Study of Visual Guidance Cues in VR Field Trips at High Schools

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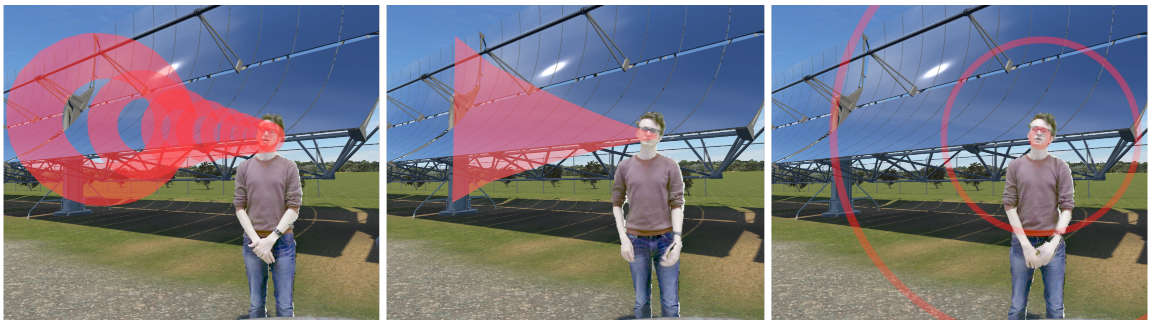

Figure 1: The three cues studied in our experiment. From left to right: Attention Funnel, Line Strip, and DynSWave. In each image, the viewer is looking to the left of the target, which is a prerecorded tour guide providing information verbally.

ABSTRACT

We assess the effectiveness of attention guidance cues in an educational platform in local high schools with real students. Three eye-tracked visual cues, previously assessed for their ability to guide and restore attention, are compared against a baseline absence of cue in a VR field trip of a virtual solar energy field. Students experienced four presentations on solar energy production including in-world animations and teacher imagery, in three of which the visual cues guided attention to the relevant object or teacher in the scene. Attention guidance using visual cues is commonly studied using "search and selection" style tasks, but has not been studied in the context of maintaining attention in real-world environments.

CCS CONCEPTS

• **Human-centered computing → Visualization techniques**.

KEYWORDS

Attention Guidance, Educational VR, Visual Attention

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1 INTRODUCTION

Virtual reality immersion can create experiences that are vividly recalled and may enhance learning. However, VR-based education/training has some challenges. In a physical classroom setting, teachers can gauge student engagement and work to maintain student attention through physical cues that are lost in the virtual setting. Moreover, students may face distractions in VR that have a detrimental effect on learning. A user, for example, may miss important details if not looking at a target object while it is being explained. Thus, for effective VR-based learning, an automated system directing and maintaining student attention towards objects of interest is necessary.

Visual cues are often used to direct a user's attention to relevant objects [3, 4]. Most research has focused on directing attention towards an object and is done in a controlled lab setting. However, there is a limited body of work on maintaining attention on targets, especially in the context of educational-VR. We attempt to bridge this gap by studying the effects of promising visual cues in a VR-based solar energy field trip performed in a real high school setting.

We tested the system with three visual cues using 126 high-school students as participants to see the real-world performance of these cues in comparison to the baseline scenario with no cue. Students visited four stations in the field trip, three of which rendered Attention Funnel, Line Strip, or DynSWave (Figure 1) in a randomized manner. We collected subjective opinions on each cue and recorded attention metrics through eye-tracking to determine which cue is most effective for this educational scenario.

2 CUE DESCRIPTIONS

Figure 1 shows the three visual cues used in our experiment. Cues were chosen based on performance in a prior validation study [6] and tuned to appropriate parameters for this environment. We wanted to test if the success of well-performing cues in a lab translated to performance in a real-world environment. Cue visuals were colored red to draw attention and contrast against other scene visuals. Eye-tracked gaze direction was used determine cue rendering positions and drove a fade parameter that rendered the cue transparent when looking at the target. Cues are described below:

DynSWave (SW): Based on the cue of the same name from Renner and Pfeiffer [5]. Concentric circles are drawn on a head-centered sphere with radius set to the distance between the user's head and the target. Circles are animated to move towards the target such that it looks like the circles are closing in on the target. Animation speed increases as the user looks farther from the target.

Attention Funnel (AF): Based on the cue from Biocca et al. [1] which placed multiple goal posts along a 3D cubic curve starting from a point on the gaze vector (.4 meters from the head) and ending at the target showing the full path. The visuals were changed from goal posts to simple red rings based on a pilot study.

Line Strip (LS): A simple cue sharing features with Wedge [3] and 3DPath [4]. A thick line strip is rendered along the same 3D cubic curve as Attention Funnel. It represents a similar style of cue but with simpler visuals that directly connect the cue to the target.

3 USER STUDY

We visited three high schools for our studies from which 126 students participated. Our experiment sent students through an approximately 10-minute virtual field trip of a solar energy production field, previously validated for its educational efficacy [2]. The field trip featured five "stations" that students traveled to, each featuring a set of 3D "videos" (RGBD teacher mesh) and animations explaining processes. Students viewed the environment through a Vive Pro Eye and used a single tracked controller to interact with content.

Throughout the field trip, the system chose a single object to be the "gaze target" based on educational context. This was generally either the teacher's face while a video was playing, an object the student is meant to select, or an animation they are meant to watch. In each of the last four stations, one of the four cue conditions (three cues plus a no cue baseline) was enabled. If enabled, a cue would always be rendered guiding the user to the gaze target.

Throughout the field trip, we recorded the angle from eye-gaze vector to target as an attention metric. After finishing the field trip, students were asked to rate each cue based on its **Strength**, how **Annoying** it was, and if it made it easier or harder for them to **Understand** the teacher. These questions were asked with a 1-5 rating scale, with 5 indicating the more positive answer.

4 RESULTS

Summaries for cue ratings are shown in Figure 2. A difference was found in the Annoying rating [$\chi^2 = 12.798, p = .002$], with followups showing that Attention Funnel ($\bar{x} = 2.688$) was rated more annoying than both DynSWave ($\bar{x} = 2.266, p = .001$) and LineStrip ($\bar{x} = 2.164, p < .001$). A difference was also found for the Understanding rating [$\chi^2 = 7.242, p = .027$], with followups showing

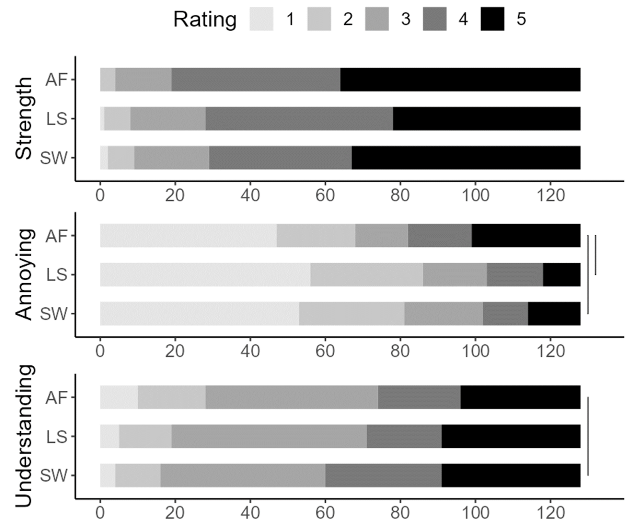

Figure 2: Ratings for cues given at the end of the field trip.

students perceived Attention Funnel ($\bar{x} = 3.375$) made it harder to understand the teacher than DynSWave ($\bar{x} = 3.664, p = .006$). No difference was found for the Strength rating [$\chi^2 = 4.141, p = .126$], with mean ratings for all cues being above 4.

Overall high strength ratings imply students did think the cues successfully caught their attention, and high Understanding ratings imply most students thought the cues had a negligible to positive effect on their educational experience. Investigation into gaze angle to target showed that Attention Funnel generally kept gaze closer to the target than no cue. This combined with its Annoying rating may suggest that it succeeded in helping to maintain visual attention, but this was out of line with what students wanted.

ACKNOWLEDGMENTS

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