ASA 2018 Engaging Architectural Science: Meeting the Challenges of Higher Density

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Foreword

The Architectural Science Association (ASA), formerly known as the Australian and New Zealand Architectural Science Association (ANZAScA), is an international organisation, the objective of which is to promote architectural science, theory and practice primarily about teaching and research in institutions of higher education.

The conference theme of the 52nd International Conference of the Architectural Science Association on *Engaging Architectural Science: Meeting the Challenges of Higher Density*, emphasizes the issue of built environments for growing cities. What is the outlook on urban futures and densification? Cities have been viewed as sustainability problems rather than solutions. As concerns about urban sprawl, densification, shanty towns and climate change grew, so did the awareness for high-performance, energy-efficient building and walkable neighbourhoods make cities liveable and offer far greater benefits for the global environment. For example, high-density living has been viewed as a key strategy to manage urban growth and is increasingly becoming a feature in city planning. By 2030, 60 percent of the world's population will live in cities (McKinsey & Company, 2013). Australian cities have seen a rapid increase of high-rise residential construction which generates, among others, a discussion on planning controls in inner cities.

It is then fitting to ask how the areas of architectural science could be engaged in expanding the dimensions or frontiers of urban sustainability. The Conference Proceedings are grouped into nine sections:

- Building Science and Built Environment Quality
- Architectural Science, Construction and Technology
- Building and Energy
- Architecture, Design and Environment
- Design Education and Research
- Cities and Outdoor Environments
- Practice, Community and Industry Engagement
- Building assessment and evaluation
- Theory, Philosophy and Society

Contributions to the above groupings of research-areas have been sought to cover relevant content relating to the architectural science of the disciplines of architecture, engineering, building science, design, urban and landscape design, computer science, philosophy, psychology, mathematics, humanities, and other relevant disciplines, who can contribute to the discussion. Researchers and doctoral students have been invited to submit research papers and critical essays and to attend the conference to widen our discussion about engaging architectural science and its future trajectories.

This publication presents 91 accepted papers presented at the Conference, hosted by the School of Property, Construction and Project Management, RMIT University, Melbourne, Australia, 28 November - 1 December 2018. Details of the Conference are currently at https://www.asa2018conference.com/, and papers in this proceedings are archived at the ASA website: www.anzasca.net.

Each paper in these proceedings has undergone a rigorous peer review process. Following the call for abstracts in April 2018, a total of 217 abstracts were submitted for review. Each abstract was blind peer reviewed by two members of our International Scientific Committee, made up of 53 experts. Of these, 193 abstracts were accepted for development into a full paper. Following this, 114 full papers were submitted, each of which was again blind peer reviewed by two to three members of our International Scientific Committee. Based on the reviewers' recommendations,95 papers were accepted for presentation at the conference, and 91 are included in this publication."

Although the editors of these proceedings have made every effort to ensure that the work presented here is correct and absent of errors, the contents and opinions of the papers are the sole responsibility of the authors. The editors' role was to structure these proceedings into a meaningful and informative sequence.

On behalf of the Organising Committee, we would like to sincerely thank all the people who have contributed to realising this Conference. Thank you to all the authors for their interest and contribution to the success and the quality of papers and discussions of the Conference and its Proceedings. We are very grateful to the members of the International Scientific Committee for their rigorous reviews, without which we would not have been able to maintain and improve the quality of the papers. We thank our Sponsors: *Chartered Institute of Architectural Technologies - Australasia Centre*, and *Sustainable Building Innovation Laboratory (SBi Lab)* at RMIT University, as well as our supporter, *International Building Performance Simulation Association – Australasia Affiliate*. We thank those who have worked behind the scenes from the School of Property, Construction and Project Management (PCPM) at RMIT University.

Priyadarsini Rajagopalan and Mary Myla Andamon
Melbourne 2018

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Contents

Using Virtual Reality and Participatory Processes to Design Interstitial Healthcare Places

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Abstract: Within healthcare architecture, there is a void of attention directed towards the non-medical spaces; the waiting rooms, hallways and all ‘between moments’ where many people spend extended periods of time under acute stress. Nowhere is this more prevalent that in the emergency departments where patients seek care and treatment for real or perceived, serious injuries or illnesses. While waiting for medical attention, exposure to high levels of harsh lighting, sterile furnishings, chaotic activity and cavernous rooms with others in distress can cause and increase anxiety, delirium and high blood pressure. The emotional experience of such spaces changes based upon a user’s unique sensory conditions and therefore their individual perception of space.

The architectural design tools and devices to explore these highly charged sensory spaces have been historically limited to technical plans and sections and rendered marketing perspectival images which do not fully communicate the immersive experience of these spaces when in use. Virtual reality is emerging as a powerful three-dimensional visualisation tool, offering designers the opportunity to comprehend proposed designs more clearly during the planning and design phases, thus enabling a greater influence on design decision making. This research explores the use of VR in a healthcare perspective, adopting a participatory design approach to simulate sensory conditions of blindness, deafness and autism and the emotions associated with these conditions within space. This approach diverges from a purely visual method of design towards an understanding of the haptic, exploring the critical phenomenology behind these non-medical spaces. The research finds significant potential for the use of virtual reality as a design tool to simulate the experience of these spaces in early design stages

Keywords: Virtual reality, participatory processes, phenomenology, emergency department

1. INTRODUCTION

In New Zealand, there is an increasing demand for more, larger and more productive emergency departments. Overcrowding and delays to treatment emerged as a problem in New Zealand in the mid-1990s (Tenbensel et al., 2017). Emergency departments provide care and treatment for patients with real or perceived serious injuries or illnesses. Over half of these incidents are deemed potentially life threatening. Among the highest of demographics attending emergency departments are the elderly (28.9% of the elderly population) and children (25.5% of aged under 5 population) along with those experiencing mental illness (Ministry of Health, 2016). This situation is predicted to worsen with the increasing demand associated with growing and ageing populations as well as incidences of long term conditions and challenges in aged residential care management (Forero et al., 2011).

Emergency department designs constitute one of the greatest threats to quality emergency care (Forero et al., 2010; Braitberg, 2007; Schull et al. 2001; Mohsin et al. 2007; Foster et al. 2005; Sbrivulis, et al. 2006) and are associated with increased risk of error, delayed time-critical care, increased morbidity and excessive number of deaths. Detrimental effects include overcrowding and increased delays in transferring patients to intensive care units (Ou et al., 2009; Carr et al. 2007); delays in pain treatment (Forrero, et al. 2010); increased mortality (Richardson, 2006); and increased numbers of patients who did not wait for treatment (Mohsin et al., 2007). Almost all of these situations occur in the interstitial spaces of emergency departments.

The architectural design tools and devices to explore these highly charged sensory spaces have been historically limited to technical plans and rendered marketing perspectival images, neither of which fully communicate the immersive experience of these spaces when in use. Design outcomes are predominantly based on architectural judgement or even medical care provider opinion, ignoring the significant influence from first-hand users of the space. Even within architecture, the relationship between the built environment and the human body is rarely considered explicitly (Heylighen et al., 2013) and in particular, there is no evidence in the healthcare literature that acknowledges the needs of people with sensory impairments or disability whether temporary or permanent. Within healthcare architecture, there is a void in the attention directed towards non-medical spaces, the waiting rooms, the hallways and all “between moments” where people increasingly spend extended periods of time under acute stress. While waiting for medical attention, these spaces typically expose patients to high levels of harsh lighting, sterile furnishings, chaotic activity and cavernous rooms and other patients in distress, leading to an increase in anxiety, delirium and high blood pressure (Ulrich, 2006).

Virtual Reality (VR) is emerging as a powerful three-dimensional visualisation tool, offering designers the opportunity to comprehend proposed designs more clearly during the planning and design phases, thus enabling a greater influence on design decision making. While computer generated, for the person experiencing it, VR closely resembles reality and allows the sharing of a single reality by multiple people. The main contribution that VR offers is that it has to be “experienced” as opposed to “viewed” and as such, the user becomes an integral part of the system.

This paper explores the potential for VR using a strategy of participatory design, thereby communicating design input from the primary occupants (patients) to the designers, during all phases of design. It examines how VR could be used to understand the critical phenomenology of these interstitial healthcare places in relation to the impairments, typically experienced by the most predominant emergency department users. It achieves this through analysis of the emotions experienced at each stage of the emergency department narrative with an emphasis of the design of ‘between-moments’.

> “This is a space where the unexpected lives, a doorway, a place where quick responses will dictate how we are to emerge. In a space where infinite possibility and uncertainty reign, careful architecture is of the utmost importance – because where there lives the possibility of chaos, so too lives the sister possibility of comfort” (Huddy and Sanson, 2016, pp. XV)

2. THEORETICAL AND PHILOSOPHICAL CONSIDERATIONS

To design for the full complexity of an emergency room and its often impaired users, an expanded approach is required. Disciplinary theories or tools can be used to bridge the gap to reality. Similarly, philosophical theories can address complexity and elaborate on the topic under investigation (Van Hoof and Verkerk 2013). In this situation, the philosophy of phenomenology and technology are considered for their potential to shed light on the imperatives of design.

2.1 Phenomenology and Healthcare

Phenomenology, a branch of philosophy, is a field that has lent itself to the area of therapeutic architecture. The discipline of phenomenology may be defined in broad terms as the study of conscious experience as experienced from the subjective or first person’s point of view (Smith, 2018). Pallasmaa explores how a haptic environment can engage with the body’s innate sensory needs and invoke emotive qualities, thereby conveying subliminal ‘truths’ – such as calm, stillness and rest – to the semi-conscious (2012). He addresses “the role of the body as the locus of perception, thought and consciousness, and the significance of the senses in articulating, storing and processing sensory responses” (Pallasmaa, 2012, pp. 11). He challenges the dominance of vision and hearing as the ‘privileged sociable senses’ and the potential for the other three senses to become “archaic sensory remnants with a merely private function” (Pallasmaa, 2012, pp. 18).

Similarly, Holl explores the role of human perception of colour, light and shadow and space in the phenomenological experience of architecture and the way in which they frame the phenomenal experiences of architecture. Each individual moment in the narrative of architecture is a moment to be experienced and the building has to be experienced by inhabiting the spaces (using all of the senses) rather than just viewing it. “As we open a door, our body weight meets the weight of the door; our legs measure the steps as we ascend a stair, our hand strokes the handrail and our entire body moves diagonally and dramatically through a space” (Holl, 1994, pp. 35). Genuine architectural experience consists of “approaching, or confronting a building rather than just the façade; of the act of entering and not simply the frame of the door, of looking in or out of a window, rather than the window itself” (Holl, 1994, pp. 35).

However, while the phenomenological approach incorporates the five senses and their relation to an embodied experience, there is little in the literature which considers how this embodied experience may change with the impairment of one or more of these senses – a criteria of high importance considering healthcare architecture. As this process involves the perception of the individual to his or her environment, it must be argued that with an individual with a sensory impairment would experience the space in completely unique way compared to a ‘healthy’, fully functional individual.

2.2 Philosophy and Technology

In Martin Heidegger's essay, 'The Question Concerning Technology', he questions the relationship of human existence with the essence of technology. Heidegger (1977) points out that technological objects are means for ends and are built and operated by human beings, but the essence of technology is something else entirely. It depends on our manipulating of technology in the proper manner as a means. He explains how technology should be interpreted as a way of 'bringing-forth' or a 'way of revealing'. Bringing-forth becomes a method of bringing what is concealed into unconcealment, therefore revealing. This means that everything we perceive or think of or interact with "emerges out of concealment into unconcealment" (1977, pp. 5) in Heidegger's words.

Technology embodies a specific way of revealing the world, a revealing in which humans take power over reality. According to Heidegger (1977) the truth in the relationship between technology and "being" can be revealed through the use and manipulation of technological intervention. Technology can become a manifestation of the understanding of being if it is reliable but not a tool of enslavement.

Traditionally in the application of these theories and in particular when contemplating the use of a participatory design approach in architectural design, three key problems must be addressed. First, the proposed designs have been presented as a set of 2D plans, which are unreadable or as rendered images, which do not communicate the human experience; or as physical models, which can be both time consuming and expensive to construct, all of which can only be produced in the final stages of design (Bruno and Muzzupappa, 2010). Second, designers and the users do not share a 'common language' which complicates both communication and cooperation. Often, designers are forced to rely on questionnaires and interviews, which do not allow the users to fully express their opinions (Bruno and Muzzupappa, 2010). Third, users are rarely involved in the evaluation phase, which significantly limits their input.

Following from the philosophical and theoretical approaches of Pallasmaa, Holl and Heidegger, it becomes paramount that we embrace use of modern technologies, manipulating them of our own accord in order to understand the essence of an individual being. For these reasons, in order to utilise technology in the study of healthcare space, VR becomes a preferred technology to work as an instrument of revealing, simulating user conditions and exploring emotional responses that are induced in these spaces.

3. METHOD

In this study, a VR simulation was undertaken through the development of personas and narrative and by manipulating spatial variables to suit the impairment. First, the in-between spaces were created based on an existing emergency department. These were then manipulated following recorded interviews with four individuals with the named impairment. Participants were recruited through organisations established for their impairment, such as the Blind Foundation. The selection of impairment was derived from analysis of prevalence of impairments in the location of the subject hospital. Following a process of participation and co-design, these participants then validated the final simulated space in order to authenticate the representation of impairment. In anticipation of a wider test involving professional healthcare providers, the simulations were piloted on future designers. Eight non-impaired architecture students then virtually explored the interstitial spaces in the designed emergency department to simulate the experience of the designer. Questionnaires seeking to understand the emotion response before, during and after the simulation captured their experiences. Participatory design was implemented in two ways. First, the personas were developed through a participatory process where people with the impairments assisted in their development to enrich and elaborate on the experience of being in the space with an impairment. Second, a participatory process was used to modify the interstitial spaces so as to visually simulate the effect of the impairment.

3.1 Personas

In order to develop simulations, three personas (Table 1) were created based on existing disability statistics. Traits such a gender, age and reason for impairment were developed as representative of the wider demographic. Impairment types include deafness, visual impairment and autism spectrum disorder. Each of the personalities were given a full backstory in order to allow participant to sympathize and comprehend their world. Following the development of the personas, simulation settings were prescribed, altering the focus, the visual information and the audio effects in order to describe the unique sensory conditions of each. These would allow research participants to experience design variables from three different points of view.

Table 1: Personas

Name	Impairment	Sex	Age	Cause of Impairment
Finn	Autism Spectrum Disorder	Male	10	Existed at birth
Bernie	Deaf/Dementia	Male	75	Age related
Eliza	Visual	Female	21	Eye Disease

3.2 Narrative

Following this, it is imperative to understand the narrative of the emergency department – the process in which a patient follows upon entering the space. From this it will be possible to determine the key 'between-moments' and to analyse the sensory conditions in areas of high stress or high monotony. To understand this journey, the narrative was mapped with the assistance of hospital personal, from the patient's arrival at the emergency department until their departure (Figure 1). Moments of waiting and moments of significant movement were identified to become the 'between-moments'. To reduce the scope, a key phase was identified when the patient moves from the public waiting room to their bed. In this short phase, the patient experiences waiting, movement, a threshold and a moment of arrival allowing for a broad range of emotional responses. This phase becomes the section of the emergency department that has been simulated.

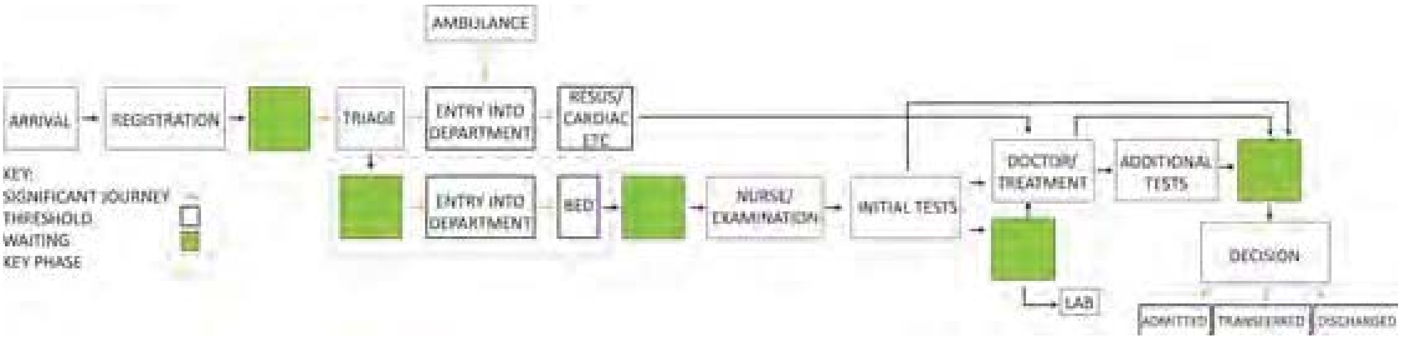

Figure 1 Emergency Department Narrative

3.3 Variables

Dependent variables were identified in relation to the perceptual systems (Table 2). Variables were selected in relation to the perceptual systems and to allow unique emotional responses for each of the personas. For each variable, there are three variations, which can be tested, with subjects choosing the best variation to suit their chosen emotion for each space.

Table 2: Design Variations and Simulations to test in

Design Variable		Simulation to test		
Variable	Perceptual System	Autism	Deafness	Visual Impairment
Lighting	Visual	Yes	Yes	Yes
Texture	Haptic	Yes	Yes	Yes
Orienting	Orienting	Yes	Yes	Yes
Acoustic	Auditory	Yes	No	Yes

3.4 Participants

For the pilot VR experiment, 8 subjects were chosen to participate in the study. By using a small number of participants, it allowed for the testing and validating of the method prior to a larger scale experiment being undertaken. All participants were over the age of 18 for ethics consideration, but as the subjects were experiencing the spaces as the personas rather than themselves, gender and age were irrelevant.

3.5 Materials

3.5.1 Equipment and Software

The VR equipment used was a HTC Vive with a 110 degrees field of view and tracking area are of 5 x 5 m. An Alienware Aurora R5 processor was connected to the VR equipment. Steam VR and Fuzor 2018 were used to run the experiment.

Simulation space was modelled with four elements; one of waiting, one of movement, a threshold and a destination (Figure 2). Waiting and destination spaces were modelled as a 4 x 4 m room, movement as a 2 x 3m space and the threshold as a 0.9 x 2.2 m opening. Greyscale material (r=200 g=200 b=200) allowed variations in white walls, providing a deeper understanding of the space and emotional impact. A single lighting system with constant brightness and colour was chosen to create consistent light dispersal over all spaces.

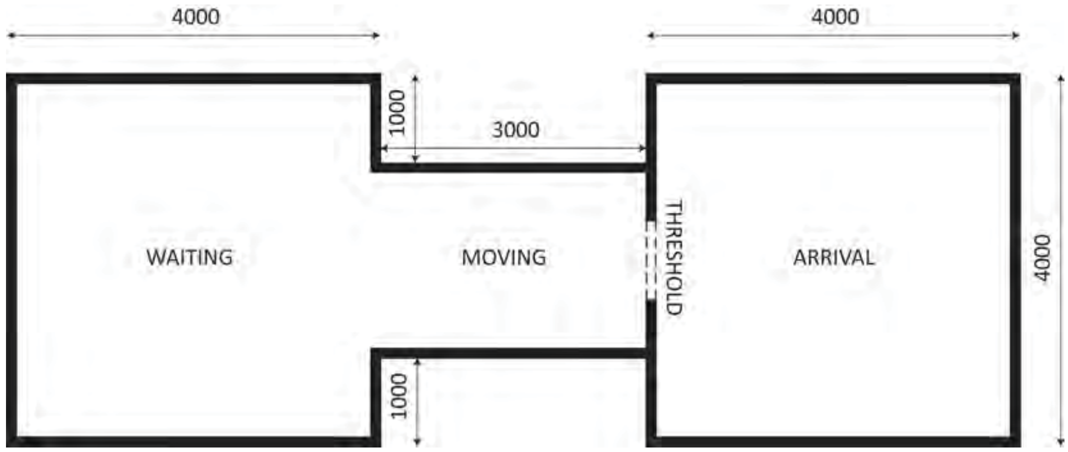

Figure 2 Plan of modelled space

Participants were able to walk through each of the spaces, swapping between the three personas in order to understand how each disability affects the perception of space and emotion. This was followed up with pre-experiment and post-experiment questions in order to analyse the emotional reaction to the design variations and how these emotions change between personalities.

Table 3: Questions

Pre-Questions	During	Post-Questions
Have you ever been a patient in an emergency department? What negative emotions would associate with each step of the narrative? What positive emotions do you think these can be transformed to?	What design variable best suits this positive emotion (for each of the perceptual qualities in each space)	How much influence do you think design variations have on emotional response (rate on scale of 1-5)

3.6 Procedure

Participants were individually introduced to the VR laboratory and asked to fill in the pre-experiment questions. Participants were provided with a list of 24 positive and 24 negative emotions to choose from and were told the background stories for each of the personas. The experiment process was explained and the subjects entered into the control simulation, beginning in the waiting space. For each of the variables, subjects tested the three design variations through the eyes of each persona, selecting those that best represented the positive emotion they wanted to establish in that space. This process was repeated as they went from waiting, to moving through a threshold and then reaching the destination.

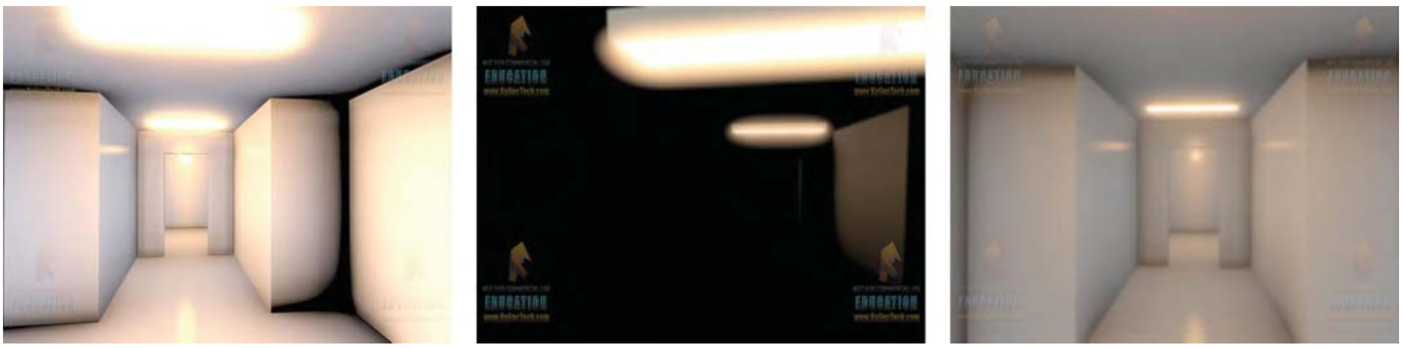

Figure 3 Simulation, from left to right: Autism, Visual Impairment and Deafness

4. FINDINGS

Results from the pilot study showed a direct correlation between the absence of the perceptual systems, the individual perception of space and how user emotions can be influenced by architectural design variables. The study found that participants initially associated emotions of envy, anxiety, insecurity and fear within the 'between-moments' of the emergency department narrative. Participant experience changed to emotions of confidence while waiting, courage as they moved; relaxation as they passed through a threshold and amusement at the point of arrival.

More specifically, when participants were experiencing Eliza, the visually impaired simulation, they found that lighting on a rougher texture gave her more visual information, increasing their sense of amusement and decreasing the sense of fear. When experiencing the spaces as Finn, light was seen with greater intensity. Participants found this increasingly apparent with light of 5,000-6,000 kelvin (fluorescent lighting), lighting which is commonly found in hospital environments (Table 4). This lighting quality increased participant feelings of anxiety due to the perception of overwhelming amounts of information. By changing the lighting to a warmer tone, the experienced emotion changed to one of courage. Participant opinion of the audio experience differed between the personas. For the autistic simulation (Finn), change in the intensity of the experience was reported where participants preferred a lower reverberation. In contrast, the experience of the visually impaired simulation (Eliza), participants relied on other senses to provide stimulation, choosing a higher reverberation to increase amusement.

Table 4: Example of one participants answers

Moment	Negative Emotion	Positive Emotion	Lighting (kelvin)	Texture	Audio (reverberation)
Waiting	Envy	Confidence	5000	Medium	0
Moving	Anxiety	Courage	4000	Smooth	0
Threshold	Insecurity	Relaxation	3000	Smooth	0
Arrival	Fear	Amusement	4000	Rough	50

Prior to the experiment, participants were often critical of the influences that design variables might have on emotion and were unsure if this would change with the addition of impairment. They found it useful knowing the background information of the personas they were embodying, including how long they had been waiting at the emergency department for and what the injury/illness the personas were there for. This additional information helped with the identification of initial emotions. Participants were also very curious about how the experiment would go, as many of them had not previously experienced VR. During the simulations, some participants reported mild feelings of dizziness while experiencing Eliza, the persona with visual impairment. This was due to the blurriness of the visuals and the inability to focus eyesight as this persona. Following the experiment, when asked 'how much influence do you think design variations have on emotional response', participants answered with either a rating of 4 or 5 indicating that the participant's opinions had changed. The use of the pilot study validated the proposed method, indicating that further experimentation would provide useful and applicable results for the design of healthcare architecture.

5. DISCUSSION

Participatory design is a well-established approach to design, which considers the users at the core of the design process. In this case, it gives healthcare professionals and patients a chance to affect the design developments and outcomes without the lengthy process often associated with traditional participatory design methods. Participatory design using VR as explored by this paper allows the designer to understand the emotional as well as the physical requirements that are held by this unique group of users. Conventional methods such as focus group interviews or questionnaires are too general for the specific stakeholders of emergency and healthcare spaces and a more focussed and fine-grained approach is required. In this way, VR can become an important medium in which a variety of participants can understand and experience the sensory conditions of others. It allows others to inhabit the space in each stage of design providing a heightened interface which can improve usability, simplicity and intelligibility of the architecture. It acknowledges that any design process that involves the participation of patients' needs to elicit their needs by considering characteristics such as their sensory conditions and their background as well as the simple pragmatics of moving them through a space. "Communication becomes a continuous process of perspective, conceptualisation and information exchange, always requiring interpretation and translation of both the designers and users" (Bruno and Muzzupappa, 2010, pp. 255).

The use of VR however, is not without limitations. The personas were developed with four individuals per impairment. These need further testing on a wider group of participants to validate the accuracy and clarity of the depicted impairments and their emotional response. The redesigned space that will follow on from the experiment will also require similar validation.

It is still limited in its simulation of sensory abilities as the program is currently unable to provide for the experiences of smell and taste. Similarly, the haptic experience is limited to a visual element and cannot simulate the experience of changes to air flows, surface temperatures, or the tactile feel of a surface. The experience of VR was further limited in this study due to access to the software used and what the programme 'Fuzor' was able to accomplish. Within the simulations, an inability to move fluently when transitioning from one space to another was limited as was the experience of the moment of moving through a threshold. The simulation also strays from a true emergency department experience by not being surrounded by other people and the associated movement and energy this brings. The experience of other people in this research was reduced to an audio component. Similarly, the simulations were also limited in the way they are able to mimic the impairments of the personas, only being able to simulate visual and auditory aspects of their impairments.

6. CONCLUSION

Impairment is a complex phenomenon, reflecting the interaction between the features of a person's body and the features of the society in which he or she lives. People facing impairment are not simply passive users of services and buildings, but can offer something powerful to architects and other building environment professionals if they are included and considered from the beginning phases of the design process. In order to meet the challenges of high density living, there will be an increased demand for new and better emergency departments. Emergency departments have one of the most diverse groups of users, experiencing permanent or temporary impairments that in the past have not been considered with respect to the design of interstitial or 'between-moments'.

This paper examined the use of VR as a technology to reveal and simulate the experiences of three different personas in this narrative. With this, it examined how design variables relating to the perceptual systems can influence the phenomenology of these spaces and therefore human emotion. The research found that despite limitations, there is significant potential for the use of VR and participatory processes, working with both people facing impairment and people in the general public in order to revise the design of these spaces. It found that by implementing these design methods, architects may be able to reduce distress, the increased anxiety, delirium and high blood pressure of patients.

The participatory approach allowed VR simulations to be developed, representing different patients and their unique sensory conditions in order to examine how these conditions alter the critical phenomenological and emotional experiences within the 'between-moments' of the emergency department. The use of a pilot study validated the proposed method, indicating that further experimentation would provide useful and applicable results for design of healthcare architecture. The results confirm that different design variables do have a significant influence on participant emotions, and that by adjusting these qualities with VR, the architect can explore and ultimately influence the way different users will experience the space.

Finally, the results demonstrated that the use of VR as a means of revealing and understanding human existence within space is valuable for interpreting the phenomenology of narrative and space, and how different design variables can evoke emotive qualities. The research confirms that VR can bridge the gap between philosophy and technology in order to design healthcare 'between-moments'.

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