Exploring the Usability of Nesplora Aquarium, a Virtual Reality System for Neuropsychological Assessment of Attention and Executive Functioning

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ABSTRACT

Virtual reality (VR) has proved to be an efficient alternative to traditional neuropsychological assessment. As VR has become more affordable, it is ready to break out of the laboratory and enter homes and clinical practices. We present preliminary findings from a study designed to evaluate self-reported usability of a VR test for neuropsychological assessment of attention and executive function.

Keywords: Virtual reality, neuropsychological assessment, usability.

Index Terms: Human-centered computing - Human computer interaction (HCI) - Interaction paradigms - Virtual reality; Human-centered computing - Human computer interaction (HCI) – HCI design and evaluation methods - Usability testing.

1 INTRODUCTION

Because VR has become more affordable and more companies have been working to create high quality VR devices and environments, a revolution in psychometrics and mental health care seems imminent. One area in which the use of VR in mental health care appears to very productive is neuropsychological assessment. The main benefit of using VR in the assessment of cognitive processes (e.g. attention, memory, executive functioning) is the increase of ecological validity of the assessment scores and test results which means that the results from a neuropsychological assessment in VR may predict real-world performance better than traditional cognitive tests. We are aware that VR has made important steps to break out of laboratory and enter clinical practices. To date, research supports the validity of VR-based neuropsychological tests. As an example, VR tests show similar sensitivity to traditional computerized or classical paper-and-pencil tests, as well as convergent validity [1]. However, in order to use VR as a clinical assessment tool, VR tests should undergo standardization procedures to obtain normative data. To our knowledge, only one VR test designed to assess attention among children developed by Iriarte et al. [2] is available on the market and has normative data, while for adult population no VR neuropsychological tests are standardized and have normative data.

By recognizing the need for further validation and standardization of VR tests for neuropsychological assessment of adult populations, we developed a VR system- Nesplora Aquarium- for the assessment of attention and executive functions and aimed to conduct normative and clinical studies. We acknowledge that beside the validity and reliability issues, VR tests should also meet high requirements concerning their usability which might impact the readiness of VR acceptance and use [3].

2 PROPOSED SYSTEM

2.1 Nesplora Aquarium

The VE used is Nesplora Aquarium. Nesplora Aquarium is a VR-based test aimed to assess attention and executive functions in adults over 18 years. To achieve this goal Nesplora Aquarium uses the continuous performance test paradigm (CPT) embedded in the VE. CPTs are known as one of the most widely used and reliable measures of sustained vigilance, attention and impulsivity. The original CPT paradigm was developed by Rosvold et al. [4] and today two types of CPT tasks are used: vigilance tasks (activation mechanism) and arousal tasks (arousal mechanism). Vigilance CPTs (known as X- or AX-types), require the participant to answer to target stimuli and to ignore non-target stimuli. Inhibition CPTs (non-X tasks) ask the participant to respond to the non-target stimuli and to ignore target stimuli. To date, CPTs in VR were embedded in a VR classroom designed to measure attention in children and research showed its validity. Nesplora Aquarium continues this direction of including CPTs in VEs to test cognitive functions. To our knowledge, it is the first VR-based test to measure attention and executive functions of adults and consists of vigilance CPTs (AXtypes) that are administered in a virtual aquarium (see Figure 1). Different distractors (auditory and visual) are delivered either separately or at the same time, which allows for more complex results (superiority of results in one modality, or interference in case of both modalities). To achieve acceptable difficulty and reliability rates, 4 different versions of the task were developed during the field trials. For the final version, the stimulus

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interval is 500ms for the visual stimuli, and 770ms for auditory stimuli. Inter-stimuli interval is pseudo-randomized between 1500 and 2000ms.

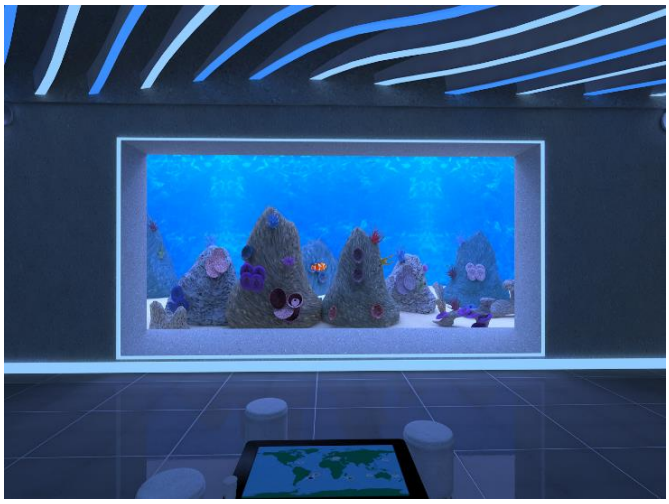

Figure 1: Screenshot of the Nesplora Aquarium VE.

The VR headset uses a Samsung Galaxy S7 smartphone, paired with Samsung Gear VR goggles and headphones. The test is monitored by the experimenter, using a laptop computer (ASUS ROG, Intel i7 processor, 8 Gb RAM, GeForce GTX 960M videocard). Both the laptop computer and the VR headset are connected using a local wireless connection.

During the test phase, the participant is placed in the main room of a VR and has to perform different CPTs composed by visual stimuli (e.g., different species of fish that are passing through two rocks that are placed in the main fish tank) and auditory stimuli (e.g., the names of the different species of fish). The participant has to follow a rule in responding to stimuli, a rule that changes between the different tasks. For example, in the first task, the user has to press a bluetooth-paired button, every time he/she sees or hears a certain fish name (e.g., the clown fish), but only if another type of fish was seen or its name was heard before (e.g., the surgeon fish). For the other two tasks, Baddeley's dual-task paradigm (x) was adapted to the CPT framework, asking the participant to respond differently to targets based on visual and auditory stimuli. Different contextual distractors are delivered during the task, either visually (e.g., people walking in front of the aquarium, other animals present in the aquarium such as turtles, lights flickering) or audibly (e.g., an invitation to coffee delivered over the PA system, a baby crying, a warning to not use the flash when taking photos). The system collects information about omission and commission errors, reaction time, variability of the reaction time and motor activity. The total time spent in the VR aquarium is approximately 20 to 25 minutes.

3 Nesplora Aquarium Usability Study

The main objective of the current study was to conduct an initial self-reported usability evaluation of our VR system, Nesplora Aquarium. Eighteen healthy participants aged between 23 and 51 years (M = 29.55, SD = 7.12), took part in the study. They were recruited via department mailing lists and word-of-mouth. The majority were females (N = 10, 55.6%) with a mean of education years of 18 (SD = 3.55). Twelve participants (66.7%) reported previous VR experience. Exclusion criteria included (a) a clinical diagnostic of neurological and psychiatric conditions, (b) a moderate to major visual and hearing impairment, and (c) age under 18 years old. The participants experienced the VR aquarium for approximately 25 minutes and completed some cognitive tasks (e.g., continuous performance tasks) during the VR exposure. After the VR exposure the participants completed the System Usability Scale [5] as a measure of self-reported system usability and learnability. The study was approved by the University Research Ethics committee (REF 6667/25.04.2018) where the data was collected and where the data was analyzed (PREC 18-305).

Our sample of healthy participants rated Nesplora Aquarium as good to excellent (M = 84.16, SD = 12.63), which in terms of percentiles indicates that a score of 85 corresponds to an A grade and a percentile rank of 90-95. Our VR system is considered more usable then 90-95% of products and less usable then 5-10%% [6]. This positive result makes us confident in the potential of the VR system to be used in the future for neuropsychological assessment by clinical practitioners. Of course, these findings are based on an initial evaluation of a sample comprising of 18 healthy potential users which limits the generalizability of the results. We have planned future studies to assess its usability among a sample of participants with a clinical diagnosis of depression and anxiety, as these psychiatric conditions are negatively associated with cognitive impairment (e.g., on cognitive functions such as attention, memory, executive functioning).

Additional analysis revealed that increased presence (r = .41, p < .05) and system situation awareness in VR (r = .52, p < .05), and reduced simulator sickness (r = -.51, p < .05) are associated with high usability ratings, while mental workload is not. Reduced levels of depression and anxiety symptoms correlate with increased system usability (r = -.54, p < .01, respectively r = -.56, p < .01).

4 Future Work

Part of the VR MIND project we will also conduct normative and clinical studies (1) to establish the validity of Nesplora Aquarium in discriminating on attention and executive functions measures between healthy controls and patients with cognitive impairment caused by depression and anxiety disorders. Depression and anxiety disorders are negatively associated with cognitive impairment (e.g., on cognitive functions such as: attention, executive functioning); (2) to assess the convergent and discriminant validity of Nesplora Aquarium by computing correlational coefficients between its outcomes and outcomes of traditional measures of attention and executive functions.

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