Visual elements influence on navigation in virtual environments

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ABSTRACT

Virtual rehabilitation often incorporates an element of travel in a virtual environment. Whether patients are transported automatically through the environment, or whether they have navigational control, it is important to understand how the design of the environment itself can supply navigational cues, and how the processing of these cues may influence perception, behaviour and task performance. This paper explores the literature, which might inform application design, and presents a case study using a think-aloud protocol to explore the perception of users to visual cues within a running game. We conclude with some preliminary suggestions for positive and negative navigational cues.

1. INTRODUCTION

Virtual rehabilitation often involves navigating through a virtual environment while performing the rehabilitation tasks. It is often necessary to guide or influence the patient's navigation direction, to lead them towards a specific point, to limit exploration of a finite environment, or to redirect their movements within the real world space.

However currently there is little known on why and how people make choices when navigating within a virtual environment. Navigational studies commonly explore participant's memory of a route, focusing on landmarks, routes and layout of an environment (Van der Ham et al., 2015), rather than their dynamic response to perceptual cues. Vasylevska et al. (2013) created an application to test participants' responses to perceptual cues. They designed a building that could be explored by the users without any instructions. The corridor would then change its features and content when a room was entered. The changes proved to be unnoticed by users, but require modifications. This suggests that by obscuring the user's sense of direction, participants experience a sense of being lost due to a lack of orientation aids in virtual environments (Vasylevska et al. 2013). Redirecting participants in different directions, in order to believe that they are in a larger space suggests that certain navigational cues are not being entirely considered by the participants explaining why they were feeling lost (Vasylevska et al. 2013). Therefore, there is a need to better understand the influence of navigational cues in a virtual environment.

Improving our understanding of user's responses to visual cues may influence navigational choices and would allow us to provide conscious or unconscious navigational aids within virtual rehabilitation applications. This would enable a patient to be guided around a virtual environment whilst creating a sense of navigational control, and could also avoid inadvertently adding to their cognitive load.

2. REACHING A TARGET LOCATION FROM THE CURRENT LOCATION

Wayfinding is the term used to describe the spatial problem solving of reaching a target location from the current location. In the context of this research, we use Emo (2014) definition of wayfinding, where wayfinding is defined as cognitive approach to a task, based upon visual perceptions in the environment. In order to explore participant perception and how visual cues may influence people to make certain navigational choices, it will be important to have an understanding of the components of wayfinding.

Effective wayfinding may use elements of location identity, landmarks, orientation cues, well-structured paths, and visually distinctive regions, as well as survey views, signs and sight lines (Foltz, 1998). Additionally, navigational aids can include 'lighting', 'architectural design', 'reference objects' and 'audio and olfactory cues' (Lee and Kline 2011; Bowman 2004).

Most of the research on wayfinding relates to interactions with keyboard, mouse or joystick, and less is known about how these cues are perceived during more active interactions. This paper presents a pilot study exploring how users perceive visual cues whilst running-in-place through a virtual environment.

3. PILOT STUDY

The aim of this research is to investigate conscious navigational aids presented within an environment. A pilot study was used to address participant's perception of applications when travelling through an environment, which does not allow for a choice in navigation. This will help to understand how a patient could travel through an environment whilst creating a sense of navigational control, but also to increase any unnecessary cognitive load.

For this pilot study, we opted to explore the perception of participants travelling along a route which did not allow them navigation choices, using the 'Wii-Fit running mini game'. This game features a populated open environment, with a structured path where the character follows the guide, along an animated path.

During the study, we followed a 'think aloud' protocol. The 'think aloud' protocol allows participants to verbalise their opinion during the pilot study. This method is appropriate to observe participants, without the bias of prompting participants to say what is expected of them. This will allow a basic understanding of user's responses to visual cues, which may influence their choices in navigation.

Four adults participated in the study: three male and one female, age ranging from 21 to 44 years old and an average age of 32 years old. The participants were familiarized with the equipment and how a 'think aloud' protocol works. They were then given a Wii-remote and stood in front of a television. There were cameras positioned behind, in front and to the side of each participant, to capture any data surrounding body movements.

At the end of the pilot study, a short interview was conducted asking the following questions in order to prompt any extra data from the participants: '*Did you find yourself at any point wanting to travel somewhere else?*', if so '*What specifically made you want to go in another direction?*' and '*How did travelling through the environment feel?'* The questions were designed to be open ended to not push participants to what they deem is an appropriate answer, but to create a basic understanding of user's responses to visual cues, which may have influence their choices in navigation.

4. RESULTS AND DISCUSSIONS

The study was used to create a basic understanding of user's responses to visual cues, to see how an environment that contains no navigational control may influence choices in navigation within predefined populations. Participant's perception of the environment altered throughout, for different reasons (see Table 1 for more details).

When prompted by the user interface, to change pace when travelling through the environment, participants either experienced deflation, or disappointment, as a result of the pace suggested not meeting the user's expectations. In virtual rehabilitation it would make sense that participants should feel a sense of control of their own pace as this could hinder the process of achieving their therapeutic goals.

Participants one and two started moving forward in the physical world, when approaching a fork in the path in the virtual world, perhaps subconsciously having made a choice in navigation. Two participants that took the longest to travel through the environment, noted the majority of navigational cues within the virtual environment. It may suggest that patients need busier environments with enough to focus their attention on, as the participants who travel faster notice fewer navigational cues. This needs to be considered within the design of virtual rehabilitation applications if patients need to see the cues.

There are certain suggestions on how to subliminally guide people in certain directions, by redirecting participant's attention to areas of interest. It can be suggested that visual cues need to blend well into the environment, perhaps by using colour coding in order to help navigate participants (Madigan, 2013). If visual cues are subliminally implemented into the design of virtual environments, this could lead to 'inattentional blindness'. This is a daily subconscious occurrence when certain situations are not noticed, as their attention is associated with something else at the time. It occurs because only a small percentage of conscious perception occurs at a given moment as a result of senses becoming overwhelmed (Green, 2013). Therefore, if a virtual environment is to be designed with influencing choices while still having a sense of openness for participants in virtual rehabilitation it will be important to consider 'inattentional blindness'.

Participant three has attention deficit hyperactivity disorder (ADHD), which may explain why they appeared more concerned with finishing the race rather than commenting on usability as instructed. It is important to

acknowledge that this pilot study was to generate a basic understanding of participant's perception of navigational cues, highlighted from literature, so there was little concern about demographics at this current stage of researching. However, as virtual rehabilitation is being adopted for clinical treatment of ADHD (Yeh et al. 2012) it is important to consider the behaviour of participants that have ADHD, as this might affect design considerations when influencing direction of travel.

Table 1. *Summarized key visual elements that were commented upon from the pilot study.*

Navigational cue	Participant One Reaction	Participant Two Reaction	Participant Three Reaction	Participant Four Reaction
Structured Path	Became bored with the path as they no longer wanted to follow everyone else.	Did not have any desire to not follow the path.	Did not have any desire to not follow the path.	Did not have any desire to not follow the path.
Small Natural Tunnel	Found the small natural tunnel fun, commented that the shadow created made them cooler.	Knew they were heading towards the tunnel, mentioning the shade, but expressed no feelings.	Knew they were heading towards the tunnel, but expressed no feelings.	Knew they were heading towards the tunnel, but expressed no feelings.
Grass	Felt compelled to run along the grass	No Reaction	No Reaction	No Reaction
Characters	Kept saying hello, and interacting with the characters by waving back. Did not enjoy being overtaken by others. Found the dogs cute.	Did not enjoy being overtaken by other runners or the dogs. Initially bemused with the waving, and physically moved backwards. Later enjoyed the characters waving and felt it became a friendly atmosphere.	Commented on other characters without showing any perception but acknowledged they were in the environment.	Commented on other characters without showing any perception but acknowledged they were in the environment.
Guide	Wanted to get past the guide within the environment.	No longer wanted to follow the same guide, wanted a different one to follow.	Was frustrated with the guide being faster, and became more and more competitive throughout.	Was frustrated with the guide being faster, and became competitive.
Change of Pace	Expected to go faster downhill, as a result became deflated.	Was happy when overtaking someone, as they commented that they were frequently trying to increase speed.	Was disappointed that they would be punished for going faster, as the character would trip as a result.	Was frustrated that the interface told them to slow down and not speed up.
Fork in the path	Sped up upon approach.	Sped up upon approach.	No reaction.	No reaction.

The main key findings of the study are:

- Participants frequently commented upon the characters in the environment.
- All participants became frustrated at the change in pace throughout the environment, not allowing them to travel at their speed, or not doing what they expected to occur.
- All participants commented on a small natural tunnel present within the environment through which the participants had to travel, and the shadow it cast.
- Majority had no desire to leave the structured path.
- All participants commented upon the environment's landmarks by expressing their feelings and perceptions.

5. CONCLUSIONS

Conducting the pilot study was beneficial. It highlighted inattentional blindness, as an important psychological consideration, as well as behaviour alterations when presented with certain navigational aids, some of which were visual. It also shows that the participants become frustrated when not allowed to control their own speed. A well-structured path may prove beneficial in order to influence their choice, yet may not lead to the openness of an environment that would be beneficial for rehabilitation. Therefore subtle navigational cues will be important to influence participants' navigational choices by association of elements such as colour. Overall it seems possible to influence the direction of travel, to help achieve therapeutic goals while allowing for an open world. However, further work will need to be carried out to validate the results.

During the pilot study, participants commented upon: 'Landmarks and Artificial Landmarks', 'User interface, with relation to maps', 'lighting', 'Colour and Atmospheric effects' and 'Signs'. Therefore the choices presented in Table 2 can be extracted as reassuring or discouraging cues.

Table 1: *Possible navigational cues for future study.*

Reassuring Navigational Cue	Discouraging Navigational Cue
Main Street	Alleyway
Illuminated	Shadowed
Good Condition (Clean, well looked after etc.)	Bad Condition (Messy, destroyed etc.)
Free Path (Without Obstacles)	Obstructed path (With obstacles)
Sun	Rain
Populated	Unpopulated
Downhill	Uphill
Bright Colours	Dull Colours

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