Describe the nature of the changes and the reason/s they are being made \*

We aim to continue our exploration of the attentional tunneling effect on augmented reality (AR) environments by conducting a study using a head-mounted display. Our previous study considered only handheld AR devices. In this study, we plan to implement an artificial intelligent agent that aims to reduce attentional tunneling in an AR application on the Microsoft HoloLens. Participants will be asked to complete a sensemaking task for which they need to find the answer to a set of questions. Textual clues for the task will be presented on virtual post it notes scattered around the AR environment. The artificial intelligent agent will minimize or highlight clues that it deems relevant to the user’s current interests thus reducing attentional tunneling according to Perceptual Load Theory (PLT). Participants will either perform the task without assistance from the AI agent (Control) or with assistance from the agent (Experiment). We will measure participant completion times for the tasks. We will also conduct a semi-structure interview at the end of the experiment to understand users experience with the system.

**Summarise your research project in plain language \***

Previously, we reported how task presented in augmented reality (AR) applications causes the “attentional tunneling effect” leading users to neglect their physical surroundings and reducing their reaction times to events. Attentional tunneling can potentially disrupt user experience, reduce task performance and place users in hazardous situations. In this study, we aim to develop and evaluate an artificial intelligent (AI) agent that reduces attentional tunneling in AR applications. The AI agent will consider current user intention (based on user eye tracking data) and the current task state to assist users in finding relevant virtual content and thus reducing the “attentional sink” into irrelevant content. We will evaluate the performance (completion time) of participants on a sense-making task with (Experiment) and without (Control) assistance from the AI agent.

**Background**

Attentional Tunnelling is a phenomenon where users allocate most of their attention to a specific channel of information at the expense of neglecting information on other channels. The term was formally defined by Wickens et al. as

“the allocation of attention to a particular channel of information, diagnostic hypothesis, or task goal, for a duration that is longer than optimal, given the expected cost of neglecting events on other channels, failing to consider other hypotheses, or failing to perform other tasks.”

The phenomenon was first explored in the context of simulated pilot training using HUD, where the researchers concluded that pilots would fail to notice unexpected events in the real-world scene when using a HUD versus a traditional head-down-display (HDD) (Fischer et al., 1980). This effect was mitigated or completely removed when the HUD digital components were “symbolically scene linked” to the real-world scene i.e., digital components in the HUD were not stationary but changed relative to changes in the real world (Levy et al., 1998). The researchers explained the mitigation of the phenomenon to the perceptual grouping of the HUD and the real-world. When there is no symbolic linking, users categorize the HUD elements and real-world as separate groups thus reducing efficient division of attention. Symbolically linking the HUD elements to the real-world scene enabled users to perceptually group the two together, resulting in a more efficient division of attention.

Later studies, in similar aviation contexts, have also compared 3D displays with an ego-centric view of the flight path to a 2D view of the flight path, both of which were presented in a Head-Down-Display (HDD). The studies reported significant delay in pilot response time when using immersive 3D displays (Fadden et al. 2001, Wickens et al. 2004) suggesting that HUDs were not the sole cause of the attentional tunnelling effect.

In the context of immersive displays, a number of studies related to AR applications have also reported a similar phenomenon, where users direct most of their attention on the AR device while neglecting the real world (Billinghurst et al. 2003, Wang et al. 2009, Chang et al. 2014). These studies, however, did not investigate the phenomenon further.

Dixon et al., explored how AR displays could affect surgeons or trainee attention when performing an endoscopic navigation exercise. They tested two different groups; one group used a standard endoscopic view – 2D display (control group) while the other group used an endoscopic video augmented with anatomic contours (AR group). They found that users using the AR display were less likely to detect a complication during the navigation than the control group. However, the AR display that they used, overlayed the information onto the real-world scene without registering the objects to the scene.

Another aspect of previous studies related to the attentional tunnelling effect is that the study designs were all task-based which may have given rise to a similar phenomenon called “Inattentional blindness” (Simons et al., 1999). Inattentional blindness is the phenomenon where users fail to detect objects within their foveal vision when they are engaged in a continuous task. Our previous work reports how task presented within AR applications cause the attentional tunneling effect rather than the AR content itself.

In this study, we aim to develop and evaluate an artificial intelligent (AI) agent that reduces attentional tunneling in AR applications. This agent considers current user intention (based on user eye tracking data) and the current task state to assist users in finding needed content by minimizing irrelevant virtual content and highlighting relevant virtual content. Reducing the number of task relevant elements (Minimizing) and making it easier to discern relevant elements (highlighting) has been known to reduce attentional tunneling based on Perceptual Load Theory (Cartwright-Finch and Lavie. 2007, Lavie. 2005). We will evaluate the systems by measuring participant completion times of a sensemaking task with (Experiment) and without (Control) assistance from the AI agent.

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**Significance of this Research**

While there are a number of studies that have been dedicated to the phenomenon of “attentional tunnelling” and “Inattentional blindness”, there has yet to be a study that attempts to understand what factors could decrease the effect in AR applications. This study aims to develop and evaluate a system that reduces attentional tunneling in AR applications based on Perceptual Load Theory. This study will contribute towards our understanding of methods used to mitigate attentional tunneling in AR applications. This will in turn contribute towards the development of future AR applications especially where the effective allocation of user attention is critical (For example: Navigation with AR).

**Key Question**

How can we create an AR applications with adaptive virtual content to mitigate attentional tunneling?

Describe the method(s) that you plan to use in the research project.

The study will take place in a workspace such as a meeting room. Participants will be handed a Plain Language Statement and Consent form when they first arrive. After they have completed the forms, we will verbally introduce the sensemaking task to participants and explain that they must find the answer to a set of questions based on textual clues. We will then introduce the AR headset (HoloLens) and explain to them the textual clues will be presented on virtual post it notes. Participants will then be able to try on the headset (after it has been sanitized) and interact with virtual clues in a tutorial. After participants are familiar with the interactions in our system, we will ask them to complete a sensemaking task using our system. Participants will either be assisted by the AI agent (Experiment Group) or participants will receive no assistance from our agent (Control Group). We will measure completion times of the tasks for each participant.

For either condition, participants are given a set of questions that they need to answer and the clues for these questions are presented on virtual post it notes in the AR applications. Participants are required to organize relevant notes on virtual whiteboards.

For the experimental group, the AI agent will either minimize, maximize or highlight virtual post it notes that it thinks is relevant to the participant. The control group will not have adaptive virtual content and participants are required to complete the task without any assistance from the AI agent.

The tasks are completed when the participant answers all the questions given to them before the start of the experience. Their completion time will be recorded for analysis.

After completing both tasks, we will conduct a short semi-structured interview centred around their experience using the system.