Neurocognitive Workload Assessment Using the Virtual Reality Cognitive Performance Assessment Test

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Abstract. The traditional approach to assessing neurocognitive performance makes use of paper and pencil neuropsychological assessments. This received approach has been criticized as limited in the area of ecological validity. While virtual reality environments provide increased ecological validity, they are often done without taking seriously the demands of rigorous research design and control for potentially confounding variables. The newly developed Virtual Reality Cognitive Performance Assessment Test (VRCPAT) focuses upon enhanced ecological validity using virtual environment scenarios to assess neurocognitive processing. After an assessment for potential confounds (i.e. appropriate level of immersion and performance on neuropsychological measures), the VRCPAT battery’s Attention Module (i.e. Humvee scenario) was administered to a sample of healthy adults. Findings suggest that increase in stimulus complexity and stimulus intensity can manipulate attention performance within the Attention Module.

Keywords: Neuropsychological assessment, neurocognitive, ecological validity, virtual environment.

1 Introduction

Attentional processing is an area of particular significance for neuropsychological research into the pattern of neurocognitive strengths and weaknesses in both normal and clinical populations. Two predominant attentional networks have emerged from studies using techniques drawn from clinical [1] and experimental neuropsychology [2], [3]. First, there is the “posterior” system which is believed to include midbrain structures and posterior parietal areas. This “posterior” system is conceptualized as being a largely bottom-up network driven by environmental salience. A second system is known as the “anterior” system which is believed to include frontal and parietal regions as well as the reticular nucleus of the brainstem. This “anterior” system is conceptualized as being a top-down regulatory network involving neurocognitively driven response control. From an applied neuropsychological perspective, this means that the “anterior” system focuses upon the voluntary maintenance of vigilance and sustained attention [4].

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In general, findings from research related to attention may be understood in terms of automatic and controlled processing [5]. Whilst automatic processing is considered as parallel, requiring little effort, and not under the participant's direct control, controlled processing is understood as serial, effortful, and under a participant's direct control [6]. Given the effortful nature of controlled processing, it has been found to have an attentional decrement, in which reaction times slow and error rates increase as an effect of time-on-task. The distinction between automatic and controlled processing can be further defined as exogenous and endogenous attention. While exogenous attention refers to the impact of external physical events upon automatic attention, endogenous attention refers to one's active direction of attention to something deemed important by the participant [7]. Adjustments to stimulus complexity are used to assess these differing aspects of attentional processing. For example, automatic processing and endogenous attention may be assessed by having a subject stare at a computer screen that has four-digit numbers consistently presented in a fixed central location on a computer screen. Contrariwise, an example of controlled processing and exogenous attention is reflected in a scenario in which the four-digit numbers appear randomly throughout the computer screen.

Neuropsychological studies of attention tend to assess neurocognitive (e.g. neuropsychological assessment in a controlled setting) and behavioral (e.g. self and other behavioral rating scales of the subject’s activities in a real-world setting) aspects of attention. It is important to note that neurocognitive measures in controlled settings and behavioral ratings based upon naturalistic observations do not consistently proffer parallel findings [8]. Further, dissimilar attentional components may be dissociated both by neurocognitive measures in controlled settings and behavioral ratings based upon naturalistic observations [3]. A related issue is that while traditional neuropsychological assessments manipulate the complexity of the stimulation, they do little to assess the impact of the intensity of the situation. The assessment of attention should reflect the varying levels of intensity found in real world situations. A more intense setting may elicit emotional responses. Findings from attentional assessments must be generalizable to real-world situations [9]. While controlled settings offer increased psychometric rigor, naturalistic observation-based behavioral ratings may better capture the subject’s performance in a real world setting.

1.1 Virtual Environments for Neuropsychological Assessment

Virtual Reality offers the capacity for merging the benefits of controlled settings (e.g. increased psychometric rigor) within environments that simulate the environment in which naturalistic observation-based behaviors occur. Recent advances in simulation technology have produced new methods for the creation of virtual environments. With these systems, users can proffer ecological verisimilude reflective of “real world” environments. When delivered via an immersive head-mounted display (HMD), an experience of presence within these captured scenarios can be supported in human users. As such, the VR assets that allow for precise stimulus delivery within ecologically enhanced scenarios appears well matched for research into attentional processing.

The value in using virtual reality technology to produce simulations targeting neurocognitive and behavioral applications has been acknowledged by an