# Guiding Gaze: Comparing Cues for Visual Search

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## Abstract

Visual search tasks are commonplace in daily life. In cases where the time and accuracy of the search is critical (such as first responder, crisis, or military scenarios) augmented reality (AR) visual cueing is potentially beneficial. Three cue conditions (3D Arrow, 2D Wedge, and Gaze Lines) were tested in a visual search task against a baseline no cue condition. Results show that any cue is better than none, however the Gaze Line design produced the lowest search time and greatest accuracy.

**Index Terms:** Human-Centered computing—Human computer interaction (HCI)—Interaction paradigms—Mixed / augmented reality Human-Centered computing—Interaction design—Interaction design process and methods—Scenario-based design Human-Centered computing—Law, social and behavioral sciences—Psychology

## 1 Introduction

As augmented reality (AR) head mounted displays (HMDs) have continued to advance and garner more support from government and corporate entities there has been an increased interest in using these technologies for time sensitive and potentially life saving work. For instance [5] developed an AR platform for search and rescue personnel to annotate and highlight important aspects of their environment. Another study [1] used simulated AR to explore the use of the technology for airborne surveillance (such as searching for sunken or on fire sailboats). In these cases the use of AR to assist in tasks may be beneficial for decreasing response time and increasing accuracy which would in turn help to save lives and prevent costly mistakes. We present a forward facing AR visual search task and compare three different cues (3D arrow, gaze line, and 2D wedge) against a baseline condition.

Visual search is a common task that we undertake daily linked to vision, information processing, and cognition [3]. Many tasks that require acting upon or in reaction to an object or aspect of our environment are predicated on visual search, where the individual must first scan the environment to find the target. A variety of factors including the salience of the target, the complexity of the environment, and the individual's cognitive state can affect performance with any given task. This presents an opportunity for AR intervention.

Visual cueing is the act of using some form of visual manipulation or visualization to guide a user to the target. This can take the form of arcs for finding moved office supplies [7], arrows or circles for airborne search [1], or lines to aid in finding a building for military operations [6]. Often these cue designs are taken from previous literature using other interfaces and are then adapted for use in AR [4]. In any case a visual augmentation is added to the environment via AR to assist in the search task. These interventions have the potential to increase search performance by decreasing search time and increasing overall accuracy.

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## 2 Method

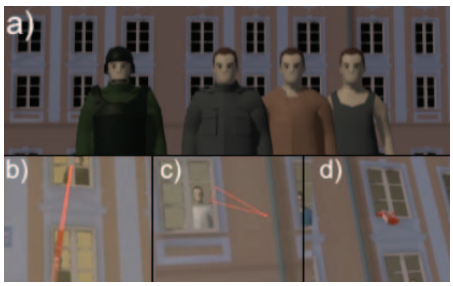


Figure 1: a) search environment and target/distractors; during task target/distractors spawned behind windows, b) Gaze Line cue, c) 2D Wedge Cue, d) 3D Arrow Cue

Our study was conducted using a Magic Leap 2 AR HMD. A testing environment resembling the side of a building was rendered over an ARUCO marker with 32 total windows (presented in a 4 by 8 grid) (see fig. 1:a). One target design was created (wearing a military vest and helmet) along with 19 distractors with varying levels of similarity . Three cue designs were selected (gaze line (see fig. 1:b), 2D wedge (see fig. 1:c) and, 3D arrow (see fig. 1:d)) and tested alongside a baseline no cue condition. The gaze line and 2D wedge cues were selected based on initial results from two pilot studies and the 3D Arrow design was selected due to it's popularity in prior literature [2, 8].

A total of 14 participants were recruited for the experiment (8 male, 5 female, and 1 non binary with an mean age of 22.79). After the informed consent process demographic data was collected using a questionnaire. From here participants completed an orientation and began the search task. Each participant was placed 2.5 meters away from a blank wall with the marker and completed 64 searches with each of the 4 cue conditions for a total of 256 searches. At any time approximately 6-8 windows were in the participant's field of view. The order of the cue conditions was counterbalanced using latin squares to minimize any learning effect. For each search the cue always pointed to the correct target. The target was present along with all 19 distractor designs and 12 empty windows leading to 20 of the 32 (or 63.5%) windows being filled. Between conditions the participant was granted a 20 second break. Both search time and search accuracy measures were collected.

## 3 Results

For response time, the IQR method was used to detect and remove one statistical outlier. After removal QQ plots were used to check for normal distribution. A one way ANOVA revealed statistically significant results for the main effect ($F(3, 55) = 56.65$, $p < .001$). Subsequent comparisons (indicated by the brackets in each graph in fig. 2) revealed that all three cueing conditions significantly reduced response time compared to the No Cue baseline condition (6.16s, $SD = 1.81$). Response time with the Gaze Line cue (1.35s, $SD = 0.2$)

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was significantly faster than the 2D Wedge (1.88s, $SD = 0.6$), which was in turn significantly faster than the 3D Arrow (2.87s, $SD = 0.8$).

For accuracy an ANOVA also revealed significant effects across conditions. Both the Gaze Line (99.11%) and 2D Wedge (97.43%) provided for greater accuracy over the No Cue condition (87.16%), however this effect was not replicated with the 3D Arrow cue. The benefits to search accuracy provided by the Gaze Line and 2D wedge were equivalent.

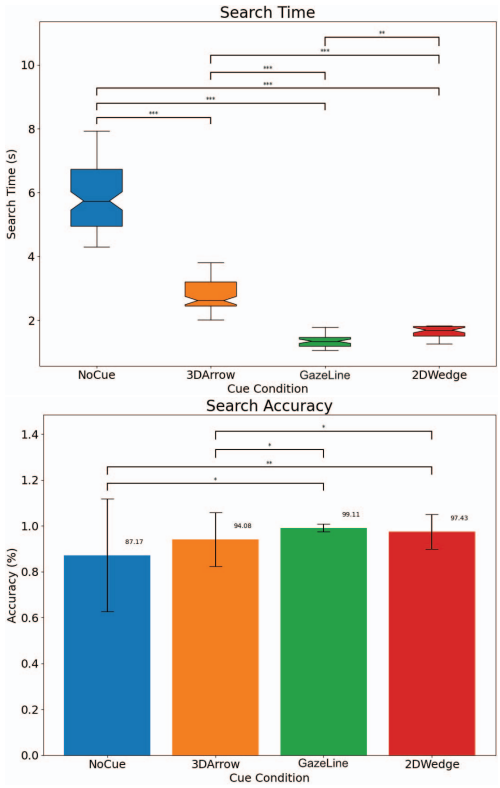


Figure 2: Search time and accuracy results.

## 4 Discussion

While any cue did provide a benefit to the search task, the most benefit was produced by using the Gaze Line cue which was nearly 5 seconds faster than the no cue condition and produced nearly 12% more accurate results. The benefits provided by the 2D Wedge cue were close to those of the Gaze Line cue with a difference of about half a second for search time and 1-2% for accuracy. 3D Arrows produced the weakest results of the cue conditions, however this design still reduced search time by more than half (6.16s to 2.87s) and increased accuracy by around 7%.

The poorer performance of the 3D Arrow cue may be due to the lack of positional information communicated by the design. With both the Gaze Line and the 2D Wedge both the direction towards the target and the position of the target are communicated by the cue design, whereas the 3D Arrow only explicitly communicates direction leaving position to be extrapolated by the user. Additionally depending on the orientation of the arrow in reference to the users view a level of ambiguity may exist. The slightly better performance of the Gaze Line versus the 2D wedge may be caused by a more intuitive design. We often are exposed to and use lines to indicate direction, connection, and location in our daily lives, so the line based visualization of the Gaze Line may be more intuitive than the scaling triangle design used by the 2D Wedge.

### 4.1 Limitations

Several limitation exist to this study design. First is the forward facing search field. Participants viewed the search field head on with less than 180 degrees of rotation needed to view the entire search area. A 360 degree search field may produce differing results. Additionally the cue was always accurate. Further experimentation may consider the role of erroneous cueing on the search task. Virtual objects were also used extensively despite the use of an AR HMD. This primarily to capture the innate limitations that exist with current AR HMDs but also for future expansion as other experiments using the current system functionality are planned that better capitalize on AR affordances.

## 5 Conclusion

In this study a comparative experiment was conducted using three different cues and a baseline no cue condition in which participants searched a forward facing search field. Results suggest that Gaze Lines provide for the greatest search performance (decreased search time and increased accuracy) over the baseline condition, however all cue conditions demonstrated statistically significant improvements over the baseline condition. As such any cue appears to be superior to no cue, however the intuitiveness of and spatial information communicated by the cue design are important to consider.

## Acknowledgments

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