The Aid of Colour on Spatial Navigation: A Study in a Virtual Hospital Environment

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ABSTRACT
The aim of this study is to explore the effects of colour as visuo-spatial cue on spatial navigation and developing a cognitive map in elderly in a simulated virtual hospital environment. The study further purports to explore whether it is possible to improve elders' spatial navigation and cognitive mapping performances as well as younger-aged group, by the aid of coloured visuo-spatial cues.

CCS Concepts
• *Human-centered computing~Virtual reality*

Keywords
Wayfinding; Spatial navigation; Cognitive mapping; Visuo-spatial cues; Colour; Age.

1. INTRODUCTION
Wayfinding systems can be supported by using appropriate environmental design elements such as layout, landmarks and signage in order to overcome the difficulties of navigating in unfamiliar environments. The use of colour is an additional tool for navigation. It can help a person to develop a mental map of the architectural environment [1]. Navigating and orientation in both real and virtual environments (VE) can be enhanced by cues. Cues are comprised of all kinds of information that is available in the environment, such as verbal, graphic, architectural and spatial cues [2].

2. LITERATURE REVIEW
Previous research indicated that in various age participant groups (among children, adults or elders) colour improves people's wayfinding performances [1, 3, 4, 5, 6, and 7]. Additionally, much research comparing wayfinding performances of elders and younger-aged people, reported that elders have more difficulties than younger-aged people in terms of memorizing maps, navigating, route learning, map learning and place learning because of cognitive decline such as; changes in learning, short term memory, attention and response times [8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and 18]. It is reported that age-related changes in the brain areas that support cognitive mapping may be partially responsible for the decline in wayfinding ability that is seen in aging [19].

Hospitals are public facilities for all ages of people (with varying levels of health and mobility).Number of visits to a hospital may increase with age due to various health risks and accidents [20]. Hospitals are particularly difficult to navigate because of complex medical terminology and high patient and visitor stress levels [21]. It has been pointed out that when people get lost and are unable to orientate themselves they experience increased blood pressure, headaches, feelings of desperation and weariness [22]. Additional possible wayfinding issues in hospitals consist of facilities being excessively large and overwhelming due to several different departments. All of these factors make healthcare facilities unique and possibly troublesome, especially to older populations [23]. Elders need more support than the younger-aged people for navigating by themselves in an unfamiliar environment. For elderly whose cognitive and physical abilities are limited, navigational aids are important elements to improve wayfinding and eventually their independent living. The aim of this study is to explore the effects of colour as visuo-spatial cue on spatial navigation and developing a cognitive map in the elderly in a simulated virtual hospital environment. The study further purports to explore whether it is possible to improve elders' spatial navigation and cognitive mapping performances as much as younger-aged group, by the aid of coloured visuo-spatial cues. One of the aims of this study was to explore the relationship between visuo-spatial abilities and spatial navigation task. Visuo-spatial ability is defined as the ability to process information that involves spatial relations [24].

3. METHODOLOGY
3.1 Research Questions
1. Do coloured visuo-spatial cues ease spatial navigation compared to neutral?

2. Do warm coloured visuo-spatial cues improve spatial navigation compared to cool?

3. Is there any correlation between spatial navigation and JLO test (measure of visuo-spatial abilities) scores?

4. Is there any correlation between cognitive mapping and spatial navigation task?

5. Is there any sex difference on spatial navigation?

3.2 Participants
The selected participant groups will consist of; 90 healthy elders (age range 60-69) and 90 young-aged adults (age range 20-29). The exclusion criterion (includes education level, handedness of

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users, visual impairment, spatial skills, cognitive impairment, independent living, depression) is suggested for the participant group of this study to eliminate individual factors that may have effects on spatial navigation. All of the participants will be at the same education level (12+ years of education) because education is one of the important factors that affect cognitive performances. Only right-handed participants will be included to the experiment. Handedness may also be a factor that influences wayfinding performance. Participants who are validated to have decreased spatial skills as a result of the Judgement of Line Orientation (JLO) Test will not be involved to the experiment. The JLO test is a widely used measure of visuo-spatial judgment [25]. Elderly people who are validated as cognitively impaired as a result of the Montreal Cognitive Assessment (MOCA) will not be involved to the experiment. It is stated that the MoCA is "a screening device used to assess attention and concentration, executive functions, memory, language, visuo-spatial abilities, abstract thinking, calculation, and orientation domains" [26]. The Functional Activities Questionnaire (FAQ) measures instrumental activities of daily living, such as preparing balanced meals and managing personal finances [27]. It's indicated that the scores of FAQ increase when the age grows and education level decreases [28]. Elderly who are validated to have depressive symptoms as a result of Geriatric Depression Scale (GDS) will not be involved in the experiment. Depression is not a natural part of aging. Depression is often reversible with prompt recognition and appropriate treatment. However, if left untreated, depression may result in the onset of physical, cognitive, functional, and social impairment, as well as decreased quality of life [29].

3.3 Selecting the route

As a typical route for both elders and young-aged group, the route starting from entrance to orthopaedist is decided on for the virtual simulation. Orthopaedist is selected because it is a place visited by both younger-aged people and elderly. The route plan including five destinations will be used for the experiment: 1) Information desk, 2) Orthopaedist's examination room, 3) Physical therapist, 4) Cash desk, 5) Exit (see Figure 1). The modelling phase of generic hospital will be created via "3DS Max" by Autodesk which is a professional 3D computer graphics program for making 3D animations, models, games and images [30]. The simulated environment will support navigation in it via "Unity 4" by Unity Technologies which is a software used for developing computer games [31]. Due to its well-designed interface and its open architecture this game engine is widely used by both computer and cognitive scientists [32]. In addition, it is easily combined with the affordable virtual reality head-mounted display (HMD) "Oculus Rift''; so that the same simulation environment can be used to empirically investigate real human wayfinding behaviour as well. Specific vertical surfaces which will be used as coloured spatial cues on the route will be determined. Three different settings (neutral-warm-cool) will be created. The only difference between these settings will be the colours of visuo-spatial cues.

3.4 Method

VE was preferred for this study because changing the colours of visuo-spatial cues in a hospital is more efficient with a simulation. The experiment will be conduct in three phases; pre-test questionnaire (consisting of tests in exclusion criterion), testing on computer (1.spatial navigation task, 2. cognitive mapping task), and post-test questionnaire.

3.5.1. Computer Test Session

In the second phase, the participants will be seated at the computer and tested individually. After the training, video watching and sequence achievement steps, the experiment phase

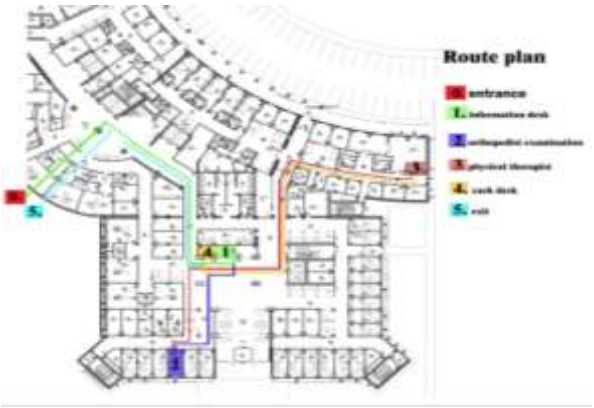

Figure 1. Partial plan of the generic hospital building with the selected route.

will be conducted in two stages; spatial navigation (route replication) task and cognitive mapping (picture classification) task. In the first stage, participants will be asked to navigate on the route in the VE that they have watched and learned the sequence. For this task the participants will have to recall the path. Thus, every movement in the VE and the four scores will be noted from this task: the time spent, the number of wrong turns (errors), the number of hesitations (stops) and the distance travelled during the spatial navigation. Cognitive mapping of the participants will be measured via picture classification task. The aim of this task is to evaluate if the participants develop route knowledge of the performed path. It will be asked to the participants to order the 12 images chronologically that corresponded to different points of views of the VE encountered along the route.

3.5.2. Measuring Spatial Presence

In the third phase, Presence Questionnaire [33] will be used, by answering the items, the spatial presence of the participants will be verified. The assessment of sense of presence is important because the participants have to feel present in order to orient themselves. The effectiveness of VEs has often been linked to the sense of presence reported by users of those VEs. (*Presence* is defined as the subjective experience of being in one place or environment, even when one is physically situated in another.).

3.5 Future Directions

The researcher is still working on the method part of the study. A very early version of VE simulation is prepared and a pilot study comparing traditional desktop system and head mounted displays will be conducted. It's known that interaction's environment has effect on sense of presence and navigational performance. There are not any studies comparing desktop system and HMD especially Oculus Rift DK2 in the assessment of navigation task. The studies in the literature compared desktop and HMD with old technology (poor quality in terms of resolution, field of view, frame rate, etc.) and these studies generally do not suggest HMD for wayfinding studies because it is found that HMD in poor technology affected navigation performance adversely [34, 35]. The aim of the prior methodology task is to determine interactions' environment (display system) of the VE experiment.

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