Investigating Mental Load and Distractibility with fNIRS

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Attentional control is essential to focus on relevant information and attenuate distracting events. The consequences of poor attentional control range from reducing the enjoyment and quality of life; for example, not being able to focus while reading, to affecting one's ability to concentrate at work or school, or even causing accidents - such as those that result from becoming distracted while driving. Previous research has suggested that the extent to which irrelevant or distracting events are perceived depends on the perceptual load of a given task (Rees et al, 1997; Forster, Lavie, 2007). If attentional resources are exhausted, then there is little capacity left to process irrelevant information, such as distractors. However, if perceptual load is low, attentional resources can easily spill over to distracting events which interfere with task-relevant information.

In '*High Perceptual Load Makes Everybody Equal'* (Forster, Lavie, 2007) it was observed that high perceptual-load eliminated individual differences in distractibility, that were otherwise present in the cognitive failures questionnaire (Broadbent et al, 1982) used as a preliminary assessment, and in low-workload conditions. In this study, participants were assessed using a perceptual load plus distractor task. Perceptual workload level was established through the use of non-target letters: in the high workload task, angular letters were used, while in the low workload task these were replaced with small circles.

The purpose of this abstract is to outline a study design for the replication and extension of '*High Perceptual Load Makes Everybody Equal'*. This extension and replication study is intended to begin addressing the main research questions posed as part of the primary author's PhD project: RQ1, which seeks to explore whether the nature of a distractor will increase or reduce it's impact on a participant, RQ2, which further develops upon this by incorporating the nature of the task being performed and how this correlates with the distractor, when measuring the effect of distractibility, and RQ3, which supplements both the above questions by also investigating the impact of workload on participants, across all conditions.

In terms of data collection, it is the intention of the authors to employ fNIRS (Functional near-infrared spectroscopy) for the quantitative measure of perceptual load, which will be analyzed alongside the performance data for each participant – correct and incorrect responses and response time - and their self-reported mental workload. This is expected to provide a more objective and unique assessment of the perceptual load experienced by each participant, when compared to the more generalized 'high' and 'low' load measures used in the previous study.

The fNIRS BCI (Brain-Computer Interface) used for this study will be the Octamon headband provided by Artinis, and the data collected will be analyzed using the Homer3 plugin for MatLab. Consideration has been given to the possibility of using a filtering function to filter out motion artifacts (Zhang et al, 2005; Molavi, Dumont, 2012).

A NASA TLX questionnaire (Hart, Staveland, 1988) will also be completed by participants at the end of each condition; this will be used for the recording of the participants own perception of their mental workload. The use of both measures is in keeping with the objectives outlined in RQ3.

In addition to this, rather than presenting the task on a monitor in front of the participant, the task will be presented in Virtual Reality, using an Oculus Quest Headset. This allows for the opportunity to present a variation of the original task that takes advantage of the additional 3D capacity of the platform.

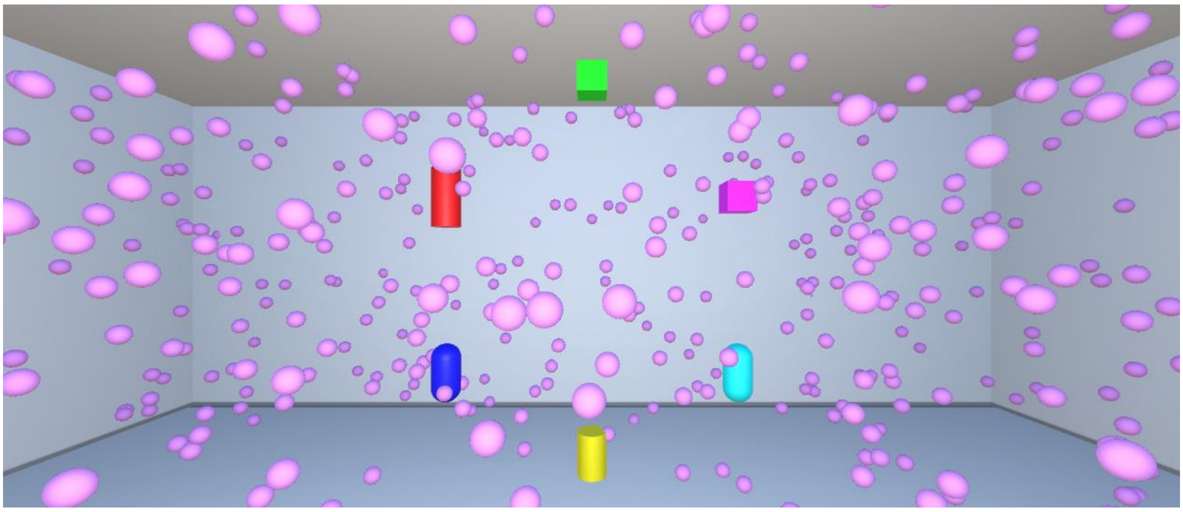

Figure 1: The task (High Workload Condition) running in Unity 3D

In terms of the structure of the study itself, we would look to begin by replicating the two original verbal study tasks in VR – with the 2D letters replaced with 3D equivalents. We then intend to first extend the study by removing the visual distractor and replacing it with an auditory distractor – playing a small audio clip of a person reading aloud the non-target letter.

We would then extend the study further with the introduction of two additional spatial tasks, in which the target letters are replaced by shapes. In the low-workload condition, participants would be tasked with finding which one of the two target shapes had appeared on screen, with both the target and non-target shapes being a uniform colour, whilst in high workload conditions they would be required to identify the target based on both its shape and colour; for example, they would be looking for either a green square or a pink cylinder – a magenta square or yellow cylinder would not be the target. Under high-workload conditions, they could also be presented with more distractors, or with distractors that move faster or more erratically (see Figure 1).

These tasks would then be followed by two in which the distractor shape is replaced by an audio clip of a person reading the name – and in the case of the high workload condition, the color – of the target shape aloud.

This extension is to allow for the exploration of the impact of distractors that employ heterogenous and homogenous mental resources, in both high and low workload conditions, and intends to address RQ2 and RQ3. This theory is based on Wickens' Multiple Resource Model (Wickens, 2008), which suggests that the brain dedicates different mental resources for processing auditory and visual information. In this context, the original tasks would use homogenous mental resources - entirely visual - while the extension would include heterogenous pairings; visual for the task, auditory for the distractor.

Investigating the various factors that lead to an increase in distractibility can have a wealth of benefits in a variety of sectors; for example, in education, when developing content that is more engaging for learners, or in high-intensity environments where focus is critical for safety, such as dangerous workplaces. Future work will focus on translating the impact and findings of this study in increasingly naturalistic applications within the field of education; specifically, investigating means by which distractibility can be reduced in those playing VR eLearning games, allowing for a great focus on content without detracting from the gamification experience.

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