The Effect of the Modality of Pre- and Retro- Cues in a Virtual Visual Working Memory Task

Margeaux Manshel, John Solorzano-Restrepo, & Kenneth J. Leising
Department of Psychology, Texas Christian University

Introduction

Working memory (WM) is a neural system that is active when thinking about stimuli currently in the environment or previously encountered. Working memory is critical for the completion of complex tasks, such as learning and reasoning.

Humans need to attend selectively to items currently in the environment that are most relevant for survival, and in many cases, continue to think about those items when they move out of view (Griffin and Nobre, 2003). These processes benefit from cues that reliably signal the identity or location of important objects, either before (pre cue) or after (retro cue) they appear (e.g., a noise that predicts where a predator is likely to appear).

Pre-cueing enhances recognition and accuracy of objects in the environment by directing attention to the upcoming location or features of an object. Retro cues are presented after a set of stimuli, which requires a different explanation. It is hypothesized that the maintenance and storage of WM for the location or identity of the object is enhanced, rather than attention and encoding. For example, if a teacher were to give a vital piece of information (target) that was going to be given on a test, she could do one of the following. She could say, "This will be on the test" followed by the target (pre). Secondly, she could deliver the target, then say "This will be on the test" (retro). Lastly, she could deliver the target and not say whether it will be on the test (control).

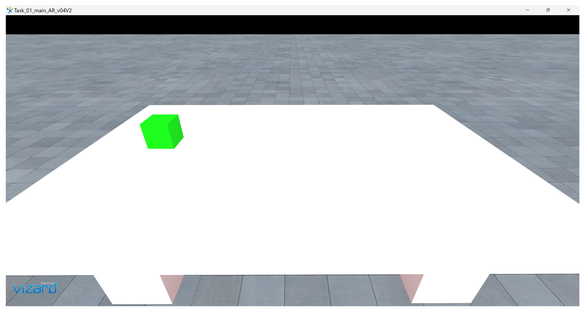
Hypothesis: The use of auditory pre and retro cues in virtual reality will improve WM performance.

Method

Table 1: *Trial distribution by property and cueing type*

Property	Cueing	Training	Test
Identity	Pre	8	16
	Retro	8	16
	Control	8	16
Spatial	Pre	8	16
	Retro	8	16
	Control	8	16

Figure 1: *VR environment developed for the task using WorldViz Vizard 7*



The study will use a MetaQuest Pro VR headset with integrated speakers. Participants will navigate a VR environment using VR controllers (Figure 2). #-d isometric cubes will be used as target and probe stimuli. The shade and spatial location of the cubes will vary to facilitate identity and spatial memory tasks within the virtual environment (Figure 1).

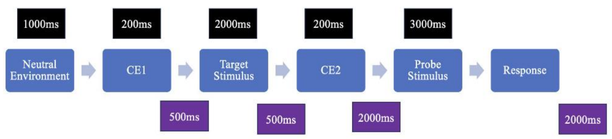
Participants will be instructed to attend to the frequency of a tone Cued Environment 1 (CE1) or Cued Environment 2 (CE2) to respond to either the identity (Id = Tone A) or spatial location (Sp = Tone B) property of the probe stimulus related to the target stimulus. For "pre" trials, the CE1 will include the relevant cue (Tone A / Tone B) while the CE2 will include the neutral one (Tone C). For "retro", CE1 will include the neutral tone (Tone C); meanwhile, the CE2 will include the relevant cue (Tone A/Tone B).

The control trials consisted of a novel tone (Tone D) displayed in both CE1 and CE2. The response must be emitted during the comparison stimulus presentation. After responding, participants will receive a visual message as feedback (correct or incorrect), and the background will turn grey for 2000 ms signaling the inter-trial interval (ITI; Figure 3).

Table 1 depicts the properties that will be studied (identity or spatial) and the cueing types within trials. The sessions will include 192 trials split into 3 blocks of 64 trials each. During training, participants will be exposed to trials in the order presented in Table 1. During test, all the trials will be presented intermixed.

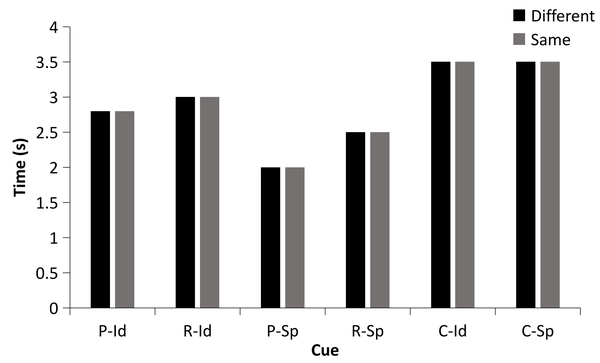
Figure 2: *Meta Quest Pro VR Headset*

Figure 3: *Trial schematics*



Predicted Results

Figure 4: *Predicted RTs in experimental task*



Based on previous research and results collected in the TCU Comparative Cognition Lab, it is expected that participants will perform better on cued trials compared to control trials (Figure 4). It is also expected that participants perform better (faster) on spatial trials compared to identity, given that retrieving spatial information from the working memory has been associated with less cognitive load than retrieving identity information.

Discussion

In future results, I hope to see that the auditory cues have a higher accuracy and faster reaction time than those using visual cues while in virtual reality. Although the stimuli are relatively simple, presenting them in a 3-D task is more likely to engage visual WM resources, which may create interference when the cues presented to benefit WM are also visual. However, interference may be reduced when a pre-cue is present, because it will direct attention toward the relevant dimension at a time when visual WM is less engaged by the task.

Despite not yet obtaining results, I am so grateful to have been given the opportunity to be a part of this experience. Through this opportunity, I was able to learn a great deal about conducting research. There are a lot of problems to be solved and hurdles to jump over, but with the right people, research can be done efficiently, ethically, and correctly.

Challenges Faced:
1. Understanding the software and technology.
2. How virtual reality can improve a study.
3. Timeline and getting organized

The hurdles listed above were difficult to solve; however, I was able to overcome them by listening, problem solving on my own, and getting help from those more experienced than myself.

References

Arnott, S. R., Grady, C. L., Hevenor, S. J., Graham, S., & Alain, C. (2005). The functional organization of auditory working memory as revealed by fMRI. Journal of cognitive neuroscience, 17(5), 819–831. ttps://doi.org/10.1162/0898929053747612

Griffin, I. C., & Nobre, A. C. (2003). Orienting Attention to Locations in Internal Representations. Journal of Cognitive Neuroscience, 15(8), 1176–1194. https://doi.org/10.1162/089892903322598139

Funding

TCU College of Science & Engineering
reSEaRCh
Science and Engineering Research Center