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Mindful navigation for pedestrians: Improving engagement with augmented reality

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ABSTRACT

Navigation systems are often followed mindlessly, as users may focus the attention on the device and not on the path. The risk of errors and bias related to the mindless adherence of the instruction is high.

We suggested that a mindful walking navigation system could reduce the errors and improve the overall exploration experience. Specifically, we tested the hypothesis with an Augmented Reality system, with information directly projected on the path, in comparison with a standard device. Moreover, we tested the hypothesis that when users feel they are in control of their path, both performance and overall experience would improve. We found that both conditions increased the navigation performance and experience, decreased travel time, errors, and confusion and it increased the number of landmarks noticed.

1. Introduction

Traditional navigation systems require visual and cognitive attention to be effective. This poses a problem to the user, who must focus on the system itself and not on the path being taken [1]. Efforts to reduce these distractions have led to a variety of solutions around alternative representational modalities such as audio and tactile interfaces [2]. Today, widely used in-car GPS navigation systems employ this voice guiding strategy along with screen-based maps that are automatically updated with users' location. This is designed to reduce cognitive load while driving [3]. Drivers still need to translate auditory information into visual cues, however, which causes an additional cognitive burden. Complex instructions might be better represented using simple visual cues, eliminating the need for this translation.

Navigation systems are not limited to drivers only. Also pedestrians may benefit from these devices. The most popular way to provide directions for pedestrians is currently to display maps on handheld devices like personal digital assistants and smartphones. Although maps on the small screen could provide a just-in-time reference for guidance, the nature of this task – holding up a handheld device to see the small screen [4] - divides our attention [5], impeding an optimal usage of the real-time assistant system while moving.

1.1. Overreliance and automation bias resulting from “mindlessness”

When a specific instruction is given by a trusted authority, often people become submissive and follow the instruction without thinking [6]. Instead of attending to the task environment, people mindlessly ignore stimuli that fall outside the given instructions [7]. Mindlessness/mindfulness theory [7,8] suggests that people will be more engaged when they make a choice to achieve a goal.

In an unpublished pilot work, we applied this idea in the context of pedestrian navigation. We led 12 subjects on a verbal tour without a navigational assistant device. The tour was administered inside a large building where the internal structure is notoriously confusing. Half of the subjects were given a choice between two alternative routes to the next landmark destination, while the other half were not given a choice. After the tour, participants were asked to find three previously visited landmarks. We measured time and

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distance. Those given a choice of route during the tour took a shorter amount of time to find the landmarks and were able to find a more direct path. The no-choice group tried to remember the tour and retrace the original path. Taking this detour caused many to get lost and never reach the destination. Accordingly, we believed that giving them a choice would encourage mindful engagement in the environment leading better spatial knowledge acquisition.

The present experiment replicated and extended the pilot study to compare the effects of reducing divided attention and the psychological effects of choice.

There are two main hypotheses in this study: a) If direction information is directly projected on the path, the users' eyes should more frequently be on the path. This should result in better acquisition of spatial knowledge, as the users will have more opportunity to engage in the surroundings as compared to screen-based guidance interfaces, which cause divided attention. b) If users feel they are in control of selecting routes, they will be more engaged in the surroundings than users who passively follow automated guidance.

2. Methods

2.1. Intervention

The study utilized a 2 X 2 design. We developed a projection-based Augmented Reality (AR) guidance system to test if engagement increases when we project guiding information directly on the surface of navigating spaces. We compared that with a screen-based guidance mobile system, that guides users with information on the screen. In both systems, we developed an interface that provides a feature to occasionally inform users about alternative paths. Thus the second variable is whether this "choice" feature is activated. Subjects were randomly allocated to one of the four conditions.

The experiment consisted of two parts. First subjects had a chance to learn their way around the area (Ray and Maria Stata Center, Massachusetts Institute of Technology), with the assistance of the navigation device. After that, they were tested on the knowledge they retained. Instead of asking subjects to find their way on the same paths, we asked them to apply their knowledge to find a novel, more direct, path. If the subjects were more engaged while learning the area, we hypothesized that they should be able to find the best path between two points more quickly.

The choice group was subdivided into actual and perceived control groups: actual control groups made choices that changed the path of their tour, whereas perceived control groups made an illusory choice – regardless of which route option they chose, they followed the same predefined path through the entire tour.

2.2. System interface description

2.2.1. Screen display based navigation system

This tablet-based system (Fig. 1) gives visual and audio cues. The user looks at the image and sees a person walking in a certain direction. By directly comparing the image to the surroundings, the user walks towards the next destination. The device also provides spoken direction using built-in text-to-speech. The experimenter manually updates users' current locations and then the system updates the guidance based on where the user is. When it is time to make a choice, two images appear and the tablet will give an audio description of each pathway.

We used a Samsung ultra-mobile personal computer (UMPC) and a Samsung phone. The phone served as a client side application, sending the user's current position and route choices to the UMPC to update the image. In the rest of the paper, we will refer to this device as "Tablet".

2.2.2. Projection and AR based navigation system

Our other device was a projection-based navigation device that uses predefined tour-routes to give arrow directions that are projected into the surroundings (Fig. 2). It is a part of our navigation assistance system, Guiding Light, which uses projection-based AR to provide navigational assistance for indoor pedestrian users [9]. The system uses multiple localization systems such as computer vision and WLAN RSSI based localization systems.

The experimenter manually calibrated the arrow directions according to the user's orientation in the space and the user's location on a map of the building. When the user is to take an elevator or stairs, an elevator or stair image will pop up with text telling the user to go to a certain floor. When it is time to make a choice, two arrows appear and the user is to walk in the direction of an arrow to make the choice. The experimenter then updates the user's choice and position and continues to guide the user in the correct direction.

We used Samsung Galaxy S phones with a mini-projector attached. There is a client side (held by the subject) that communicates to the server side (held by the experimenter) with Wi-Fi. As the client side updates the user position and calibrates the arrow directions, the server side receives all the relevant information and presents it to the user in a minimalistic way – either through a simple image or an arrow.

In the rest of the paper, we will refer to this device as "Projector".

2.3. Experimental tasks

Phase one: Tour. This was designed to measure usability of the device to follow the directions to six landmarks in the building (Fig. 3).

Phase two: Phase two assessed subjects' engagement. They were asked to find their way to three locations introduced in the tour to

Fig. 1. Screen-based guidance system on a tablet.

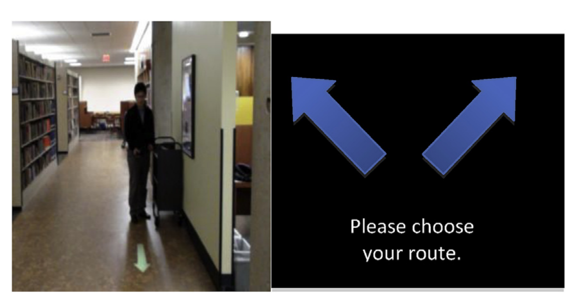

Fig. 2. Guiding light, a projection-based AR guidance system.