, Cognitive Walkthrough, and Subjective or Objective Evaluation, are also primarily implemented for particular sets of end users. Group studies and survey-based empirical approaches are found to help capture the participant feedback to understand the impact of their usability evaluation. Besides, metric-wisely, unique metrics such as Interaction Capacity and Efficacy are suggested for consideration in addition to regular usability metrics.

2.3 Long-Term Engagement

Ensuring long-term engagement is a vital factor in determining a product's success, as initial motivation, however robust, is susceptible to fading over time. An effective approach to counteracting this issue is to foster behavior change in users by transforming the product into a habit. In the field of persuasive design, Eyal [2] and Fogg [3] have proposed principles to increase user engagement and influence behavior. Eyal's Hook Model offers a four-step sequence of experiences, comprising triggers, actions, variable rewards, and investment, to guide users toward habit formation with a product. Triggers can be either internal (e.g., emotions) or external (e.g., reminder notifications), and initial actions should be simple and effortless to complete. Rewards must be fulfilling, leaving the user craving more, while investment requires user effort to increase the likelihood of a return. Another effective model in this area is Fogg's Behavioral Model (FBM), which is a theory of behavior change that focuses on the interplay between motivation, ability, and triggers. The model posits that behavior occurs when these three elements converge at the same moment. Motivation can be classified into three levels: Sensation, Anticipation, and Belonging, representing the driving force that leads individuals to modify their behavior. Ability pertains to the ease of task performance, which can be enhanced by simplifying the task, and triggers, similar to Hook's model, are the prompts that initiate user action. Leveraging these established frameworks in the product design process can facilitate the cultivation of sustained engagement with self-administrative tools over time.

3 METHODOLOGY

3.1 Problem Statements

In order to ascertain the suitability of bWell for home use, it is imperative first to identify the challenges that users may encounter when utilizing the headset and application independently. Moreover, given that bWell is intended for prolonged usage, it is crucial to investigate strategies that can maintain user motivation. Thus, the present study aims to address the following two key objectives:

(1) **Potential Usability issues**: Is bWell intuitive and easy to use as a self-administrative tool, especially for people with little to no prior experience with VR? What are some common usability issues users face when using bWell (software usage) or the VR headset (hardware usage)?
(2) **Maintaining long-term engagement**: How do we maintain users' motivations to engage with bWell long-term?

3.2 Study Design

Adopting a human-centered approach, the study is designed to encompass three consecutive phases, namely:

(1) **Cognitive Walkthrough:** A low-fidelity prototype of bWell was developed using Figma encompassing all essential interfaces to assess general interactions and flow beyond VR interactions. An additional button was added to the prototype for simulating interactions without a VR controller. The 30-minute cognitive walkthrough approach was used to assess interface learnability. We recruited seven participants with a male-to-female ratio of 5:2 and analyzed their actions, assumptions, and decision-making processes during the task using the think-aloud method and a semi-structured interview.
(2) **Expert Heuristic Evaluation:** The study used the extended version of Jakob Nielsen's 10 usability heuristics for VR to facilitate a comprehensive evaluation of bWell's usability, aiming for the identification of its usability issues from an expert perspective. All four team members served as evaluation experts. To prevent group confirmation bias, discussions about the interface were limited before the evaluation stage. And an additional document containing the definition, example, and interpretation of each heuristic in the context of VR scenarios(Appendix B.3) was created to ensure consistent interpretation of each heuristic in the context of VR scenarios. Self-reported evaluations lasted 30 to 45 minutes. The summarized results are attached in Appendix B5.
(3) **Usability Testing:** In the usability testing phase, 5 participants (4 male and 1 female, with an average age of 28.8) were recruited, with varying levels of prior VR experience (average self-reported familiarity of 3.4/5), two of whom had no prior exposure to VR. This approach enabled the assessment of bWell's usability with users interacting with the system in a real-world setting. Prior to the official testing, a pilot study was conducted to validate the study protocol. During the study, participants were requested to perform tasks in three distinct stages (onboarding, general tutorial, and exercise) while verbalizing their thought processes using a think-aloud protocol. This study investigated two exercises, Tent (3 participants) and Egg (2 participants), which were identified as the least tested in previous studies by the CHT team, and have covered the majority of important interactions utilized in the application. A post-study semi-structured interview was designed to elicit feedback on hardware and software-related issues and gain insight into participants' perspectives on long-term engagement. All sessions were video-recorded and lasted approximately one hour, and a thematic analysis using the affinity diagram method was conducted later with data collected (attached in Appendix C.4).

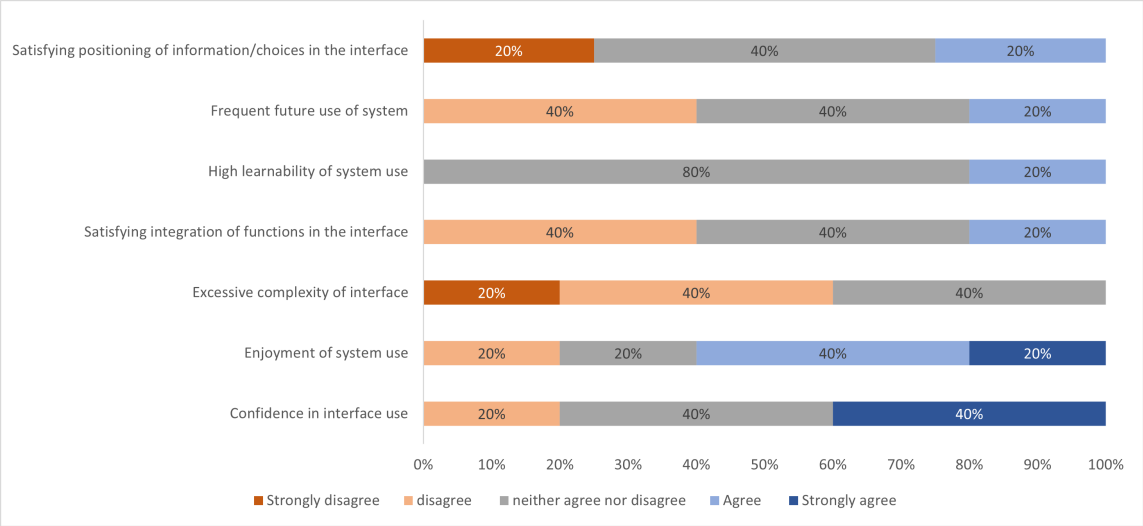

Fig. 2. General ratings in the last phase of the study on the usability of bWell

4 RESULTS

The study was divided into three distinct phases, each focusing on a specific aspect of in-app usage. Consequently, the results from each phase reflect different aspects of the product's usability. Participants' general opinion toward bWell is positive, citing its engaging environment and clear user flow, shown in Figure 2. In the following sections, we present a comprehensive analysis of the results categorized based on the three stages of in-app usage, the stage of interaction with VR hardware, and the potential for long-term engagement.

4.1 Use of VR Headset

To support the use of bWell at home, we decided to study about the potential issues that users may face when using the VR headset for the first time.

From the testing, we observed that users with prior experience had little difficulty with the initial setup, but inexperienced users encountered several issues, such as securing the headset and adjusting the bands. One major issue for figuring out general controller interactions may result in random clicking. Participants who were unable to adjust the headset properly reported experiencing fatigue and neck pain following the VR experience. While the system's instructions on setting guardians and defining the play area were deemed effective, some participants expressed the need for a quick guide to help them get started. Four participants who wore glasses encountered difficulty in using the spacer that came with the device. Despite the initial challenges, participants had above-average expectations of the product's learnability (rated 3.2 out of 5, and all reported being able to use it without help at home), indicating that they anticipate becoming more confident in their future usage of the headset. All participants expressed a preference for having a "getting started" document. Participant P2, in particular, suggested that a more visual format, such as a video, would be more effective, stating, "I probably wouldn't read a long document, but if it's short and visual ... that's better"

As per the interview findings, several other potential barriers to at-home usage were identified by the participants,

which included: the weight of the headset causing fatigue during prolonged usage, ensuring enough safe play area, the possibility of experiencing VR sickness, and adjusting the headset securely for a clear image.

4.2 Onboarding

Although some participants navigated through the flow with ease, less experienced users encountered difficulties in understanding the usage of buttons and scrolling. 20 issues were labeled for onboarding in the heuristic evaluation regarding "visibility of system status", "match between system and the real world", and "help and documentation". We observed visibility and findability issues as only one participant noticed the virtual keyboard by chance. Many participants found the "Eye Level cm" and "Hand Side" terms in the setting view unfamiliar, which posed a significant challenge. Consistency issues were observed in both the heuristic evaluation and usability test for the onboarding phase. P3 expressed concern about being restricted to only using the controller on the side they had chosen for "Hand Side" in the settings. This issue was rated as a severity of 3/4 by three evaluators in the heuristic evaluation. In addition, participants had difficulties distinguishing between various body types at this stage. P1 and P2 were overwhelmed by the abundance of options in each category and requested clearer indications of available skin colors. "Maybe [you can] show how many options I have for skin color", and "It's hard to know which one I'm at and which one I wanted." Participants lacked confidence in their choices and expressed skepticism about the necessity of the provided information, as the available options lacked sufficient details and reassurance that they could change the settings later.

4.3 Main Tutorial

The primary tutorial is the initial step for first-time users after sign-up. Participants provided positive feedback regarding their overall experience, finding it engaging and enjoyable, with a particular highlight being the presence of the robot as a supportive guide. However, less experienced users showed an increased frequency of random button pushing and clicking, leading to unintended app exited for one participant (P3) and confusion when the exit menu appeared for another (P5). Although the tutorial effectively covers all the requisite interactions throughout the application, switching between instructions presented on the blackboard and those delivered by the robot caused some confusion among participants, resulting in extended periods of time spent attempting to discern the next step or even missing them entirely. Moreover, the mismatch between the shown illustration in the robot's instructions and the real controller made them less effective. Participants frequently encountered the issue of attempting to remove the previous disk before inserting a new one, as such operations conform to their daily experience. Two participants (P3 and P4) reported feeling overwhelmed by the diverse range of interactions presented to them and were unsure of the primary focus. The most confusing interaction for users was the selection through gaze, which was further corroborated by a participant (P1) with prior VR development experience who stated that "Eye-tracking input is usually only used when there is no VR headset ... The delay was not enough ... so I can't read without selecting, which forces me to look away quickly ... or read from the sides."

4.4 Exercises

To provide a comprehensive analysis within the time constraints of our study and based on our partners' recommendations, we limited the number of exercises tested to three out of the available eight. Specifically, we used the "Theatre" exercise in the first and second phases of the study, while the remaining two were tested in the final phase. The results are presented below, organized by exercise.

(1) **Theatre:** The "Theater" exercise was selected for the cognitive walkthrough, and three areas for improvement were identified: additional clarifying information, a reminder of tutorial information, and the need for feedback. During the exercise, participants expressed uncertainty about the meaning of the "table offset" option. One participant (P3) asked, "What's the purpose of that option? Which offset are we talking about? What does that mean?" Additionally, participants stressed the importance of a reminder of the game mechanics if they had forgotten any details. One participant (P5) asked, "Is there an option for me to go back or just display it mid-game real quick?" Moreover, several participants mentioned the lack of feedback during the exercise as a significant issue. One participant was interested in knowing the number of points required to advance to the next level, while another asked for audio/visual feedback in the event of successful or failed attempts at getting the right answer. One participant (P1) commented, "Is there any confirmation whenever I get something right? Maybe a short sound clip? How do I know if I beat a level; is there gonna be some sort of victory screen?". Similar problems were labelled by evaluators in the heuristic evaluation for heuristics including "visibility of the system", "user control and freedom", "recognition rather than recall".

(2) **Egg:** During the exercise, participants primarily interacted using selection by gaze, which was also the most challenging aspect of the tutorial phase. Participants expressed confusion due to a lack of sufficient visual and audio feedback. Participants frequently spent extra time gazing in the wrong direction and failed to notice the small circle that only appeared when they looked close enough. Furthermore, the change in color went unnoticed by two participants. One participant (P2) expressed frustration due to the lack of room for error when hatching a distance egg, resulting in accidental loss of progress. P2 also noted, "The gazing is fake; I can look somewhere else, and it still hatches." The correlation between the ticking clock and the points received was challenging for participants to realize. Additionally, the use of the "B" button on the controller to access the exit menu and return to the main menu was not intuitive for participants. The use of "gaze for selection" and the similarity of options caused one participant (P2) to accidentally quit the application.

(3) **Tent:** In this exercise, participants encountered difficulties with entering their "breath per minute," as the instructions provided were insufficient in clarifying its purpose. Additionally, participants had trouble noticing the virtual keyboard. While participants found interacting with the book to be convenient, one participant (P1) experienced frustration when moving back and forth between locations and inquired, "Why doesn't the book teleport with me?" They also questioned: "Why do you need [to point to] very specific points to teleport." Another participant (P3) expressed similar frustration with having to click multiple times to travel. Furthermore, the buttons on the book were too close to one another, resulting in an increased number of accidental clicks. Participants also expressed uncertainty due to the lack of information beyond icons on what each button does. Akin to the previous exercise, the participants encountered similar difficulties in exiting the virtual environment back to the main menu.

4.5 Long-Term Engagement

In the cognitive walkthrough, participants were asked about the applications they frequently use in their free time, most of which were unrelated to mental health. Nevertheless, the factors that contribute to long-term engagement are transferable to any application. Three themes emerged from the interviews regarding the motivation for using these apps. Firstly, participants expressed that they are motivated to use tools more if they experience positive outcomes or progress toward their goals. Secondly, long-term usage of an application leads to the development of a habit of using it. As one participant stated, "[...] habit. I sometimes find myself opening the app without thinking" (P7). Finally, a moderate

amount of reminder notifications and emails were identified as triggers for motivation. Participants mentioned that the type, frequency, and content of notifications play a crucial role in their motivation to use an application. If notifications occur more frequently than 1 to 3 times a week, they resemble spam, and participants prefer to mute them. However, if the notification provides helpful information about their progress and assists them in planning forward or reaching a goal, they prefer to keep the notification on.

During the final phase of the study, further investigation into the factors that contribute to long-term engagement was conducted. However, no consistent preferred methods of receiving notifications or optimal timing for external triggers were established, suggesting that personal preference is a significant determinant in this domain. While some participants reported that a counselor's recommendation was sufficient motivation and would opt to track their progress independently using tools like Google Calendar, others preferred to receive notifications via text or email. Notably, three participants expressed a preference for receiving a weekly overview, regardless of the type of reminder. One participant (P1) highlighted the potential value of gamification in sustaining engagement, stating that "Gamification could help [in] ... keeping me coming back."

5 DISCUSSION & DESIGN SUGGESTION

During our study, all participants expressed a generally positive attitude towards bWell, indicating a potential interest in utilizing the platform and the ease of learning associated with it. However, as discussed in previous sections, certain usability issues were identified that need to be addressed to enhance the overall user experience of bWell. The objective of this section is to examine the implications of these significant issues and suggest potential areas for improvement while emphasizing low-cost solutions based on the current design. Further recommendations are also available in Appendix B.4 from the second phase of our study.

(1) **Use of VR headset:** As bWell targets potentially first-time users and serves as a self-administrative tool, it is essential to anticipate and address potential challenges prior to use. To achieve this, it is recommended to provide users with a concise visual guide, preferably in video format, to boost their confidence in using the headset. It is also important to account for the variability in commonly used hardware. This guide should ideally include instructions on how to install the application on the headset, set up the play area, use glass spacers if needed, and interact within the system. Furthermore, the starting sessions should be designed to be brief, considering that VR sickness is a prevalent issue for new users that can improve with time. This would enable users to wear the headset for longer periods.

(2) **Onboarding Section:** One of the most frequent usability issues encountered by users was the difficulty in noticing the virtual keyboard due to its position beneath their field of view and its distinct visual style. To address this issue of findability, we recommend maintaining consistency in the UI elements and incorporating signifiers such as an arrow pointing downwards or a line connecting the keyboard to the active input box. As users encounter this step before the tutorial, we suggest displaying relevant controller button icons beside each VR button in the application to make it more user-friendly. Additionally, it is necessary to provide sufficient information about each option in the settings, which can be accomplished by integrating tooltips into the current design. It is also important to inform users about the possibility of changing these settings at a later time. We suggest separating settings related to the avatar and ideally placing them before the Stroll exercise, as it is the only exercise that uses this information. Finally, using an expanded view for all available options is preferable over using right/left arrows to provide a better user experience.

(3) **Tutorial Section:** The perusal of the tutorial constitutes a valuable strategy to acquaint oneself with the diverse anticipated interactions within the application. Therefore, we propose its integration as part of the onboarding process for new users, with the inclusion of an option to opt out. This integration could be executed by adding an extra step following the setting phase but preceding the main menu, or by emphasizing its commencement through explicit instructions in the current flow. The presence of the robot figure in the tutorial elicited a positive response from the participants. Thus, we recommend adopting the robot as a friendly instructional resource to enhance the appeal and effectiveness of each exercise instruction and beyond the tutorial. Combining the two sources of instruction - robot, and blackboard - in this section is necessary to avoid confusion, and the use of accurate 3D figures of controllers can be more beneficial than the current 2D figure illustrations. It was evident that a common source of confusion resulted from attempting to extract the previous CD, which can be readily addressed by accounting for the removal of the CD before commencing each step. Furthermore, we advocate for the elimination of the "gaze to select" interaction during all non-essential navigations, particularly while navigating the back menu, as it presents a considerable challenge to the users. Lastly, the implementation of signifiers, such as guidelines from users to objects, and consistent audio-visual feedback, can significantly enhance the user experience.

(4) **Exercise Section:** When designing exercises for bWell, it's important to minimize the amount of written instructions, as reading text in VR can be challenging. Instead, instructions can be presented in sections or through visual aids. Progress bars can also be included within each exercise to provide users with a sense of accomplishment and help them understand how much more they need to complete the task. To make hints more discoverable, the current hint option can be leveraged to its fullest potential by incorporating real-world examples. For instance, the hint option could be changed to a smart wristwatch that displays brief instructions. However, this requires a proper introduction in the tutorial section. Back options can also be incorporated into the concept of a smartwatch, anchored to the user, to facilitate a consistent and convenient mode of navigation. To make bWell more forgiving, we suggest increasing the tolerance level in gaze-to-select or allowing for broader coordinates as acceptable inputs for teleportation. Moreover, incorporating more visual warnings, such as using the color red for destructive actions, like quitting the application, accompanied by an option for confirmation, as well as providing more distinctive visual-audio feedback, can make the system more user-friendly.

(5) **Accessibility:** Ensuring accessibility in VR applications is crucial to providing equal access to individuals with disabilities and creating an inclusive virtual world. It is important to consider the potential needs of this user group to broaden the user base, promote inclusivity, and bridge the digital divide. One way to address accessibility is by providing edge enhancement, which outlines the edges of important objects in a distinctive, user-selected view that can assist individuals with depth perception issues. Offering saturated views or different color combinations can benefit individuals with varying degrees of color blindness. Providing adjustable font sizes or an accessible magnifier can enhance the readability of text, especially for those with visual impairments. Additionally, allowing users to choose their preferred interactions that accommodate potential hand movement limitations is crucial to improving accessibility in VR applications.

(6) **Promoting Long-Term Engagement:** Utilizing the Hook model as a framework for experience design or integrating gamification strategies into a software application could be beneficial for promoting sustained engagement. By establishing milestones or virtual achievements to convey progress, individuals may be incentivized to continue using the application, while weekly tasks may encourage prolonged investment. Given that individuals tend to use their smartphones more frequently than virtual reality headsets, we propose using

external motivation in the form of reminders delivered via a companion mobile application, which may also incorporate gamification elements or alternative low-cost methods such as personalized texts or emails. As there appears to be no universally preferred approach, we recommend offering users the flexibility to customize notification preferences and times. Options for receiving reminders on the day of the scheduled activity or a summary at the beginning of the week may be beneficial.

6 LIMITATION

Although the study was carefully designed to mitigate limitations, the early stages were significantly constrained by the unavailability of the headset, resulting in a lack of in-depth data on VR-specific interactions. Also, given that the sign-up and login functionality of the onboarding process was still in development and had limited capabilities, we were unable to conduct a thorough assessment of its overall usability. Additionally, due to ethical considerations, participants with a history of depression were not included, and therefore the system was tested solely with general users. Although we do not anticipate any significant differences in the user experience between these two groups, this approach restricted our exploration of long-term engagement, as individuals with a history of depression may require specific attention due to their potential lack of general motivation and commitment.

7 CONCLUSION

In conclusion, the development of bWell by the CHT team represents a highly innovative approach to cognitive rehabilitation and remediation. Their work has resulted in a state-of-the-art platform that offers a range of benefits to both patients and clinicians, including highly accurate assessments of cognitive functioning and the ability to transfer improvements to real-world functioning. Moving forward from the existing bWell platform, We, together with the CHT team members, decided to figure out the further improvements needed to ensure that patients with little or no previous experience with VR technologies can use bWell at home independently. The three-phase study conducted by us provides valuable insights into user demands for such VR-based self-administrative cognitive applications, which can inform the development of similar programs in the future. Ultimately, potential designs to be integrated for long-term engagements are also provided according to the qualitative feedback collected from participants or heuristic evaluation. We believe that the use of VR-based self-administrative cognitive applications has enormous promise for addressing the global challenge of mental health disorders, and the ongoing development of bWell and similar programs is essential for improving patient outcomes.

REFERENCES

[1] Shi Cao. 2016. Virtual reality applications in rehabilitation. In *Human-Computer Interaction. Theory, Design, Development and Practice: 18th International Conference, HCI International 2016, Toronto, ON, Canada, July 17-22, 2016. Proceedings, Part I 18*. Springer, 3–10.

[2] Nir Eyal. 2014. *Hooked: How to build habit-forming products*. Penguin.

[3] Brian J Fogg. 2009. A behavior model for persuasive design. In *Proceedings of the 4th international Conference on Persuasive Technology*. 1–7.

[4] Vincent Gagnon Shaigetz, Catherine Proulx, Anne Cabral, Nusrat Choudhury, Mark Hewko, Elicia Kohlenberg, Melanie Segado, Michael SD Smith, and Patricia Debergue. 2021. An immersive and interactive platform for cognitive assessment and rehabilitation (bWell): design and iterative development process. *JMIR Rehabilitation and Assistive Technologies* 8, 4 (2021), e26629.

[5] Maria Elena Hernandez Hernandez, Erin Michalak, Nusrat Choudhury, Mark Hewko, Ivan Torres, Mahesh Menon, Raymond W Lam, and Trisha Chakrabarty. 2023. Co-design of a Virtual Reality Cognitive Remediation Program for Depression (bWell-D) With Patient End Users and Clinicians: Qualitative Interview Study Among Patients and Clinicians. *JMIR Serious Games* 11, 1 (2023), e43904.

[6] Sai Anirudh Karre, Neeraj Mathur, and Y Raghu Reddy. 2020. Understanding usability evaluation setup for VR products in industry: A review study. *ACM SIGAPP Applied Computing Review* 19, 4 (2020), 17–27.

[7] Bonni Lynn Kinne, Katelynn Jo Owens, Brittany Ann Rajala, and Stephanie Kay Ticknor. 2019. Effectiveness of home-based virtual reality on vestibular rehabilitation outcomes: a systematic review. *Physical Therapy Reviews* 24, 6 (2019), 280–290.

[8] Janice Lin, Caitlin L Kelleher, and Jack R Engsberg. 2013. Developing home-based virtual reality therapy interventions. *GAMES FOR HEALTH: Research, Development, and Clinical Applications* 2, 1 (2013), 34–38.

[9] Kimberly J Miller, Brooke S Adair, Alan J Pearce, Catherine M Said, Elizabeth Ozanne, and Meg M Morris. 2014. Effectiveness and feasibility of virtual reality and gaming system use at home by older adults for enabling physical activity to improve health-related domains: a systematic review. *Age and ageing* 43, 2 (2014), 188–195.

[10] Giuseppe Riva, Valentina Mancuso, Silvia Cavedoni, and Chiara Stramba-Badiale. 2020. Virtual reality in neurorehabilitation: a review of its effects on multiple cognitive domains. *Expert Review of Medical Devices* 17, 10 (2020), 1035–1061.

[11] Lisa Sheehy, Anne Taillon-Hobson, Heidi Sveistrup, Martin Bilodeau, Christine Yang, Vivian Welch, Alomgir Hossain, and Hillel Finestone. 2019. Home-based virtual reality training after discharge from hospital-based stroke rehabilitation: a parallel randomized feasibility trial. *Trials* 20, 1 (2019), 1–9.

[12] Sebastian Trautmann, Jürgen Rehm, and Hans-Ulrich Wittchen. 2016. The economic costs of mental disorders: Do our societies react appropriately to the burden of mental disorders? *EMBO reports* 17, 9 (2016), 1245–1249.

[13] Nan Zeng, Zachary Pope, Jung Eun Lee, and Zan Gao. 2018. Virtual reality exercise for anxiety and depression: A preliminary review of current research in an emerging field. *Journal of clinical medicine* 7, 3 (2018), 42.

A COGNITIVE WALKTHROUGH

A.1 Low-Fidelity Figma Prototype Interface

Low-Fidelity Figma Prototype: Link

A.2 Consent Form

THE UNIVERSITY OF BRITISH COLUMBIA

Department of Computer Science
2366 Main Mall
Vancouver, B.C., V6T 1Z4

Consent Form

Human-Computer Interaction Course Projects

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Introduction: Thank you for considering participating in this study. This work is affiliated with the UBC course "Topics in Human-Computer Interaction - DFP PROJECT" (CPSC 554K). Please note that we are seeking people who have fundamental knowledge about VR application and interaction.

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- answer interview questions

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This should take about 30 minutes and be completed in 1 session.

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course project in its current form, this project may, at a later date, be extended by one or more of the student investigators to be submitted as a research publication.

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_____

Participant's Signature Date

A.3 Study Protocol & Interview Questions

[Get the consent form signed and uploaded to the folder - Make a copy of this doc in the same folder and use it to take notes during your study]

User Test Protocol

- User test interviews will be conducted virtually The session will be audio/video-recorded.
- The participants will be asked to conduct a think-aloud study as they use the current prototype to complete our 3 task examples. Participants are then asked to participate in a semi-structured interview.
- Session length: approximately 45 minutes to 1 hour
- The interviewer will be taking notes and recording significant issues and feedback from the participant throughout the session.
- Purpose of the interview: We are conducting this preliminary user test interview to better understand how well the current UI of bWell works for users as well as to gather some information on the potential user engagement and use habits. Due to the limitations of providing a VR headset to users, we have created a low-fidelity prototype that resembles the interface of bWell. Further user testing is needed before in-depth data analysis. The collected information will be utilized to improve the current design so as to better serve our target users.

Introduction

Thank you for taking the time to participate in this study. This session is audio and video recorded and the data will be anonymized before further analysis. We are a team working on improving the design for a self-guided immersive cognitive application named bWell. bWell is an application developed for providing individuals recovering from depression and aimed to improve cognitive capabilities through a set of exercises. It is a VR application that users can access through a VR headset. Due to the limitations of providing a headset, we are conducting this study through an accessible 2D platform. The interface you will see in this study is the 2D version of bWell; thus, there might be some changes in perspective between screens that we ask you to kindly ignore. Ideally, you would have a controller to navigate through the experience which has been replaced by mouse clicks, and an additional “B” button at the bottom of each page that stands for “back” action. Some steps might require you to interact with the B button while others might not. I will provide more information during the steps. There are some

overlayed buttons/writing in white on the left and button of each session that is not part of the intended interface and are not interactive; so please ignore those as well.
I will provide you with instructions and you will interact with the interface following those instructions. Please try to think aloud and tell me your thought process and comments during the study. After the study, I will follow up with some questions to understand your experience better. Do you have any questions before we start?

Please use this link to sign the Consent Form and confirm you are volunteering participating this study.

Great! Let's get started.

Tasks Scenario and steps:
Imagine you have recently recovered from depression and your counselor has advised you to use bWell for the next month, 3 times a week, to improve your cognitive performance. The exercises are short games that you can play through the app. We have broken down this process into 3 steps:

First please open the prototype using this link, and make sure the screen size is fit to screen using the option button at the top right.

Step 1 - onboarding:
You are now in the bWell environment. Please go ahead and create an account. Read through the options in the setting and let me know what you think any one of them might represent.

Step 2 - tutorial:
Now that you are in the main menu, I'm going to ask you to find the theater exercise and launch the tutorial.
[Once the participant is in the theater exercise] now please go back to the main menu

Step 3 - exercise:
Now that you have been through the tutorial once, please launch the theater game without going into the tutorials.

Interview Questions:

1. Demographic information:

    1. Age:
    2. Gender :
    3. Occupation (If student, Degree, University & Major)
    4. Openness to learning a new technology on a scale of 1-5 (Definitely won't learn - Try to learn if it's essential to life - Learn it with medium effort - Pay extra effort to learn new technologies - Interested in new technology and follow the trend actively)
    5. Previous experience with learning a new technique on a scale of 1-5 (Quite difficult and frustrating - difficult - neutral - easy - quite easy and inspiring)
    6. Familiarity with VR technologies on a scale of 1-5 (Never heard about it - Have heard about it - Have used it a number of times - Use it frequently - Expert(serious users/was or is in development))
    7. Have you used a VR headset?
        1. If yes, how frequently do you use it? Do you own one?

2. Observation Follow-up Questions:
    1. Please answer the following questions on a scale of 1-strongly disagree to 5-strongly agree:
        a. I felt very confident using the interfaces
        b. I found the prototype enjoyable to use
        c. I found the interfaces unnecessarily complex
        d. I found various functions in the interfaces well-integrated
        e. I imagine that most people would learn to use this function very quickly
        f. I think I would like to use this function frequently
        g. I think the necessary information and possible actions were well-placed in interface

    2. [Follow-up on the questions above if needed]
        a. Can you explain why you felt confident/unconfident…
        b. Can you explain why you feel it is (not) enjoyable …
        c. Can you explain why you feel the interface is complicated …
        d. Can you explain why you find the functions (not) integrated…
        e. Can you explain why you believe people will (not) learn to use it quickly…
        f. Can you explain why you would like (not) to use the function…
        g. Can you explain why you find the information intuitive or not…

    3. Which part of the interface did you find enjoyable about completing the interaction?

4. What did you find confusing…
    a. In the onboarding step? [Show pages]
    b. In the tutorial step? [Show pages]
    c. In the exercise? [Show pages]
5. In general, how is your experience using these interfaces?
6. If any, how do you think the system can be improved?
7. Are there any points that I did not cover, but that you would like to share?
8. Is this application something you could see yourself using over a longer period of time (2-3 months of frequent usage)? Why or why not?

3. Mental health and engagement Questions:
    1. Have you used any self-help tools for your mental health? (Youtube channels, applications, etc.)
        a. If yes, can you name your favorites?
        b. What do you enjoy about them?
        c. What motivates you to use them?
    2. Is there an application you frequently use in your free time for any purpose (excluding those used for work/school)? (e.g., social media, games, video-editing software, etc.)
        a. How many times/hours do you use them per day/week?
        b. What motivated you to start using it for the first time?
        c. What makes you go back each time and use the app again?
        d. Do you think notifications/emails affect the frequency of your use?

B EXPERT HEURISTIC EVALUATION

B.1 Consent Form

THE UNIVERSITY OF BRITISH COLUMBIA

Department of Computer Science
2366 Main Mall
Vancouver, B.C., V6T 1Z4

Consent Form

Human-Computer Interaction Course Projects

Principal Investigator: Dongwook Yoon, Assistant Professor, Department of Computer Science, University of British Columbia, yoon@cs.ubc.ca, 604-822-1993

Co-principal Investigator: Antony Hodgson, Professor and Associate Head, Department of Mechanical Engineering, University of British Columbia, ahodgson@mech.ubc.ca, (604) 822-3240

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Participant's Signature Date

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Heuristic Evaluation Task List

0. Wearing the VR Headset:

Pick up the controller
Put on the device
Power on the device
Confirm you can using the controller to point to your target
Confirm you can using the buttons and triggers on the controller to operate the system
Calibrate your environment
Confirm you can see the living room scenario, including the table, sofa and door
Use A to activate the App - bWell WP - enter

1. Active the b-Well App

Confirm you are in the bWell system
Confirm the surrounding environment
Sign up in b-Well
Check “Going back” and re-enter the Sign up
Skip the register information and Sign up
Agree on the terms
Adjust the personal setting for each section
    Gender
    Body Type
    Skin Color
    Eye level
    Hand
Reach the Home page
Enter the “Personal” setting page and adjust the setting
Enter the “Sensor” page and confirm the page
Back to the Home page

2. Go through the App Tutorial

Activate the tutorial section
Enter the tutorial
Unlock the box
Pick up the CD
Place the CD
Water the Plant
Switch a new CD
Light up the Candle
Switch to a new CD
Light the Firework
Switch to a new CD
Teleport to 3 locations

3. Go through 8 exercise

3.1 Exercise 1 Tutorial

Activate the exercise 1 section
Go through the animation tutorial
Enter the tutorial mode
Go through the text tutorial
Complete two example tasks
Finish the tutorial
Go back to the Home page

3.2 Exercise 1

Activate the exercise 1 section
Go through the animation tutorial
Enter the exercise mode
Go through the text tutorial
Complete two example tasks
Finish the exercise
Go back to the Home page

3.3 Exercise 2 Tutorial

Activate the exercise 1 section
Go through the animation tutorial

Enter the tutorial mode
Go through the text tutorial
Complete two example tasks
Finish the tutorial
Go back to the Home page

3.4 Exercise 2

Activate the exercise 1 section
Go through the animation tutorial
Enter the exercise mode
Go through the text tutorial
Complete two example tasks
Finish the exercise
Go back to the Home page

3.5 Exercise 3 Tutorial

Activate the exercise 1 section
Go through the animation tutorial
Enter the tutorial mode
Go through the text tutorial
Complete two example tasks
Finish the tutorial
Go back to the Home page

3.6 Exercise 3

Activate the exercise 1 section
Go through the animation tutorial
Enter the exercise mode
Go through the text tutorial
Complete two example tasks
Finish the exercise
Go back to the Home page

3.7 Exercise 4 Tutorial

Activate the exercise 1 section
Go through the animation tutorial
Enter the tutorial mode
Go through the text tutorial
Complete two example tasks

Finish the tutorial
Go back to the Home page

3.8 Exercise 4

Activate the exercise 1 section
Go through the animation tutorial
Enter the exercise mode
Go through the text tutorial
Complete two example tasks
Finish the exercise
Go back to the Home page

3.9 Exercise 5 Tutorial

Activate the exercise 1 section
Go through the animation tutorial
Enter the tutorial mode
Go through the text tutorial
Complete two example tasks
Finish the tutorial
Go back to the Home page

3.10 Exercise 5

Activate the exercise 1 section
Go through the animation tutorial
Enter the exercise mode
Go through the text tutorial
Complete two example tasks
Finish the exercise
Go back to the Home page

3.11 Exercise 6 Tutorial

Activate the exercise 1 section
Go through the animation tutorial
Enter the tutorial mode
Go through the text tutorial
Complete two example tasks
Finish the tutorial
Go back to the Home page

3.12 Exercise 6

Activate the exercise 1 section
Go through the animation tutorial
Enter the exercise mode
Go through the text tutorial
Complete two example tasks
Finish the exercise
Go back to the Home page

3.13 Exercise 7 Tutorial

Activate the exercise 1 section
Go through the animation tutorial
Enter the tutorial mode
Go through the text tutorial
Complete two example tasks
Finish the tutorial
Go back to the Home page

3.14 Exercise 7

Activate the exercise 1 section
Go through the animation tutorial
Enter the exercise mode
Go through the text tutorial
Complete two example tasks
Finish the exercise
Go back to the Home page

3.15 Exercise 8 Tutorial

Activate the exercise 1 section
Go through the animation tutorial
Enter the tutorial mode
Go through the text tutorial
Complete two example tasks
Finish the tutorial
Go back to the Home page

3.16 Exercise 8

Activate the exercise 1 section

Go through the animation tutorial
Enter the exercise mode
Go through the text tutorial
Complete two example tasks
Finish the exercise
Go back to the Home page

3.19 Scheduler

Activate the scheduler section
Follow the scheduler to complete the tasks

Closing

Quit the bWell App
Confirm you are in the living room scenario
Power off the device

B.3 Heuristic Evaluation Form

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Heuristic Evaluation Form

Please refer to these two links before you conduct the heuristic evaluation if you are not familiar with any of the 10 heuristics applied in the evaluation.

10 Usability Heuristics for User Interface Design

10 Usability Heuristics Applied to Virtual Reality

Heuristic	Original	Applying to VR
1. Visibility of System Status	The design should always keep users informed about what is going on, through appropriate feedback within a reasonable amount of time. Systems that clearly communicate their current state foster trust and predictability.	
2. Match Between System and the Real World	The design should speak the users' language. Use words, phrases, and concepts familiar to the user, rather than internal jargon. Follow real-world conventions, making information appear in a natural and logical order.	Many people have little to no experience with virtual reality and thus rely on past (physical and digital) experiences to drive their behaviors and expectations in the virtual realm. Building on existing mental models helps users (correctly) predict interactions in a VR system. In fact, since virtual reality often has a close relationship with actual reality, it ought to be easier to apply this heuristic for VR designers than it sometimes might be for traditional 2D-GUI designers.

3. User Control and Freedom	Users often perform actions by mistake. They need a clearly marked "emergency exit" to leave the unwanted action without having to go through an extended process.	Getting stuck in a virtual environment can be frustrating. Providing a way out, through buttons like Back or Exit, supports users' sense of freedom and can get them out of an unpleasant experience.
4. Consistency and Standards	Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform and industry conventions.	Jakob's law of user experience says that users spend most of their time on websites other than yours. Since many of these follow design standards and users are familiar with them, interfaces that go against these standards are prone to increasing the user's cognitive load.
5. Error Prevention	Good error messages are important, but the best designs carefully prevent problems from occurring in the first place. Either eliminate error-prone conditions, or check for them and present users with a confirmation option before they commit to the action.	Interface slips and mistakes happen all the time. Aim to design proactive systems that can anticipate and prevent errors.
6. Recognition Rather than Recall	Minimize the user's memory load by making elements, actions, and options visible. The user should not have to remember information from one part of the interface to another. Information required to use the design (e.g. field labels or menu items) should be visible or easily retrievable when needed.	Humans' short-term memory has a limited capacity and virtual experiences are often complex enough (especially for new users). Don't overburden VR users by asking them to remember additional information.
7. Flexibility and Efficiency of Use	Shortcuts — hidden from novice users — may speed up the interaction for the expert user such that the design can cater to both	Virtual environments, like traditional interfaces, must cater to novice and experienced users. Good defaults are important to

	inexperienced and experienced users. Allow users to tailor frequent actions.	keeping everyone happy, but shortcuts and customizations may be needed to keep experienced users engaged.
8. Aesthetic and Minimalist design	Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.	Virtual interfaces can offer a great deal of complexity, which makes it even more important to prioritize the essentials.
9. Help Users Recognize, Diagnose, and Recover from Errors	Error messages should be expressed in plain language (no error codes), precisely indicate the problem, and constructively suggest a solution.	Clear communication and helpful suggestions are key to effective error messages.
10. Help and Documentation	It's best if the system doesn't need any additional explanation. However, it may be necessary to provide documentation to help users understand how to complete their tasks.	Virtual-reality experiences often contain a high volume of interactions, some of which are complicated or unfamiliar to users. Instances like these require thoughtful documentation that enables users to solve their problem and get back on track.

Please follow the task list here during the evaluation

Evaluation #1

Evaluator:
Evaluate Date:

SEVERITY RATING

0 = I don't agree that this is a usability problem at all

1 = Cosmetic problem only: fix if time is available

2 = Minor usability problem: fixing this should be given low priority

3 = Major usability problem: important to fix, given high priority

4 = Usability catastrophe: fix this before product can be released

Heuristic	Issues	Severity (0-4)	Recommendation
1. Visibility of System Status			
2. Match Between System and the Real World			
3. User Control and Freedom			
4. Consistency and Standards			
5. Error Prevention			
6. Recognition Rather than Recall			
7. Flexibility and Efficiency of Use			
8. Aesthetic and Minimalist design			
9. Help Users Recognize, Diagnose, and Recover from Errors			
10. Help and Documentation			

B.4 Merged Evaluation Results

Heuristic	Issues	**Reviewer**	Severity (0-4)	Recommendation	Phase
1. Visibility of System Status (19)	Starting the VR headset was troublesome, three steps are drawn on the box but what are the other steps to navigate the application were missing	Himani	3	Showing some icon would help to determine the VR application has started	Other
1. Visibility of System Status (19)	How to use the hand controller, what is the correct handling? Which buttons are for OK and QUIT. Many times I exit in the middle of the game just because it is not clear to me which EXIT button is.	Himani	2	Having a picture that shows the buttons position and names is a good idea.	Other
1. Visibility of System Status (19)	While entering the application, there is no loading bar, so user won't know whether the app is stuck or not	Zhe	2	Add a loading bar or animation to indicate the entering procedure	Onboarding
1. Visibility of System Status (19)	For personal setting page, after body type, skin color are selected, no preview of avatar is provided, so users won't know what their setting means and whether that matches their preference	Zhe	2	Give a preview of the avatar updated immediately with the users' preference setting.	Onboarding
1. Visibility of System Status (19)	No preview of the chosen avatar and other options before starting	Pegah	2	Add a page where they can see all selected characteristics and confirm it	Onboarding
2. Match Between System and the Real World (17)	Avatar setting is confusing	Merry	1	Move avatar setting to the relevant exercise only - give an option to choose from pre made ones and move on	
1. Visibility of System Status (19)	For personal setting page, eye level in cm is confusing, also user won't know the reason to enter an accurate number, won't know the number, and won't know the consequence of entering a wrong number	Zhe	2	Explain the reason for collecting eye level, or change it to a less accurate level (160, 170, 180, etc.)	Onboarding
1. Visibility of System Status (19)	Eye-level in the login part and the number of item table are confusing	Pegah	3	Describe with clearer words	Onboarding
2. Match Between System and the Real World (17)	Eye level and in game options are not clear on what they do	Merry	2	Getting height instead of eye level	
1. Visibility of System Status (19)	Profile set up is but tricky as the questions are bit irrelevant and tricky	Himani	2	Show them examples of what eye distance is?	Onboarding
1. Visibility of System Status (19)	Sensor button: no loading bar, don't know whether the app is stuck	Zhe	2	Add a loading bar or animation to indicate the entering procedure	Onboarding
1. Visibility of System Status (19)	Sensor page: Does not have the correct content, the refreshing and recording button does not have function, and user won't guess what is happening with the button	Zhe	2	Make sure the function is intuitive, or something user need to control, otherwise remove the content to distract user less	Onboarding
1. Visibility of System Status (19)	Entering tutorial mode and game mode button are too similar	Merry	2	Having one in different color or different place which is consistent for all exercises	Tutorial
1. Visibility of System Status (19)	IsToturial toggle button	Merry	2	Not visible enough	Tutorial
1. Visibility of System Status (19)	In Tutorial session, there is not sound effect to lead users to the specific direction	Zhe	1	Add sound effect when needed	Tutorial
1. Visibility of System Status (19)	In tutorial session, when the teleport spot is turning yellow, it is not guaranteed to be transport to it.	Zhe	2	Give a clear match, if color changes, you can teleport	Tutorial

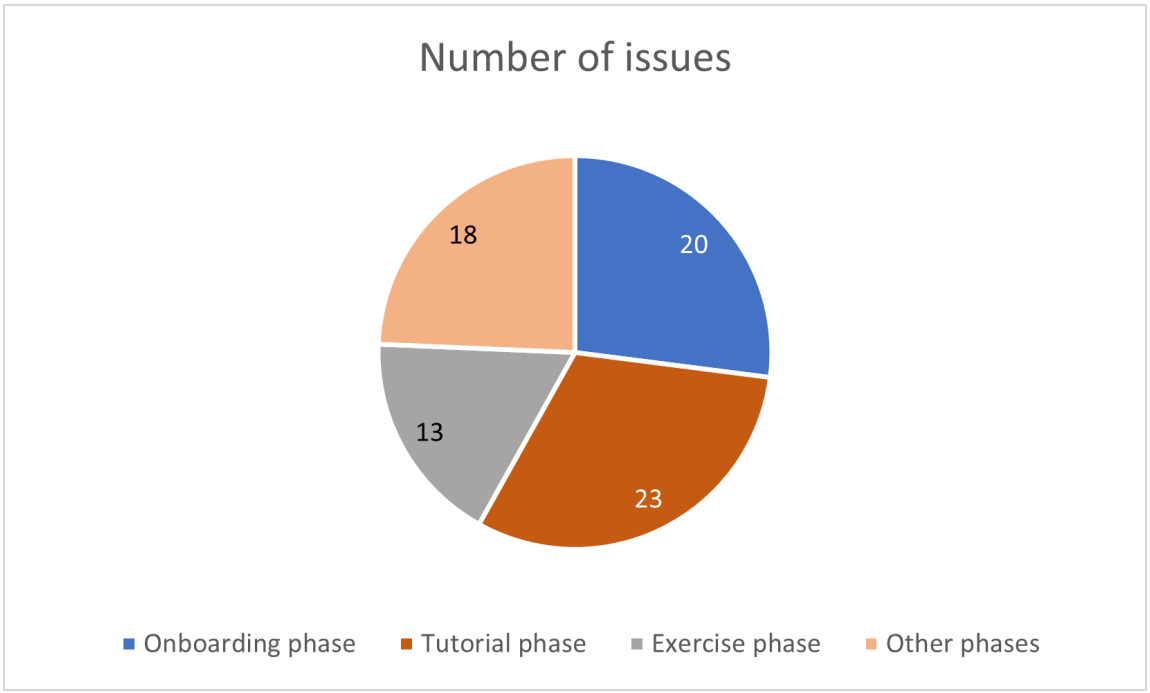
1. Visibility of System Status (19)	In the theater introduction page, the image is gif, indicating user should look at that as a tutorial, but actually the real tutorial is later	Zhe	2	Just keep one tutorial	Tutorial
1. Visibility of System Status (19)	When exercise is paused (B button) it's not clear - major issue in Lab as the white screen (exit menu) falls behind the black	Merry	2	Loading icon for between pages Redesigning exit menu to be part of the game items / displaying pause icon with an overlaid color on the whole room	Exercise
1. Visibility of System Status (19)	How much longer should I continue	Merry	1	Adding progress bar to exercises - Setting goals	Exercise
1. Visibility of System Status (19)	Changes in texts in the exercises (black board) are not clear	Merry	1	Adding steps/progress bar for the black board Having very visbile animation or sound as feedback	Exercise
1. Visibility of System Status (19)	Placement of exit menu relevant to user's perspective is not convenient as they might look around a lot	Merry	3	Having it being accessible through a fixed point (e.g., on the left hand)	Exercise
2. Match Between System and the Real World (17)	Controller illustration in toturial is hard to understand	Merry	2		Tutorial
2. Match Between System and the Real World (17)	Gazing at a button to press	Merry	3	This will not be too intuitive for new VR users. Perhaps give an option to also press.	Other
2. Match Between System and the Real World (17)	Scheduler - Not clear what it does	Merry	1		Onboarding
2. Match Between System and the Real World (17)	After signing up, the "term and condition" page will jump directly to the homepage wherever clicked, even for the scroll bar, scroll bar should be used for viewing all terms, unmatch with common experience	Zhe	1	Make the scroll bar scrollable, make the clickable area limited to the "agree" button	Onboarding
2. Match Between System and the Real World (17)	For personal setting, skin color selection, the color does not cover all available selection, I feel it does not provide enough option and I cannot find a perfect fit for me	Zhe	1	Provide more color covering frequently used skin color	Onboarding
2. Match Between System and the Real World (17)	For personal setting, hand section is not matching with users' understanding: left, right, both and undefined, what's the last two means?	Zhe	2	Remove other 2 options, or give more explanation about that this selection means.	Onboarding
2. Match Between System and the Real World (17)	Home - Tutorial is not matching with users' understanding, it is a general tutorial for all potential interaction, not within the same level of the other exercise	Zhe	3	Make the tutorial session a separate page other than the other exercise, and allow user to review the interaction if they forget the interaction	Tutorial
2. Match Between System and the Real World (17)	The real word VR headset looks a bit like the robot guide, make it a little confusing about the robot's role	Zhe	1	Replace the robot with another style	Tutorial
2. Match Between System and the Real World (17)	Grab gesture's operation is different from the animation, because of the change of device	Zhe	2	Adding an extra tutorial before, or change the animation based on the device	Tutorial
2. Match Between System and the Real World (17)	For tutorial, change CD part is not so matching with real world experience	Zhe	1	2 hand operation, or 1 hand operation? Give some instruction.	Tutorial
2. Match Between System and the Real World (17)	I feel some buttons are for touch, some for scrolling, as mentioned this could a real problem to new users	Himani	1	Having a picture that shows the buttons position, names and their functions is a good idea.	Other

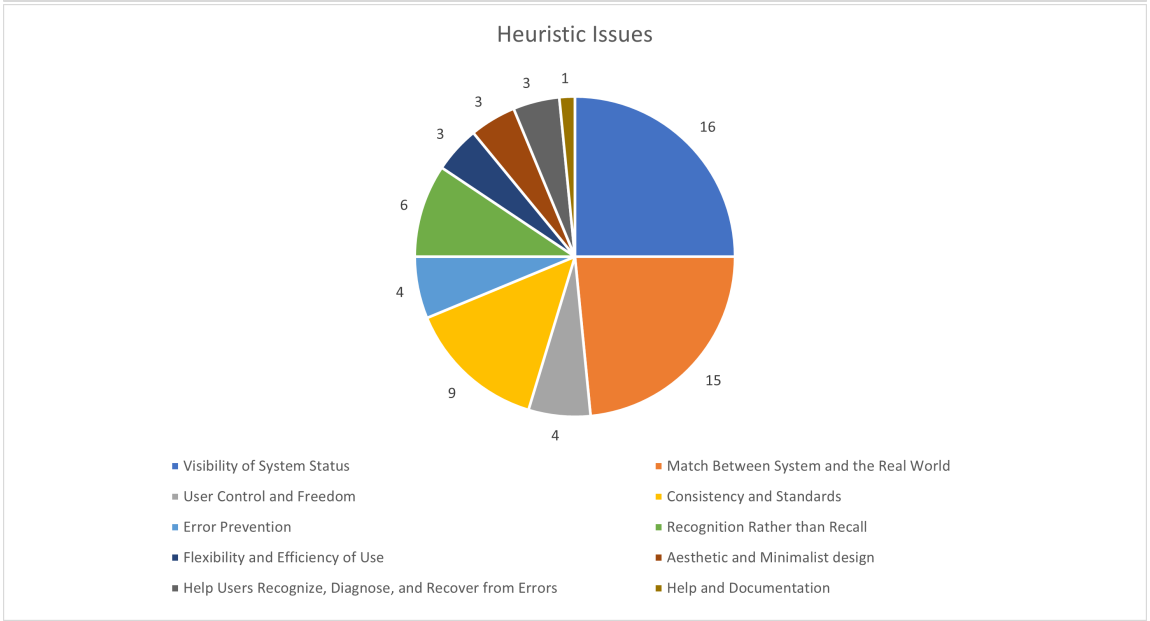
2. Match Between System and the Real World (17)	Setup has a lot of cons for eg. should it have people from all ethnicity? Better not to keep?	Himani	1	Include other ranges of skin color types.	Onboarding
2. Match Between System and the Real World (17)	I haven/t tried but what does hand control in both hands mean? If I select both, how will the two hand controller be used?	Himani	2	Provide more insights on the last two options.	Onboarding
2. Match Between System and the Real World (17)	Tutorial is something that assist the understanding of the actual task, I feel like there is great mismatch between the tutorial and the actual exercises	Himani	3	Make the tutorial with related exercises with sound effects to make the process easier to understand and co-relate.	Tutorial
2. Match Between System and the Real World (17)	In some games, the result of the success is not shown. For example, in the butterfly game, when they catch a butterfly, they cannot see the butterfly in their net, and they can only sense the vibration.	Pegah	1	Add the visualization of each step, like a butterfly in the net.	Exercise
3. User Control and Freedom (4)	In sensor page, there is no “back” button to operate, and B button is also not allowing going back, but “quit” and “reset view”	Zhe	2	(This is actually serious problem, but since users won’t use this page a lot, or may remove this page, I put 2) Providing a back button in sensor page	Onboarding
3. User Control and Freedom (4)	In the tutorial section, user cannot manually start the game. So when user is still exploring, the task have already started	Zhe	3	Provide a start option for user to control	Tutorial
3. User Control and Freedom (4)	I face lots of trouble in operating the hand controller. It is just going to QUIT, why?	Himani	4	Details about operating should be provided	Other
3. User Control and Freedom (4)	There is no description of how to select by looking at the option	Pegah	3	A brief explanation of how to select options by looking at them/ or adding the option to select with pressing.	Onboarding
4. Consistency and Standards (10)	Teleporting highlighted colors vary in tutorial and exercise	Merry	2	Making both green or yellow	Tutorial
4. Consistency and Standards (10)	Buttons in the book in meditation are not seen anywhere else and are not consistent with buttons in tutorial	Merry	1	Making them 3D instead of 2D	Tutorial
4. Consistency and Standards (10)	Toturial is too much similar to other in the Home page eventhough it is a very different type	Merry	1	Separate it from the menu	Tutorial
4. Consistency and Standards (10)	In the tutorial, the lighting of a candle task is not similar to others, the lighter cannot be put down.	Zhe	2	Confusing, may consider allowing lighting and putting off the fire, and putting down the lighter	Tutorial
4. Consistency and Standards (10)	In tutorial, the ending of the lighting task and firework task is different, you need to use eye gaze interaction	Zhe	3	Make it consistent with other endings of tasks.	Tutorial
4. Consistency and Standards (10)	After the tutorial, user is brought out to the first page for sign up, not the home page for exercise selection, this is different from the general quit standard	Zhe	3	Change the quit destination to home page	Tutorial
4. Consistency and Standards (10)	Istutorial is different from normal user operating button	Zhe	2	Change all user’s operation into buttons	Tutorial
4. Consistency and Standards (10)	I feel like sometimes information was provided for the exercises and other times it is missing	Himani	2	Be consistent with information	Exercise
4. Consistency and Standards (10)	When you want to draw the limit/ border of the play, there is no guide to describe the minimum space needed for each game. For some games, a small space does not work, and the user should go back and edit the border multiple times,	Pegah	1	Give a recommended space at the first of each game.	Onboarding

4. Consistency and Standards (10)	The page of tutorial is on the same level as other games, making it confusing for users.	Pegah	2	Place the tutorial at the different levels of the other 8 games.	Tutorial
5. Error Prevention (7)	How to go back from clicking B button by mistake	Merry	3	Add an option for closing the exit menu	Other
5. Error Prevention (7)	Quit and go back to menu options are too close to one another considering that one is very destructive and can be clicked by mistake	Merry	3	Changing the word to “quit the game” - requiring confirmation	Exercise
5. Error Prevention (7)	In any stage, quit the app happens directly, maybe user will quit by mistake	Zhe	2	Need to add confirmation to make sure user wants to quit the app	Exercise
5. Error Prevention (7)	Most troublesome was the overuse of QUIT, I don't know but everytime it has ended the game without my intention of quitting the game	Himani	4	Pop up should come to ask for the final confirmation to quit the game.	Exercise
5. Error Prevention (7)	When you want to exit the game, choosing between options is hard, as it needs a new kind of engagement and is so close to each other.	Pegah	3	More space between each operation, and a guide on how to select it	Exercise
5. Error Prevention (7)	In tutorial session, the light on the ceiling seems interactable, may make it more background like	Zhe	1	Not too serious, just change the style or even remove the light.	Tutorial
5. Error Prevention (7)	Out of reach items	Merry	1	If the exercises are design to be completed in stationary setting, some objects (e.g., candles in tutorial) are beyond the default safe play zone	Other
6. Recognition Rather than Recall (6)	Highlighting bowls in Lab-toturial instead of relying on text to direct user to left/right	Merry	1	By use of color, arrow, or an outline on the bowl’s screen	Exercise
6. Recognition Rather than Recall (6)	In tutorial session, the information about the purpose of tutorial session is not well-provided	Zhe	2	Create a better introduction, and also make the purpose text easier to get access	Tutorial
6. Recognition Rather than Recall (6)	In tutorial session, different tasks have different CD image, but this is not obvious, so user need to interpret, and guess whether they should select other CD	Zhe	1	Give a highlight of the suggested CD	Tutorial
6. Recognition Rather than Recall (6)	Hand controller page should be easily accessed in order to make a good VR experience.	Himani	2	Marking or highlighting the individual role of the hand controller.	Other
6. Recognition Rather than Recall (6)	How to do the exercises? The recall that some steps are provided on how to do the exercises.	Himani	1	Exercises steps should be in a different background color to identify this important information.	Exercise
6. Recognition Rather than Recall (6)	After the tutorial, there is no way to get the information during the game)especially tutorial is so long)	Pegah	3	For the first time playing the game, for each step, a pop-up message will be shown to guide (a short format of the tutorial)	Tutorial
7. Flexibility and Efficiency of Use (3)	Question mark on left hand	Merry	2	Cover it in toturial	Onboarding
7. Flexibility and Efficiency of Use (3)	In terms of VR application, everything is provided but major information should be highlighted to improve the efficiency of the application.	Himani	1	Beginning adding this information on important things would be helpful	Onboarding
7. Flexibility and Efficiency of Use (3)	More feedback on the progress of the game, and how much more scores will lead to the next level.	Pegah	2	Adding a bar, which is filled during the game by getting a score, and shows the threshold for reaching another level.	Exercise
8. Aesthetic and Minimalist design (5)	Some exercises can be very text heavy with overlaying information (initial white screen) that contains similar info	Merry	2	Omitting repetitive info + breaking long texts into multiple screens	Exercise

8. Aesthetic and Minimalist design (5)	For personal setting page, since body type, skin color are not directly used in the exercise, adding these settings does not fit the “minimalist” design requirement	Zhe	1	Move these settings to the exercises where the “body type” and “skin color” are required and essential.	Onboarding
8. Aesthetic and Minimalist design (5)	Repeating tutorial and text-based tutorial is not quite user friendly	Zhe	1	Skip one or two, or make the tutorial easier to perceive, e.g. audio tutorial	Tutorial
8. Aesthetic and Minimalist design (5)	Some steps are just time consuming for eg., body type, most exercises have no use of avatar. Would help to keep this setting when that particular game starts.	Himani	1	Adding this information when the particular game start would be good.	Onboarding
8. Aesthetic and Minimalist design (5)	The tutorial has a long text and is boring to follow	Pegah	2	Need to chunk the tutorial text and show it with more examples	Tutorial
9. Help Users Recognize, Diagnose, and Recover from Errors (3)	Losing point in “egg” by moving head to much by mistake is very easy	Merry	3	Showing the white/yellow circle at all times + adding a little leniency in making errors	Exercise
9. Help Users Recognize, Diagnose, and Recover from Errors (3)	No information provided on where the user is going wrong. I kept repeating the same mistake again and again.	Himani	3	Sound or use of visuals to make aware that something went wrong.	Exercise
9. Help Users Recognize, Diagnose, and Recover from Errors (3)	Home page and other pages or not identified/labeled on each page. When the user wants to press the B button, they are not sure which option led them to the desired page.	Pegah	1	Put a label with the name of the page for each page at the top or bottom of the page.	Onboarding
10. Help and Documentation (3)	No “?” or “Help” option for the personal setting page, users won’t know why they are setting for, what each column means, what they should enter.	Zhe	3	Add help explanation, or make the wording of each setting more understandable	Onboarding
10. Help and Documentation (3)	A lot of new information and interaction for a new user	Merry	1	A short doc/into can be very helpful. Maybe a video tutorial hosted outside of VR?	Onboarding
10. Help and Documentation (3)	The help option and FAQ option are not visible in the game.	Pegah	2	Need to add a help option visible on each page. Also, some options like eye level cm, need to have an information sign, which presents a description/ definition of it.	Onboarding

B.5 Heuristic Evaluation Summary





C USABILITY TESTING

C.1 Consent Form

THE UNIVERSITY OF BRITISH COLUMBIA

Department of Computer Science
2366 Main Mall
Vancouver, B.C., V6T 1Z4

Consent Form

Human-Computer Interaction Course Projects

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Introduction: Thank you for considering participating in this study. This work is affiliated with the UBC course "Topics in Human-Computer Interaction - DFP PROJECT" (CPSC 554K). Please note that we are seeking people who have fundamental knowledge about VR application and interaction.

Purpose: The overall purpose of this research is to evaluate the usability of a VR application on cognitive exercise and improve its long-term engagement through design.

What you will be asked to do: After you have read this document, I/we will respond to any questions or concerns that you may have. Once you have signed this consent form, you will be asked to:

- be observed while doing a series of required tasks (e.g., operating with VR headset)
- interact with digital systems (e.g., a VR headset)
- answer interview questions

No activities that involve in-person interaction will take place during the suspension of in-person activities due to COVID-19, with the exception of two cases: with the exception of three cases: (Case 1) naturalistic observation can take place with physical distancing, (Case 2) research done with people in the same household/bubble, e.g. family, so long as remains low-risk and non-coercive, and (Case 3) the research plan satisfies both Safe Research Guidelines and Safe Research Plan provided by UBC BREB.

This should take about 60 minutes and be completed in 1 session.

The sessions may also be video and/or audio recorded. You have the option not to be video/audio recorded.

How the data collected will be used: Data collected (including any audio/video recordings) will be used for analysis and may also be used for class project presentations and other research presentations. Although only a

course project in its current form, this project may, at a later date, be extended by one or more of the student investigators to be submitted as a research publication.

Compensation: There is no compensation for participating in this study.

Confidentiality: The results of your participation will be reported without any reference to you specifically. All information that you provide will be stored in Canada. It will be treated confidentially and your identity will not be revealed in reporting the study results. The two exceptions are: (1) excerpts from the video/audio recording in which a participant can be identified may be presented in a class project presentation (but any other presentation venue, such as a scholarly conference, will require that participants be non-identifiable in the video/images), and (2) we request but cannot enforce focus group members to keep discussions from any focus group confidential.

Data retention: Identifiable data and video/audio recordings will be stored securely in a locked metal cabinet or in a password protected computer account. All digital data will be encrypted. All data from individual participants will be coded so that their anonymity will be protected in any reports, research papers, and presentations that result from this work.

Protecting identities while using Zoom: If using Zoom, you can log in using only a nickname or a substitute name or research code given ahead of time by the researcher, you can turn off your camera, and you can mute your microphone (if it is not needed).

Contact for information about the rights of research subjects: If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Ethics at 604-822-8598 or if long distance e-mail RSIL@ors.ubc.ca or call toll free 1-877-822-8598.

Indicate your agreement to **one** of the following options by providing your **initials**:

- I consent to being video/audio recorded for this study. _____
- I consent to being audio recorded only (no video) for this study. _____
- I do NOT consent to being video/audio recorded for this study. _____

I, _____, have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in this study. However, I realize that my participation is voluntary and that I am free to withdraw at any time.

_____

Participant's Signature Date

C.2 Study Protocol & Interview Questions

Researchers' Starter Guide:

- Follow the instructions included in the protocol, which are as the following format: [instructions]
- Get the consent form signed when prompted and upload to the folder
- Make a copy of this doc in the same folder and use it to take notes during your study
- Change the name to P# where # is your participant's number
- Update the name and # in the master list kept on UBC drive and do not record personal identifier information in this doc

User Test Protocol

- Users' tests and interviews will be audio/video-recorded.
- The participants will be asked to conduct a think-aloud study as they use bWell to complete our 3 task examples. Participants are then asked to participate in a semi-structured interview.
- Session length: approximately 1 hour
- 2 researchers will be presented during each study session. One will take the lead, and the other will help lead in conducting the study.
- Both researchers will be taking separate notes and recording significant issues and feedback from the participant throughout the session. This is to ensure that nothing is missed due to the potential bias of each individual.
- During the interview, if necessary to expand on some frustrations, participants will be presented with sections of their recorded experience as a visual reminder.
- Purpose of the interview: We are conducting this user test to better understand how well the current UI of bWell works for users, what needs to be improved, and to gather some information on the potential user engagement and use habits. The collected information will be utilized to improve the current design so as to better serve our target users.

Introduction

Thank you for taking the time to participate in this study. We are a team working on improving the design for a self-guided immersive cognitive application named bWell. bWell is an application developed for providing individuals recovering from depression and aimed to improve cognitive capabilities through a set of exercises. It is a VR application that includes activities that are designed to challenge and stimulate the brain, with the goal of improving

cognitive abilities such as memory, attention, and problem-solving skills. **You will not be expected to comment on the effect of these exercises, as we are focused on the usability of this app.**

In this study, you will be asked to put on a VR headset and go through a set of pre-defined tasks to work with bWell. This will be a think-aloud study, so we encourage you to voice your thoughts during the experiment. Let us know what you are thinking about, whether it's something confusing or you're just deciding what to do next. We will not respond to you during the study, but we will take notes of your comments, and afterward, we'll have the chance to discuss them more. We will give you general instructions for the next steps, but we will not be able to give you exact steps since we are interested in how you perceive and interact with the app. Nonetheless, we are aware that there might be some confusing parts, and if you are stuck in a step, we will help you move forward. Before we move forward, please review the information in this consent form and let us know if you have any questions/concerns.

[Get the consent form signed]

Before we start, we kindly ask you to answer the following demographic and general questions. This session is audio and video recorded, and the data will be anonymized before further analysis. Your data will be anonymized for analysis, and **you can choose not to answer any questions that you don't feel comfortable answering.** Do you have any questions before we start? [The researcher will then answer any questions the participant might have]

PreTest Questions:

1. Age:
2. Gender :
3. Occupation (If student, Degree, University & Major)
4. On a scale of 1-5, how motivated are you to learn a new technology (Definitely won't learn - Will learn if I need to - Neutral/Depends - would be tempted to learn if need minimal effort - Would be willing to invest time to follow the trend actively)
5. On a scale of 1-5, how easy is it for you to learn a new technology (Quite difficult and frustrating - difficult - neutral - easy - quite easy and inspiring)
6. How familiar are you with VR on a scale of 1-5 (Never heard about it - Have heard about it - Have used it a number of times - Use(d) it frequently - Expert)

    a. Do you own one/In what context have you used it? How frequently do you use it?
7. Do you have a history of depression?
    a. If yes, have you been diagnosed clinically?
        i. What methods did/are you using to manage the symptoms? Which has been the most helpful?
8. Have you ever used any application/exercises for improving cognitive functioning, such as skills in multitasking, memory, or attention? Please expand.

Headset instructions.

[Start casting and recording:

- Open ocul.us/cast on your browser
- Make sure you are on the same WiFi
- Navigate to the casting code before handing the participant the headset (Unlock admin panel - sharin - cast - browser - next)
- Enter the code on browser
- Screen share and start recording on Zoom

]

[Get participant to put on headset. Wait for them to interact with it themselves, and only help if necessary - ask them to navigate to apps and choos WP one]

Do you have any questions before we start? [Answer]

Great! Let's get started.

Tasks Scenario and steps:

Imagine Peter is a graduate student that has currently recovered from a brief period of depression. He has been advised to use bWell for the next month, 3 times a week, to improve his cognitive performance and make sure he is at his peak mental capabilities. The exercises are short games that you can play through the app. To use the app, he as go through the onboarding process where he can sign up/in, and once he has finished the general tutorial, he can go through the exercises. We would like you to test this app, given the context of the target user.

[Gentaly remind the participant to think aloud if they forgot to do so during a task]

Tasks:

#	***General Instruction***	Notes
	Turn on the headset and put it on, and grab the controllers	
	Set your guardian as described before, and you will see the instruction in the headset	
	Now you are at the main menu, Point at the Apps button and select it.	
	Select the second option (the one on the left side)	
	Step 1 - Onboarding: *You are now in the bWell environment. Please go ahead and create an account. Read through the options in the setting and let me know what you think any one of them might represent.*	
1		
2	Choose to sign up	
3	You don't need to provide any information here, please select sign up	
4	The terms and condition is not provided yet, please confirm	
5	Choose your preferred avatar and user setting and then confirm	
	Step 2- Tutorial: *Now that you are in the main menu, the following tasks will ask you to find the theater exercise and launch the tutorial.*	
6	Select the tutorial option	
7	Select play to go through the tutorial	
8	Read and follow the instructions provided during the tutorial *The tutorial will give you information on the functions of the controller and headset. You will see different texts and examples which help you get a better understanding of the function of the device. The tutorial has **5 steps**. By finishing each of them, a message will appear to 'move on to the next step.' Please select moving on to the next step.*	

	Step 1: touch or gaze at the lock to open the lockbox	
	Step 2: grab the CD and put it in the disk player and water a plant	
	Step 3: change the CD and light up the candles; then move to the next step by gazing at the ok button	
	Step 4: change the CD and make fireworks; then move to the next step by gazing at the ok button	
	Step 5: Change the CD and teleport to 3 locations	
9	After finishing the 5th phase, you will end up in the onboarding steps. Please complete these steps again with the new knowledge of using the controller and headset.	
	Step 3a- Exercise 1: *Now that you have been through the tutorial once, please launch the Tent game without going into the tutorials.*	
10	Choose the Tent game	
11	Choose the number of the breath per minute	
12	Select to lunch the tutorial.	
13	Read the provided instructions. Make sure you understand them and then move on to the next instruction. This game has *2 steps* to introduce the game in the tutorial.	
14	Select Play to enter the tutorial and follow the instruction provided to you.	
15	Decrease the volume to 1 level, and then increase it to 2 levels. Make it mute, and then unmute.	
16	Play two different sound effects	
17	Choose to move to the different locations and after that change your environment.	
18	After experiencing 3 different environments, please go out of the game page to the main menu.	
	Step 3b- Exercise 2: *Now that you have been through the tutorial once, please launch the Tent game without going into the tutorials.*	
19	Choose the Egg game	

20	Select the tutorial phase.	
21	Lunch the tutorial and read the provided instructions. Make sure you understand them and then move on to the next instruction. This game has *2 steps* to introduce the game in the tutorial.	
22	Play the tutorial and follow the instruction provided to you.	
23	Make an egg disappear without hatching it.	
24	Hatch the 10 eggs while following your score and level.	
18	After 3 times of playing, please go out of the tutorial page to the main menu.	
19	Now choose the Egg game again and select play the game	
	Switch to the play mode and select play	
20	Play the game and hatch 5 eggs and mention the difference you notice with the tutorial	
21	Exist from the Egg game to the main menu	
	Step 3c- Exercise 3: *Now that you have been through the tutorial once, please launch the theater game without going into the tutorials.*	
22	Choose the Theater game	
23	Select the tutorial phase.	
24	Choose the number of the tabletop of the set	
25	Lunch the tutorial and read the provided instructions. Make sure you understand them and then move on to the next instruction. This game has *2 steps* to introduce the game in the tutorial.	
26	Play the tutorial and follow the instruction provided to you.	
27	After your first try, please get a hint.	
28	See and follow your score and level	
29	After 3 times of playing, please go out of the tutorial page to the main menu.	
30	Now choose the theater again and select to play the game	
31	Play the game 2 times and mention the difference you notice with the tutorial	

32	Exist from the first game to the main menu	

Interview Questions:

a. General Hardware-Related Feedback:

1. How was your experience using a VR headset and controllers in general (without considering the software experience)?

2. What did you find to be most confusing about the use of the headset and controllers, if any?

3. On a scale of 1-strongly unconfident to 5-strongly confident, how confident did you feel using a VR headset?
    a. [If rated 3 or under] Do you think you could have used one without any help at home?
    b. (i) If people have used VR before: What could be some barriers that you may face when using VR at home?
    (ii) If people have never used VR before: What could be some barriers that you may expect when using VR at home?

4. Do you think having a document on how to use the headset itself would be helpful for you? What about an introductory video?

b. General Software-Related Feedback

5. Please answer the following questions on a scale of 1-strongly disagree to 5-strongly agree: [Show respective interfaces]
    a. I felt very confident using the interface
    b. I found the system enjoyable to use
    c. I found the interfaces unnecessarily complex
    d. I found various functions in the interfaces well-integrated
    e. I imagine that most people would learn to use this system very quickly
    f. I think I would like to use this system frequently
    g. I think the necessary information and possible actions were well-placed in Interface

6. [Follow-up on the questions above if needed]
    a. Can you explain why you felt confident/unconfident…
    b. Can you explain why you feel it is (not) enjoyable …
    c. Can you explain why you feel the interface is complicated …
    d. Can you explain why you find the functions (not) integrated…

e. Can you explain why you believe people will (not) learn to use it quickly…
f. Can you explain why you would like (not) to use the function…
g. Can you explain why you find the information intuitive or not…

7. Which part of the interface did you find enjoyable while completing the interaction?
    a. In the onboarding steps? [Show interface]
    b. In the tutorial steps? [Show interface]
    c. In the exercise? [Show interface]

8. What did you find confusing in particular …
    a. In the onboarding steps? [Show interface]
    b. In the tutorial steps? [Show interface]
    c. In the exercise? [Show interface]

9. Anything else about the system that you think can be improved?

10. [Any follow-up question based on the observation]

11. Are there any points that I did not cover but that you would like to share?

c. Long-Term Engagement Feedback

For the following questions, you can also think back to the apps you use regularly.

12. If you were to use this app to improve your cognitive functions, what do you think would keep you motivated to use this application throughout a week and for a month of use?
    a. [Follow-up on internal and external triggers, and ask if the participant didn't mention one - can also give examples for triggers: personal motivations - calendar reminders - etc]
13. Considering the application is supposed to be used a couple of times a week, would you like to receive notifications to remind you when your next session is?
    a. How often would you like to receive a reminder for a session? Just once or more?
    b. When would be the best time to receive a reminder for a session- a couple of hours before the session or 1/2/3 days in advance? Or maybe an overview at the start of the week?
14. What would be your preferred way of receiving reminder notifications for your session? [Receiving scheduled emails, texts, etc, or keeping track of it on your own through the personal calendar, etc?]

C.3 Coding Sheet

Task & Stage	Observation	Quotes
Onboarding - Sign Up		
Onboarding - Personal Setting		

Tutorial - Robot and Guidance		
Tutorial - CD related operation		
Tutorial - Tasks (Watering Plants / Lighting Candles / Fireworks / Teleport)		

Tutorial - Transferring between tasks		
Exercise - Tutorial Mode (Instruction / Setting)		
Exercise - Tutorial Mode (Exercise)		

Exercise - Exercise Mode (Instruction / Setting)		
Exercise - Exercise Mode (Exercise)		

C.4 Merged Participant Feedback