COMPARING THE EFFECTS OF REFERENCE-BASED, ORIENTATION-BASED, AND TURN-BY-TURN NAVIGATION GUIDANCE ON USERS' INDEPENDENT NAVIGATION

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(a) Map Turn-by-turn   **(b) AR Turn-by-turn**

(c) Orientation-based   **(d) Reference-based**

ABSTRACT

Research has shown that turn-by-turn navigation guidance has made users overly reliant on such guidance, impairing their independent wayfinding ability. This paper compares the impacts of two new types of navigation guidance – reference-based and orientation-based – on their users' ability to independently navigate to the same destinations, both as compared to each other, and as compared to two types of traditional turn-by-turn guidance, i.e., map-based and augmented-reality (AR) based. The results of our within-subjects experiment indicate that, while the use of reference-based guidance led to users taking more time to navigate when first receiving it, it boosted their subsequent ability to independently navigate to the same destination in less time, via more efficient routes, and with less assistance-seeking from their phones than either map-based or AR-based turn-by-turn navigation guidance did.
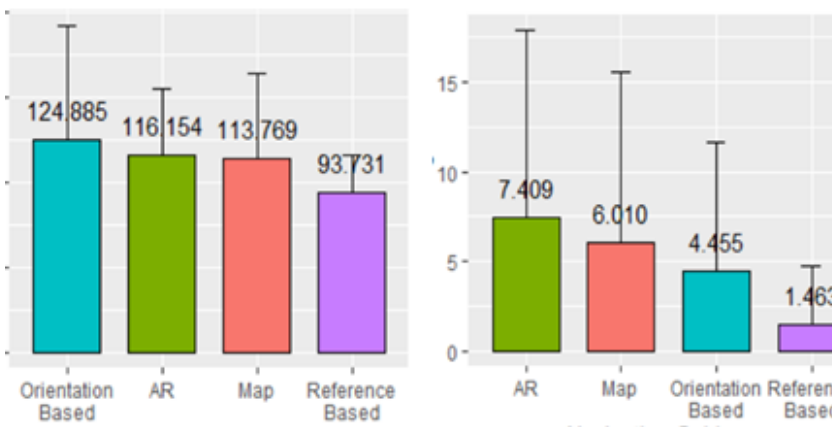
REFERENCE-BASED GUIDANCE

The design of the Reference-based mode was inspired by the concepts of cognitive maps and global landmarks [4]. The "Reference" alluded to its name is a landmark that the user already knows how to navigate to by him- or herself. Its guidance comprises a textual description of the user's current location relative to the reference destination, plus a short navigational description such as "The destination is 190 meters southwest of the Ferris wheel. Turn right at the first intersection after the Ferris wheel. Go straight for 110 meters. The destination is on the right-hand side." The idea is to leverage users' existing place knowledge as a reference/anchor for their learning of how to navigate to the destination in the future. We hypothesize that this mode will help users build cognitive maps by gradually expanding the geographic scope of their knowledge about relative locations, a key element of survey knowledge.

ORIENTATION-BASED GUIDANCE

In the Orientation-based Mode (Fig. 1(c)), a blue arrow displayed in the camera view always points to the user's destination, and text immediately beside that arrow displays the distance between the user and the destination.

plots that show mean and standard deviation completion time and phone checking time in independent wayfinding task phase

RESULTS OF INDEPENDENT-WAYFINDING PHASE

With regard to the performance of Reference-based mode, the independent-wayfinding task phase yielded opposite results. That is, the completion time and travel distance were both shortest among users who had previously followed Reference-based guidance, and completion time was significantly shorter among former Reference-based Mode users than among their Orientation-mode counterparts (p=0.01). Differences between Reference-based modes and the other two modes were marginal, however. Travel-distance results were again similar to completion-time ones. Surprisingly, participants who had previously used Orientation-based Mode took the longest time to finish the task, and devised the longest routes.

RESULTS OF ASSISTED-WAYFINDING PHASE

We recorded how much time (in seconds) it took each participant to complete each assisted wayfinding task, and the distance s/he had traveled (in meters). We found that there was a significant difference in completion time across the four navigation-guidance modes: with the Reference-based mode taking the longest, and AR Turn-by-turn Mode the shortest. Reference-based mode's completion time was further found to be significantly longer than that of AR Turn-by-turn Mode (p<0.001), Map Turn-by-turn Mode (p=0.02) and Orientation Mode (p=0.002). The travel-distance results were similar.

When participants turned on their phones to look up navigation guidance during the independent phase of each task, the time they spent looking at them was recorded by our system. This data revealed that the overall duration of phone-checking by former users of Reference-based Mode was significantly lower than for their turn-by-turn counterparts, both from Map Mode (p=0.03) and AR mode (p=0.005). However, it was not significantly different from the phone-checking duration of those who had used Orientation-based Mode. This indicates that the Reference-based mode was the best of the four when it came to enabling users to navigate independently without assistance from their phones.
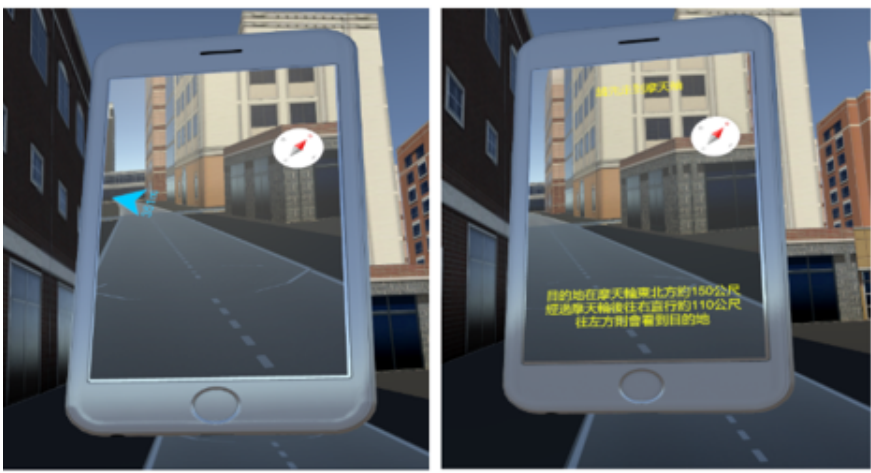
CONCLUSION

The results of our experimental virtual-world comparison of wayfinding performance across four different modes of navigation guidance indicate that Reference-based Mode performed the best in terms of enabling users to independently navigate after receiving guidance, despite their having taken more time while using it than when using the other three systems. This was likely because they were processing spatial information more deeply while using this guidance mode than when using the other three modes. This active processing of spatial information, in turn, reduced their dependence on the navigation system, thus boosting their performance when navigating without assistance.

It is also worth noting that only those participants who had used Reference-based Mode had shorter travel distances in independent wayfinding tasks than in assisted ones. Unexpectedly, users who had first used our novel Orientation-based Mode took the longest to reach their destinations by themselves. Before the experiment, we expected that users would be able to find the destination by orientation alone, i.e., without memorizing any specific route, thus reducing users' mental effort and improving their independent wayfinding task performance. However, observation of participants' actual behavior revealed that some of them focused on following the arrow so closely that they ended up ignoring the route they were taking. This approach sometimes resulted in complicated, hard-to-memorize, inefficient routes comprising numerous turns.