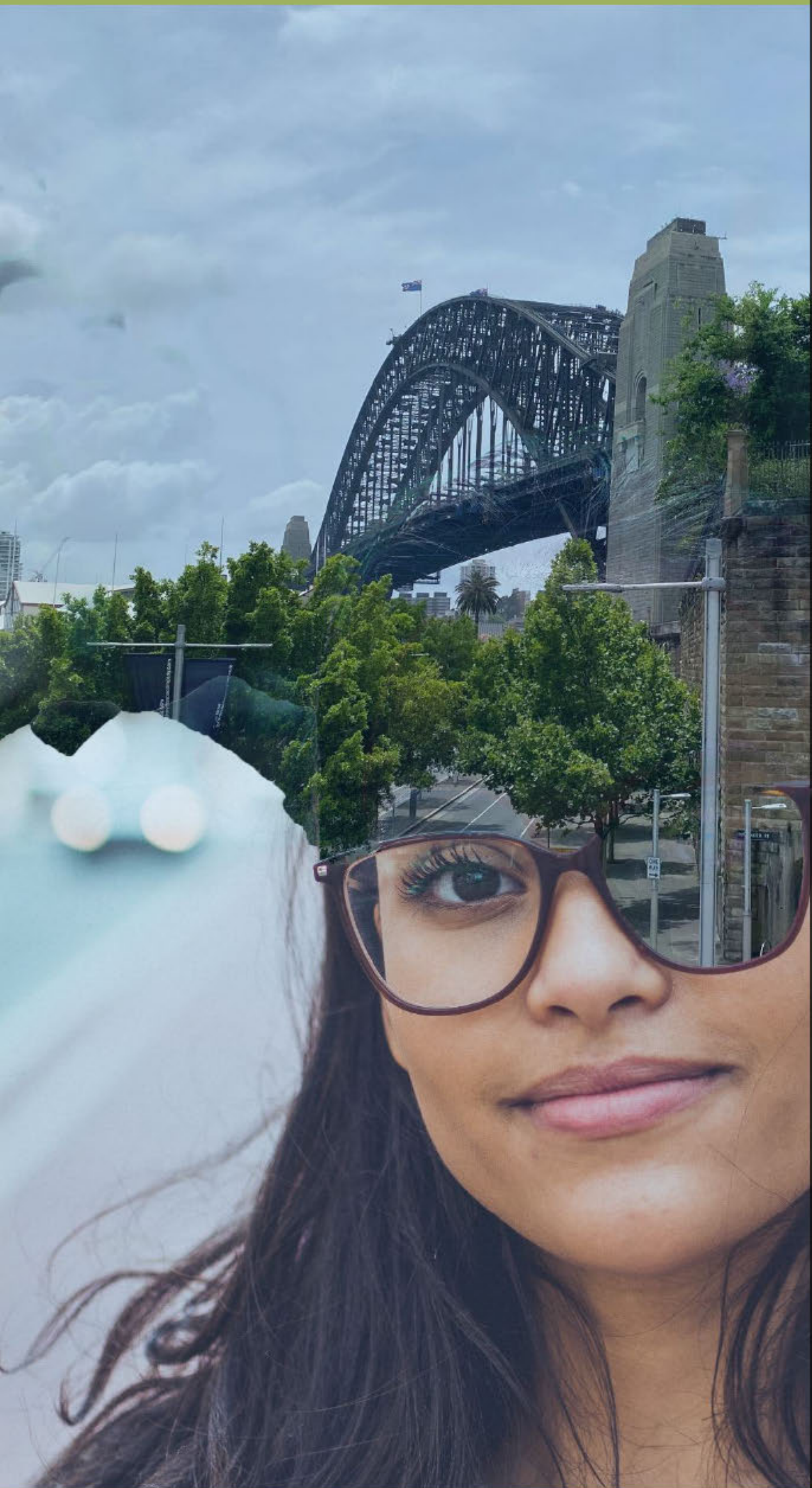

Embodied responses to the public realm: Applying embodied cognition to people's experience of public space

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A thesis submitted to fulfil requirements for the degree of Doctor of Philosophy

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School of Architecture, Design and Planning

The University of Sydney

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Originality Statement

This is to certify that to the best of my knowledge, the content of this thesis is my own work. This thesis has not been submitted for any degree or other purposes.

I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

Tanya Eldridge,
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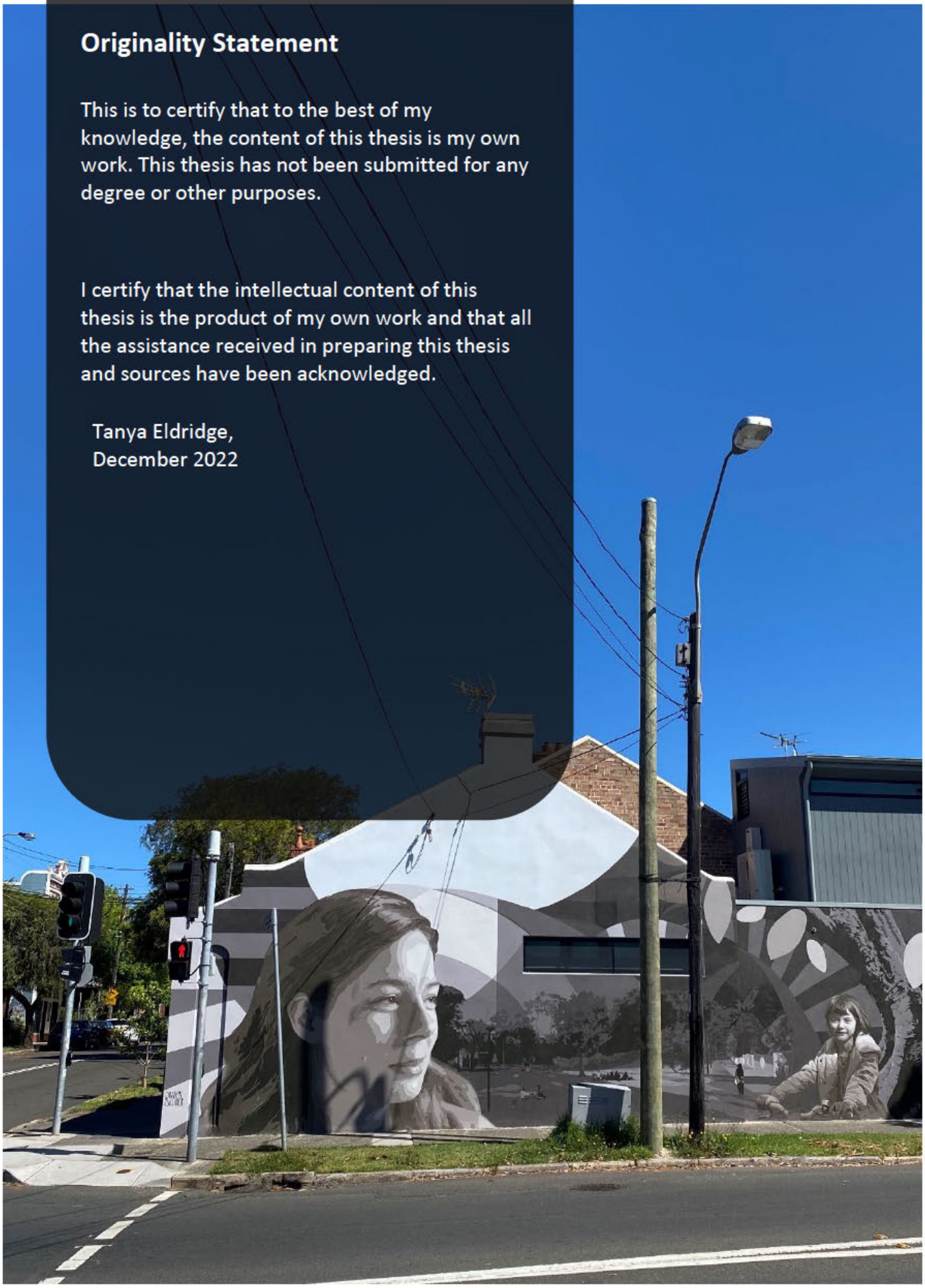

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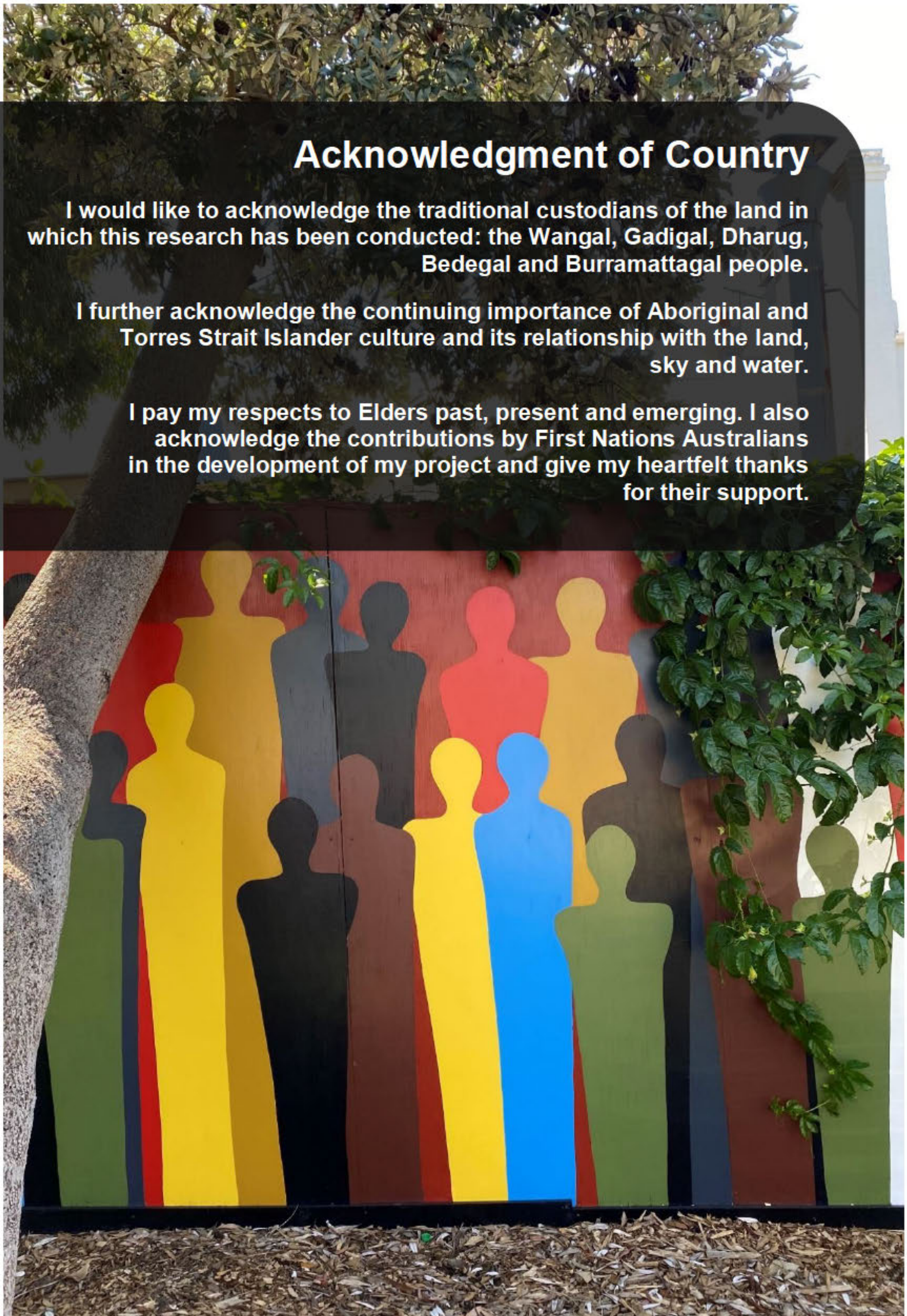
Mural: Billinge, S, 2019. https://sharonjbillinge.wixsite.com/sharon-billinge)

Acknowledgment of Country

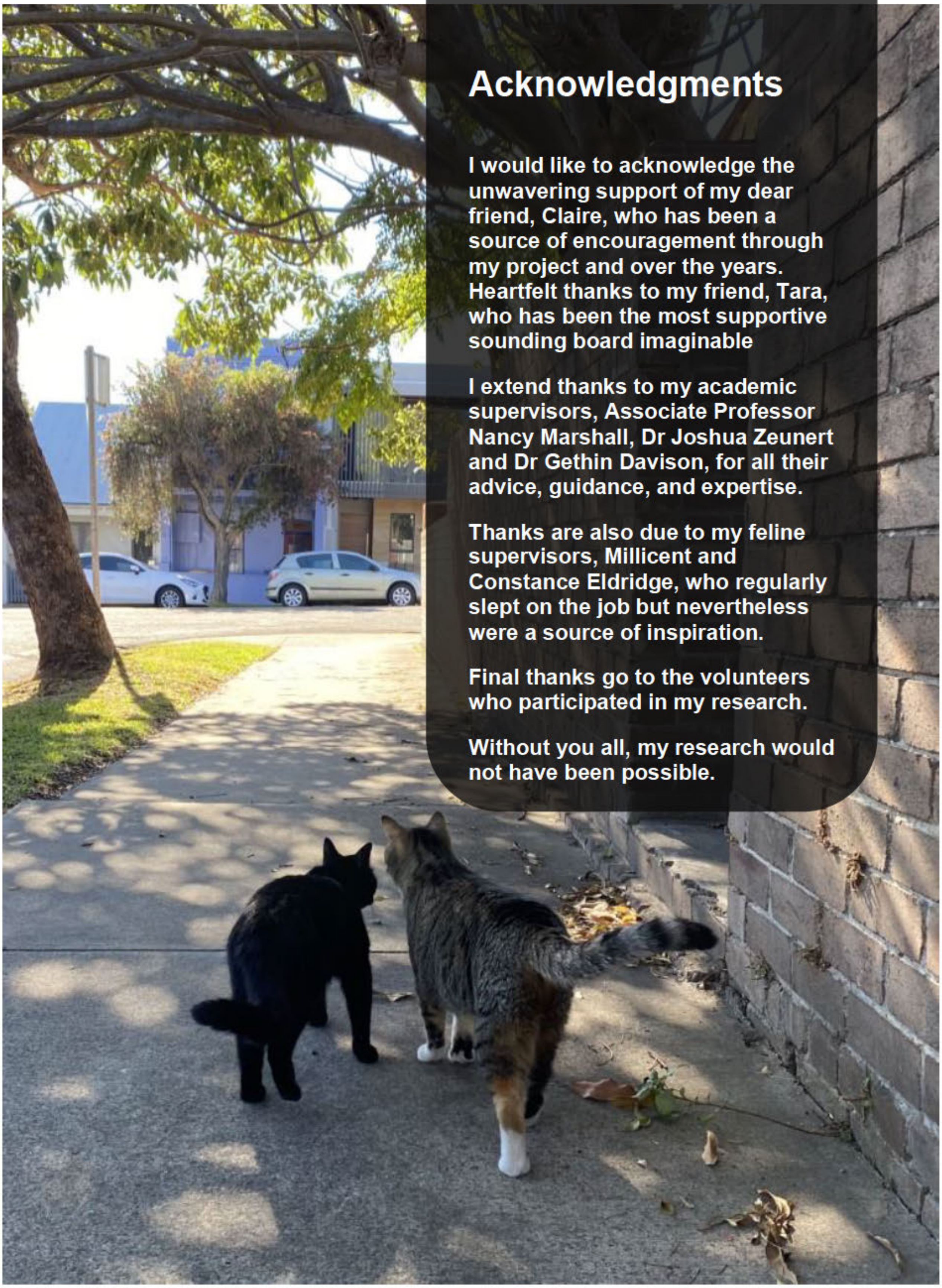
I would like to acknowledge the traditional custodians of the land in which this research has been conducted: the Wangal, Gadigal, Dharug, Bedegal and Burramattagal people.

I further acknowledge the continuing importance of Aboriginal and Torres Strait Islander culture and its relationship with the land, sky and water.

I pay my respects to Elders past, present and emerging. I also acknowledge the contributions by First Nations Australians in the development of my project and give my heartfelt thanks for their support.



(Photo: Eldridge, T, Hugo Street Reserve, Redfern 6/11/19
Mural: Brancroft, B & Jones-Evans, D, *United we stand, divided we fail…the future*, 2008



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Final thanks go to the volunteers who participated in my research.

Without you all, my research would not have been possible.

(Photo: Eldridge, T, left Constance Eldridge, right Millicent Eldridge, 6/11/19)

ABSTRACT

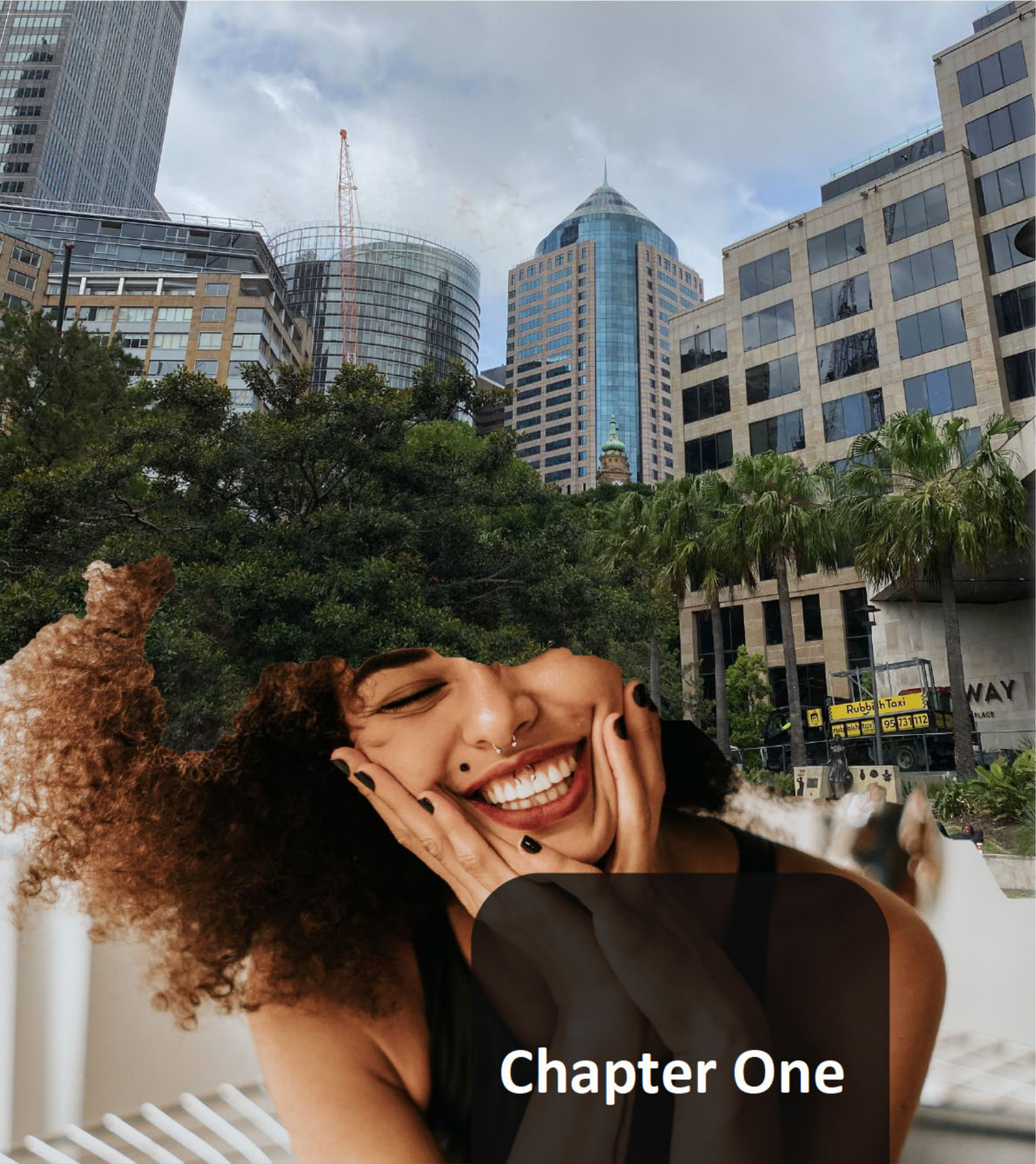
Public space plays a critical role in facilitating people coming together to participate in public life. While there has been an abundance of studies the examine what makes public spaces successful in drawing people to them and encouraging them to linger, there is still an overabundance of poor quality public spaces. The pressures of high density living and the COVID-19 pandemic have renewed focus on the important function of quality public space for the liveability of the city.

This thesis brings together a new mix of theories and new mix of methods to gain improved insights into how people experience and respond to the design of public space. Embodied cognition theory posits that our understanding is shaped by our bodily experience of the world around us and draws on cognitive science technologies to explore this phenomenon. Embodied cognition offers an avenue that addresses the shortcomings of existing urban theory that draws on phenomenological approaches to understand the people–place relationship. The practical applications of embodied cognition are demonstrated by a new mix of methods that combines measuring conscious responses to design through surveys and walking interviews while using an electroencephalography (EEG) headset that records the wearer's brainwaves.

This research involved 20 randomly selected participants wearing an EEG headset as they experienced two plazas, World Square and Darling Square, in the central business district of Sydney, Australia. Participants were asked to respond to survey questions that rated their positive attraction, stimulation, stress and relaxation when presented with key urban design elements in World Square and Darling Square. These survey questions directly mirrored the recordings taken by the EEG headset for positive attraction, stimulation, stress and relaxation.

This was undertaken to capture both a conscious response through the survey to contrast with the unconscious response from the EEG headset.

The range of key design elements at World Square and Darling Square were expected to elicit different responses from participants; however, the data collected does not always show participants responding as anticipated. It was expected that participants would feel a stronger positive attraction and be more relaxed in response to the design of Darling Square over World Square, yet this was not true of the EEG data. The findings of this experiment demonstrate there is a promising foundation to apply embodied cognition theory and EEG into urban studies. In particular, EEG may be especially useful in understanding design elements that elicit stress and bodily stimulation, however, further study is needed to understand other unconscious responses.



Chapter One

Introduction

CHAPTER ONE – INTRODUCTION

INTRODUCTION

Built environments around the world share a common trait: they are mostly human-made environments. This is a noteworthy characteristic as it highlights that we, as humans, have the capacity to shape urban spaces into the forms that best suit our needs. While people have a diverse range of needs depending on their circumstances, there is also a common experience all people share: the world is experienced through our bodies in the environments we inhabit. As such, gaining insight into the relationship between people and places is key to understanding how to design places that suit people's bodily experience of place.

Person-centred design is not a new idea. There have been studies and theories beyond counting attempting to explain the relationship between people and place. Despite this research and improved approaches to design, there are countless places around the world that fail to engage people. There is further work to be done to gain insight into the relationship between people and place.

This research aims to find new understandings by broadening the scope of theory and practices used to analyse the relationship between people and place by combining existing urban studies with a field of the cognitive sciences known as embodied cognition. Embodied cognition theory and research methods (such as electroencephalography (EEG) and functional magnetic resonance imaging (fMRI)), when used in combination with existing urban theory and research, provide the opportunity for new datasets on people's responses to place. This is demonstrated in practice using two case study sites from Sydney, Australia, as examples of how embodied cognition can offer new understanding of people's response to place. While this research has been conducted in Australia, there are wider implication for the theoretical understanding of people's relationship of place and also planning and design practices globally.

SOCIAL CONTEXT

The role of the public realm in supporting public life is arguably becoming increasingly important in the wake of growing high urban density, rising urban isolation and the proliferation of privately owned public spaces. Public life is played out on the stage of the public realm. The plazas, parks, streets, and lanes that make up the public realm in cities are the scenes in which we live our public lives. It is in these environments that we see other people and we ourselves are seen, that we meet other people, both through chance encounters and planned engagements.

Increasing urban density goes hand in hand with a decreased level of private open space[1], putting additional pressure on public space as private ownership brings increased regulation of public life (Carmona 2010). Private owners are legally able to exercise control over the spaces by, for example, prohibiting activities like skateboarding, photography, protesting, or rough sleeping. Banning certain activities can effectively be a ban of some social groups, like people experiencing homelessness from the area.

The estrangement from local communities can further exacerbate urban isolation. Patterns of housing and accommodation have shown a rising prevalence of single-person households. There is also an increasing number of young families with children living in apartments who rely on public open space for their recreation (Nguyen et al. 2020). For these sorts of households, the importance of public space cannot be understated as it is often a primary setting for their social interactions. Without ready access to quality public spaces, people can further withdraw from their communities and risk urban isolation, which has been linked to

[1] Note that the two case study sites, World Square and Darling Square, are both privately owned public space.

adverse health repercussions such as depression and anxiety for individuals, and leads to a less healthy, less connected community at a larger scale (Jackson 2003; Klinenberg 2001).

The quality and quantity of open space is further challenged by the increase of private ownership of publicly accessible spaces. Private ownership of public space is often criticised for undermining the value of public space through increased regulation in the use and behaviour allowed in these spaces. Private ownership can further impact on the accessibility of these spaces as owners are able to close off areas for private events or permanently restrict access to all but a select (usually affluent) group (Atkinson 2003; Carmona, de Magalhaes & Hammond 2008).

Previous research has identified aspects of design that can be found globally that impact people's responses to space. A sense of order, readable patterns, openness, natural elements, good upkeep and liveliness have been found to elicit positive responses from people while disorder, senses of exposure, and overly fabricated and derelict design tend to elicit negative responses (Alexander, Ishikawa, & Silverstein 1977; Gehl & Koch 2006; Jacobs 1962; Nasar 1998). Yet despite extensive investigation into public life and the design of public space, there continues to be poorly designed public spaces worldwide. While it is not the intention of this study to re-examine these trends, as they have already been well documented by others, it is important to note that despite the wide range of research already conducted, poor quality space in the public realm remains as pertinent a problem as ever to planners.

RESEARCH STATEMENT

Public spaces have an important role to play in facilitating a sense community, as public space offers a forum for human connection that has become increasingly important in the context of the COVID-19 pandemic. Social isolation and changed work patterns have increased reliance on public space, especially in areas with high density dwellings. Given the centrality of public spaces to the quality of people's lives, there is a clear need to continue improving our understanding of how people respond to different elements of design in the public realm. To this end, this thesis seeks to deepen our understanding of the interrelationship between people and place by drawing linkages to theories that have not been widely used in urban studies.

This research hypothesises that new insights regarding people's responses to design can be found by combining existing urban studies with the cognitive sciences, in particular, embodied cognition theory. The central supposition of embodied cognition is that while the brain plays a critical role in processing inputs and stimuli, it is not the sole resource at our disposal. The body also plays a role in creating our perceptions of the world (Jasanoff 2018). Mind and body are viewed as a single entity in embodied cognition, which interacts with the environment to shape our perception. Therefore, the research methods seek to gather information from the brain, the conscious mind and the body as people experience public spaces in the city.

As such, the core research question this thesis asks is:

To what extent can embodied cognition be used to better understand how people experience and respond to the design of the public realm?

The central research question is addressed through four sub-questions. Namely:

1. What is embodied cognition and how has it previously been used to understand the relationship between people, the mind and the environment?
2. How have urban theorists predominantly studied people's responses to place and what are the limitations of theorists' current understanding of space?
3. What are the key design features of public plazas as an example of public space, which we understand as eliciting positive and negative responses?

4. What new data can EEG provide on how people experience and respond to design elements in public space?

By addressing each of these sub-questions within this thesis, I illustrate the opportunities to use embodied cognition to better understand how people respond to the design of the public realm.

CONCEPTUAL THEORIES USED

Embodied cognition theory is introduced into the study of the built environment by this thesis. While to date the cognitive sciences have not been widely utilised by urban theorists, this research posits that it has a role to play in increasing our understanding of people's responses to the design of the public realm. These theories are explored extensively in Chapters Two and Three, but are briefly described here to provide context to this thesis.

Embodied cognition is a school of thought that looks at the role a person's environment plays in developing one's cognitive processes. Embodied cognition theory holds that our mental representations of the world can be influenced by states of the body (Varela Thompson & Rosch 2016). In its broadest sense, embodiment refers to the way that people's sensory capacities enable us to interact with and be shaped by the places in which we live (Jasanoff 2018). Cognition is a process for gaining knowledge and understanding through experience and thought. Combining embodiment with cognition gives us insight into the way mind, body and world mutually interact and influence each other to produce a person's experience of their environment (Turner 2011).

Embodied cognition treats the body and the environment as critical parts in forming our perception and understanding. Cognitive activity is situated within the environments we encounter in our everyday lives and influenced by our actions within these environments

(Wilson 2002). This focus on the people in their environment would suggest that embodied cognition is a useful lens with which to approach this question.

Among urban theorists, there are already many lenses used that examines people's responses to the design of public spaces. Designing the built form in response to the human body can be traced as far back as circa 50 BCE to Vitruvius, who asserted that beautiful, engaging design must be based on the symmetry and proportions of the human body. Immortalised in Da Vinci's Vitruvian Man, this image illustrates the correlations of the human body's proportions within geometric shapes to explain people's preference for geometric designs. Da Vinci's diagram shows how Vitruvius's definition of the parts of this idealised body can work as units of measurement in architectural design to directly link the human body into the design of places (Hight 2007; Vitruvius 2020.

The metaphoric understanding from the Renaissance that the earth was modelled on the human body was expanded upon by Porteous (2008). Porteous investigates perception of place through both sensory and existential approaches. He explores the experience of smellscapes and soundscape as well asmetaphoric understandings of the body as a bodyscape and the mind as an 'inscape'. Tuan (1975) also used the classical understanding of the body/world relationship from the Renaissance and earlier historical periods as examples to illustrate his own analysis. Tuan links perception of place through the lenses of sensory perception, cultural influence, social needs and historic context. More recently, noteworthy theorists such as Gehl (2011; Gehl & Svarre 2013) have drawn connections between people's sensory experience and their responses to activities and physical elements in public spaces. Theorists such as Nasar (1998) have sought to identify which key design features are more likely to elicit positive or negative responses.

The foundations of embodied cognition are rooted in phenomenology, with particular influence from early phenomenologists like Husserl and Merleau Ponty (Barbaras 2002; Varela

1996). This base of phenomenology provides some common ground with existing urban research. There is a wealth of phenomenological studies of the body moving through urban environments and research that focuses on sensory experience, especially the visual and auditory aspects of the city (Kang 2007; Lefebvre 1991; Yang et al. 2021). Embodied cognition takes this approach a step further by incorporating understanding from neuroscience (Borrett, Kelly & Kwan 2000a, 2000b; Carel & Meacham 2013; Harney 2015; Petit 2014; Toadvine 1999; Whitehead 2015). This research posits that many urban theorists and designers have been able to intuit people's preferences for urban design through these methods. However, the advances made through cognitive science now provides us with an opportunity for new insights through the use of new technology, especially EEG monitoring.

RESEARCH DESIGN & METHODS

An innovative mix of methods has been used to gather data on people's responses to design elements in the public realm. This research combines lived experience through case studies, conscious responses through walking interviews and surveys, and unconscious and physiological responses through the use of EEG monitors to record participants' brainwaves.

Two case study sites have been selected in Sydney, Australia's central business district: World Square and Darling Square. These plazas are located close to each other, and both have a mix of design elements that elicit a range of responses from the people experiencing these places.

Participants' conscious responses to the design of these two plazas were recorded through walking interviews to track their narrative understanding of place. At key points of the walk participants were asked to quantify their responses to various design features. The survey questions directly mirrored the data captured by an EEG.

Participants' unconscious responses were captured through the use of an EEG headset, which was worn throughout the experience to track changes in the participants' brainwaves as their attention was drawn to different aspects of the case study sites design.

These datasets were then compared to build a nuanced examination of people's responses to design elements. This approach brings together data collected through well-established place study methods and the innovations offered by EEG measurements to create new insights.

RESEARCH SIGNIFICANCE

As mentioned above, although extensive research and analysis has been undertaken to understand how we can improve the public realm and what styles of design can appeal to people, there is still an overwhelming surplus of poorly designed places that fail to foster public life (Lang & Marshall 2016). As the problem of poor public space continues to hamper communities around the globe, we must expand our scope of analysis to explore new avenues for understanding.

Scientific advances into cognitive sciences have now opened up new research methods, such as EEG headsets, which are the focus of this study. There are also other technologies that measure the body's physiological responses as a means to understand emotional responses, such as galvanic skin response, which tracks sweat gland responses, and blood volume pulse readings, which track heart rate as sweat production and heart rate are linked to emotional responses. There is now a range of EEG headsets that are commercially available and affordable, able to be used without specialised training, and safe and non-invasive for participants to wear while performing activities in daily life. The ability to have participants wear EEG monitors in situ provides an opportunity to gather data on people's responses – both conscious and unconscious – in real time as they interact with the diverse range of stimuli we encounter when immersed in public life.

THESIS ORIGINALITY

There are theoretical and methodological implications from this research. Highlighting the connections between embodied cognition and place studies offers a new mix of theories, while combining standard methodologies and research methods used in the cognitive sciences with urban research practices provides a new mix of methods that can be used to gain greater insight.

In terms of theory, this project shows that embodied cognition is a useful school of thought that can be applied to urban design in order to elicit improved responses from people. This addresses an existing gap in current literature, which is only in its infancy in terms of incorporating embodied cognition into our understanding of people's relationship with their environments. The majority of studies that have begun to draw linkages between the cognitive sciences and place studies have tended to focus on people's responses to the natural environment rather than a range of design elements (Berman, Jonides & Kaplan 2008; Neale et al. 2020).

Embodied cognition is a relevant school of thought to urban design given its focus on the impact of the environment on people's perception of the world. As mobile, affordable technologies have now become commercially available, there is now an opportunity to bring embodied cognition into urban design in ways that have previously not been practical or affordable to pursue. This is demonstrated through the literature review and case studies.

There are methodological implications as introducing EEG monitoring into this research, and neural activity opens new avenues for understanding how people engage with the built form. Strengthening the links between urban design and embodied cognition has the capacity for long term improvement of the design of the built environment as it provides an interdisciplinary evidence basis for people's perception of the built form. Successful designers may have been able to intuit people's general response to certain types of design but bringing in EEG monitoring provides new evidence on how accurate this intuition has been. Continuing to combine these disciplines in line with scientific advancements provides ongoing opportunities to use this knowledge to further refine person-centred design.

THESIS STRUCTURE

This thesis will present this research over the course of eight chapters. Chapter One, the present chapter, introduces the key focus of the research by outlining the question to be answered and identifying the main theories and methods that are explored in this thesis.

Chapter Two is the first instalment of the literature review, which introduces embodied cognition's central philosophical tenets and how it incorporates cognitive science to support its theory. This chapter further introduces what EEG is and the data it can gather from people's brainwaves. As this thesis has a dual original contribution of introducing a new combination of theory and new mix of methods, the literature review covers a wider scope to demonstrate the relationship of innovative research methods providing further insights to theory. The phenomenological roots of embodied cognition are discussed with a view to show how embodied cognition can directly address some of the limitations of a strictly phenomenological approach. The relationship between embodied cognition and phenomenology is used to illustrate the scope for neurourbanism as an emerging academic discipline, which promotes an interdisciplinary approach to studying people's responses to urban environments.

Chapter Three is the second section of the literature review. Chapter Three builds on Chapter Two by delving into literature that focuses on our existing understanding of the interrelationship between people and their environments. Three areas of urban study, namely cognitive mapping, attention restoration theory, and rhythmanalysis, which have already begun to incorporate EEG and other methods from cognitive science, are discussed. This provides the understanding of the potential these methods have for expanding current research practices used to analyse people/place relationships. Chapter Three then explores the key design features within public space that this research is analysing through a mix methods approach. This is done with a focus on the public realm and its role in public life. Plazas are used as a microcosm to unpack specific design elements that are generally believed to elicit positive responses from people as well as design elements that can elicit more negative responses from people interacting with them.

Together, Chapters Two and Three provide the theoretical foundations to address each of the sub-questions while the remaining chapters deliver practical insights to illustrate the theory through the experimentation. This new combination of theories addresses a gap in existing literature and will be one of the two contributions this thesis makes. Chapters Four through Six then demonstrate how embodied cognition can act as a useful lens to understand people's responses to place through the adoption of EEG as a research method to address the limitations of methods such as interviews and surveys.

Chapter Four explores the research design used to combine research methods from both the cognitive sciences and urban studies. Method 1 EEG is used as a quantitative method to record participants' unconscious response to design elements. Method 2 Survey is used in parallel with Method 1 EEG as a qualitative method to capture participants' conscious response to the same design elements. Method 3 Walking interviews are used as a qualitative, phenomenological approach to explore participants' narrative accounts of their responses to the design elements. The design of this research is unpacked to show how each method was used in this study, how the data was recorded, and the strengths and limitations of this approach. This clearly sets out one of the two key contributions made by this thesis: that an innovative mix of methods can be used to improve our understanding of people's responses to place.

Chapter Five is devoted to the first case study site, World Square, Sydney, Australia. This chapter provides a description of the site, its context, and the design elements to which the participants are responding. The data collected through Method 1 EEG, Method 2 Survey and Method 3 Walking interviews is provided. These findings are analysed with reference to the key theorists discussed in Chapters Two and Three.

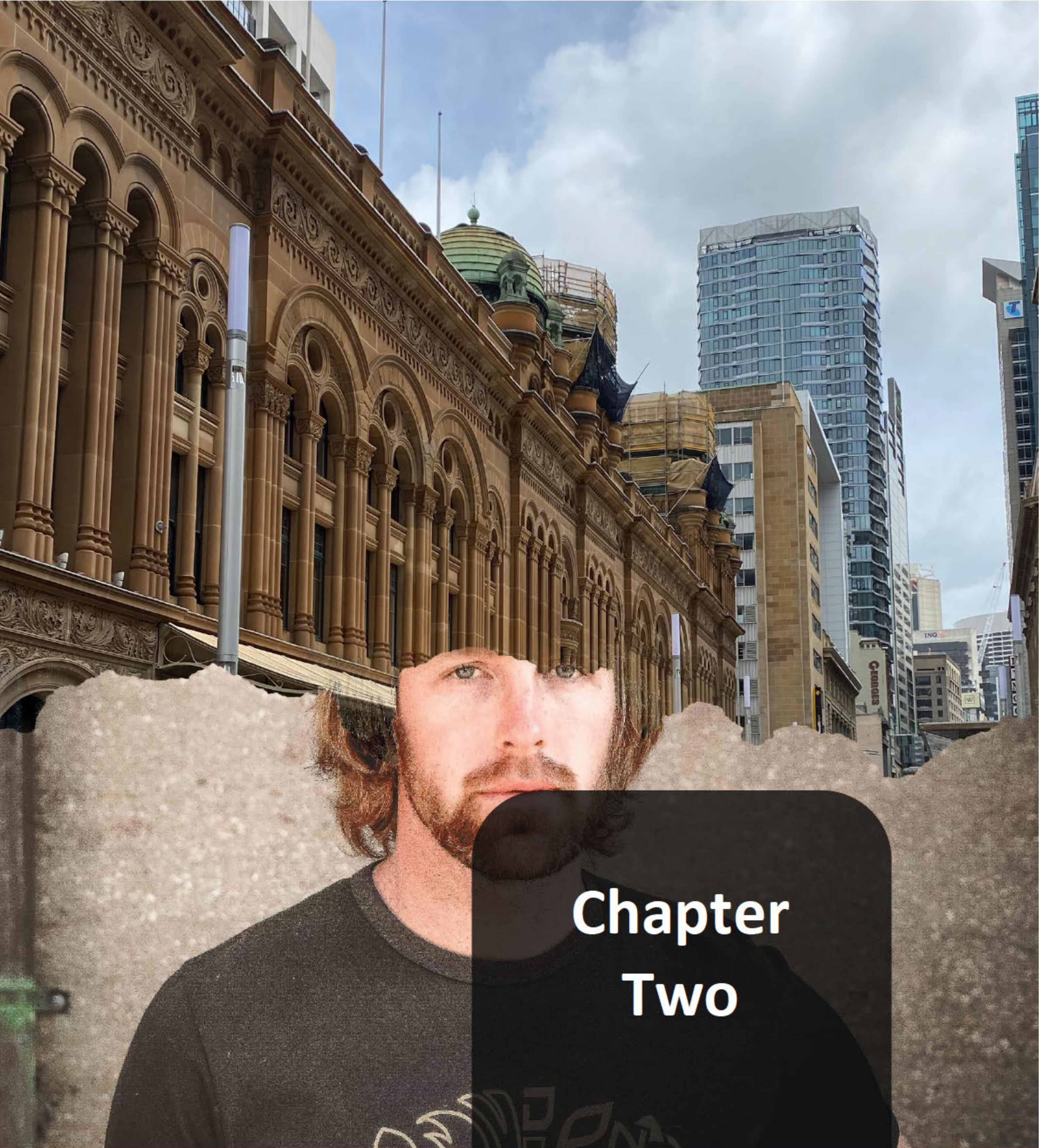
Chapter Six follows the same structure as Chapter Five but turns to the second case study, Darling Square, Sydney. Chapter Six provides a description of Darling Square, its context, and the design elements to which the participants are responding. The data collected through Method 1 EEG, Method 2 Survey and Method 3 Walking interviews is provided. These findings are analysed with reference to the key theorists discussed in Chapters Two and Three.

Chapter Seven compares and contrasts World Square and Darling Square to identify the similarities and differences between their respective design features. The data collected from each site is presented side by side to show the difference in people's responses when presented with contrasting design features. This comparison highlights the influential role design elements can have in shaping people's experiences of place in the public realm. This chapter revisits theoretical literature and combines the learnings of Chapters Two and Three with the findings presented in Chapters Five and Six to provide a fulsome answer to the central question: to what extent can embodied cognition be used to better understand how people respond to the design of places in the public realm.

Chapter Eight is the concluding chapter, which restates each of the sub-questions posed by this thesis and how each has been responded to over the course of the preceding chapters. This approach draws on the conclusions from the preceding chapters to show how the two academic contributions of this thesis have been established. Firstly, that embodied cognition can be combined with place studies to improve our understanding of people's responses to place and, secondly, that a new mix methods approach that integrates EEG with surveys and walking interviews can provide new datasets that offer an original contribution to academia to in terms of better understanding people's responses to the design of the public realm.

CONCLUSION

Chapter One has set out the road map for this thesis by introducing the aims of this research, namely, to determine to what extent embodied cognition can be used to better understand how people respond to the design of the public realm. The key theories have been briefly introduced as well as the research methods that will be used to test how embodied cognition can be practically applied to researching people's response to design.



Chapter Two

Literature Review

CHAPTER TWO – NEUROURBANISM: TOWARDS AN EMBODIED UNDERSTANDING OF PERCEPTION OF PLACE

INTRODUCTION

This thesis brings together embodied cognition and studies of people's responses to place and design elements. To explore these areas of study, this literature review is divided into two sections. Firstly, this current chapter introduces embodied cognition and contextualises it within the emerging academic discipline of neurourbanism. The second part of the literature review in the next chapter applies embodied cognition to studies on people's responses to place and design elements. Combined, these two chapters discuss how embodied cognition can be used to further extend our understanding of people's relationship with their environments.

As mentioned in Chapter One, the first sub-question of the thesis is:

> **What is embodied cognition and how has it previously been used to understand the relationship between people, the mind and the environment?**

This chapter explores what embodied cognition is by discussing the philosophy and the scientific approaches used within embodied cognition studies. The central theory, as initially introduced by Varela, Thompson, and Rosch's *The Embodied Mind* (1991) is explained to provide an understanding of how people's perception is shaped by their movement within the world. This theoretical introduction is then expanded upon by outlining how embodied cognition incorporates empirical studies of the brain's neurons to support its central tenants of philosophy. As this research advocates the use of EEG, the role of EEG in embodied cognition studies is illustrated by the 'sword and shield hypothesis' (Brookshire & Casasanto 2012), which utilises EEG to analyse how the brains functioning may have been influenced by people's movement.

The second sub-question, as noted in Chapter One, is:

> **How have urban theorists predominantly studied people's responses to place and what are the limitations of theorist current understanding of space?**

This is be addressed in both the present chapter and with literature from Chapter Three. This chapter discusses how phenomenological approaches have been used widely to understanding people's perception of the world within urban studies. Embodied cognition has its roots in phenomenology, drawing of theorists such as Husserl and Merleau Ponty, while simultaneously looking to biology and neuroscience to use empirical evidence to ground theory. This thesis argues that there is scope to naturalise phenomenology through embodied cognition. While phenomenology has been a useful approach, there are limitations on how far our understanding can be extended while using a purely phenomenological approach. By discussing what phenomenology is and its limitations, I make the case that using embodied cognition is an opportunity to gain new insights into people's relationship with the world they inhabit.

The opportunities for new insight through adopting research methods from the cognitive sciences to understand people's responses to place has opened a new academic discipline: neurourbanism. The foundations for an embodied understanding of urban environments has been laid by key theorists, including Gehl (2011), Lynch (1960), and Jacobs (1962), who identify the important role of sensory stimuli in fostering engaging environments. Additionally, the wealth of existing phenomenological studies has provided a sound base for embodied cognition to build on. Neurourbanism takes the next step by using an interdisciplinary approach that includes the social sciences and cognitive sciences to provide a holistic perspective. Neurourbanism is then contrasted with smart cities studies to demonstrate the different ways wearable tracking devices are being used to gather data on people's responses to urban environments.

AN OVERVIEW OF EMBODIED COGNITION'S PHILOSOPHY AND SCIENCE

This section responds to the sub-question: **What is embodied cognition and how has it previously been used to understand the relationship between people, the mind and the environment?**

Embodied cognition is a diverse field of study that draws from phenomenology, psychology, biology and neuroscience to conceptualise the 'mind of life' by bridging the subjective and objective. To understand how embodied cognition brings together these diverse basses of knowledge, the section first introduces the philosophy of embodied cognition and then expands how empirical scientific studies have been incorporated to support embodied cognition theory.

THE CENTRAL PHILOSOPHY OF EMBODIED COGNITION

This section explores the core philosophy of embodied cognition by defining what embodied means and how movement through the world forms perception. This also introduces the key theorists within embodied cognition, including Varela, Thompson, and Rosch (1991), Clark (2008), Gibson (1968), Noë and O'Regan (2001).

In its simplest form, embodied cognition is the theory that the mind is connected to the body and the body can influence the mind (Carsetti 2010). This means that our cognition is not limited to the physical structure of the brain. Embodied cognition theorises that our cognition is influenced, if not determined by, our lived experience of the world (Carsetti 2010).

Embodiment, as it was defined by Varela, Thompson, and Rosch, has two main properties:

> First, that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual

> sensorimotor capacities are themselves embedded in a more encompassing biological, psychological, and cultural context. By using the term action we mean to emphasize once again that sensory and motor processes, perception and action, are fundamentally inseparable in lived cognition. (1991, p. 173)

To unpack this definition, the body is firmly positioned as the central conduit for experiencing and understanding the world given the body's ability to receive and interpret sensory input while moving through the environments of daily life. Both perception and motion are bound together in a tight loop to form a lived understanding of the world. As a body moves through an environment, new opportunities for interaction are available; in practice, motion shapes perception, which in turn influences motion, which impacts future motion, and so on in a perpetual system of cognition. In short, perception and action are bound inseparably in that they determine each other through lived experience (Varela, Thompson & Rosch 1991).

Thorough this definition of embodied cognition Varela, Thompson and Rosch (1991) move away from the traditional objectivist and subjectivist positions of Western science and philosophy to find a middle route, which they call 'enactivation.' Enactivation recognises that our understanding is not a depiction of a pre-given world by a pre-given mind. Instead, our understanding is an enactment of a world and mind formed through its history of experience and actions performed by being in the world.

While Varela, Thompson and Rosch's (1991) conception of embodied action has been largely accepted, the introduction of enaction has been the catalyst for rethinking the relationship between perception and sensorimotor functions, in particular, how an individual's sensorimotor capacities are embedded in a shared biological, psychological and cultural context. Given the unique, personal experience of each individual can vary significantly, the mechanism for defining a shared reality remains rather vague using this definition. By positioning cognition in terms of embodiment within the individual, Varela, Thompson and

Rosch (1991) reject any possibility for a ‘pre-given’ world and understanding is constituted through lived experience.

It is important to note that rejecting a pre-given world is a controversial stance to take within the psychological sciences. This is demonstrated by the responses to Pinker’s (2022) *The Blank Slate*, in which Pinker argues for the relevance of biology to an understanding of inequality, violence, gender, and other key social and political issues. This position has been met with strong criticism (Eoyang 2007, Evans 2004, Keil 2004, Schlinger 2002) for not adequately considering existing theorists such as Hume (2009) and Locke (1982). Hume and Locke view human nature in line with phenomenology theorists that posit our understanding of reality is gleaned through sensory experience but note that these senses are unreliable and can result differently for different people. Critics of Pinker argue this is not the same as having a ‘blank slate’ as Hume and Locke believed each person had inherent properties or characteristics that impacted how sensory stimuli was interpreted.

The philosophical discussion on embodied cognition has been influenced by Clark (2008), who has tempered Varela, Thompson and Rosch’s (1991) stance of positioning the body as a container for the brain by established key elements with embodied cognition theory that recognise a more equitable partnership between brain and body in the production of cognition. While the body maintains an essential role in determining sensory experience, Clark (2008) hypothesises that brain and body share the processing of sensory inputs and structuring of information. The key elements from Clark (2008) most relevant to this study are information self-structuring, open channel perception, and perception as sensorimotor experience. Each of these elements operates on the assumption that brain, body and world as so inextricably linked that drawing distinction between these elements would be problematic.

Rooted in Gibson's (1968) theory of perception, information self-structuring posits that perception is an active process that depends on the ability to move within an environment to discover the range of stimuli. Being able to touch, move, and generally interact with the environment creates the information structures of perception. The self-structuring element refers to the individual's perception of the interaction and that it is through their own personal experience that the perceptual systems are continually being built and refined (Goldman & de Vignemont 2009).

Open channel perception focuses on navigational perception in terms of connection to the world. Other theories of navigation hypothesise that wayfinding relies on internal representations of the environment that one uses to mentally plot a course and that surroundings are only occasionally referenced to ensure progress matches expectations of the mental route. Open channel perception emphasises continual perception of the world. As the name suggests, the channel of perceptual system refers to a constant state of perception of the world and individuals act in the moment rather than following a pre-prepared mental script (Shapiro 2019).

First introduced by Noë and O'Regan (2001), the concept of perception as sensorimotor experience theorises that interaction with the world creates certain expectations on how movement will impact an individual's experience. Touching and moving various objects builds expectations about how objects should look for future interactions with comparable objects and, therefore, explains why things look the way they do. The significant aspect of this theory is that it challenges the idea that the brain is the locus for perceptual experience; instead, it highlights the importance of the body being in constant tactile relationships with the world to establish perception. Under this theory, bodily movements do not simply influence perception experience or mental states. Bodily actions constitute perceptual experience (Noë & O'Regan 2001; Goldman & de Vignemont 2009).

THE SCIENTIFIC BASIS OF EMBODIED COGNITION

This section sets the foundation for understanding the relationship between theory and science within embodied cognition. Canonical and mirror neurons are explained in terms of their role in the perception of objects and actions. Linkages are then drawn to Husserlian phenomenology, which is a foundational theory within embodied cognition. This will demonstrate how embodied cognition brings together philosophy and science in understanding people's perception of the world.

Embodied cognition extends beyond philosophy and into the cognitive sciences, where it draws on empirical research to ground its theory. This connection between philosophy and science in shaping cognition is described by Lakoff and Núñez (2000, p. 42) as follows:

> Cognitive science calls this entire philosophical worldview into serious question on empirical grounds [...]. [The mind] arises from the nature of our brains, bodies, and bodily experiences. This is not just the innocuous and obvious claim that we need a body to reason; rather, it is the striking claim that the very structure of reason itself comes from the details of our embodiment [...] Thus, to understand reason we must understand the details of our visual system, our motor system, and the general mechanism of neural binding.

Simply put, embodied cognition strives to incorporate scientific knowledge of the body's sensorimotor systems and brain functioning with our lived experience in the world to understand how these factors influence and shape cognition.

The utilisation of scientific discovery to inform embodied cognition theory is best demonstrated by the impact of canonical and mirror neurons (Barsalou 2008). Canonical neurons respond to being presented with an object, and mirror neurons respond when preforming an action or observing someone else preform an action (Pineda 2009). Both canonical and mirror neurons are located in the premotor cortex, which is the area of the brain that activates when planning movement. This process in turn influences the motor cortex, which is the area of the brain that executes the motor activities that comprise an action (Gallese & Lakoff 2005).

In practice, this means that the same canonical neurons operate when a person sees an object, for example, a tennis ball, and when the person picks the ball up. If the person was presented with a smaller object, like a grain of rice, which would necessitate a more precise grip to pick up, different canonical neurons would fire. In this way, canonical neurons can operate selectively, activating in response to properties like size and shape and the motor actions needed to interact with them. Mirror neurons, in contrast, fire when observing others interact with objects (Caramazza et al. 2014; Kohler et al. 2002). For example, mirror neurons fire when observing another person reach for food or eating. However, if there was no object involved, such as reaching out without food to grasp, then mirror neurons would not fire. Additionally, auditory stimuli can have the same effect as visual triggers. The sound of actions being performed is enough to trigger some mirror neurons. For both canonical and mirror neurons, action is essential (di Pellegrino et al.1992).

Canonical and mirror neurons function to perceive objects. Among proponents of embodied cognition, actions are considered to be evidence of a common code for the embodiment of perception, as these neurons fire in relation to how bodies interact with objects and the environment (Fischer & Zwaan 2008; Kiefer & Pulvermüller 2012). The phenomenologist Husserl (2006) described our relationships with other people as 'transcendental societally', which is founded on the *einfühlung* (empathy) arising from two bodies interacting with each other. Direct links between Husserlian phenomenology and the discovery of canonical and mirror neurons have been drawn by Zahavi (2012). Although Zahavi is reluctant to draw any definitive conclusions on whether a current scientific understanding of mirror neurons completely proves Husserl's theory for empathic intersubjective relationships due to the complexity of Husserl's work, Zahavi nevertheless shows significant parallels support phenomenological descriptions.

It should be noted, however, that although the role of canonical and mirror neurons opens up interesting discussion, further research is needed to understand the exact role these neurons play in perception. The evidence currently available shows correlation, not causation, between overserving actions and the firing of neurons. As more is discovered about the functionality and relationship of canonical and mirror neurons, it may yet be revealed that there are other factors that need to be considered when linking neuroscience to philosophy (Borg 2007; Jacob 2008; Lohmar 2006). However, as is discussed in the upcoming chapters, there is scope to use what is currently understood about the functionality of canonical and mirror neurons to theorise about people's responses to design elements within the public realm.

THE USE OF EEG IN EMBODIED COGNITION RESEARCH

This section introduces EEGs, explains how they work and what data they can track. This is then linked to an embodied cognition theory, the sword and shield hypothesis, which hypothesises that people's dominant hand influences brain functionality. Together, this shows how EEGs have been used to gather empirical data in support of embodied cognition theory.

The differences in our bodies influence our thinking (Varela, Thompson & Rosch 1991). The way in which people use their bodies to interact with their environment shapes the mind over time. While there are always contextual factors that must be taken into account, the body is a constant part of the context of our thinking and actions (Shapiro 2019). The influence of the body on the neurocognitive activity that constitutes thought has been supported through empirical evidence gathered by EEG studies.

To understand the role of EEG research in embodied cognition – the functionality and use of an EEG – the areas of the brain must first be discussed. Figure 1 below shows the regions of the brain where EEG sensors are typically placed (Fu, Daly & Cavusoglu 2006). The functionality of each area is as follows:

- The prefrontal cortex has a central role in cognitive control functions and decision making (Domenech &Koechlin 2015).

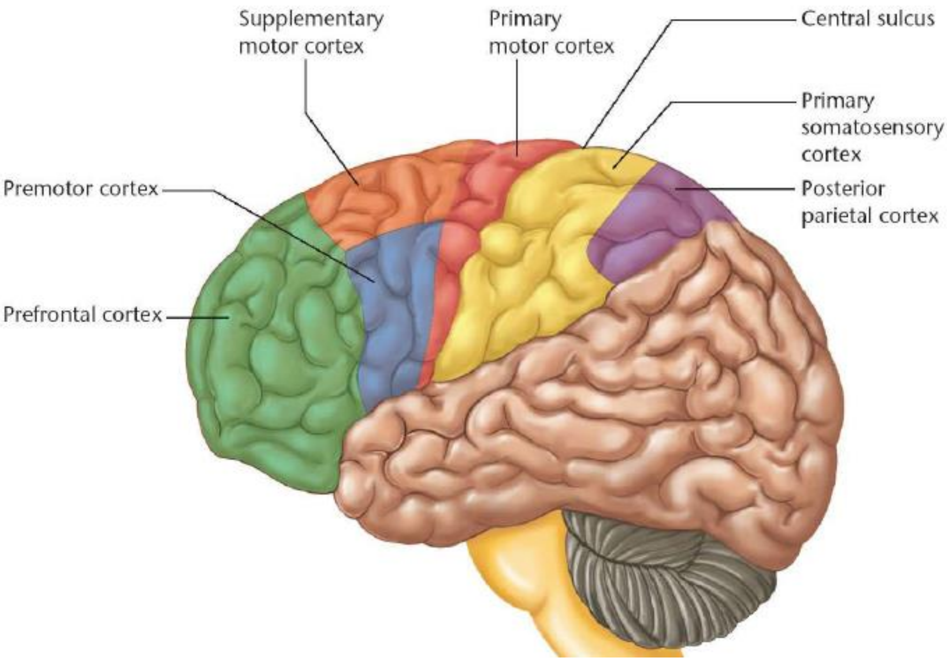


Figure 1. The major cortical regions of the brain over which EEG electrodes were placed (Fu, Daly & Cavusoglu 2006)

- The main function of the premotor cortex is the integration of sensory and motor information to help control the body's movements (Domenech &Koechlin 2015).
- The supplementary motor cortex is involved in learning new motor skills and controlling sequences of movement, such as changing movements to respond to incoming sensory information (D'Esposito & Grafman 2019).
- The primary motor cortex controls the body's movement by generating the majority of neural impulses that pass down the spinal cord (D'Esposito & Grafman 2019).

- The central sulcus is a groove in the brain that divides the parietal lobe from the frontal lobe and separates the primary motor cortex from the primary somatosensory cortex (Hopkins 2016).
- The primary somatosensory cortex processes somatic sensations, such as touch, pain, temperature, and proprioception (the position of the body in space) (Franzen & Terenius 1996).
- The posterior parietal cortex receives a range of inputs and is believed to integrate these inputs to facilitate the execution of functions that require diverse information, which are sometimes called 'higher-order' functions (Franzen & Terenius 1996).

An EEG tests electrical activity in the brain (Priyanka et al. 2016). Electrical signals are produced by billions of neurons that fire across the higher layers of the cortex outlined above. As brain cells communicate with each other through electrical impulses, an EEG records the brainwave patterns made by these communications. An EEG uses electrodes that fit against the scalp to monitor and record electrical impulses of the brain so that the brain wave activity can be analysed. An EEG uses electrodes spread across the scalp to record many waves with different characteristics as the various regions of the brain emit different brainwave frequencies at different times (Eugene 2013).

EEG signals are typically tracked according to their frequency and power. There are several rhythms to brainwaves commonly studied, each associated with different brain states, as outlined in Table 1 (Priyanka et al. 2016):

Table 1. Characteristics of the Five Basic Brainwaves

Frequency band	Frequency	Brain states
Gamma (γ)	35+ Hz	Concentration and problem solving
Beta (β)	12–35 Hz	Active and busy mind, external attention, relaxed

Alpha (α)	8–12 Hz	Very relaxed, passive attention
Theta (θ)	4–8 Hz	Deeply relaxed, inward focused
Delta (δ)	0.5–4 Hz	Sleep

EEG is a particularly useful approach for tracking cognitive processes as it can record multiple electrical signals per second to record spikes in neural activity in real time, and also track longer cognitive processing that may take several minutes (D'Esposito & Grafman 2019). This makes EEG well-suited to monitoring changes to cognitive process as people are exposed to different stimuli and environments (Eugene 2013).

This functionally also means that EEG has been an advantageous method for gathering empirical evidence to underpin theories such as embodied cognition. This can be seen, for example, in the 'sword and shield hypothesis' (Casasanto 2014). This hypothesis links to embodied cognition as it relates to the impact bodily experience in the world has in shaping the brain. The sword and shield hypothesis posits that the functioning of the right and left hemispheres of the brain have been influenced by whether people are right- or left-handed. As our emotional states are linked to our actions, hands preforming actions also have a role in this process (Berkman 2010). Over countless centuries, people have gone into battle with a weapon in their dominant hand and a shield in their non-dominant hand. For the majority of people, this means that their right hand held the sword to attack while their left hand held the shield to defend. This has been linked with an observed tendency that many people approach things with their dominant hand and avoid things using their non-dominant hand. When startled, for example, it is a common reflex for people to raise their left, non-dominant hand in defence (Berkman 2010; Casasanto 2014).

Brookshire and Casasanto (2012) have used EEG to track alpha-band power (as described in Table 1) in left- and right-handed people to contrast their respective brain activity when approaching objects. By comparing the alpha power asymmetries across the two hemispheres of the brain, this study found right-handed people exhibited stronger motivation to approach an object in the left hemisphere of the brain, while left-handed people had higher alpha power in the right hemisphere (Brookshire & Casasanto 2012). This means for both right- and left-handed people, the brain activity corresponded to the same hemisphere responsible for controlling the dominant hand, which supports the sword and shield hypothesis.

THE EMERGENCE OF EMBODIED COGNITION AND ITS LINKS TO PHENOMENOLOGY

This section contributes to answering the second sub-question:

How have urban theorists predominantly studied people's responses to place and what are the limitations of theorist current understanding of space?

This section provides an overview of what phenomenology is and how it has already been used to understand people's relationship with place. The limitations of phenomenological studies are outlined and how these weaknesses can be addressed by combining cognitive sciences with phenomenology to provide new data and improved understanding of people's experience with place.

A BRIEF OVERVIEW OF PHENOMENOLOGY

This section provides context by providing a brief introduction to what phenomenology is and some of the central ideas of this philosophy. This establishes the foundation needed to understand how phenomenology has traditionally been used in urban studies to analyse people's interrelation with place.

Historically, phenomenology emerged from the first half of the twentieth century with Husserl's first volume, *Logical Investigations* (Husserl 2001 [1900]), which is regarded as the central inspiration for the existentialist movement. This seminal work influenced the intellectual milieu of Europe and directly impacted other key theorists, such as Heidegger and Merleau Ponty (Detmer 2013).

Phenomenology is a field of philosophy that studies the structures of experience and consciousness (Crowell 2001). This involves analysing 'phenomena' to understand the appearance of things and the ways we experience them, and how we create meaning from these experiences and perceptions (Dermot 2000). Conscious experiences are first and foremost *experienced*; we live them, we observe them, we engage with them. Because of this, phenomenology is subjective, studying experience from a first-person perspective. This differentiates itself from Cartesian analysis, which proposes the world is being made up with object interacting with each other (Dreyfus & Hall 1982). From this subjective viewpoint, the structure of a range of experiences can be examined, such as perception, thought, memory, emotion, imagination, awareness of the body, actions performed by the body, and social activities like language (Sokolowski 2000).

The structure of experience involves 'intentionality,' which Husserl (2001) explains as the directedness of experience towards any given object in the world. Intentionality is also a property of consciousness present when you think *of* or *about* something (Dermot 2000). Intentionality depicts a representational view of consciousness in which reality is only discernible through perceptions of reality that are themselves representations in a person's mind (Crowell 2001).

This intentional structure of consciousness can then be used to analyse different forms of experience, including temporal awareness, spatial awareness, self-awareness, awareness of the body, and movement as embodied action. This view of consciousness can further be extended to explore awareness of other people through empathy and intersubjectivity, and awareness of culture through social interactions and activity in our surrounding life world (Dreyfus & Hall 1982). There are also conditions that enable intentionality, such as embodiment, language, social background, and social and cultural practices. Husserl (2001) argues that conscious experience leads into the conditions that give rise to the intentionality of experience. It is the role of phenomenological studies to describe these phenomena when they are consciously experienced (Dreyfus & Hall 1982).

A key feature of conscious experiences is that they are *experienced*. While we may observe or hear parts of the world around us, experience comes from living through or preforming actions (Barnacle 2001). It follows that as we each live through our own personal experiences, descriptive analysis of these experiences must come from a subjective, first-person perspective. It should be noted that this facet of the structure of consciousness is both phenomenological as it includes what is it to experience and ontological as it includes what it is to experience being (Westphal 2013).

Studying conscious experience occurs primarily through reflection on past experience through *epoché* (Jacobs 2013). *Epoché* involves attempting to bracket out the observer when describing the phenomena being experienced. This is necessary as while a person is in the midst of an experience and there is not always scope or capability for critical self-awareness, especially if there are strong emotions involved, such as fear or anger (Dermot 2000). As we live our lives, we accumulate multiple sorts of experiences, for example, singing songs, kicking balls, thinking about our passions, or playing imaginative games as children. Phenomenology assumes a level of familiarity with the sorts of experience that it describes (Barnacle 2001).

THE LIMITATIONS OF PHENOMENOLOGY

This section summarises some key weaknesses in phenomenological research in order to provide context for the need to expand into other schools of thought such as embodied cognition. Although phenomenology opens channels for interesting analysis, there are notable weaknesses to phenomenological research. Patton (2002) adroitly observes that the focus on people is simultaneously phenomenology's best strength and fundamental weakness. The above outline has explored how phenomenology is fertile ground for describing the structures of consciousness and lived experience, yet given the subjective nature of phenomenology, phenomenological research is limited by the abilities of the people involved. A wide range of factors may impact people's responses, such as linguistic abilities, age, sex, cognitive ability, and even whether they feel embarrassed speaking candidly (Patton 2002). For research participants, the information they share is limited by the self-awareness of their thoughts and feelings as well as their ability to articulate them. For researchers, a great deal of skill is needed to extract personal accounts from their participants without influencing the interview or using their own bias and assumptions to interpret the information they collect (Patton 2002).

This leads to the question of whether the Husserlian concept of *epoché* is actually achievable. *Epoché* attempts to bracket out the observer to produce detached descriptions of phenomena, yet how would it be possible for the observer to identify let alone remove the complex layers of their own perception and comprehension to interpret people's accounts without bias? It would be impossible to do this perfectly (Jacobs 2013).

The subjective nature of phenomenology also limits the scope of using this as a research method. The first-person perspective is useful for examining the experience of that one person, but it can be difficult to establish the reliability and validity of the data collected (Moran 2000). The highly personalised nature of the data further complicates the ability to use this data to predict or examine larger trends in the population. This weakness is usually compounded by the fact that phenomenological studies tend to deal with small samples that do not attempt to establish a true representation of the population. This narrow scope results in many policymakers viewing phenomenological studies as less credible research (Van Manen 2016).

Moran (2000, p. 4) describes phenomenological research as ‘a practice rather than a system,’ as he sees phenomenology as largely rejecting systematic approaches. The need for moving away from systematic approaches is understandable as intricate multilayered subjective experiences lose rich texture and personal meaning when analysed through systematisation and reductionism (Moran 2000).

It is, however, the position of this research that there are advantages of using a mixed method approach that draws from both qualitative and quantitative methods. Within neurourbanism, several studies (Spinney 2015; Osborne & Jones 2017; Olafsdottir, Cloke & Vögele 2017) intentionally combine biometric sensors with phenomenology and narrative accounts to validate the reliability of results outside laboratory settings and to support drawing casual links rather than being limited to discussing correlations between datasets (Pykett, Osborne & Resch 2020).

A CASE FOR NATURALISING PHENOMENOLOGY

This section shows that although the union of phenomenology and cognitive science may not be perfect, there is nevertheless scope to gain new insights through this paring. The common ground between phenomenology and the cognitive science is outlined to show the compatibility of naturalising phenomenology and how this can address some of the limitations of phenomenology.

Cognitive phenomenology was appropriated and reshaped by a cognitive neuroscientist, Francisco Varela, in the 1990s to introduce embodied cognition. Embodied cognition was considered radical when first introduced as it essentially rejects Cartesian dualism (Haugeland 1993). Cartesian dualism views the mind and body as being separate and distinct and consequently casts mind and matter as divided. Descartes (as cited in Haugeland 1993) theorised that the mind was a non-physical site of consciousness and self-awareness and the physical brain was the site of intelligence. This theory has been woven through Western philosophy so thoroughly-that is now almost invisible. It has become normalised to approach objectivism and subjectivism as a dualism where the objective is typically most valued as being 'real' while the subjective is routinely undervalued as a 'soft' science (Haugeland 1993).

Barbaras (2002) has reviewed Varela's early work (Varela 1979 & 1992; Varela, Lachaux, Rodríguez & Martinerie 2001; Weber & Varela 2002) to highlight the contributions Varela has made to philosophy and phenomenology. Barbaras (2002) sees Varela's main contribution as his rejection of the objectivist perspective, which conceptualises perception as an act of recreating the pre-given world as an internal construction, and the subjectivist perspective, which describes perception as being constituted by each person. Across his work, Varela argues that both objectivists and subjectivists suffer the same flaw: they both portray perception as representational. Instead, Varela uses a basis of neurophysiology to argue that perception should be viewed in terms of action, or more specifically, enaction.

Varela's work is recognised as a turning point from cognitive phenomenology to embodied cognition as it sets a new direction that is still being explored by both philosophers and neuroscientists (Barbaras 2002, Varela 1996). Since its introduction, a growing body of literature has emerged from philosophers that focuses on using phenomenology to explore consciousness.

A central theme to this body of literature is a growing acceptance that objective experimentation has limitations for areas of inquiry such as logic, ethics, aesthetics, and psychology (Detmer 2013). This includes Husserl (2001) and Merleau Ponty's (2013) work being studied by cognitive scientists as a resource to understand the subjective nature of consciousness (Gallagher 2012; Jensen & Moran 2013; Chudnoff 2015). There has been a growing movement (Toadvine 1999; Borrett, Kelly & Kwan 2000a, 2000b; Carel & Meacham 2013; Petit 2014; Harney 2015; Whitehead 2015) that supports naturalising phenomenology, which means combining phenomenological research on the structures of consciousness with naturalism's reductionist explanation of the consciousness through objective science, such as biology, neurology and physiology.

Phenomenology has been used to open new fields of investigation by studying things and experiences as they appear to us through our interactions with the world. This approach avoids issues of determining what can be objectively defined as real or existing independently of our experience and puts the emphasis on the meaning created through these experiences for analysis (Chudnoff 2015). In particular, phenomenology is used with the field of cognitive science, which studies cognition in humans and animals as well as artificial intelligence in machines.

Cognitive science takes an interdisciplinary approach that draws from philosophy (such as phenomenology), anthropology, psychology, linguistics, neuroscience and computer science (Stausberg, Engler & Geertz 2016). Within the field of cognitive neuroscience, phenomenology is being incorporated into biological and physical science to conduct empirical experimentation. This style of experimentation works on the assumption that conscious experience is grounded in the neural activity of embodied action within a given environment. This involves using the tools of neuroscientific experiments, such as magnetic resonance imaging (MRI) scans or EEG monitors to confirm or contest aspects of experience (Ellard 2015). For example, Leder, Tinio and Bar (2011) used MRI scans to show the neural activity that correlated with people's different emotional responses to curved and sharp objects, and how experience may impact our preference for round or sharp things.

There are key parallels between cognitive science and phenomenology that can be drawn together to build a more detailed view of human experience and cognition (Stausberg, Engler & Geertz 2016). Phenomenology does not delve into whether phenomena are objectively real;

if the person perceives it as real then the validity of the experience itself is not called into question (Crowell 2001). Cognitive science tempers this by acknowledging the limitations of human cognition and accepts that what we perceive of as reality is largely an illusion constructed by our brains (Bermúdez 2010). What we perceive as the world around us is highly filtered and constructed by our brains, which act as a central information processer. The brain creates patterns of information, gives meaning to these patterns, then combines these patterns to build even more complex patterns, which results in our perception of the world being largely constructed by the brain (Bermúdez 2010). Only a small fraction of the sensory information we receive is used to construct this perceived reality and there is a constant possibility that sensory information could be manipulated or distorted, which impacts upon what we think is real. For example, optical illusions are something many of us have consciously observed. These illusions occur when the brain incorrectly assumes what is most likely to be true and builds a perceived reality that omits details that do not fit its assumption (Von Eckardt 1996).

A second key parallel between phenomenology and cognitive science is the importance of attention. A founding concept in Husserlian phenomenology is intentionality – that our experience is directed towards something (Cerbone 2006). Cognitive science acknowledges the importance of intentional focus but uses the simpler terminology of 'attention' and takes a step further by considering the neural functionality involved in the cognitive process (Bara 2017). Attention plays a significant role in the construction of our perceived reality given it acts as a filter. We are constantly overloaded with sensory information and it is not feasible for the brain to give equal weight to all these inputs. Our attention can focus in on what our brain views as being relevant. The majority of sensory information we receive is filtered out and the brain adds in pieces of information as they are needed (Cerbone 2006). For example, we are all constantly breathing and experiencing the sensations that go with it, but until there is some need to be aware of our breathing, this information is filtered out and we continue the action unconsciously (Bara 2017).

The mixed method approach of combining cognitive science with phenomenology has resulted in the emergence of cognitive phenomenology, or neuro phenomenology, depending on the preferred terminology. Cognitive phenomenology is a union of cognitive science and Husserlian phenomenology that takes a first-person perspective of consciousness. Cognitive phenomenology is explained by Walsh (2017, p. 35) as 'the phenomenal character of thinking a thought, as opposed to the more standard examples of phenomenal consciousness, like feeling pain or seeing red.' Here a 'thought' is used in a broad manner to include judging, remembering, supposing, doubting and so forth. Cognitive phenomenology focuses on how to characterise the 'what its likeness' of our conscious lives (Montague 2016).

Given that a weakness of cognitive science is the inability to bridge the gap between describing mental or cognitive content and lived experience, introducing phenomenology offers a means to address this. Simultaneously, given the limitation of phenomenology outlined above, cognitive science offers the more systematic approach for understanding human experience that is otherwise lacking (Roth 2004). Combining the two disciplines overcomes the limitations of using either phenomenology or cognitive science in isolation, especially when studying knowing and learning (Chalmers 1995)

It should be noted, however, that the combination of philosophy and science does have some weaknesses. While Armezzani (2009) notes advantages in combining philosophy and science, she argues that the inherent dualism results in reshuffling issues rather than necessarily transcending their opposition to create a new field. Armezzani sees neuroscience as revealing correlations with lived experience, but because the traditional scientific method does not take consciousness into account, there will be limitations on how phenomenology can be wedded to cognitive science.

Other writers, such a Pitt (2004), argue that some separation should be maintained and recommends that cognitive phenomenology be differentiated into distinct fields within cognitive phenomenology. As Pitt (2004) explains, the phenomenological characteristics of having thoughts is different to the phenomenology of grasping thoughts as they are separate sorts of experience. However, Pitt's criticism does not take into account that having thoughts and realising thoughts are seen as different states with distinct phenomenological properties instead of unique fields of analysis (Voltolini 2016).

Cognitive phenomenology has strong potential for understanding embodied, situated phenomena and through continued work to refine its uses for research. Cognitive phenomenology's use in studying awareness of abstract reality is championed by Chudnoff (2015), who unities the Husserlian theory of memorial consciousness to illustrate his stance, highlighting that if we were to *remember* seeing something – for example a tree – as opposed to *seeing it in the present*, different mental processes are at play to consciously perceive said tree. While seeing and remembering a tree may seem like an unambiguous activity, there is a matrix of prior experiences that have shaped a person's perception of a tree, creating an intuition on what we think a tree should look like, which Husserl calls 'intellectual seeing.' This also shapes both memory and perception in the present moment (Chudnoff 2015).

There is also fertile ground for discovery in the combination of Merleau Ponty's approach to phenomenology (2013) and cognitive science, which is explored by Levin (2016). Levin asserts that Merleau Ponty's conceptualisation of the body as being simultaneously physical and phenomenal was a key factor in uniting neurophysiological processes with the first-person perspective of phenomenology. Zahavi (2012) similarly credits Merleau Ponty as being a forerunner for contemporary phenomenology. In Zahavi's perspective, Merleau Ponty broke down the false dichotomy of objectivism and subjectivism in order to find a space in between external scientific explanation and internal phenomenological description. Additionally, incorporating more hermeneutic phenomenology – which is a phenomenological approach to interpretation to make sense of individual's subjective lived experience – would increase the scope for analysing a first-person perspective from an empirical, third-person position. This approach would be useful to scrutinise personal meaning within the context of lived experience (Larkin, Eatough & Osborn 2011).

USING EMBODIED COGNITION TO EXPLORE PEOPLE'S RELATIONSHIP WITH PLACE

This section further contributes to answering the second sub-question:

How have urban theorists predominantly studied people's responses to place and what are the limitations of theorist current understanding of space?

This section triangulates the gap in current literature being addressed through this thesis. There are existing foundations within existing literature from notable theorists, such as Gehl (2011), Jacobs (1962) and Lynch (1960), who delve into the sensory relationship between people and the design of place. There is also a wealth of literature that uses sensory phenomenology to understand people's perceptions of place. These foundations are built on by neurourbanism, which takes these approaches a step further by using an interdisciplinary approach to the mind–body–environment relationship in the interest of creating healthier cities. Juxtaposed with this is an overview of smart cities literature and how smart cities studies are approaching a better understanding of people's responses to the environments they inhabit. This is provided to further support the positioning of this research within neurourbanism rather than smart cities.

FOUNDATIONS OF AN EMBODIED UNDERSTANDING OF PLACE AND URBAN LIFE

This section highlights the embodied approach that key urban theorists have taken to examining people's relationship with place at a meta level. The example of how sensory phenomenology is used in this context then demonstrates how these methods exist in the current literature to understand people's responses to sensory stimuli. This sets the context for this thesis within existing urban theory.

There is a sound foundation for taking an embodied approach to urban studies. Observing public life and sensory understanding have been a central aspect of many key urban theorists' approaches to examining city life and people's relationship to the places they live. In *How to Study Public Life*, Gehl and Svarre (2013) argue that using one's senses to observe public life is the best means to gain a greater understanding of public life. Similarly, Jacobs prefaces *The Death and Life of Great American Cities* (1962, p. xxiv) with a note to 'please look closely at real cities. While you are looking, you might as well also listen, linger and think about what you see.' Lynch's (1960) seminal work, *The Image of the City*, brings together urban design and people's interpretations of the city, which he describes as the 'imageability' of the city. Lynch (1960) explains the image of the city as a product of a two-way process between the person experiencing the city and the environment of the city. This image is simultaneously part of a larger cultural narrative of the city and a personalised understanding, unique to each person's experience and meaning of the city. In Lynch's (1960) view, the form of the city is not the final goal. Instead, it is the sum of the city's parts within the perception of the individual that is of paramount importance. The common thread to these approaches is using human physiology and experience as the basis for understanding people's relationship with the city through observable public life play out on that stage that is public space.

There is also a large foundation of literature that approaches the people–place relationship from a sensory phenomenological perspective. As previously discussed, embodied cognition builds on phenomenological approaches, especially from sensory phenomenology. Existing urban studies that have used this approach provide further foundations upon which embodied cognition can build. There are, for example, many studies that use phenomenological methods to investigate people's perceptions of sound (Raimbault & Dubois 2005; Hall, Lashua & Coffey 2008; Ihde 2007; Duffy & Waitt 2011; Norman 2012; Paquette & McCartney 2012; O'Keeffe 2015). A soundscape is the auditory equivalent of a visual landscape, which includes the sounds that arise from an environment (Wissmann 2014). Phenomenological research methods to study soundscapes were first introduced by Schafer (1969, 1977), who pioneered *soundwalks*, which involve walking through the environment to listen to the surrounding soundscape. The aim of soundwalks is to gather feedback from research participants on their perception of the sounds they hear rather than document a specific sound at a specific time or place (Paquette & McCartney 2012).

The subjective nature of phenomenological studies has resulted in a principally qualitative understandings of people's responses as the underlying neuro systems that process the auditory stimuli are not addressed. This makes it difficult to unequivocally categorise sounds as either positive or negative, as this subjective judgement will vary from person to person and by context and time. However, as soundscapes are not the focus of this research, a simplified approach will expedite the discussion: sounds that are generally unwanted or unpleasant will be called noise (Maris et al. 2007). In the urban environment, noise mostly comprises road and air traffic, industrial sites, and construction zones (Banerjee & Southworth 1990; Southworth 1969). The most common response to these forms of noise is an annoyance, but anger and fear are sometimes also reported by research participants (Wissmann 2014). Part of the reasoning behind the annoyance of urban noise is that it interferes with social interactions, particularly loud trucks passing or air traffic overheard (Maris et al. 2007).

Conversely, pleasant sounds are those that do not bother listeners but can contribute to a generally positive ambiance and even attract listeners. Pleasant sounds can also be louder before they risk becoming annoying to people (Kang 2007). Most pleasant sounds are natural, such as water flowing in a river or at the beach, gentle breezes, and bird song (Schafer 1994). Natural sounds can be both pleasant in themselves and can reduce people's annoyance of noises (Kaplan & Kaplan 1982, 1989). Coensel, Vanwetswinkel and Bottledooren (2011) found that adding natural sounds of water via the introduction of a fountain reduced the negative perception of traffic noise and adding sounds of birds had a considerable impact improving people's perception of a soundscape. They hypothesised that part of the reason for people perceiving soundscapes with added natural sounds as being more pleasant was due to their attention being directed towards the sounds of the bubbling fountain and birds, therefore paying less attention to the noise.

NEUROURBANISM, AN EMERGING FIELD OF STUDY

This section provides an introduction to neurourbanism as an interdisciplinary approach to understanding people's relationships to place from an embodied perspective. Neurourbanism sets the context for this thesis. The key features of neurourbanism are integrated into the design of this thesis to position it firmly among emerging neurourban approaches to embodied understanding of place.

The main area of investigation in neurourbanism centres on the interrelationship between urban environments, social trends and mental health, with a particular focus on the brain (Fitzgerald & Callard 2015; Fitzgerald, Rose & Singh 2016). Neurourbanism takes an interdisciplinary approach that uses research and methods from neuroscience to address problems arising from urban contexts. Taking a purely neuroscientific approach risks narrowing our understanding of people's experience in urban environments, given that laboratory-based research has a tendency towards reductionism, determinism and medicalisation. Taking a more holistic view of people's complex lives that includes perspectives from social sciences, such as sociology and anthropology, provides a greater scope for understanding the interrelated factors at play with embodied experience (Adli et al. 2017; Manning 2019; Söderström 2019).

It is important to note that neuroarchitecture is closely related yet distinct from neurourbanism. Neuroarchitecture was pioneered by Thomas Albright, the founder of the Academy of Neuroscience for Architecture (Karandinou & Turner 2017), and Eberhard, with the influential book *Brain Landscape* (2009). The primary focus of this discipline is people's perceptions of and orientations in space, building from a foundation of environmental-behaviour theory. Due to this foundation, neuroarchitecture takes a less embodied approach, arguing that the brain is a driver for behaviour and that environmental factors may influence changes to the growth of brain cells through the process of neurogenesis (the process of forming new neurons in the brain), which in turn shapes behaviour (Pykett 2015).

The emergence of neurourbanism is very new. As best as can be determined, the use of the term 'neurourbanism' to describe an academic discipline was introduced as recently as 2017 by Adli et al. 2017), who argue that the small scale of focus within neuroarchitecture studies and lack of interdisciplinary approaches to health and wellbeing warranted a new discipline to explore urban stressors and their impact on people. Adli et al. (2017) define neurourbanism as encompassing:

- Epidemiology
- Experimental urban stress research and emotional mapping
- Urban prevention and therapy research
- Exploitation of results and advisory functions.

Using Adli et al. (2017) to define the divergences between neuroarchitecture and neurourbanism, the parameters of focus between these two areas of study become clear in positioning this research. As neuroarchitecture focuses more on the design of the built form while neurourbanism tends to focus on social trends via interdisciplinary approaches, this research addresses the gap in between by exploring people's responses to design elements in public space. The embodied perspective employed in this research firmly positions this study within the context of neurourbanism rather than neuroarchitecture.

Much of the neurourban literature explores stressors and the health impacts they pose. This includes a wide variety of stimuli, ranging from social density and social isolation, to prevalence of discrimination and violence, to the chaos and unpredictability of urban settings (Geis & Ross 1998; Prelow et al. 2004; Steptoe et al. 2004; Evans et al. 2005; Dickerson, Gruenewald & Kemeny 2009; Frankenhuis, Panchanathan & Nettle 2016). However, as Manning (2019) notes, the interdisciplinary approach of neurourbanism is a double-edged sword. On the one hand, there is clear potential for a better understanding of the body–mind–environment relationship by studying it in situ to include the specific experiences of place, communities, politics, economics and time. Conversely, there is little shared vocabulary and disagreements as to what counts as knowledge between such diverse fields as biology and sociology, which can hinder the progress of neurourbanism as a distinct discipline.

Neurourban studies have been shaped by the prevalence of taking neuroscience conceptually and methodologically out of clinical settings and into urban environments to study emotional responses being studied (Pykett, Osborne & Resch 2020). The use of bio-sensing devices has opened opportunities to gather real-time data as people go about their daily lives. For example, salivary cortisol has been tested as a biomarker in studies investigating the impact of green spaces in reducing stress (Roe et al. 2013; Ward Thompson et al. 2012). EEG is also used to better understand the role that urban environments play in human health. The study by Neale et al. (2020) of older people's experiences contrasted older people's responses to busy urban environments with to quieter green spaces to explore the different neurological processes at play when experiencing different settings.

SMART CITIES AND WEARABLE TECHNOLOGY STUDIES

This section provides a high-level overview of the literature from smart cities to contextualise wearable devices and their current usage. This demonstrates that, although there is work being undertaken in gathering data at an individual level to better understand people's responses to their environments, there is a gap in terms of the cognitive responses being tracked by current wearable devices.

Using data to understand and improve people's lives is a central focus within studies on smart cities. Given the mixed methods approach of this research, there may be a temptation to position this thesis within smart cities research. However, by providing an overview of existing smart cities literature in relation to people's responses to the design of place, this overview can be juxtaposed with the above introduction to neurourbanism. This will further support the positioning of this research within neurourbanism rather than smart cities.

Within smart cities studies, 'human context sensing' delves into monitoring people at an individual level rather than drawing on big datasets that illustrate broad trends. Human context sensing (Thakuriah et al 2017) is divided into four interrelated areas that use different methods to gather data on different aspects of a person's interaction with the world around them. The four categories are:

- Emotional sensing, which often focuses on responses such as anger, frustration and confusion to better understand when key stress points are being encountered by people in their daily lives.
- Physiological sensing, which tracks biological indicators and is often used in the detection, prevention, and treatment of diseases.
- Functional sensing, which explores how people go about tasks while embedded in the context of everyday life rather than clinical settings.

- Location sensing, which tracks people's patterns of movement through space in terms of navigation as well as where people linger within an environment (Nakashima, Aghajan & Augusto 2010, Al-Turjman 2020).

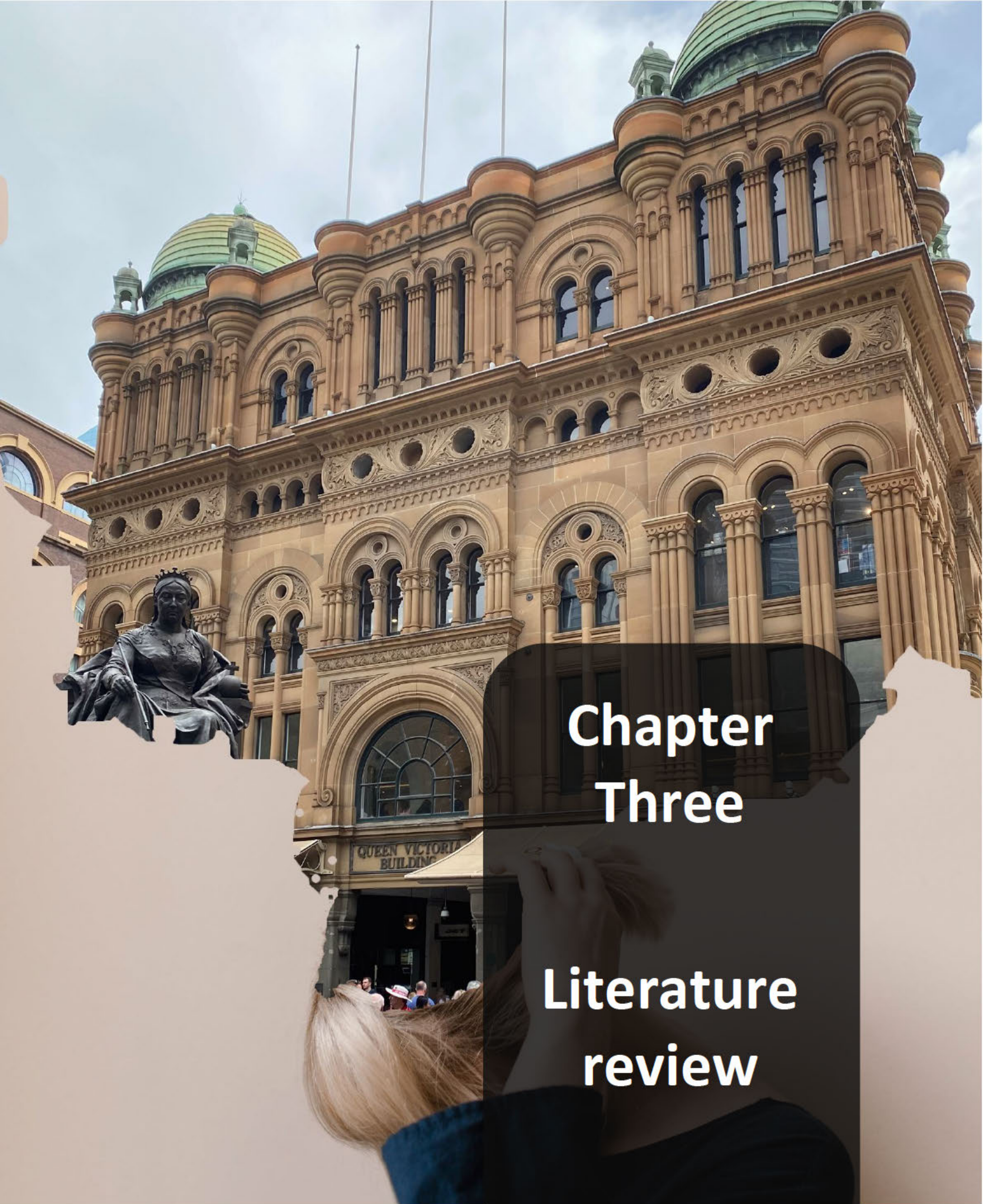
Of particular relevance to this study is emotional sensing. Within smart city studies, emotional states are typically interpreted from facial expressions, like smiling and frowning, body language, like leaning towards a point of interest and gestures, and verbal signals, like raised voices and diction. As these cues are generally recognised indications of emotional states in social situations, computer applications (apps) are designed to look for these behaviours as a means of tracking the emotions people communicate. There are also studies that monitor the effect of emotional states within the body, such as increased heart rate to indicate stress or excitement, and variations in sweat gland activity (via galvanic skin responses) to track the intensity of an emotional state (Healey & Picard 2005; Sathyanarayana et al. 2008). While studies can use one or a combination of these indicators, this approach is limited as there can be a range of factors influencing a person's physiological responses. For example, a raised heart rate may be caused by physical exertion, stress, or both, which means it is difficult to draw definitive conclusions using these approaches (Alghowinem et al. 2013; Wu et al. 2013).

As best as can be determined, there are no current studies within human context sensing that incorporate cognitive monitoring methods. The most common technologies being used for human context sensing are video and audio recording, wearable devices, smart phones, and sometimes a combination of these methods. Tracking emotions through facial expressions and body language, for example, can be taken through a video recording with a smart phone and run through an application that tabulates emotive responses (Dybdal et al. 2012; Cohen et al. 2013). Wearable sensors have grown in popularity in recent years and are now available for a wide range of uses. For instance, devices that track breathing can give indications of a person's level of physical exertion and their emotional state as exercise, boredom and stress can be associated with different breathing patterns (Likamwa et al. 2013). There are also wristband-mounted devices that track the wearer's mood based on blood pressure readings and heart rate to monitor stress levels. Efforts have also been made to detect mood through people's usage of their smartphone (Kapur et al 2005). This method works on the assumption that people will use their phone differently when experiencing different moods. It should be noted that emotional state tracking devices and apps tend to operate through algorithms that combine multiple sensory inputs to give a broad indication of emotional states. This can create challenges with these approaches, as the assumptions and datasets built into these algorithms can be flawed or may not be finely tuned enough to the specific responses of the wearer (Petrushin 1999, Lebak et al. 2003, Lu et al 2012).

CONCLUSION

The philosophy of embodied cognition and its linkages to science offer a way to gain new insights into people's relationships with place. This chapter has introduced embodied cognition theory and explored how it incorporates biology and neuroscience to build an empirical evidence base for theory. The benefits of naturalising phenomenology have also been explored and a case has been made that this approach can address some of the limitations of using a traditional phenomenological approach to research.

This chapter has also contextualised the contributions of this thesis by showing where this research sits within current literature. This thesis addresses a gap within literature while having strong foundations for an embodied perspective; it does not extensively draw from the cognitive sciences. Smart cities literature presents a similar gap, as although there is greater usage of wearable devices, there has not been a strong focus on the cognitive experience of the individual. Neurourbanism is introduced as the most fitting context for this research given its focus on embodied experience and strong connections to the natural sciences.



Chapter Three

Literature review

CHAPTER THREE – USING EMBODIED COGNITION TO UNDERSTANDDPEOPLE'S RESPONSES TO URBAN ENVIRONMENTS

INTRODUCTION

Embodied cognition has the potential to provide new insights into our understanding of how people interact with public spaces. This research is emerging with some preliminary work already undertaken to use the cognitive sciences to better understand established urban theories. This is demonstrated through three theories: cognitive mapping, attention restoration theory, and rhythmanalysis. An overview of each theory is provided and an exploration of how the evidence base of each respective theory has been expanded using EEG data and other research methods typically used within neuroscience is also canvassed.

Taking the next step, new linkages are drawn between the cognitive sciences and design elements commonly found within public space. Public squares are used as an example of public life to focus this analysis, and to lay the foundation for understanding the case study sites, World Square and Darling Square, used in this research. Nasar's (1998) criteria for design elements that elicit positive and negative responses from people forms the basis of identifying key aspects of public squares, with additional elements of pattern from Alexander, Ishikawa and Silverstein (1977) and the presence of people as per Gehl's (2006) recommendation for fostering lively places. Each of these design elements are linked to studies from the cognitive sciences to propose a new perspective on people's responses to design in public spaces.

BUILDING ON EXISTING URBAN STUDIES THROUGH THE COGNITIVE SCIENCES

This section explores three existing urban studies theories: cognitive mapping, attention restoration theory and rhythmanalysis. A brief overview of each theory is provided that identifies areas of commonality with embodied cognition and emerging studies that have combined EEG and other neuroscientific approaching to improving the empirical evidence basis for each theory.

COGNITIVE MAPPING, WAYFINDING AND THE INCORPORATION OF EEG STUDIES

This section outlines the central theory of cognitive mapping, its relationship foundational urban theorists such as Kevin Lynch, and how neuroscience has been used to develop an empirical evidence basis for the cognitive mapping process. This demonstrates that there are fields of urban studies already being combined with cognitive science to produce deeper insights into people's interactions with the urban environment. Studies incorporating EEG into wayfinding are summarised to show that EEG in particular is a useful research method for gathering data as people navigate within urban spaces.

A cognitive map is a person's mental construct of how they know and understand the environment. Cognitive mapping refers to the mental process people use to collect, interpret and remember information about their environments (Golledge & Garling 2003). This environmental information includes the physical attributes as well as personal impressions of a place's character, function and sociocultural meaning (Salama, Al-Maimani & Khalfani 2013).

Cognitive mapping theory is built on the foundations of mental mapping, pioneered by urban theorists such as Lynch and his influential book, *The Image of the City* (1960), which introduced key terms such as wayfinding and imageability. Wayfinding refers to the multiple ways that people navigate within space and between places. Imageability describes the degree to which an object evokes a strong mental image for the observer. The five elements that impact the imageability of the city are defined by Lynch as paths, edges, districts, nodes and landmarks, as his observations found these to be the physical elements people used to understand and navigate the urban environment.

Lynch (1960) explains the image of the city as a product of a two-way process between the person experiencing the city and the environment of the city. This image is simultaneously part of a larger cultural narrative of the city and a personalised understanding, unique to each person's personal experience and meaning of the city. In Lynch's view, the form of the city is not the final goal; rather, it is the sum of the city's parts within the perception of the individual that is of paramount importance.

Cognitive mapping expands on Lynch's foundation approaching wayfinding behaviour by simultaneously considering people's subjective perception and the objective physical properties of an environment (Miglino & Ponticorvo 2009). The combination of subjective and objective information that constitutes cognitive maps has both accuracies and inaccuracies, where a level of flexibility and decision making is needed by people to navigate through space. For example, there is often a degree of incompleteness to a person's cognitive map, partly due to the person's interactions with the environment being limited to certain areas and other inconsistencies, such as a distorted sense of distance that is influenced by personal perception. Downing (as cited in Kitchin 1996, p. 2) describes place cognition as:

> [Suspending] impressions, thoughts, feelings and ideas until, for some reason, consciously or unconsciously, the mind solicits, changes, and often distorts or manipulates its contents for some immediate purpose. In this way cognitive maps (images) allow us to bridge time, by using past experiences to understand present and future situations.

Downing's description highlights that experience of place plays a constitutive role in the cognitive mapping process. Cognitive mapping occurs within the context of a person's daily activities within and moving between places as well as interactions with other people (Moffat & Resnick 2002). The lived experience of purposeful interactions gives values and meanings to the physical characteristics of the environment, and these feed into a larger social understanding of place (Hund & Gill 2014).

Cognitive mapping has faced criticism for being conceptually weak and needing more research to explore people's learning strategies for acquiring spatial knowledge as well as how information is processed to influence spatial thought and behaviour (Downs & Stea 2017; Golledge 1999; Ishikawa 2021; Yamu et al. 2018). In particular, cognitive mapping theories tend to lack easily discernible links to verifiable hypothesises. As a result, many experiments have been too general to be able to draw definitive conclusions. Early cognitive mapping studies have been approached by geographers in terms of how people learn and remember the various elements of their cognitive map, whereas psychologists have traditionally focused on the process of thinking and storage of knowledge through words and images (Gärling & Evans 1991; Kitchin 1996).

Contemporary studies have since moved towards more rigorous experiments, aided by improvements to scientific research, to understand how the brain processes spatial knowledge (Mizumori 2007). Research supports the hippocampus as having a primary role in shaping an individual's cognitive map. This is due to neurons identified in the hippocampus, which are known as place cells (Gaussier et al. 2002). Place cells fire when an individual enters particular environments and they interact with other neurons in the hippocampus to process spatial awareness. The interactions of these neuron in the hippocampus to produce mental representations of a person's cognitive map (O'Keefe et al. 1998).

Studies have suggested that place cells respond to complex stimuli rather than individual sensory inputs (Moser, Kropff & Moser 2008; Save et al 2000). Visual information is believed to be a key source of contextual information utilised by place cells, which allows new information to be gathered as a person moves through space (Mizumori 2007; Moser, Kropff & Moser 2008). Less is known about the interaction of place cells and non-visual sensory information; however, olfactory information can also be used to create a memory of place. Experiments conducted without light found that different odours can provide reference points for place cells in the navigation of space (Save et al 2000).

Lynch's (1960) list of qualities, namely paths, edges, districts, nodes and landmarks, has been supported by studies from the cognitive sciences as a useful shortlist of legible wayfinding features. Wayfinding is a decision-making process for navigating between places. Effective wayfinding depends on legible features that can be interpreted to orientate and guide a person as they move through space (Hölscher, Tenbrink & Wiener 2011). Following well defined paths helps facilitate wayfinding as it reduces the cognitive demands on the user by reducing uncertainty and opportunities for veering off in the wrong direction. Landmarks function as commonly understood reference points that can be understood by people who are unfamiliar with a place (Lingwood et al. 2015; Zhou & Mou 2016). Edges and landmarks have also been the focus of Burgess (2008), who used fMRI to examine the multilayered neural systems that combine to support spatial memory, navigation and imagery. This study concluded that spatial cognition is one of several systems that work side by side to process the various aspects of the environment through corresponding sets of neural systems in different parts of the brain.

EEG has the potential to play a role in increasing the empirical evidence basis for cognitive mapping. While it must be noted that EEG does not have the functionality to study the medial temporal lobe structures, such as the hippocampus, it is able to monitor theta brain waves. Theta frequency oscillations have been linked to wayfinding processes such as decision making and accessing episodic memory (Bischof & Boulanger 2003; Kober & Neuper 2011). In practice, this means capturing data that reflects whether people are passively following a route or actively navigating within the environment based on the patterns of theta activity. Higher theta activity has been linked to active navigation that necessitates decision making to pick a path, and also complexity of an environment where the decision making can be impacted by a lack of legibility in the design of the environment (Burgess 2008, Mavros et al. 2016). This would mean the EEG could be used to study people's wayfinding behaviours by investigating the difficulty people faced in navigating when presented with a range of urban environments.

ATTENTION RESTORATION THEORY AND EEG STUDIES

This section provides an overview of the Kaplan's attention restoration theory and how it has been used to understand people's responses to natural elements of their environments, followed by a summary of studies that incorporate EEG to demonstrate deeper insights into the theory. This provides an example of an emerging line of inquiry that combines existing urban theory with cognitive sciences to produce new datasets.

While the idea that urban environments can have restorative potential for people was first explored by Simmel (1984) and Milgram (1970), Rachel and Stephen Kaplan built on this foundation to introduce attention restoration theory (Kaplan & Kaplan 1982, Kaplan & Kaplan 1989). Attention restoration theory posits that nature has the ability to replenish a person's ability to concentrate or direct their attention from fatigue. The Kaplans theorised that focusing too much attention on anything was likely to result in mental fatigue. In response, they recommended that contact with nature could remedy this fatigue by observing that the natural environment involved effortless attention. The Kaplans' theory divides attention into two: involuntary attention, where a person's attention is drawn by important stimuli or by something inherently intriguing, and voluntary attention, which is consciously directed by a person (Kaplan, Kaplan & Ryan 1998).

Restorative environments are defined under attention restoration theory as having four key characteristics: fascination, being away, extension and compatibility.

- Fascination is explained as the capacity for an environment to inspire awe that invokes involuntary attention in a person, thereby allowing directed attention a chance to be rested.

- Being away is described as a feeling that can encompass both the literal sense of a person being removed from their location and as being mentally adrift from the cares and worries of everyday life.
- Extension is defined as the connection between all the facets within an environment that can instil a feeling that invites a person to move through an environment with a sense of orderly coherence.
- Compatibility refers to the ability of an environment to meet the goals and preferences of the person experiencing it (Kaplan & Kaplan 1989).

These characteristics are most commonly found in natural environments that provide 'soft fascinations,' meaning that no effort is needed to capture a person's attention when observing things like the sound of water in a stream, clouds drifting overhead, and verdant plant life, which are, according to the theory, compatible with people's want and needs (Kaplan & Kaplan 1989).

Over the decades since the introduction of attention restoration theory, the principles of this theory have been supported through investigations in numerous settings ranging from predominantly natural environments, such as forests and rural areas (Hartig, Mang & Evans 1991; Miles, Sullivan & Kuo 1998; Park et al.2010; Roe & Aspinall 2011; Shin et al. 2010) as well as smaller scale green spaces, including parks, schools and suburban neighbourhoods (Fuller et al. 2007; Hartig et al. 2003; Korpela et al. 2008, Krenichyn 2006, Lin et al. 2014; Matsuoka 2010; Rappe & Kivelä 2005; Taylor, Kuo & Sullivan 2002; Tennessen & Cimprich 1995; Wells 2000).

Despite a large body of evidence in support of the validity of attention restoration theory, there have also been criticisms that warrant further examination. The three main criticisms that are explored here are that, firstly, there is a paucity of evidence to support the assumption that a restorative response is founded on evolutionary biology; secondly, key elements of the theory, such as soft fascination and directed attention, are vague and would benefit from further refinement; and thirdly, there is a lack of a framework needed to thoroughly test the impact nature has on people's improving people's wellbeing.

Attention restoration theory has been linked to biophilia in a hypothesis that people's affinity to nature can be understood from an evolutionary perspective. Fuller et al. (2007) and Irvine et al. (2013) agree with the Kaplans that the natural elements that most effortless elicit fascination are those with some sort of evolutionary significance, such as the inherent danger of fire or the sustenance offered by plant life, and that people are predisposed to natural environments as these settings are closest to the conditions that humans evolved within and depended on for survival. Furthermore, Fuller and Irvine argue that not all nature is equal in its ability to relieve mental fatigue, suggesting a direct causality between increased positive psychological effects from experiencing nature and perceived increased biodiversity.

Joye and Van den Berg (2011) are critical of the idea that restorative responses to nature have developed through evolution as an adaptive trait in humans and highlight the questions still in want of answers from current literature. If natural environments contained all the means for safety and survival through habitats and food, as well as threats such as predators, why would these elements not be a source of more intense directed attention rather than soft fascination, given their importance to survival? With the wide variety of environments humans have inhabited, such as icy tundras and arid deserts, how have we all evolved to be predisposed to verdant vegetation when this would have been scarce for many groups of people? At present, there is not enough empirical evidence to support these assumptions (Joye & Dewitte 2018, Joye & Van den Berg 2011).

The idea of 'directed attention' is of critical importance in attention restoration theory, as it is through this effort to focus while blocking out other stimuli that causes fatigue. The 'soft fascination' with nature is proposed as able to counter this cognitive depletion as it captures people's attention effortlessly (Kaplan & Berman 2010; Kaplan & Kaplan 1989; Kaplan 1995). In practice, directed attention and soft fascination can prove difficult to operationalise. Of the multiple studies already cited that support the validity of attention restoration theory, a myriad of research methods has been used but no standardised scale for defining the specifics of when a person is in a state of soft fascination or directed attention has yet emerged. Soft fascination in particular can be seen as particularly nebulous, as people may or may not be conscious of entering soft fascination (Peschardt & Stigsdotter 2013; Lin et al. 2014). It is possible that methods from the cognitive sciences, such as EEG or fMRI, may be able to elucidate the functioning of the brain when it is in a state of directed attention and soft fascination.

While there is literature to provide empirical evidence to support the hypothesis that nature can have restorative benefits on people's cognitive functioning, currently, there is no hierarchy to determine what the ideal natural settings are for cognitive restoration. The wide breadth of studies shows that much work is needed to develop a framework for understanding what the optimal interaction with nature might be to yield these positive cognitive effects. Studies have investigated a range of elements, such as what dose of exposure to nature is required (Barton & Pretty 2010; Shanahan et al. 2016), whether virtual exposure through photos, videos and virtual reality or in person interaction is needed (Li et al. 2020; Snell et al. 2019; Van den Berg, Jorgensen & Wilson 2014), whether orderly or more chaotic natural environments change people's cognitive restoration (Szolosi, Watson & Ruddell 2014), and what impact competing elements that elicit stress responses may have on the restorative effects of nature (Peschardt & Stigsdotter 2013, Nasar & Jones 1997). These studies represent important progress in developing a framework, but are nevertheless still ongoing and offer fertile ground for further experimentation.

It is possible that research methods from the cognitive sciences have the potential to build upon existing literature that demonstrates a clear relationship between exposure to nature and cognitive benefits by investigating the neurological functions that process this response. Equipment such as EEG and fMRI may be able to provide new data to improve our understanding of weaknesses in attention restoration theory by defining states of directed attention and soft fascination and providing detail in the nuanced responses people have to different sorts of natural stimuli. While there are other criticisms of attention restoration theory that cannot be addressed thorough EEG, the following examples demonstrate that there is nevertheless an opportunity to improve current understandings and strengthen existing evidence basses (Chen et al. 2016; Grassini et al. 2019; Hopman et al. 2020; Li et al. 2020; Neale et al. 2020; Tang et al. 2017).

Brown and Lee (2016) have sought to draw connections between neurological studies and the evolution of the human brain to understand the biological basis for people's design preferences. As they highlight, the transition from nomadism to sedentary agriculture was a process that spanned thousands of years, allowing time for an evolutionary process to unfold. These biological underpinnings may have included people's general preference for safe refuge and prospects for observing possible threats, which is supported by sensorimotor networks in the brain. However, it must be noted that, while cognitive neuroscience methods such as EEG can provide insight into the current functionality of people's brains, the inability to preform retrospective longitudinal studies means that it cannot be definitively prove this theory at this point in time.

Since the introduction of attention restoration theory decades ago, efforts have been made to link the theory to studies on brain activity (Kaplan & Berman 2010, Tang et al. 2017). The involuntary attention of soft fascination has been compared to bottom-up attention, which refers to observable brain activity in the ventral frontal cortex and temporal cortical. Directed attention has been equated to top-down attention, where the dorsal-anterior, dorsal-frontal and parietal cortical areas of the brain are active. However, it should be noted that these comparisons remain theoretical and further empirical evidence is needed through fMRI studies to categorical prove this link (Tang et al. 2017).

Incorporating EEG studies into investigations of attention restoration theory can provide neurophysiological responses of people presented with natural stimuli. Hopman et al. (2020) have used EEG to track the impact of visual and auditory stimuli from nature on cognitive performance. Their study found that extended periods in natural environments related to fluctuations in neural biomarkers. In particular, resting posterior alpha power is a biomarker that fluctuates in attention. Higher posterior alpha power suggests focused attention (Bowman et al. 2017) while lower levels of posterior alpha power correlates to a narrower field of attention (Pitchford & Arnell 2019). The study by Hopman et al. (2020) found resting posterior alpha power to be consistently lower in the research participants who spent prolonged periods in natural environments, which supports the hypothesis that natural stimuli are less taxing on people's attention.

The data provided from EEG may be useful in capturing datasets that provide nuanced detail on the impact of different stressors, which is needed to refine a framework for determining the optimal environmental stimuli to elicit positive cognitive benefits. The aforementioned study by Neale et al. (2020) used EEG with a group of older people to explore the impact of different urban settings, such as busy, quiet and green spaces. The study tracked participants' alpha and low beta waves, which are associated with relaxation and attention respectively, as the participants walked through varying urban environments. Participant low beta activity was reduced when exposed to green spaces, which suggests lower levels of attention consistent with attention restoration theory. The largest shift in neural activity was found in comparing participants' responses to busy urban spaces with quiet urban spaces and green spaces. Neale et al. (2020) believe that the participants' neural responses to the stimuli of the busy urban setting suggests that elements such as buildings and heavy traffic are stimuli that play a significantly influential role in responding to urban environments.

Although EEG studies that focus on people–place interactions, such as the above-mentioned, are only recently emerging, the findings provided thus far suggest that there is a capacity for yielding new datasets that can provide new insights into existing urban study theories such as attention restoration theory.

RHYTHMANALYSIS AND MOBILE EEG HEADSETS

This section brings together Lefebvre's (1991) theories of embodied movement and explores how studies using cognitive science methods have built on Lefebvre's foundation. This will demonstrate the synergies between existing urban studies, such as rhythmanalysis, and mobile devices that allow tracking of people's responses in situ. This is juxtaposed against laboratory conditions that are often conducted while stationary and with the use of artificial stimuli.

There are already urban theories that approach understanding people's relationships to place through an embodied perspective. Lefebvre explores the relationship between body and space in his influential book, *The Production of Space* (1991), which describes the body as having a central role in the production of space. Lefebvre believes that the body both *is* space and *has* space. This means that the body simultaneously produces space and produces itself within space. The role of the body in understanding a person's experience is strenuously asserted by Lefebvre, who also challenged traditional Cartesian dualism. Lefebvre writes that

> Western philosophy has betrayed the body; it has actively participated in the great process of metaphorization that has abandoned the body; and it has denied the body. The living body, being at once 'subject' and 'object', cannot tolerate such conceptual

> division, and consequently philosophical concepts fall into the category of the 'sign of non-body,' (Lefebvre 1991, p. 407, emphasis in original).

For Lefebvre, the concept of body and space are inextricably intertwined with history as a sociocultural context in which a person lives their life. This means that the world is constituted through practical bodily involvement with the surrounding environment and draws from the specific sociocultural context of that place to form understanding.

Yet despite Lefebvre emphatic description of the importance of the body, he is seldom credited for his contribution towards understanding embodied movement. This is largely due to Lefebvre failing to produce a complete theory of embodiment. Instead, he elects to expand on the relationship between body and space, which opens his analysis to a broad scope ranging in scale from individual gestures to bodily attitudes, all within a historical context that stretches from daily activities to wide sociocultural practices (Elden 2004; Pile 1996; Shields 1998; Simonsen 2005; Tartia 2018).

Lefebvre's key contribution towards embodied movement is arguably the introduction of 'rhythmanalysis'. Rhythmanalysis is a phenomenological description of the interrelationship between time, space and action (Graham 2015; Simonsen 2005). Lefebvre proposes that rhythms are perceptible through the traditional senses; that is, sight, hearing, taste, smell and touch rather than thinking of rhythm in terms of musical or dance rhythms. Rhythmanalysis highlights the importance of the body as the primary receptor for sensory stimuli, making the body the centre for understanding rhythms (Lefebvre 2004; Elden 2004). According to Lefebvre's theory of polyrhythmia (meaning there are multiple sympathetic rhythms simultaneously), rhythms are experienced across several dimensions, as through daily life a person will be exposed to overlapping and interacting rhythms in the sight, sounds and smells of the city, but also intersubjective sociocultural cues that come from interacting with other people (Lefebvre 2004; Wunderlich 2008).

At its core, rhythmanalysis is a method of analysis that brings together embodied movement with space and time to explore the lived experience of places (Crang 2001; Shields 1998). Lefebrve theorised that rhythms are only perceptible through sensory experience of sights, sounds, smells, touch and taste, and there have been a wide variety of phenomenological studies that examine the biological, psychological and social rhythms of experience when walking in urban environments (Adkins et al. 2012; Bassett 2004; Degen & Rose 2012; Edensor 2010; Ewing & Handy 2009; Ingold 2010, 2011; Mehta 2008; Middleton 2010; O'Neill & Hubbard 2010; Pinder 2001; Wunderlisch 2008). For example, Seamon (1980) analyses walking as a routinised spatiotemporal experience through which we form patterns or 'choreographies' of habitual practices, such as going to the shops, meeting at a café, or taking a stroll in the park. These daily choreographies and social interactions play out in meeting and congregating and produce rhythms particular to the spaces and time they are played out in. When these situated choreographies are combined, they produce 'place-ballets,' (Seamon 1980). Over time, repeating the choreographies of place-ballets wears these patterns into the body through regularly treading on pavements, grassy parks, wooden floorboards, and these surfaces gradually align body and place (Edensor 2010; Seamon 1980).

The phenomenological context of rhythmanalysis has been built on by Karandinou and Turner (2017), who have incorporated the use of EEG into their study of people's moods while walking through space. Their experiment used the Emotiv EPOC EEG headset (the same model of EEG headset used in this research), which analyses the beta, alpha, theta and delta frequency bandwidths via an algorithm to track responses such as stress, relaxation and interest. This approach yielded interesting insights, including peaks in beta activity to indicate interest when participants encountered new views along the route, and lower beta readings when participants were more familiar with their environments. Different methods of crossing the street also elicited different responses from participants. When crossing at a pedestrian crossing with traffic lights, there was a decrease in beta activity that suggests their level of attention dropped while waiting for the lights to change to green. In contrast, when crossing streets without the aid of traffic lights, participants were observed to be more alert and recorded increases in beta activity, suggesting a higher level of attention.

Spinney (2015) has also argued that remote sensing devices, including EEGs, can provide useful data when coupled with phenomenological studies on embodied movement. Spinney identifies EEG techniques as being especially well suited to tracking people's emotional responses to stimuli as EEGs can measure both conscious and unconscious responses under controlled conditions. The mobility offered by EEG headsets has the added benefit of allowing the researcher to physically distance themselves from the participant to allow participants to act without direct involvement from the researcher, which may influence the participants' behaviours or reactions. Combining EEG headsets with other bio-sensing technology, like galvanic skin response (GSR), which tracks sweat gland activity as a measure of emotional and sympathetic responses, is an approach that Spinney (2015, p. 5) sees as enriching phenomenological understanding, saying that it 'enables bodies "speak for themselves" by providing new narratives around the intensity of affects in relation to other phenomena.' However, this statement is tempered by Spinney's admission that the data collected via EEG and GSR can only partially show people's experiences and further notes that the software gathering the raw data has inbuilt values that influence the interpretation of the gathered information.

The use of mobile EEG devices opens two important dimensions to evaluations: the ability to track people's responses to real-life stimuli rather than artificial stimuli such as photos, videos or virtual reality, and the ability to track these responses while moving. While there is no doubt that there are benefits to conducting studies in controlled laboratory conditions, a notable detraction is that people are given recreations of real-world stimuli that typically cannot afford the same multisensory experiences as encountered in real life (Ladouce et al. 2017). Photos can offer partial visual recreations, while videos can add sound. There is, nevertheless, a clear shortfall to passively observing these recreations compared to experiencing the environment in situ. Additionally, laboratory settings usually entail participants sitting or lying down, and they are often given specific instructions on how they can interact with the stimuli. This limits our understanding by bounding the scope of research to orchestrated interactions without allowing for the multitude of organic responses people can have when allowed to freely explore their environments (Bara 2017; Bowman et al. 2017; Ishikawa 2021).

Movement is essential for an embodied experience and virtual reality has taken it a step further by offering a more immersive experience for research participants. For example, Banaei et al. (2021) have studied the impact of architectural design on people's experience by incorporating EEG monitoring with virtual reality environments. The virtual reality environment was comprised of three-dimensional architectural forms that people could walk among within a physical room. Although this mix of methods allows for a wider scope of multisensory experiences, it still falls short of real-life experience. While participants can walk and turn their heads and torsos, is not the same as natural movement within urban environments (Vecchiato et al. 2015). Additionally, it must be recognised that the virtual reality environment, however detailed, is a simplified version of reality that lacks the multisensory experience of real life. While the sights and sounds of city life may be recreated, there have not been (as far as presently available literature can show) any studies that also recreate feelings like the rush of air that comes with passing traffic or the different sensations of pavement and gravel underfoot, or the jostling of crowds on busy streets (Ewing & Handy 2009). The dynamic nature of real life is, as yet, not replicable with current technologies and, therefore, it must be acknowledged that there are gaps in our research methods and consequently our understanding of human experience.

ROLE OF PUBLIC SQUARES AS MICROCOSM OF PUBLIC LIFE

This section briefly contextualises the focus of research on people's responses to public space played out in public life. Squares are introduced as the main form of public space examined in this research, as squares represent a microcosm of public space within a relatively contained, observable area that are also free of hazards such as traffic.

Public life is diverse and dynamic. It is impacted by a wide range of factors, such as people's age, gender, economic status, cultural practices, and the regulations of the governing authority. This complexity of public life makes it difficult to describe in concrete terms, yet regardless of which urban setting is under investigation, the core of public life is the interactions between people and also between people and the built environment as daily life is played out (Makagon 2003, Miller 2007).

Urban public space encompasses the elements of the city between buildings. Streets, squares and parks are clear examples of this, but it arguably extends to wherever we can observe the goings on of life, such as balconies and front yard gardens, as these spaces also allow for people to see and been seen – a critical aspect of involvement in public life (Gehl & Koch 2006).

Squares are the focus of this research as they typify public life within an observable, enclosed space. Historically, squares have been the commercial hubs of cities, hosting markets and trade; however, since the 1960s this function has noticeably shifted towards private shopping malls. Squares nevertheless remain places where people come together for shared experiences, ranging from causal meetings, chance encounters, celebrations and protests (Burns 2020, Carmona 2010, Worpole 2003).

Squares have also been chosen as the focus of this research as they typically prioritise pedestrian movement over vehicular traffic. Road traffic has been linked to a trend known as 'community severance', which refers to the physical and psychological barrier to pedestrian movement caused by modern transport infrastructure. The pedestrian environments offered by squares are less likely to be impacted by community severance and the associated impacts, such as poor air quality, overcrowding and high causality rates from traffic collisions (Coogan & Coogan 2004; Rui Anciaes et al. 2016).

Note that while this research focuses on two squares in Sydney, Australia, as case studies, this is primarily due to resource limitations of this study. The intention is to use World Square and Darling Square as examples that are comparable to public squares in other cites and other countries where this mix methods research may be utilised. It is not the focus of this study to draw any specific conclusions about public life in Sydney.

RESPONSES TO KEY DESIGN ELEMENTS OF PUBLIC SPACE

This section introduces and examines key elements of design commonly found in public spaces, such as squares, that impact on people's responses. The elements identified are order and pattern, openness, nature, upkeep and liveliness. These elements are primarily based on Nasar's work with additions from influential urban theorists Gehl (2011) and Alexander (1977). An overview of each element is provided and then extended by delving into the additional insight offered by combining existing urban literature with studies from the cognitive sciences.

ORDERLY DESIGN AND PATTERNS

This section introduces order and patterns as design elements that typically appeal to people. The similarities of order and patterns are highlighted and compared. Some criticisms of pattern languages are presented alongside an embodied cognition perspective to illustrate synergies between these approaches to understanding place.

The aesthetic value of design is explored by Nasar's *The Evaluative Image of the City* (1998) and Alexander's *A Pattern Language* (1977) by taking a generalised view on people's broad preferences. For Nasar, order was defined as a key characteristic of likeability. The people surveyed by Nasar showed a general preference for a clearly understood and uniform style as opposed to the confusion that came with chaotic settings. The basis for this preference was attributed to the Kaplans by Nasar, who agreed that there was an evolutionary predisposition among humans to prefer a sense of visual order in the environment. Nasar does deviate somewhat from Kaplan, however, as Kaplan posited that there is also a preference for complexity within order in natural environments, whereas Nasar's observations in urban settings do not find evidence for any preference towards complexity (Nasar 1990, 1998).

Alexander (1977) also introduces a sense of order though patterns. Patterns are presented as flexible yet systematic approaches to a wide variety of design scenarios, offering a hypothesised 'best-fit' approach as an entry point to understanding effective design. Similar to Nasar, Alexander posits the effectiveness of patterns is grounded in the historic underpinning of human development, suggesting early architecture was able to intuit environments that best suited people's natural predispositions. For example, Alexander advocated positioning bedrooms to allow for sunlight, arguing that, regardless of people's preference for sleeping late, there is a biological need for the body to work in conjunction with natural daylight cycles.

Generalisations such as the above example have attracted criticism as *A Pattern Language* (1977) often claims a causal link between human behaviour and design without providing the empirical evidence needed to substantiate it. Additionally, Alexander frequently leans towards determinism, which does not allow for the diversity of responses that people can have to any given stimuli (Dovey 1990; Protzen 1978). While these criticisms do have merit, becoming too fixated on these weakness risks losing sight of the point Alexander is making; that the 'rightness' of a design stems from human sensations and biological need.

Alexander's approach of blurring the objective and subjective to present a form of holistic knowledge dovetails with embodied cognition, which also rejects Cartesian dualism. Alexander's work highlights how the experience of design can influence people's feelings of vitality and ease when things are 'just right.' Alexander challenges us to develop a holistic understanding by pushing for a greater awareness of the cognitive impact design can have, drawing attention to what makes the built form come 'alive.' Alexander writes,

> When I say something is real, I mean that the fundamental neurological processes and deep-seated cognitive processes going on in the brain are actually taking place in a holistic way […] and the person who is seeing a thing holistically is actually seeing what is congruent within it instead of just its physical geometry (Alexander, as cited in Bhatt 2010, p. 725).

In other words, Alexander is calling for greater awareness of how people's experience of space, rather than passive observation, is pivotal in understanding the building blocks of good design.

Advances in cognitive science have begun to provide an empirical evidence base to explain why people are generally predisposed to prefer order and patterns in their environments. Human cognitive systems have found people's perception is often goal orientated and immediately seeks to gather information to identify and make sense of our surroundings. Being able to recognise a pattern or understand the nature of something's order triggers a release of opioids in the area of the brain associated with 'liking.' We experience a sensation of pleasure at being able to quickly make sense of our environment (Williams Goldhagen 2017).

OPENNESS AND EXPOSURE

This section presents openness as a trait people often enjoy and a commonly observed behavioural trait of pedestrians walking along the edges of open space. This contrast between liking openness and not necessarily venturing out into it is then explored through thigmotaxis, or 'wall-hugging' behaviours observed by evolutionary biologists.

Nasar (1990) identified that people generally prefer a sense of openness experienced with open spaces and open views where they can easily take in the scenery. Correspondingly, a sense of restriction through crowding, congestion, or narrow spaces is typically disliked by people. Juxtaposed with people's preference for open space is the behavioural trait of walking along the edges of the space rather than venturing out into the centre. Jacobs (1961) observed this behaviour while watching pedestrians in the streets, noting that even in the absence of traffic people 'do not sally out in the middle and glory in being kings of the road at last. They stay to the sides.' She hypothesised the cause of this behaviour, saying 'I think, because that is where it is most interesting. As they walk, they occupy themselves with seeing – seeing in windows, seeing buildings, seeing each other.'

It seems counterintuitive that people simultaneously prefer open spaces with open views yet also prefer to remain on the edges as this provides visual stimulation. Taking an embodied cognition approach can help shed light on this apparent contradiction. Our conscious thoughts first begin as unconscious thoughts and, as such, the unconscious drives much of human behaviour (Kandel 2012). One such unconscious trait has been identified as thigmotaxis: the influence of a solid body on movement and orientation. This is also referred to as 'wall-hugging' for simplicity (Sussman & Hollander 2014).

Thigmotaxis is a very old trait. It has been exhibited by 3.6-billion-year-old bacteria and continues through evolution to be present in a range of animals, including insects, reptiles, amphibians and mammals (including humans). In the human brain, thigmotaxis is believed to be one of many spatial traits governed by the hippocampus. Owing to this evolutionary background it is hypothesised that thigmotaxis is linked to a fear of exposure to predators and familiarising oneself with possible escape routes. Wall-hugging behaviour can manifest to different degrees for people depending on the situation and individual anxiety levels but produces a general tendency to avoid the open centres of new places. The faster a person is at developing a cognitive map of a new area, the quicker they are to venture out into the open (Sussman & Hollander 2014).

Within the context of urban spaces, accounting for wall-hugging behaviour can bring new understanding to the importance of edges. For example, in regards to Pattern 124, Alexander (1977) noted 'the life of a public square forms naturally around its edge. If the edge fails, the space never becomes lively' and goes on to say 'a big space will be wasted unless there are trees, monuments, seats, foundations – a place where people can protect their backs as easily as they can around an edge.' With an awareness of thigmotaxis, the unconscious anxiety that can contribute to people's use or avoidance of space adds a new level of understanding to support intuitive urban theorists.

NATURAL AND FABRICATED ENVIRONMENTS

This section outlines people's preferences for natural over human-made design elements. It builds on the themes already explored under attention restoration theory by introducing a new aspect of biophilic design theory to explain why people can find artificial design dissatisfying. This is then combined with a cognitive science perspective that adds empirical data to support the theory presented by biophilic designers.

People's preferences for natural environments is addressed earlier in this chapter in relation to attention restoration theory (Kaplan & Kaplan 1982, 1989); however, given the importance of this aspect of design it merits being revisited. Briefly, people generally enjoy having natural elements in their environments such as plants, water and birdsong. Human-made elements, such as wires, poles and other infrastructure, and industrial and commercial strips, are often seen an obtrusive features that detract from the likeability of a place (Nasar 1990).

Biophilic theorists such as Kellert (2012) assert that people's general dislike for fabricated design elements is due to the lack of aesthetic value and complexity that can be found in natural environments. Modern design has created many urban environments that abound in monotonous expanses of concrete and buildings covered in featureless glass exteriors, which are the same around the world. Artificial imitations like plastic woodgrain veneers or plastic flowers may ape the appearance of the original but do not address the other sensory elements, such as texture or smell. This proliferation of artificial environments that constitute many people's daily interactions with the city is, according to biophilic designers, ill-suited to people's sensory needs (Heerwagen 1990, Kellert 2012).

The cognitive sciences have added weight to the argument that multisensory stimulation is important through data collected from brain scans. Scans have shown that tactile sensations stimulate the visual and auditory cortices of the brain, and visual sensations stimulate the auditory and somatosensory cortices. This means that our cognitive processes for sight and touch are closely linked together and with sounds as well. We do not experience our interactions with the environment in a singular way that can be satisfied by artificial substitutes that do not cater to the multilayered way we experience the world (Williams Goldhagen 2017).

UPKEEP AND DERELICT PLACES

This section expands on Nasar's point that people's preferences for upkeep may be linked to perceptions of good social behaviour. This is explored through a study that suggests a correlation between the perception of tidiness and trust, and the role of canonical and mirror neurons in perception of other's actions.

Upkeep refers to the level of maintenance carried out within a place with people generally preferring cleanliness and things to be in good condition. Places that appear run down, dirty, overgrown with weeds, littered with rubbish or marked with graffiti are regarded as reflecting a poor level of upkeep (Nasar 1998).

Nasar (1998) notes that people have reported their dislike of poor upkeep as it can act as a cue for social disorder. The idea that tidiness can communicate a higher degree of respect for social norms has been supported by experimentation from evolutionary biologists Wilson and O'Brien (as cited in Montgomery 2014). In the study, participants were shown either images of derelict streets with broken pavement, rundown homes and poorly maintained lawns or pictures of undamaged pavement, newly constructed homes and well-manicured lawns. The participants were then asked to play a game where they were asked to trade money with a person from an area that had just been shown in the images. People tended to trust residents from the well-maintained area far more than those from the poorly maintained neighbourhood, suggesting upkeep can have a strong influence on the perception of a streets residents.

Taking the understanding of this phenomena a step further may be possible when considering canonical and mirror neurons. As previously described, canonical neurons fire when we are presented with an object that we can potentially interact with, such as seeing a flight of stairs we might climb, while mirror neurons fire when we prepare to interact with an object or observe someone else preforming an action, such as watching someone else climb a flight of stairs. This suggests that human motor systems and sensory systems may be, if not unified in a single system, at least closely related. In other words, 'perception is never passive. Perception is perception for action' (Williams Goldhagen 2017, p 205).

While studies investigating the impacts of these neurons are still emerging, it is possible that they play a role in our preference for good upkeep. Maintenance clearly involves regular human intervention to ensure things are tidy while derelict environments have often become run down due to a lack of care taken. It may be that observing places where there are signs that people have undertaken steps to care for a place may spark an unconscious sense of empathy in us. If we can see that a place is cared for, we in turn are more likely to care for it ourselves (Ellard 2015).

LIVELINESS AND PEOPLE

This section connects Gehl's observations on the importance of people in creating lively places with embodied cognition studies. To further understand the neural processes underpinning our attraction to lively places, an EEG study and mirror neurons are used to suggest how the brain may be responding to encountering people in public places.

Gehl (2006) has been a strong proponent of the importance of people in creating liveliness within an urban environment. Gehl describes this phenomenon as a process whereby when people are gathered or engaged in an activity, more people will be drawn to the area. The activities grow as more people join in, which will attract more people, and so on. This becomes a self-perpetuating process as 'something happens because something happens because something happens' (Gehl 2006).

Karandinou & Turner (2017) have used EEG headsets to gain further insight into the brain activity that occurs when we encounter people in public spaces. They observed that when their participants encountered other people there was an increased level of activity in the theta/alpha ranges, which are associated with cognitive and memory performance. Additionally, the closer the participant came to other people passing by, the more intense the activity occurred. They hypothesised that this pattern of brain activity may suggest that we unconsciously scan the people we encounter to look for recognition of a familiar face.

Returning to the aforementioned canonical and mirror neurons may also shed further light on the appeal of watching other people engage in activities in public spaces. As mirror neurons fire in response to other engaging in activities, being able to observe people in a range of activities, such siting, eating, walking, talking, and playing is likely to stimulate mirror neurons from a range of stimuli. It may be that we find liveliness especially stimulating because of the close connection of our motor and sensory systems (Montgomery 2014).

CONCLUSION

The compatibility of pairing embodied cognition with urban theory and research methods is beginning to emerge. This has been explored through studies using the cognitive sciences and technology such as EEG headsets to add deeper understanding to three urban theories: cognitive mapping, attention restoration theory, and rhythmanalysis. This research has drawn further connections with the cognitive sciences by introducing avenues that connect Nasar, Alexander and Gehl's elements of design and public life that elicit positive responses from people.

Chapter Four

Research Design

CHAPTER FOUR – RESEARCH DESIGN

INTRODUCTION

This chapter provides the foundation to answer sub-question four, which is:

> **What new data can electroencephalography (EEG) provide on how people experience and respond to design elements in public space?**

To be able to answer this question, it must first be established how EEG can be used together with existing research methods. There are a variety of well-established research methods used for investigating people's responses to place. Influential theorists and practitioners, such as Whyte (1980), Jacobs (1962), Alexander (1977) and Gehl (2006, 2011), have advocated techniques that have yielded insightful datasets relating to how people interact with urban environments. This has established a solid foundation that can be built upon by adopting research methods from the cognitive sciences to open new avenues for analysis.

Mobile EEG headsets provide the opportunity for data collection outside clinical settings. Participants can easily wear an EEG headset within the public spaces they encounter on a daily basis. Case study sites offer real-world environments for the participants to interact with and have been selected to provide different design elements that can elicit a range of responses from participants. The two case study sites, World Square and Darling Square, both in the City of Sydney, are discussed. This chapter also outlines how the key design features explored in Chapter Three have been identified in Sydney's public space.

The innovative mix of research methods that combines EEG to gather data on unconscious responses and surveys and walking interviews to understand conscious responses to design elements is (as far as can be determined) the first instance of mixing these methods and thus part of the original contribution to planning and design literature made in this thesis. Three research methods are used to produce a comprehensive dataset that uses both quantitative and qualitative approaches to capture participants' conscious and unconscious responses to design elements:

- Method 1 EEG, which records participants' brainwaves as they experience different aspects of design.
- Method 2 Surveys, which has been designed to closely match the data collected by the EEG to combine participants' conscious experiences with their unconscious EEG measurements.
- Method 3 Walking interviews, which enables participants to move within space and reflect on their experience through semi-structured questions.

This chapter discusses how the three research methods relate to embodied cognition theory and urban studies, and how this connection has been embedded into the design of each research method. Details on the recruitment of the research participants' selection and role in the study are also provided.

This research was conducted under the University of New South Wales Ethics Approval number HC190698 (12/9/19). Note that this thesis was originally started at the University of New South Wales, not the University of Sydney. A copy of the Ethics Approval is provided as Appendix A.

ESTABLISHED RESEARCH METHODS FOR STUDYING PEOPLE'S RESPONSES TO PLACE

This section provides a high-level overview of commonly used research methods to study people's responses to place, as pioneered by Whyte (1980), Jacobs (1962), Alexander (1977) and Gehl (2006, 2011). This contextualises the mix of methods used in this study by establishing the foundations that are being built upon by incorporating EEG as a means for data collection.

From the 1960s into the 1980s, urban theorists such as William H. Whyte, Jane Jacobs, Christopher Alexander and Jan Gehl all questioned the impact of modernisation on public life (Gehl & Svarre 2013). Each theorist proposed a different approach to investigating people's interaction with public space.

Whyte found it difficult to pinpoint the root cause of a city's vitality and used the term 'sorcery' to describe the nature of city life, admitting there may be need for further theory to explore the phenomena of urban interactions. From a practical standpoint, however, Whyte's micro-level study of people's behaviour in urban spaces has unquestionably proved insightful for understanding social patterns. For example, Whyte's (1980) Street Life Project, which focused on social clustering, relied on observing people's movements through space and their use of public seating rather than basing his study on what people said they did. Whyte often incorporated the use of time lapse cameras into his studies to illustrate his observations. This method demonstrated a general trend that people gravitated to spaces that were already populated rather than avoiding crowds, which was the assumed behaviour generally accepted by planners at the time (Fitzpatrick 2016; Whyte 1980).

Jacob's *The Death and Life of Great American Cities* (1961) explores the crucial aspects needed to make public space lively and safe, arguing a better understanding was needed of how cities operate to ensure conviviality was not further eroded by modernist infrastructure and rational planning models. Jacob's primary approach to building this understanding was observation of people's behaviour and interactions with public space. This approach provided an ideological foundation for studying public life; however, it does not introduce the tools needed to go beyond the framework she set out.

Alexander responded to modernism by emphasising principles of design that he considered to be timeless through his primary work, *A Pattern Language* (1977). Alexander criticised modernism for its lack of understanding of the complexities of city life and how these elements of design create beauty and place based public life. Unlike Whyte and Jacobs, who relied on observation, Alexander argued the importance of people's participation in design as users have more knowledge about what works for them than architects or planners. *A Pattern Language* presents 253 qualities that invite people's participation in the design of furniture, rooms, buildings, gardens, and cities. This approach provided people with a guide to approaching the design of everyday life.

In *Life Between Buildings*, Gehl (2006) sought to identify the underlying reasons behind design that promoted vibrant public life in public space. Gehl's early focus was on public squares, studying how Italian piazza design impacted daily life by delving into details on where and how long people stayed in the square, whether people sat or stood, and how patterns of use changed over the course of a day and into the night. Gehl expanded on these observations by interviewing people on their motivations for being in the city and was able to confirm the connection between design and usage and thereby inform strategic thinking about the design of public space (Gehl & Koch 2006).

CASE STUDY SITES

This section contextualises the case study sites within the mix method approach used in this study. Connections are drawn between the importance of experiencing environments within embodied cognition theory and urban theorists that identify design features that can elicit positive and negative experience and responses from people. An overview of the different design elements in World Square and Darling Square is provided.

RATIONALE FOR USING THESE CASE STUDY SITES

This section outlines the importance of case study sites as a means of presenting a range of design elements as stimuli to elicit responses from the participants. The case study sites, World Square and Darling Square, have been selected as each site presents a different range of design features that are expected to elicit varying responses from the participants.

Using case study sites is a critical element in exploring the embodied response to space as it enables participants to have multisensory interactions with their physical environment. In order to present different stimuli to the participants, the two case study sites were selected on the basis of their contrasting design features. The design features identified in the literature review were synthesised from Nasar, Alexander, Gehl and Jacobs as widely accepted attributes from influential urban theorists. These features are:

- Orderly design and patterns
- Openness and exposure
- Natural and fabricated environments
- Upkeep and derelict places
- Liveliness and people.

This study has been intentionally designed to compare and contrast participants' responses with a mixed methods approach that draws from the cognitive sciences (Method 1 EEG) and commonly used urban research methods (Method 2 Survey and Method 3 Walking interviews).

DESIGN ELEMENTS OF THE CASE STUDY SITES

This section provides an overview of how World Square and Darling Square exhibit the elements of design using the criteria previously discussed in the literature review. Squares are used as a typologies that typify public life within an enclosed, observable public space. According to Nasar, Alexander, Gehl and Jacobs, the mix of designed elements in World Square is less likely to elicit positive responses while the mix of design elements in Darling Square in more likely to elicit positive responses from participants. This is summarised in Table 2 to compare and contrast the differences in design between World Square and Darling Square.

Both case study sites were observed rigorously at different intervals over a fortnight to determine general patterns of use, areas that people tended to linger in, sections that were avoided, and the locations of thoroughfares. This information, combined with the mix of design elements present in each site, was used to identify locations that participants were guided towards to ensure the walking interview covered a range of experience within each square.

Table 2 below provides a summary of the elements of place participants experienced during the research. Further detail about the specifics of World Square and Darling Square is provided in the site analysis sections of Chapters Five and Six, and the Appendices.

Table 2. Overview of key design elements in World Square and Darling Square[2]

	World Square	Darling Square
Orderly design and patterns	**Layout** There are seven laneways that extend out from the centre square on the ground level and more laneways on the lower level. Not all of these laneways have a distinctive style or theme, with a diverse selection of businesses in each. Some laneways offer shopping and dining while others serve as access points to corporate offices.	**Layout** There are two laneways and a large pedestrian thoroughfare that branch of the main square. The two laneways have different designs with different styles of artwork. One laneway is primarily devoted to retail business while the other is primarily focused on dining options.
	Theme There is a strong Asian influence in the design of the square, with a Chinese-style dragon sculpture and regular pop-up events that cater to Asian	**Theme** Being part of the Darling Quarter, Darling Square blends into the design of Darling Harbour, which is aimed at a more international audience of tourists. This

[2] Note that there are photos illustrating these design elements in Chapters Five and Six, which provide greater detail on the two case study sites.

	celebrations such as Chinese New Year and the Cherry Blossom Festival.	square also aims to cater for local residents as it abuts the University of Technology campus and accommodation.
	Patterns Patterns are used minimally as the facades are generally dominated by the branding styles of the respective businesses that occupy the square. The patterns that are present tend to be monotonous rectangular shapes in a palette of whites, greys and beiges, such as the facades of buildings and the paved floors.	**Patterns** Patterns are varied with different styles of rounded pavements used throughout the square. The building facades offer a mix of monotonous and varied patterns. The colour palette is wider, with a mix of warmer hues such as browns and yellows mixed in with beige.
	Shapes The dragon sculpture is the main round shape that dominates the design of the square. There is a sharp angle protruding into the square at the western side. The vast majority of other shapes are square and rectangular.	**Shapes** The wooden facade that wraps around the circular library emphasises the building's roundness. The tables and chairs located on pavements with circular patterns also provide rounded shapes. There are also long rectangular wooden features, such as the pergola and wooden slat benches for public seating.
Openness and exposure	There are multiple high-rise buildings surrounding the square that often leave the open area in shadow. World Square often functions as a thoroughfare for office workers cutting through the space to access Town Hall Station.	The surrounding buildings are lower (six to seven stories) in comparison to those surrounding World Square. The surrounding buildings tend to be residential dwellings in the upper levels. The open space in the centre is grassed and regularly strewn with beanbag chairs to provide space for recreation.
Natural and fabricated environments	**Natural** There are three garden beds with matching designs, a tree in the centre and short shrubs along the edges. The shape of the trees and shrubs have been pruned to match. There was some wild bird life observed at World Square, mainly ibis and pigeons.	**Natural** There are numerous garden beds with a mix of different plant species, both native and introduced. There are both flowering plants, such as jasmine, and non-flowering, such as ferns and succulents. There is a mix of deciduous and native evergreen trees, meaning the square became progressively greener during the study as the deciduous trees regrew their leaves. There is also a grassed area in the centre of the square.

	Fabricated There are free-standing lampposts off centre along the northern side. The bins are primarily located between the seating on the southern side. There is an abundant amount of advertising in the square to signpost the various businesses and their locations.	**Fabricated** There are lampposts and surveillance cameras spread throughout the square. There are numerous bins for recycling and general waste spread through the area. There are also drinking fountains for public use.
Upkeep and derelict places	World Square is an older place in comparison to Darling Square so exhibits more signs of wear but is generally well maintained. The level of litter fluctuated somewhat over the time of the research but was generally low given the private owners of World Square employ maintenance staff.	At the time of this research, Darling Square had only been open to the public for a matter of weeks, which meant everything was new and in very good condition. The level of litter varied during research and in some instances the public tables had litter sitting on them. A maintenance person was often observed at Darling Square removing litter and sweeping bark chips back into the garden beds.
Liveliness and people	While there are generally always people in World Square, it is busiest during weekdays during business hours when the offices surrounding the square are being used. World Square is a popular place for lunch breaks. A steady flow of people using it as a thoroughfare can be observed in the mornings as people arrive at work and early evening when people are leaving for the day.	Darling Square is patronised on both weekdays and weekends and is busiest during lunch and dinner times. There are regularly people making use of the ample public seating at all hours of the day for passive recreation, such as meeting friends, reading and relaxing. Bean bags have been introduced to help facilitate relaxation on the grassed area at the centre of the square.

To ensure participants' experiences of World Square and Darling Square were as consistent as possible, additional factors were considered in recruiting participants, which will be detailed later in this chapter. Note that when recruiting research participants, all volunteers where asked if they could attend during a window of 10am–6pm to ensure consistent sunlight exposure. No interviews were conducted after dark. Fieldwork was undertaken within October–November 2019 to ensure that there was minimal change in the ambient temperature (average Sydney temperature for October–November is 20°C–25°C). This period was selected as it avoided the cold of winter and heat of summer. A list of the times and dates of the interviews is provided in Appendix B. Some pop-up events were held during the interviews, such as a day where a delivery company had people handing out free gifts in World Square. These have been noted as variables and are listed in Appendices C and D.

APPROACH TO RECORDING THE DESIGN ELEMENTS AT THE CASE STUDY SITES

This section explains the design elements of World Square and Darling Square, which are presented visually via photographs used throughout this thesis and additional site descriptions in Chapters Four and Five.

The design elements of World Square and Darling Square are primarily recorded through photographs, which are used throughout this thesis to illustrate the stimuli to which the participants were responding. Details of the case study sites is provided through descriptions of the sites' respective contexts in Chapters Five and Six.

EXPLANATION AND RATIONALE OF RESARCH METHODS

This section details the three research methods used in this study: Method 1 EEG, Method 2 Surveys, and Method 3 Walking interviews. Each research method is linked to embodied cognition theory to show how this selection of research methods can work together to answer the main research question of this thesis. The design of each research method is explained and the approach to recording the data collected is outlined.

METHOD 1 – EEG

This section connects EEG to embodied cognition theory and the main research question as part of a mixed method approach. The functionality of the Emotiv EPOC EEG headset and EmotivPRO software are explained and examples of the data collected through this method are given.

RATIONALE FOR USING THIS RESEARCH METHOD

This section draws the connections between using Method 1 EEG with the research question by discussing how EEG dovetails with embodied cognition theory and the practicalities of fieldwork in public spaces.

Part of the original contribution to scholarship and knowledge represented through this thesis is exploring the feasibility of combining research methods from the cognitive sciences with research methods commonly used in urban studies to expand our understanding of people's responses to place. As discussed through the literature review, gathering EEG data is a commonly used method within cognitive science and is adaptable to urban studies. Other research methods used in cognitive science were considered but ultimately rejected, which is discussed later in this chapter.

EEG was selected for several reasons. Firstly, a central tenet of embodied cognition theory is the interaction between people and their environment, which means that it was of paramount importance to use a method that allowed participants to be within the environments being studied as opposed to being in a lab setting. Additionally, embodied cognition theory has a strong emphasis on movement through 'enactivism', so a method that allowed for movement is important for enabling people to interact with the environment with minimal encumbrance from equipment. EEG addresses both these issues, as the lightweight EEG headsets can be worn easily and allow participants to move through public spaces in a manner similar to their everyday interactions with space.

High quality EEG has the added benefit of being commercially available, easy to operate and affordable. This is a relatively new piece of equipment in the marketplace, previously used mainly in laboratory settings. Many of the alternative methods discussed later in the chapter were rejected as they were not accessible outside clinical conditions and required extensive training to be able to operate safely. Selecting equipment that is easily accessible means that the mix of research methods used in this thesis can be recreated in different settings to explore people's responses to other places.

THE SELECTION AND UTILISATION OF EEG EQUIPMENT

This section discusses why the Emotiv EPOC EEG headset was selected for use, the responses that it measures, and how it functions in the field. This information demonstrates the rigour used in pursuing EEG as a research methodology and its suitability for measuring people's responses to environmental stimuli.

Several low cost, mobile EEG monitors have been developed to overcome limitations of medical grade brain recording equipment, which is typically very expensive, requires specialised expertise to set up, and is usually too bulky to be used outside of static clinical settings (Al- Barrak et al. 2017; Berka et al. 2004; Duvinage et al. 2013). Of these commercially available alternatives, the Emotiv EPOC EEG headset was selected for use in this study for several reasons, as discussed below.

The Emotiv EPOC EEG headset has been tested in comparable studies to this research focusing on streetscapes rather than squares, and not combining the EEG data with other research methods. These studies found the Emotiv EPOC EEG headset to be an effective device (Karandinou & Turner 2017; Mavros, Austwick & Hudson Smith 2016). Previous studies have compared the use of the headset in indoor and outdoor settings, as well as seated and walking studies, and found that it was able to record data with consistent quality (Aspinall et al. 2015; Debener et al. 2012). Normal movement, such as eye blinks and walking, can create 'noise' in the electrical information processed by the headset, which may distort the data. This has been taken into account through the addition of a gyroscope in the headset to track movement and the algorithm used in the accompanying software that filters out extraneous electrical information (Mavros et al. 2016; Neale et al. 2020).

The algorithm used by Emotiv is not publicly available due to intellectual property restrictions, so the exact specifications are unknown. This has been addressed through other studies that have sought to validate the algorithm used by EmotivPRO software (Aspinall et al. 2015; Duvinage et al. 2013; Rodríguez, Rey & Alcañiz 2013). Although it was found that the data collected by the Emotiv EPOC EEG headset was not of sufficient quality for medical grade diagnostic work, this research does not seek to diagnose any medical conditions (Duvinage et al. 2013; Michel & Murray 2012). Rodríguez, Rey, and Alcañiz (2013) tested the reliability of the Emotiv EPOC EEG headset and algorithm in emotional studies by showing people images designed to elicit positive changes to mood and found that the data collected through the Emotiv device was consistent with data collected from more sophisticated equipment.

Figure 2. The Emotiv EPOC EEG headset modelled by K. Beer during pilot testing. Photo by T. Eldridge, World Square, 19/9/19.

The Emotiv EPOC EEG headset has been further tested in comparison to medical grade equipment (Emotiv, n.d.). The 14 sensors used by Emotiv EPOC EEG headset are small in number compared to medical equipment, which can use up to 200 sensors; however, the cost in developing a headset with such as high number of sensors would be prohibitive for commercial use and the volume of data would be too great to be able to transmit wirelessly

(Berka et al. 2004). In comparison to Emotiv, other commercially available wearables have fewer sensors; the NeuroSky headset MindWave Mobile has only a single sensor, and the Melon Headband has only two. The Emotiv headset offers a satisfactory compromise among these options (Al-barrack et al. 2017; Duvinage et al. 2013; Hollander & Foster 2016; Peng et al. 2020; Mavros et al. 2016).

THE FUNCTIONALITY OF THE EMOTIV EPOC HEADSET AND EMOTIVPRO SOFTWARE

This section explains how the Emotiv EPCO EEG headset collects data and how it is presented through performance metrics via the EmotivPRO software. This illustrates how the EEG headset and software were used within this research.

The Emotiv EPOC EEG headset has 14 sensors positioned to record the wearer's antero-frontal (AF3, AF4, F3, F4, F7, and F8), fronto-central (FC5 and FC6), occipital (O1 and O2), parietal (P7 and P8), and temporal sites (T7 and T8). These points cover the front of the brain, the top, back and sides to provide wide, simultaneous coverage of the brain's activity to create a visual representation of where different brain waves are occurring (Aspinall et al. 2015, Duvinage et al. 2013). Each sensor records the individual reading and charts this raw data in a graph that shows real time changes in brain activity. A sample of this data is provided in Appendix E.

The raw data is converted via an algorithm into performance metrics that are shown as graphs through the EmotivPRO software. The performance metrics measure six key responses (Emotiv, n.d.):

- **Frustration/Stress**. This measures the wearer's level of comfort with the situation that they are experiencing. High readings may occur when being confronted with a challenging problem that is not easily solved, or fear of failing to complete a task.
- **Engagement**. This measures the focus of attention towards a stimuli and alertness through a mixture of concentration and absorption in the task at hand. High levels of

engagement are measured through high readings of beta waves and with attenuated alpha waves.

- **Interest/Valence**. This measures the wearer's level of attraction or aversion to a stimuli or environment. High readings indicate strong interest, low readings indicate strong aversion, and mid-range readings indicate the wearer neither likes nor dislikes the stimuli or environment.
- **Excitement/stimulation**. This measures a positive feeling of awareness, characterised by activation in the sympathetic nervous system. These physiological responses can include pupil dilation, eye widening, sweat gland stimulation, and increased heart rate and muscle tension. The device is tuned to measure short-term changes in excitement over short time periods.
- **Focus.** In contrast to interest, focus measures fixed attention on a single stimulus. When the direction of attention frequently changes, this can indicate distraction.
- **Relaxation/Meditation**. This measures the wearer's ability to recover from intense focus and switch off their attention in a positive way (Emotiv.com n.d.; Karandinou & Turner 2017; Mavros et al. 2016).

The main research question of this thesis is centred on understanding how people respond to the design of place and of these six measures; the best suited to answer this question are interest, excitement, stress and relaxation. Engagement and focus are measures most commonly used in studies that focus on decision making and problem solving as a means of understanding how different factors impact people's abilities to perform tasks. Engagement and focus would be suited to urban studies research on subjects like wayfinding, as participants could be asked to independently navigate and decide on their route, or studies that seek to understand how various environmental factors impact on neurological processes by giving participants a puzzle to solve (Babini, Kulish & Namazi 2020; Berka et al. 2004;

Blanco, Vanleer & Calibo 2019; Peng et al. 2020; Wang, Gwizdka & Chaovalitwongse 2016). As this study is focusing on squares as an example of public space and the behaviours people would typically engage in within squares, the decision-making measures for engagement and focus were not applicable. Due to the relatively enclosed nature of squares, this typology negated the need for participants to exercise much thought towards wayfinding navigation and public space is not usually the setting for behaviours that require focused concentration, such as study. To reflect general patterns of use of public squares, the participants were asked questions to reflect on their experience of space and perceptions of the case study sites rather than assessing how these different environments may impact their ability to think or solve problems.

The performance metrics are presented via the EmotivPRO software as shown in Figure 3. The abbreviations along the left-hand side of the image are:

- St – Stress.
- En – Engagement.
- In – Interest.
- Ex – Excitement.
- Fo – Focus.
- Re – Relaxation.

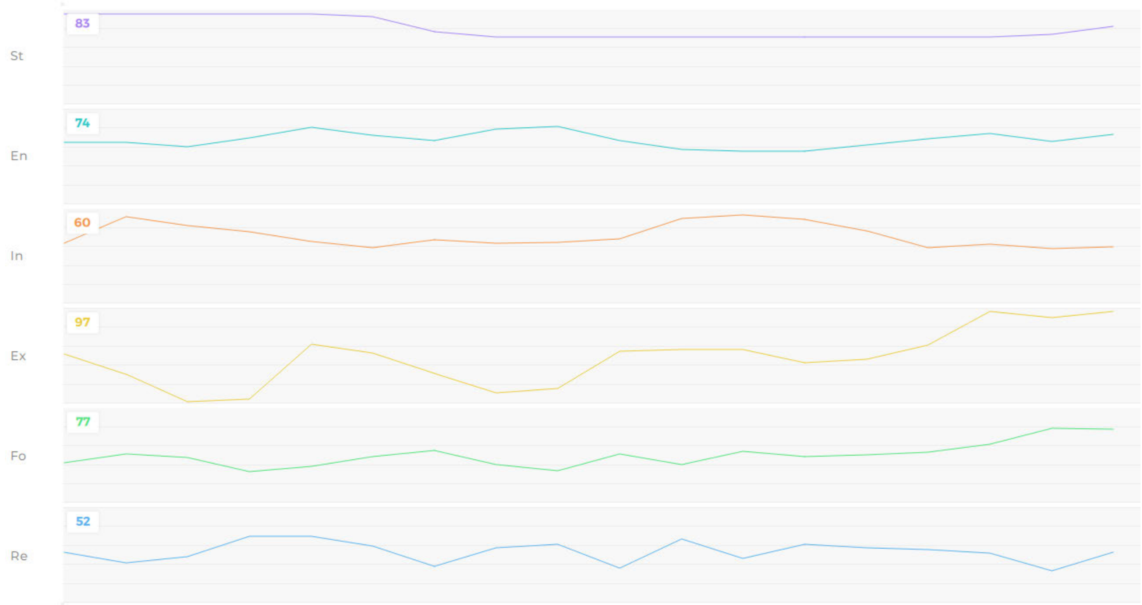


Figure 3. Screenshot of EmotivPRO software showing the readings of a participant during pilot testing, 19/9/19.

The data is presented as a score out of 100. The data is updated in real time to show the changes in neural activity throughout the experiment to reflect the multisensory experience of the participant at any point in time. The EmotivPRO software indicates the level of connectivity of each sensor throughout the course of each interview. Figure 4 below shows the graphic provided by the software, illustrating what level of connectivity each sensor currently has, with grey representing zero connection, red showing poor connection, yellow as a fair connection and green as a good connection. This ensures the equipment is getting the best possible data input with its connection points.

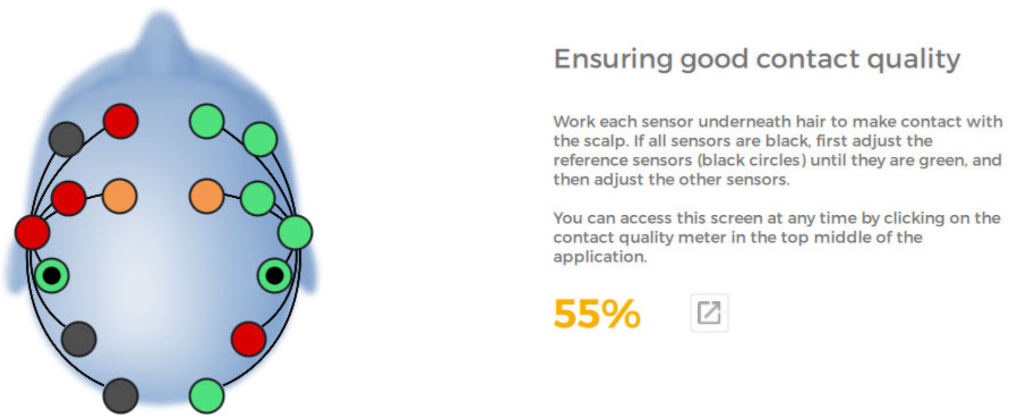


Figure 4. Screenshot of EmotivPRO software showing poor connectivity of the EEG headset.

At the beginning of each interview the headset was adjusted until all sensors showed a good level of connection, as illustrated in Figure 5. The sensors needed to be thoroughly wet with saline for a good connection as, through the course of the interview, some sensors began to dry from exposure to air and body warmth. Consequently, in some interviews the level of connectivity dropped slightly below 100%. Provided that the sensors had only changed to yellow and the connection remained above 90%, this margin of error was accepted. In the few instances where connectivity dropped below 90%, the headset was readjusted during the interview. The specific instances where connectivity was impacted are recorded in the participants interview notes in Appendix D.

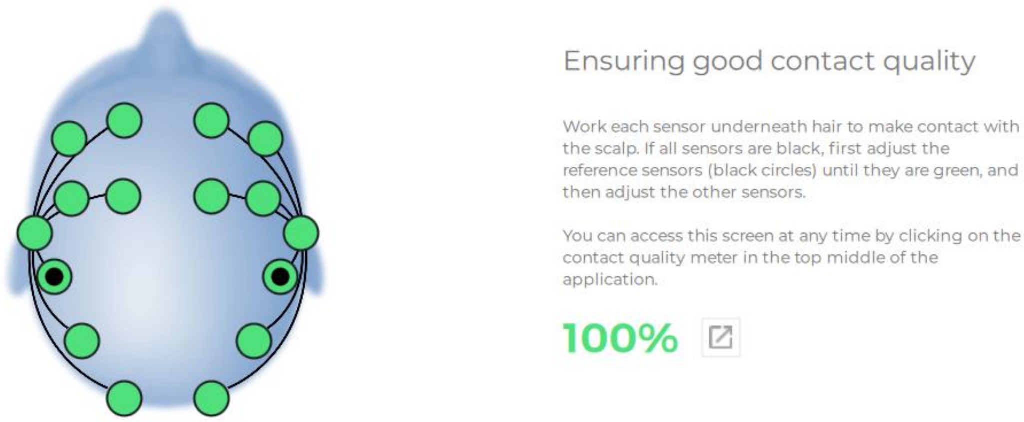


Figure 5. Screenshot of EmotivPRO software showing good connectivity of the EEG headset.

APPROACH TO RECORDING THE DATA

This section explains how the EEG data collected via the Emotiv EPOC head is presented via the EmotivPRO software. It explains the approach to recording each participant's EEG scores for the four selected performance metrics used in this study.

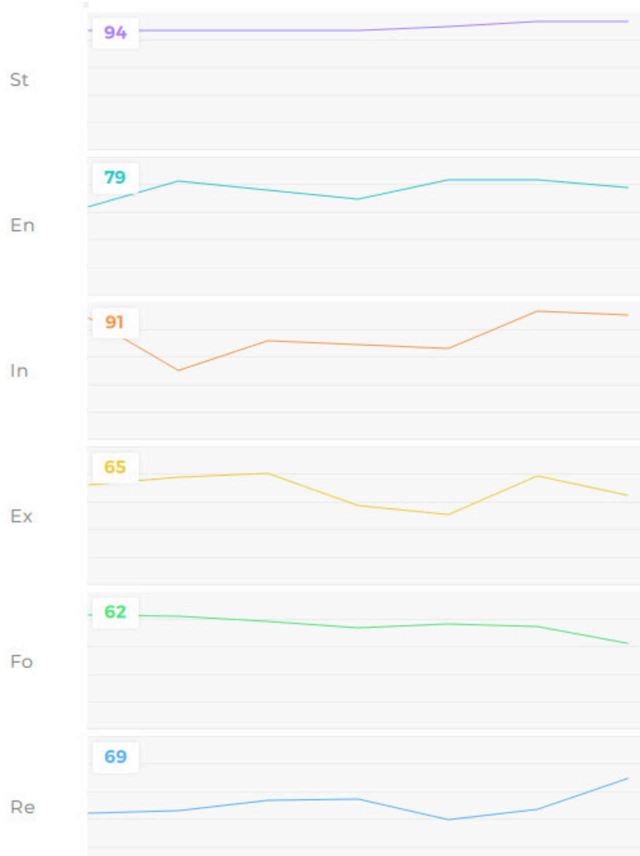


Figure 6. EEG data snapshot from EmotivPRO software showing Participant 1's reading to the first set of survey questions in World Square.

The audio recordings of the interviews are synchronised with the EEG recordings to allow both to be played together simultaneously. The EEG measurements were taken at the same point in time that the participant verbally responded to the survey questions. Figure 6 shows a snapshot of a 75-second section of the EEG data from Participant 1, Laura, while answering the first series of survey questions regarding an interesting feature in World Square. In this reading scores are shown as a number out of 100 along the left-hand side of the graph. These numbers were simplified to be shown as a number out of ten by moving the decimal place over. For example, the first row is stress (ST), which shows a reading of 94 and was recorded as 9.4. This allowed for a direct comparison with the survey scores, which range from zero to ten.

There was the possibility of some lag between the data shown in the software and the participants' responses as the EmotivPRO software charts the readings at ten second intervals. However, EEG studies have previously shown that the brain activity of a decision can be present up to seven seconds before a person is consciously aware of their decision (Keim 2008; Chun et al. 2008). Additionally, as Figure 6 shows, there are no major changes to the readings during the last 20 seconds of recording where the participant was responding to the survey questions, so it is unlikely the time delay of the software would have significantly impacted the accuracy of the EEG scores recorded.

DEFENCE OF THE RESEARCH METHODS

This section briefly explains other research methods that were considered and outlines the limitations of each respective method that resulted in the decision not to pursue them as part of this research.

There is a growing range of wearable devices that can be used to gather data on people's responses to stimuli. Alternative methods for measuring participants' responses were considered but ultimately rejected given their respective limitations. The main alternatives considered were electrodermal activity, blood volume pulse and virtual reality.

Electrodermal activity (EDA), also known as GSR, measures changes in the activity of our sweat glands, which reflects emotional arousal. Significant changes in GSR activity triggered by a stimulus is referred to as an event-related skin conductance response. Skin conductance is modulated by sympathetic activity that drives aspects of human behaviour, as well as cognitive and emotional states. Due to this relationship, skin conductance offers insights into emotional regulation (Boucsein 2012; Critchley 2002).

It is important to note that EDA does not indicate which emotion has been elicited, only the intensity of the emotion. Negative emotions like fear and positive emotions like joy can both result in an increase in skin conductance. This poses significant limitations for conclusively correlating data with the precise emotion being experienced (Ohme et al.2009).

EDA has other limitations in that it can be influenced by external factors like humidity and ambient temperature, which reduce the reliability of the data collected. EDA measurements can also be impacted by internal factors, such as medications and hydration, which may reduce the skin conductance response to the same stimulus (Villarejo, Zapirain & Zorrilla 2012).

Blood volume pulse (BVP) measures a person's heart rate by tracking the volume of blood passing through their tissue in an area of the body with a pulse. Generally, the pads of people's fingers or the earlobes are used given their easy accessibility. Similar to EDA, BVP is commonly used for indications of psychological arousal as states of stress and relaxation have been linked to higher and lower blood pressure respectively (Khan & Lawo 2016).

The reliability of data collected via BVP can be impacted by movement and is generally recommended to be used on people in seated or prone positions (Kushki et al. 2011). Given the importance of movement in embodied cognition theory, a method that allowed participants to walk through case study sites in a manner as close as possible to their everyday interaction with place rendered BVP an unviable research method.

Virtual reality (VR) headsets consist of a head mounted display that provides a separate image for each eye, stereo sound, and some models have additional features, such as eye tracking sensors and gyroscopes. VR headsets were considered as an alternative to psychical case study sites to ensure participants were presented with a consistent set of stimuli, free of the uncontrollable changes that come with public space, such as crowd size or weather (Barfield 2015).

Although VR technology has become quite immersive, it is not yet at the point where it can completely recreate the multisensory experience of the physical world. Latency (the time needed for changes to translate into visual effect) is an issue for VR headsets as there may be lag between the participant's movement and updates to the images they are being shown.

Delays in latency can bring on forms of motion sickness due to conflicting sensory inputs (Isoyama et al. 2020).

Additionally, other sensory experiences of place cannot be recreated via VR as it primarily focuses on audio and visual stimuli. For example, while VR may be able to recreate a streetscape with the images and sounds of traffic, it cannot recreate the smell of exhaust or the rust of air as the vehicle passes (Alampi Sottini et al. 2018). Given the importance embodied cognition theory places on interactions with the physical world, VR was not considered fit for purpose.

METHOD 2 – SURVEYS

This section connects the research method of surveys to embodied cognition theory. It also discusses how Method 2 Surveys worked together with Method 1 EEG to present a dataset that captured participants' conscious and unconscious responses to elements of design through designing the survey questions to mirror the EEG performance metrics.

RATIONALE FOR USING THIS RESEARCH METHOD

This section explains why surveys were used as a research method by linking the data collected through surveys with EEG datasets and embodied cognition theory.

Surveys were selected as a research method that complements Method 1 EEG. As the EEG measures people's unconscious responses via their brainwaves, survey questions measure people's conscious responses to stimuli. This was an intentional element to the design of this mixed methods approach as it mirrors embodied cognition theory's rejection of Cartesian dualism. Rather than either prioritising objective data gathered through the EEG or the subjective responses gathered through survey responses, both were collected as two equally important perspectives of people's experience. Combining these two datasets provides more robust information, which in turn opens a wider scope for more nuanced analysis through triangulation of data.

DESIGN OF THE SURVEY QUESTIONS

This section maps out how the survey questions were designed to synchronise with the EEG datasets collected via Method 1 EEG, thereby producing a cohesive dataset that captured both conscious and unconscious responses to the design of place.

The survey questions were designed to mirror the data collected through Method 1 EEG. During the study, participants were able to move through the case study site and had their attention directed to different design elements. While Method 1 EEG recorded their unconscious response to each stimuli, participants were simultaneously asked to verbally respond to survey questions to rate their conscious response to the stimuli they were presented with. The participants were given a card with the survey questions and the scale for their responses to hold and refer to during the study, which is provided in Appendix F. Participants were also verbally asked the survey questions at each of the same design elements in the same place in the square as the EEG recording was taken. Appendix H provides a map of where each reading was taken for each participant at both World Square and Darling Square.

Method 1 EEG measured four performance metrics (like/dislike, stimulation, stress and relaxation), which were measured in response to each design element the participants were asked to focus on. Correspondingly, there were four survey questions that were asked in response to each of the design elements the participants were asked to focus on.

Through the performance metrics the EEG measured participants' levels of liking or disliking within the range of zero to 100, where 0 was a strong dislike and 100 was a strong like. To match this unconscious measurement of like/dislike, the survey question was designed to ask participants to rate their conscious level of like/dislike. To match the range of the EEG, participants were asked to rate their level of like/dislike using a scale with 0 being strong dislike and 10 being strong like. The survey question used was: *To what extent do you like/dislike this aspect of the space you're experiencing?*

The EEG measured participants' levels of stimulation within the range of 0 to 100, with 0 being not at all stimulating and 100 being very stimulating. The survey question matched this by asking participants to rate their level of stimulation, with 0 being 'not at all' stimulated and 10 being very stimulated. The survey question used was: *To what extent do you find this aspect of the space you're experiencing stimulating?*

The EEG measured participants' levels of stress within the range of 0 to 100, with 0 being not at all stressed and 100 being very stressed. The survey question matched this by asking participants to rate their level of stress, with 0 being not at all stressed and 10 being very stressed. The survey question used was: *In relation to this aspect of space, to what extent do you feel stressed?*

The EEG measured participants' levels of relaxation within the range of zero to 100, with 0 being not at all relaxed and 100 being very relaxed. The survey question matched this by asking participants to rate their level of relaxation, with 0 being not at all relaxed and 10 being very relaxed. The survey question used was: *In relation to this aspect of space, to what extent do you feel relaxed?*

The same survey questions were repeated for each design element in both World Square and Darling Square.

APPROACH TO RECORDING THE DATA

This section explains how the survey scores were recorded as part of Method 3 Walking interviews.

The survey scores were reported verbally by participants during Method 3 Walking interviews and were subsequently transcribed. This is discussed further in the Method 3 Walking interviews section below.

METHOD 3 – WALKING INTERVIEWS

This section connects Method 3 Walking interviews to the theory discussed in the literature review and how Method 3 Walking interviews was designed to work together with the other research methods in this study. The approach to designing the research questions and the semi-structured route participants were given to follow is discussed as well as how the comments from the walking interviews were transcribed.

RATIONALE FOR USING THIS RESEARCH METHOD

This section connects Method 3 Walking interviews to embodied cognition theory and rhythmanalysis by revisiting the importance of movement through space. This section also contextualises Method 3 Walking interviews as a subjective, qualitative research method within the mix of methods used in this study.

Movement through space is a key element in the design of this mix of research methods. Walking interviews have been selected as this method links to enactivism within embodied cognition theory and embodied movement from the perspective of Lefebvre’s rhythmanalysis. As discussed previously in the literature review, embodied cognition theory and rhythmanalysis have areas of synergy, including an emphasis on bodily and sensory experience of place, and a rejection of Cartesian dualism.

The mix of methods used intentionally reflect key elements of theory with Method 1 EGG and Method 2 Surveys representing quantitative approaches to people's unconscious and conscious responses to place. Method 3 Walking interview brings qualitative methods into the mix to reflect the rejection of Cartesian dualism and gives equal importance to subjective and objective data. The inclusion of walking interviews into the mix of methods simultaneously embeds the research in place by requiring participants to walk through the case study sites and provide a narrative account of their experience.

DESIGN OF THE WALKING INTERVIEW QUESTIONS

This section explains how the semi structured questions and semi structured walking route of Method 3 Walking interviews was designed to incorporate

The walking interview questions were designed to be semi-structured and as open ended as possible to allow people the space to reflect on their experience of moving within the case study sites. The questions asked people to describe their experience and talk about their opinions of the design elements. A copy of the schedule of questions is available in Appendix G. Depending on people's responses to these questions, additional questions were asked to delve further into their responses to place and to tease out their understanding of place.

The walking route was a mix of allowing the participant to direct themselves and being directed to specific areas of the square. The design element previous discussed in the literature review, which were synthetised from Nasar, Alexander and Gehl, informed the key focal points of the walking route that people were directed towards during the interviews.

Firstly, participants were invited to identify aspects of each case study site that they found interesting and uninteresting, and to walk freely around to experience the design. Participants were then directed to stand in the most open part of the respective square to oblige them to a sense of exposure. Next, they were directed to find the most pleasant part of the landscaped area. As literature suggested, it may be stressful to be exposed in the centre of a square and relaxing to be exposed to natural elements; this sequence was a deliberate choice to compare and contrast these experiences (Sussman & Hollander 2014). To respond to the final questions participants were directed to areas that people seldom lingered according to previous observations of both sites. This approach prompted the participated to cover a wide mix of experiences within each square.

A map of each participants' positions when each measurement was taken for Method 1 EEG and Method 2 Survey in World Square and Darling Square is provided in Appendix H.[3]

Note that when moving from World Square to Darling Square, the same walking route was taken to ensure there was a relatively consistent experience for all participants. The route minimised exposure to traffic and noise by taking participants through back alleys where possible. The route is mapped in Appendix I.

APPROACH TO RECORDING THE DATA

This section explains the process used to transcribe the participants' verbal responses to both the Method 3 Walking interview questions and Method 2 Survey questions.

The transcriptions from the audio recordings of participant interviews were outsourced to an online company, Rev.com, which promises 99% accuracy rate (Rev n.d.) The website provides a transcript that is hyperlinked to the audio recording so that it can be listened to while double checking accuracy of the draft transcript. All transcripts were doubled checked to ensure the transcript reflected the interview as closely as possible. A sample excerpt of a transcript is provided in Appendix J.

[3] Note that it was not possible to map the walking route each participant took within the case study site as they were encouraged to wander throughout the site to increase their bodily experience of the places.

There were some limitations to the transcription process. Due to the windy conditions in World Square, there were some sections of the recording that could not be heard over the sound of the wind. These sections were noted in the transcript with references to the time of the recording where the wind rendered the interview inaudible. Some other minor edits were made to the transcript and were mainly due to Rev's unfamiliarly with words from First Nations Australian languages, such as place names and the names of plants, as well as some misunderstandings of Australian colloquialisms. These instances were amended in the transcript so that none of the participants' responses were lost in translation.

RECRUITMENT AND INVOLVEMENT OF THE RESEARCH PARTICIPANTS

This section details the characteristics of the research participants, the size of the participant group, the recruitment of participants, the approach to de-identifying participants and the timeframe of their involvement in this project. Providing this context for the research participants sets up how their individual contributions will be presented to maintain their confidentiality.

CHARACTERISTICS OF THE RESEARCH PARTICIPANTS

This section outlines the criteria used for selecting research participants and the reasoning behind these criteria.

The participating research volunteers were required to self-assess their eligibility against the following selection criteria:

- Between 25–45 years of age.
- Living in urban areas of Sydney for at least five years.
- Able to walk 2 km unassisted.
- Free of any visual, auditory or mobility impairments.

These criteria were developed to ensure the data collected from the participants would be comparable. The lower limit of the age bracket was set at 25 years of age as the human brain at this age is generally regarded to be fully developed, while the upper limit was set to acknowledge that brain functioning changes as we age, and to therefore decrease the risk of results being skewed with an older cohort group whose brains may be deteriorating due to age (Russell 2011).

Local residents of Sydney were targeted as research suggests being exposed to vastly different or new environments can be a source of stress and may result in increased brain activity to process the new experience (Jasanoff 2018). Participants were all generally familiar with Sydney central business district (CBD), where the two sites are located, and although the case study site at Darling Square was newly constructed, the design was in keeping with the adjacent Darling Harbour area, which is a broadly recognisable area of the city that most people have visited at some point.

The final criteria focused on recruiting able-bodied people as impediments to participants' ability to move and perceive the case study sites would cause a significant variable in their experience of the two case study sites (Jasanoff 2018).

Although it was not included in the original criteria, if this research method is to be repeated in other studies there may be some merit in including participant selection criteria that addresses any medication taken. It was discovered during one interview that that participant was taking lithium, which limited their ability to feel stress (Machado-Vieira 2018). The data collected from this participant has been included in this research despite the influence of the medication; the data collected was not significantly different to the other participants. However, this may not be true of other medications and should therefore be considered in any future attempts to replicate this study.

As this research was design to be a pilot study, the selection criteria were deliberately set broadly to capture a random sample. This approach could be further refined by future studies by narrowing the selection criteria to focus on, for example, cohorts from specific socio-economic backgrounds, or with different cognitive functions, or physical disabilities that would impact their bodily experience of place. However, it was not the focus on this study to investigate one specific demographic.

All participants signed an information and consent form, which is provided as Appendix K.

Participation was voluntary and no compensation was offered.

SAMPLE SIZE

This section defines the number of participants recruited as a sample of 20 people who visited both case study sites.

Twenty people were recruited to participate in the study; each participated in the two case study sites, creating individual datasets. Forty interviews and forty surveys accompany the forty EEG datasets. While it is acknowledged that this sample is not statistically reliable within the context of Sydney's population of almost five million people, the purpose of this study is not to determine the general experience of Sydney residents (ABS Census data 2016). The sample reflects the nature of this study as a pilot project to test the achievability and usefulness of this mix of research methods, rather than seeking to draw definitive conclusions regarding people's responses to the design of place.[4]

[4] It is acknowledged that the small sample size is not statistically significant. This research is intended to investigate the feasibility of the mix methods approach to research rather than draw conclusions on participants responses to design elements.

PARTICIPANT RECRUITMENT

This section explains how the participants were recruited to volunteer via advertising using social media and through presentations to groups of people with a general interest in this research project.

Participation in the experiment was advertised broadly to allow a diverse cross section of the local Sydney community to be involved. A flyer (Appendix L) was posted on Facebook social media groups (named below) comprised of residents in areas in and around Sydney city, including:

- Chippendale locals.
- Waterloo/Zetland/Rosebery Community and Business Group.
- Darlo Darlings.
- Pyrmont locals.
- I love the inner west.

The experiment was also advertised through three presentations in September and October 2019. These presentations were held at the Psychologists for Social Justice discussion group, a University of Sydney conference on embodiment, and a presentation at the NSW Aboriginal Housing Office. These locations were chosen as they each expressed a general interest in this research.

The 20 participants were drawn from a mix of these avenues, as well as some people who had heard about the study through word of mouth.

PARTICIPANT DE-IDENTIFICATION

This section explains that participants' identities have been protected through the use of pseudonyms.

All participants are referred to with pseudonyms to de-identify the data. The participants were given the opportunity to choose their pseudonym so they were able to decide how they are represented in this research.

DEMOGRAPHICS

The 20 participants were recruited with an even split of female and male participants. Please note that transsexual and intersex people were not excluded from this study, however, all participants identified as cis gender.

The study was open to people between the ages of 25–45 years of age but, as shown in Figure 7 below, the participants were aged between 30–45 years of age. It is unclear why no participants between the ages of 25–29 years volunteered for the study.

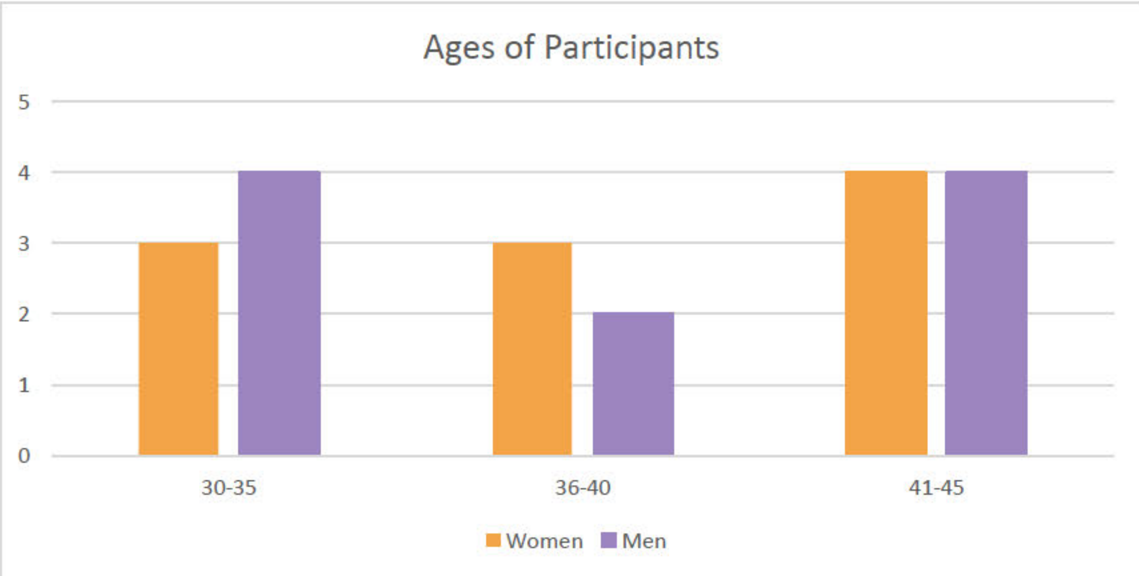


Figure 7. Graph showing the age and sex of the participants.

All 20 participants self-identified as having lived in Sydney for a minimum of five years to ensure they were familiar with the city. Figure 8 below illustrates the diverse range of backgrounds of the participants. Country of birth was not a factor that was considered in the recruitment of participants; however, the range of countries of origins does reasonably reflect the demographics of the Greater Sydney Area that shows the majority of people being born in Australia, with the most common countries of birth outside Australia being China, England, India and New Zealand (ABS Census data 2016). Of the people who identified as being born in Australia, two people identified as being First Nations Australian.

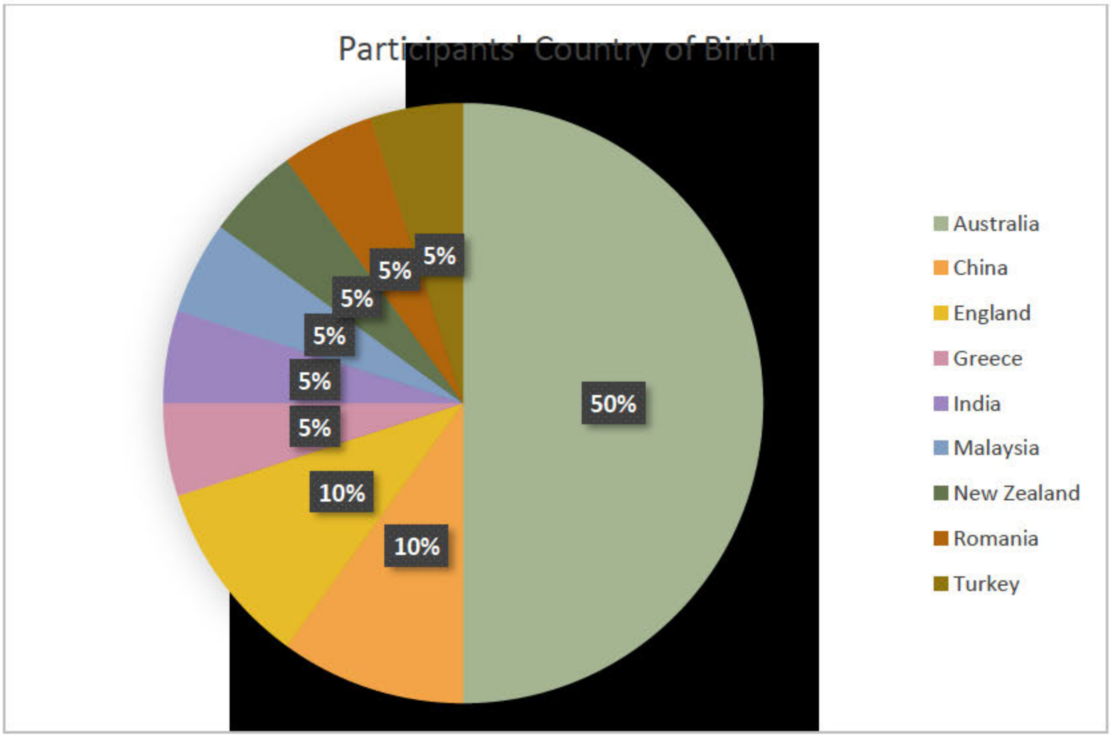


Figure 8. Graph showing the country of birth for all the participants.

Please note that these participants are the same people who visited both World Square and Darling Square.

PARTICIPANT INTERVIEW TIMES AND DATES

This section contextualises the participants' involvement by outlining the timeframe used for collecting data and the reasoning behind selecting this period of time.

Interviews were conducted between 5 October 2019 and 14 November 2019. This time period was chosen as the first weekend in October marks the beginning of daylight savings time and thus allowed for interviews to be conducted with natural sunlight after business hours for participants who worked in the city. The window for conducting interviews was intentionally as narrow as possible to minimise the chance of variables to climate, as October and November are reasonably warm without obligating people to venture out in the warmer summer months from December–February. Additionally, the study was concluded in mid-November as it was anticipated that people's availability in December would be impacted by the Christmas season festivities and the likelihood of people leaving for summer holidays.

See Appendix B for a full list of the specific times and dates each participant interview was conducted. All participants were sent thank you letters to acknowledge their contributions to this research. See Appendix M for a copy of the letter.

PILOT TESTING

This section describes the pilot testing conducted, the issues that arose from testing, and how these issues were addressed. This provides the context of how the final approach to Methods 1, 2 and 3 were refined for accuracy and more reliable data collection.

The initial testing focused on the EEG headset to understand the parameters that it could function within. The original plan was to set up the laptop that received the data from the headset in a backpack for participants to wear; however, interference from ambient signals in World Square proved to adversely impact the connection. The first phase of testing consisted of wearing the headset myself and walking methodically through transects of World Square and Darling Square to map out any black spots where the Bluetooth connectivity may drop out. The laneways in World Square were particularly difficult to maintain a steady signal and were therefore rendered out of scope. For consistency, the laneways in Darling Square were also deemed to be out of scope despite the fact connectivity could be maintained.

Three test participants were used to pilot this study on Thursday evening, 19 September 2019, Saturday morning, 21 September 2019, and midday Wednesday 25 September 2019. These times were chosen to provide different circumstances, such as weekday compared to weekends, during business hours and outside business hours. The participants were accompanied by the interviewer within a 1.5m radius to maintain the optimal connection between the EEG headset and laptop, but it was noted that the connection was still susceptible to dropping out within the centre of World Square. Consequentially, all interviews were conducted with the laptop being regularly monitored to ensure connectivity was re-established before continuing with the interview.

The pilot participants were asked the schedule of questions and the survey questions and participants generally found the questions easy to respond to. Only minor adjustments to the wording were made to clarify the draft survey questions. The order of the questions was changed slightly to respond to the fact the pilot participants found it confronting to stand in the most open area of World Square. The following questions were changed to allow them to next address the landscaped area of World Square to offset the uncomfortable feelings that arose from standing in the middle of the thoroughfare. The pilot participants were not included in the datasets for the final 20 participants.

FURTHER DETAILS AVAILABLE IN THE APPENDIX

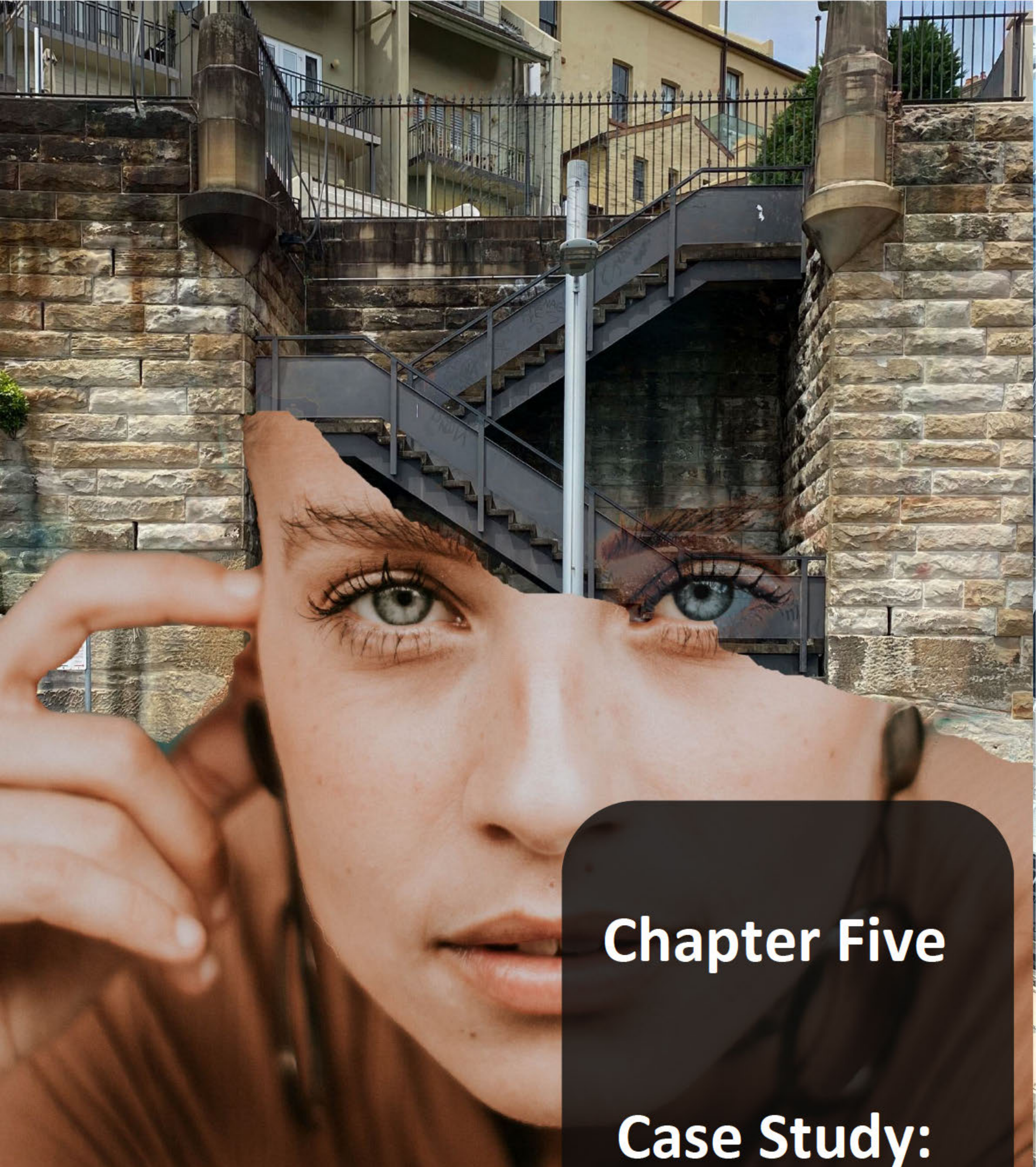
A list of further information provided in the Appendix is summarised in the below table.

Reference	Name	Description
Appendix A	UNSW ethics approval	Letter from University of New South Wales Ethics Committee approving this study.
Appendix B	List of participant interview times and dates	A table listing the times and dates that each participant engaged in the study.
Appendix C	Photos of variables at the case study sites	A series of photos to show elements of design that changed through the course of the study.
Appendix D	Interview reflections	Notes taken while conducting fieldwork with each participant.

Appendix E	Sample of raw EEG data	A sample image of the EEG raw data collected by the Emotiv EPOC EEG headset.
Appendix F	Survey questions	A copy of the cue card given to each participant as a visual prompt when responding to Method 2 Survey questions.
Appendix G	Schedule of questions	A copy of the semi-structured questions asked of each participant as part of Method 3 Walking interviews.
Appendix H	Measurement locations	A series of maps for each participant indicating where they were standing when measurements were taken for Method 1 EEG and Method 2 Survey.
Appendix I	Walking route between case study sites	A map showing the route each participant was escorted on to navigate between World Square and Darling Square.
Appendix J	Sample extract from participant transcript	A copy of the opening section of the transcription provided by rev.com.
Appendix K	Participant information and consent form	A copy of the information and consent form signed by each participant before engaging in the study.
Appendix L	Recruitment flyer	A copy of the flyer used to advertise participant recruitment.
Appendix M	Participant thank you letter	A copy of the letter sent to each participant thanking them for their contribution to the study.
Appendix N	Individual participant survey scores and EEG scores	Graphs that show each participants' scores across all datasets.

CONCLUSION

While there is a strong foundation of commonly used research methods for studying people's responses to place, as demonstrated by Whyte, Jacobs, Alexander and Gehl, there is an opportunity to gain further understanding by combining research methods from the cognitive sciences. This thesis has developed an innovated mix of methods that incorporates commonly used methods from the cognitive sciences by incorporating Method 1 EEG with Method 2 Surveys to provide a dataset that shows both unconscious and conscious responses to design elements. These methods are combined with qualitative perspective through Method 3 Walking interviews and the embodied experience of using case study sites.



Chapter Five

Case Study: World Square

CHAPTER FIVE – CASE STUDY: WORLD SQUARE

INTRODUCTION

The first of the two case study sites is World Square, Sydney. This chapter provides a context for the site in terms of its history, geography and over all appearance. Written descriptions and photographs of the design elements of World Square are provided to show the key stimuli that participants responded to when engaged in the study.

The research methods undertaken at World Square are described to show how the methods outlined in Chapter Four were carried out in situ. The data collected at World Square is presented according to each of the design elements being focused on (discussed in the previous chapters) through graphs that show survey scores and EEG sources. A summary of participants walking interview answers are provided to show participants' reflections on their experience at World Square.

The analysis of participants' responses to the design elements brings together the datasets collected through fieldwork (namely survey scores, EEG scores and walking interview responses). The discussion also reflects on theory discussed in the literature review to explore possible reasons for the various responses participants had in their experience at World Square.

WORLD SQUARE SITE ANALYSIS

This section provides an overview of the first case study site, World Square, to provide the context. The context is outlined through a brief overview of the First Nation's understanding of place from local Aboriginal people, an overview of postcolonial uses of area, and the geographic location of the site. The current design of World Square is described and illustrated by photographs of the ground plane of the square. This information provides a necessary familiarisation with World Square as the foundation for understanding the participants' experiences in these spaces in the following section of this chapter.

PRE-COLONIAL HISTORICAL CONTEXT

The following information has been provided with the permission of First Nations people as the traditional custodians of the land.

World Square is located on the land of the Gadigal people of the Eora Nation. Running along the western side of the case study sites was a traditional pathway that was co-opted by early settlers and renamed George Street. This pathway linked to other key tracks that were similarly co-opted and renamed Parramatta Road and City Road respectively, and which continue to be main roads used by Sydneysiders today. Prior to colonisation changing the topography of the area that World Square has been built on, the area was sloped, and the rainwater ran to the low ground around the site where Darling Square has been constructed (Personal communication, Gadigal man, 10/2/20; Personal communication, Education, Culture & Tourism Office, Sydney Metro Aboriginal Land Council, 22/1/20).

POSTCOLONIAL HISTORICAL CONTEXT

In the early 1800s the site that is now World Square was then known as Brickfield Hill. It was used as a cattle market until the expansion of development pushed the markets further afield (Karskens 2010).

From 1856, the site that was to become World Square was a store owned by the Horden family, which was developed into a major department store that dominated George Street. At its height, the site was operated by the Hordens as the Palace Emporium, which offered six stories of shopping, tearooms, postal services and a doctor. The store finally closed in 1973 and was demolished to make way for World Square; however, development was stalled by legal battles and financial troubles, which meant that World Square was not constructed until the early 2000s (Karskens 2010, City of Sydney Achieves 2016).

GEOGRAPHIC CONTEXT

Topographically, World Square is in a mostly flat area. It is located in Sydney's CBD within an 8–10-minute walking radius from Central Station. World Square and Darling Square are located on either side of Sydney's Chinatown, as shown in Figure 9. World Square spans across an entire city block in the heart of Sydney's CBD and is bound by Liverpool Street on the north side, Pitt Street on the east, Goulburn Street to the south and George Street on the western side.

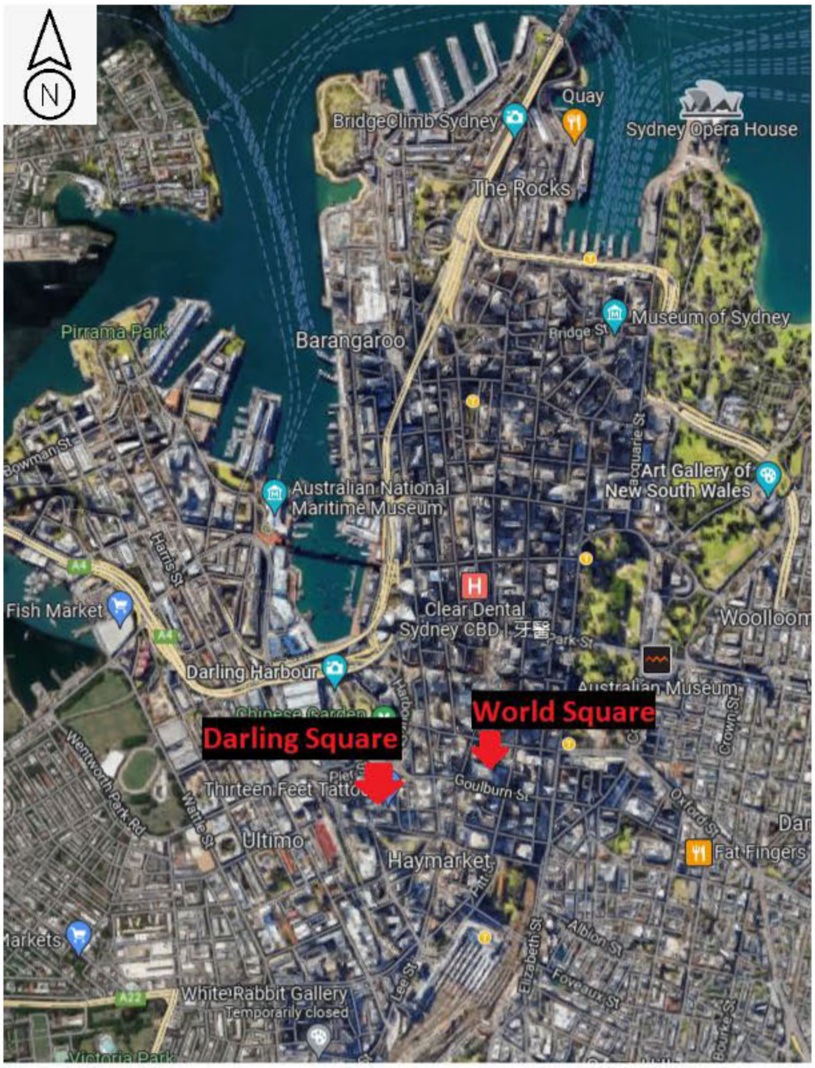


Figure 9. Map showing geographic context of World Square and Darling Square within Sydney's CBD. Image: Google Maps.

DESCRIPTION OF WORLD SQUARE

World Square is a mix of shopping, dining, business offices and hotel accommodation. The focus area of this study is the plaza on the ground level. It has a shopping area that extends from the plaza into a lower ground level, although the underground space is out of scope of this study. The plaza is flanked by high-rise buildings that are used as corporate offices, such as the Ernst & Young building, and hotel accommodation of Rydges, shown in Figure 10. Due to the multiple high-rise buildings, the open space is often in the shadows cast by these buildings.

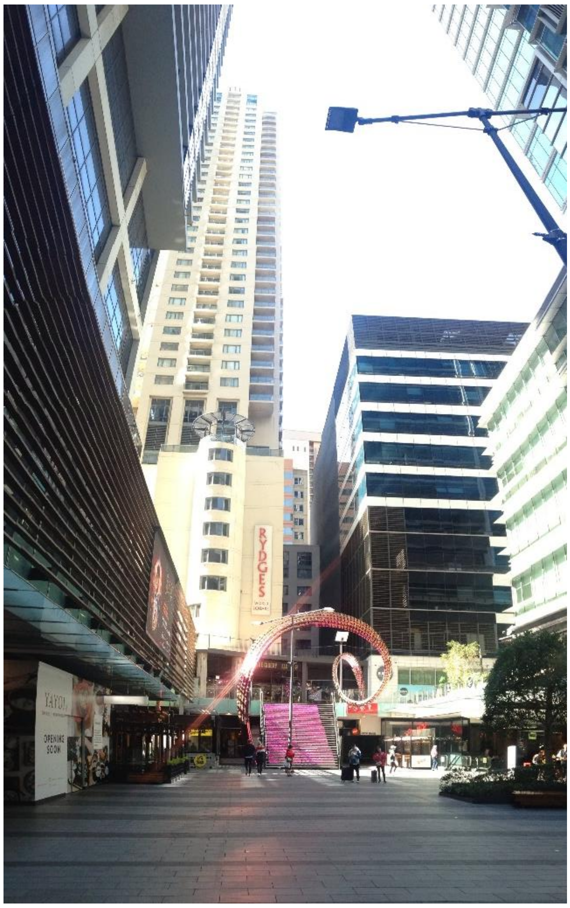


Figure 10. Photo: Eldridge, T, Panorama of the high-rise buildings such as Rydges Hotel at World Square, 9/9/19.

World Square is most patronised during business hours and early evening, with spikes of higher activity over lunch and dinner times. In the morning and at close of business hours there is a clear path that people take diagonally through World Square to access public transport options at Town Hall via the square's north-western exit. On weekends the area is still regularly used, especially at mealtimes, however the absence of people in the corporate offices makes a noticeable difference to the level of activity.

The northern side of World Square is mainly shopfronts for retail businesses and eateries on the ground level, while the upper level is used as a childcare centre, as shown in Figure 11. The northern side of the square also has a large television screen that runs a constant loop of advertising.

Figure 11. Photo: Eldridge, T, Panorama of the Northern side of World Square, 29/9/19.

The eastern end of the square is dominated by an artistic sculpture of a dragon that arcs above a staircase of LED lights, shown in Figure 12. The lights in the stairs are generally set to either a loop of animations that show various patterns or remain a static pink colour. Periodically, the lights will change to novelty designs, which can be seen in Appendix C and in Figure 12.

The upper level at the top of the stairs offers more restaurants, however, this space was outside the scope of this research.

Figure 12. Photo: Eldridge, T, Panorama of the Eastern side of World Square, 8/9/19.

Figure 13. Photo: Eldridge, T, Panorama of the Southern side of World Square, 29/9/19.

The southern side of World Square is mainly retail shopfronts. There are also some garden beds with public seating between the three trees, shown in Figure 13.

The western side of World Square provides access to George Street and is flanked by a coffee shop on the left and commercial shopfronts on the right. There are large wooden benches to provide public seating. The ground in between these benches is angled to provide a ramp for people with mobility issues. There is also an extension of the dragon sculpture from the opposite end of the square, which stands at the top of the mobility ramp and can be seen in the centre of the photo in Figure 14.

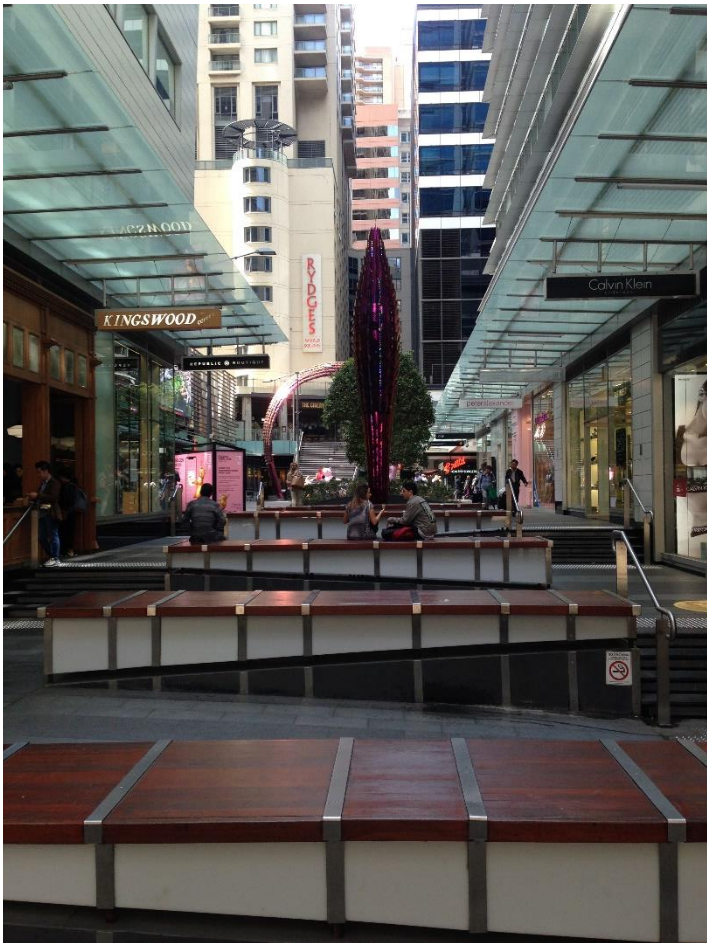


Figure 14. Photo: Eldridge, T, Photo taken from George of the western side of World Square, 29/9/19.

DESIGN ELEMENTS AT WORLD SQUARE

This section identifies, describes and illustrates (through photos) the key design elements in World Square that are the focus of this study, namely orderly design and patterns, openness and exposure, natural and fabricated elements, upkeep and derelict elements, liveliness and people. These descriptions are provided to show the stimuli that participants were asked to focus on during Method 3 Walking interviews and when answering the questions from Method 2 Surveys.

ORDERLY DESIGN AND PATTERNS

LAYOUT

There are seven laneways that extend out from the centre square on the ground level and more laneways on the lower level. Not all of these laneways have a distinctive style or theme, with a diverse selection of businesses in each. Some laneways offer shopping and dining while others serve as access points to corporate offices.

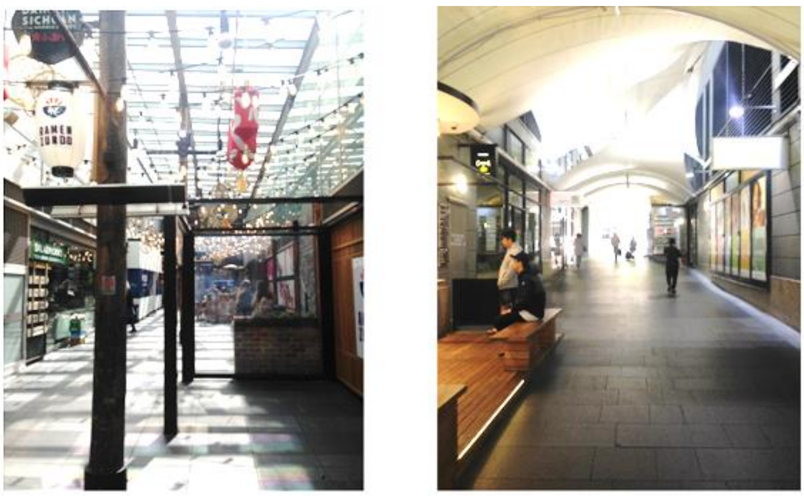


Figure 15. Photo: Eldridge, T, Laneways branching out of the centre of World Square, 8/9/19.

Figure 16. Photo: Eldridge, T, Laneways branching out of the centre of World Square, 8/9/19.

THEME

There is a strong Asian influence in the design of the square, with a Chinese-style dragon sculpture. There are regular pop-up events that cater to Asian celebrations, such as Chinese New Year and the Cherry Blossom Festival, which (based on personal observation of the site) draws patrons to the square for photo opportunities.

Figure 17. Photo: Eldridge, T, Pop-up event themed on Chinese New Year, World Square, 6/10/19.

PATTERNS

Patterns are used minimally in World Square as the facades are generally dominated by the branding styles of the respective businesses that occupy the square. The patterns that are present tend to be monotonous rectangular shapes in a palette of whites, greys and beiges, such as the facades of buildings and the paved floors.

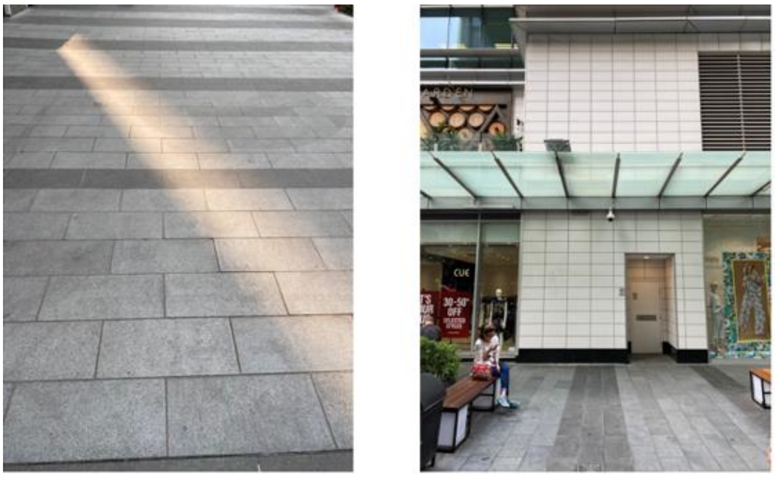


Figure 18. Photos: Eldridge, T, Patterns of the pavement and tiles, World Square, 8/9/19.

Figure 19. Photos: Eldridge, T, Patterns of the building facades with monotonous repetition of horizontal lines and square windows dominating the building facades, World Square, 8/9/19.

SHAPES

The dragon sculpture is the main round shape that dominates the design of the square. There is a sharp angle protruding into the square at the western side. The vast majority of other shapes are square and rectangular.

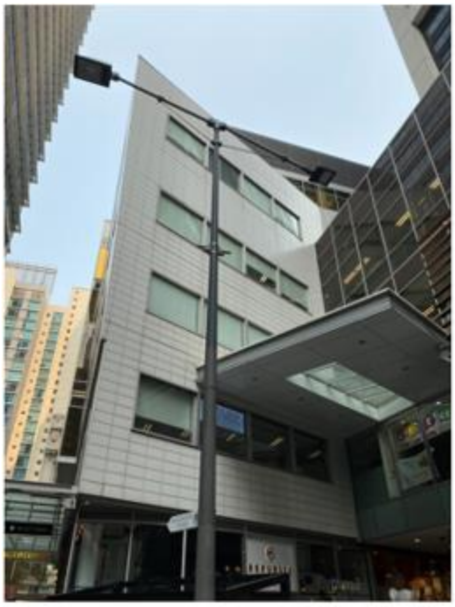


Figure 20. Photos: Eldridge, T, Sharp shapes of buildings and the looping curves of the sculpture, World Square, 8/9/19.

OPENNESS AND EXPOSURE

There are multiple high-rise buildings surround the square that often leave the open area in shadow. World Square often functions as a thoroughfare for office workers cutting through the space to access Town Hall Station.

Figure 21. Photos: Eldridge, T, Empty open space in World Square, 8/9/19.

NATURAL AND FABRICATED ELEMENTS

There are three garden beds with matching designs, including a tree in the centre and short shrubs along the edges. The shape of the trees and shrubs have been pruned to match each other. There was some wild bird life observed at World Square, mainly ibis and pigeons.

Figure 22. Photos: Eldridge, T, Minimal landscaping shown with two of the three garden beds, World Square, 8/9/19.

There are free-standing lampposts off centre along the northern side. The bins are primarily located in between the seating on the southern side. There is an abundant amount of advertising in the square to signpost the various businesses and their locations.

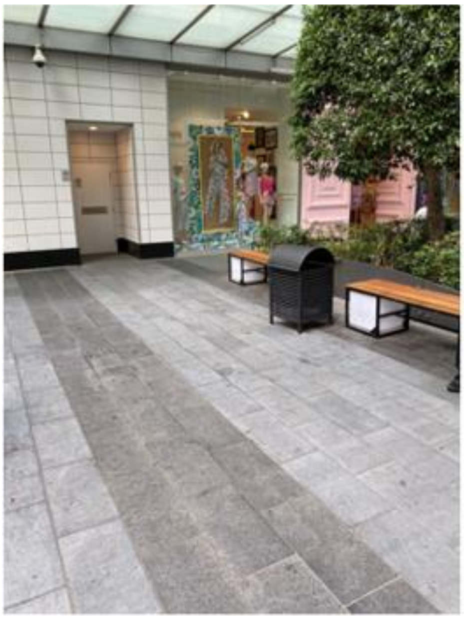


Figure 23. Photos: Eldridge, T, Bins and lampposts, World Square, 8/9/19.

UPKEEP AND DERELICT PLACES

World Square is older than Darling Square, so it exhibits more signs of wear but is generally well maintained. The level of litter fluctuated somewhat over the time of the research, but was generally low given the private owners of World Square employ maintenance staff.

LIVELINESS AND PEOPLE

While there are generally always people in World Square, it is busiest during business hours on weekdays when the offices surrounding the square are being used. World Square is a popular place for lunch breaks. A steady flow of people using it as a thoroughfare can be observed in the mornings as people arrive at work and early evening when people are leaving for the day.

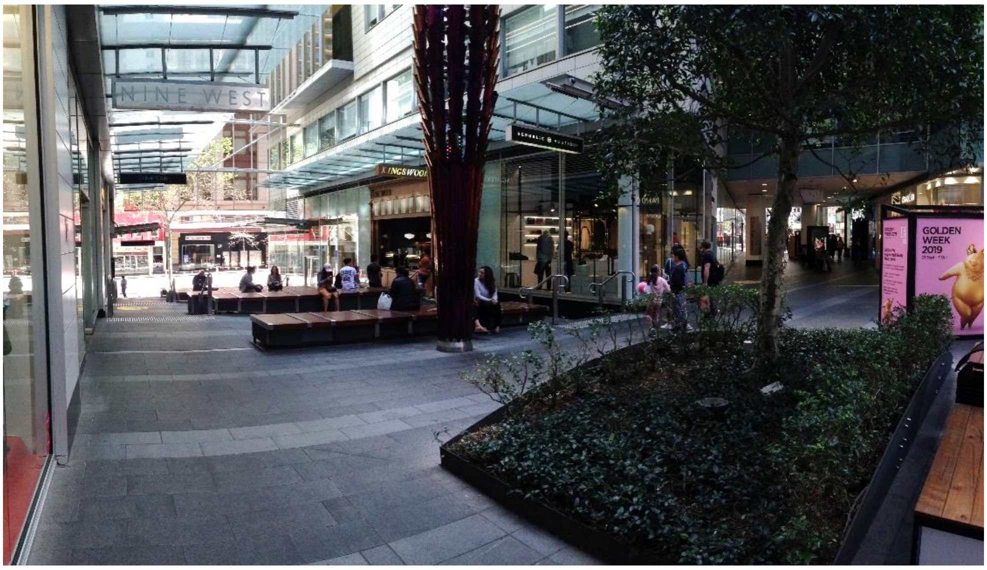


Figure 24. Photo: Eldridge, T, People relaxing on benches next to a coffee shop, World Square, 29/9/19.

RESEARCH METHODS AT WORLD SQUARE

This section outlines the steps taken in the field with participants to gather data, showing what was done in situ with each participant and how this approach differed between World Square and Darling Square.

RESEARCH METHODS IN PRACTICE

This section discusses the steps that were taken at World Square to collect data for the three methods used in this study to provide transparency on how this mix methods approach was executed and how the participants were involved. Note that the Appendices provides further details, including graphs of each participant's individual results, where each participant's recordings were taken, and notes taken throughout the fieldwork.

All participants were met at the public benches at the western entrance to World Square. A verbal explanation of the study and the scope of their involvement was given and participants were then given the information and consent form (a copy is available in Appendix K) to sign. The information and consent form was also scanned and emailed back to each participant for their records.

Participants were fitted with the EEG headset and, where necessary, small adjustments to the position of the sensors where made, such as parting people's hair to ensure closer contact between the sensors and the participants scalp. Figures 4 and 5 in Chapter Four illustrate the readings given in the EmotivPRO software to indicate the connectivity of each sensor. Each participant commenced the study at 100% connectivity; however, due to the sensors progressively drying out over time, this reading dropped for some participants and a range of 96%–100% connectivity was treated as acceptable, as per the recommendations in the instruction manual.

Once the EEG headset was positioned to show 100% connectivity, a baseline reading was taken. This involved having participants relax with their eyes open for 15 seconds and then relax with their eyes closed for 15 seconds. This is a feature of the EmotivPRO software to take into account the impact of participants' eye blinks, which could otherwise impact the accuracy of the measurements.

The audio recording for Method 3 Walking interviews was started when the EmotivPRO software asked participants to relax with their eyes closed for 15 seconds. This synchronised the audio recording and EEG recording so that the EEG readings could be reviewed simultaneously with the audio to track what the participants reported they were experiencing parallel with the EEG data.

Participants were given a cue card with the Method 2 Survey questions (Appendix F) for their reference and then instructed to walk around the open-air section of World Square as per Lefebvre's rhythmanalysis to familiarise themselves with the space. I walked side by side while holding a laptop with the EmotivPRO software to maintain Bluetooth connectivity with the EEG headset to record the data for Method 1 EEG and to take an audio recording of participants' responses for Method 3 Walking interviews for the entirety of the fieldwork.

Participants were asked semi-structured questions to reflect on their initial experience of World Square (Method 3 Walking interview questions are at Appendix G). Participants were then asked to identify the feature of World Square's design that they found *most* interesting and to stand beside it (please note the locations where each participant choose to stand for each reading is available at Appendix H). After briefly discussing their thoughts on the most interesting feature, participants were asked to refer to the cue card for Method 2 Survey. The questions were also read aloud to them. The point where participants verbally communicated their rating for Method 2 Survey was the same point in time that Method 1 EEG measurements were taken from the recording to synchronise participants' conscious and unconscious data. Participants were then asked to identify the design element of World Square that they found *least* interesting, and the same steps were taken to gather the next dataset.

Participants were next instructed to continue walking around World Square and asked to reflect on the design, theme, and patterns using semi-structured questions from Method 3 Walking interviews. Method 2 Survey questions were asked, and the Method 1 EEG data was collected through the EEG headset.

Participants were asked to identify the most open part of World Square and were directed to stand in the area they felt was most open. While standing in the open, participants were asked semi-structured questions from Method 3 Walking interviews. Method 2 Survey questions were asked and the Method 1 EEG data was collected through the EEG headset.

Participants were instructed to find a space that had the most appealing natural elements and to stand there. While standing beside the natural design elements, participants were asked semi-structured questions from Method 3 Walking interviews. Method 2 Survey questions were asked and the Method 1 EEG data was collected through the EEG headset.

Participants were next instructed to go to the first landing of the staircase at the eastern end of World Square and to look out over the square. While standing on the landing, they were asked to reflect first on the upkeep and order of World Square and finally on the liveliness of World Square using semi-structured questions from Method 3 Walking interviews. Method 2 Survey questions were asked and the Method 1 EEG data was collected through the EEG headset.

Participants were offered a final opportunity to add any further comments and the interviews was ended. The audio recording was turned off and the EEG headset was removed.

Participants were escorted to the second case study site, Darling Square, via the route shown in Appendix I.

DATA AND DISCUSSION ON PARTICIPANT RESPONSES TO WORLD SQUARE

This section provides the data on the fieldwork conducted in World Square. The average of the participants' scores are presented side by side via line graphs. The graphs compare the participants' unconscious responses through the EEG measures and the conscious response recorded through the survey questions. The participants' results are further illustrated with comments and observations made by the participants during the walking interviews.

The data is presented to match the performance metrics gathered by the EEG, which are like/dislike, stimulation, stress and relaxation. Participants' responses in terms these performance metrics are analysed in the context of each design element (interesting feature, uninteresting feature, orderly design and pattern, openness and exposure, natural and fabricated, upkeep and derelict, liveliness and people).

Each of these datasets are presented via graphs that show the average participants EEG and survey scores for each of the key design elements in World Square. The results are discussed and further illustrated by extracts of the walking interviews conducted in between the survey questions. The scores are rounded to one decimal point in the commentary for the reader's ease.

UNDERSTANDING THE DATASETS

The data is presented as averages from all participants, grouped to show EEG scores and survey scores side by side. This arrangement is intended to compare and contrast the participants' unconscious responses captured via the EEG and the conscious responses recorded via the survey.

The EEG performance metric for **like/dislike measures the level of attraction or aversion** to a stimuli or environment. High readings indicate strong interest, low readings indicate strong aversion, while mid-range readings indicate the wearer neither likes nor dislikes the stimuli or environment. The survey question mirrors this by asking to what extent the participant likes or dislikes the feature to which they are responding, with 0 being dislike and 10 being like.

The EEG performance metric for **stimulation measures a positive feeling of awareness**, characterised by activation in the sympathetic nervous system. These physiological responses can include pupil dilation, eye widening, sweat gland stimulation, and increased heart rate and muscle tension. The device is tuned to measure short-term changes in excitement over short time periods. The survey question corresponds to this metric by asking participants to rate the extent to which they feel stimulated by the various design elements, with 0 being not at all stimulating and 10 being very stimulating.

The EEG performance metric from **stress measures the wearer's level of comfort** with the situation that they are experiencing. High readings may occur while being confronted with a challenging problem that is not easily solved, or fear of failing to complete a task. The survey question has been synchronised by asking participants to what extent they feel stressed by the design elements encounter in World Square, with 0 being not at all stressed and 10 being very stressed.

The EEG performance metric for **relaxation measures the wearer's ability to recover from intense focus** and switch off their attention in a positive way. The survey questions echo this measure by asking participants to what extent they feel relaxed by the features they are responding to in World Square, with 0 being not at all relaxed and 10 being very relaxed.

Participants' individual scores are available in Appendix N, which allows for maximum transparency of the data. Should anyone like to undertake further analysis based on characteristics such as gender, the individual scores provided in Appendix N allows for this to be independently pursued.

Maps of where each participant was standing when the scores were taken is available in Appendix H.The survey questions used in the study are in Appendix F and the semi-structured walking interview questions are in Appendix G.

PARTICIPANTS' RESPONSES TO THE INTERESTING FEATURE AT WORLD SQUARE

THE FEATURES OF WORLD SQUARE PARTICIPANTS FOUND INTERESTING

The participants were asked to identify the features of World Square that they found to be most and least interesting. This question established the participants' EEG and survey scores for the features participants personally identified as eliciting the highest and lowest poles of their responses to the like/dislike readings for both the survey and EEG.

The features participants identified as being interesting and uninteresting have been expanded on below as participants focused on different features when asked their response, whereas with other design elements participants were looking at the same stimuli. As can been seen in the following two figures, there is a range of features that participants identified and these features are the stimuli that are being referred to in Figure 26.

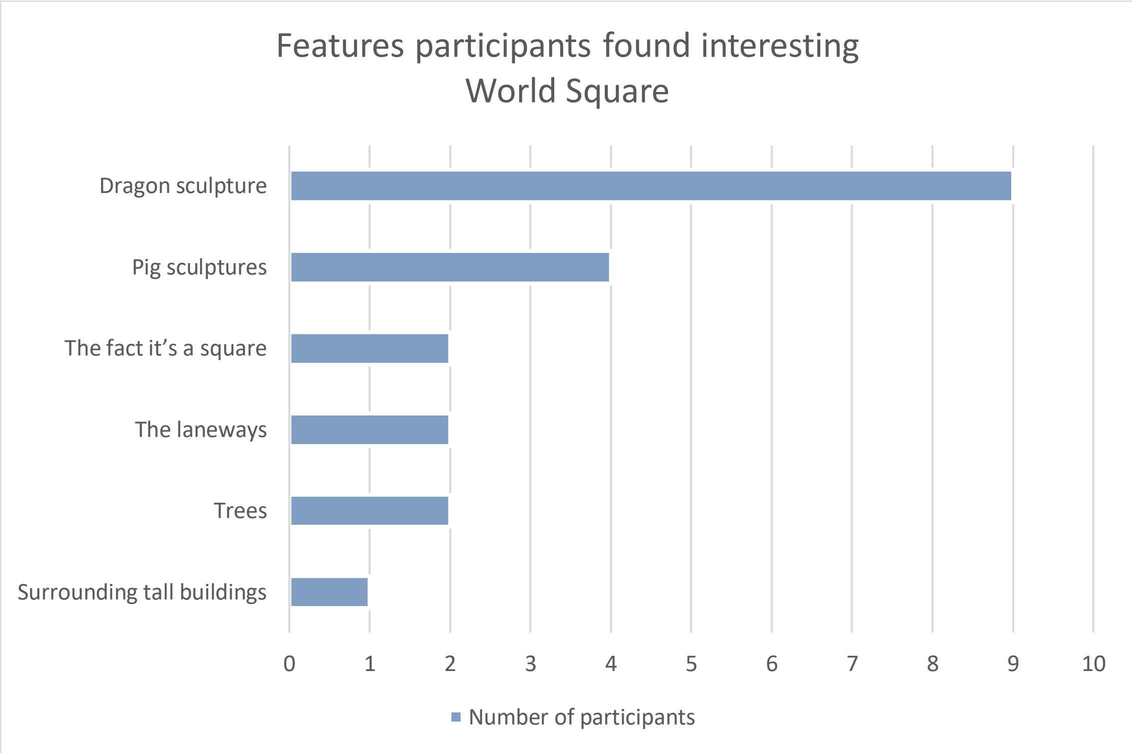


Figure 25. The features of World Square participants identified as being interesting.

The features that participants found most interesting tend to be aesthetic elements of World Square's design, namely the sculptures. The feature that the majority (nine participants) found interesting was the dragon sculpture, followed by the sculptures of dancing pigs (four participants). The features the remaining participants found interesting tended to relate to the layout of World Square's design, namely it being a square and how it was connected to its surroundings. Two participants were interested in the fact that it was a square, as opposed to a streetscape, while the laneways branching out from the square was of interest to two participants. Additionally, natural elements were an interesting feature for participants as the trees drew the focus for two participants. One participant was most interested in the surrounding tall buildings.

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE INTERESTING FEATURE AT WORLD SQUARE

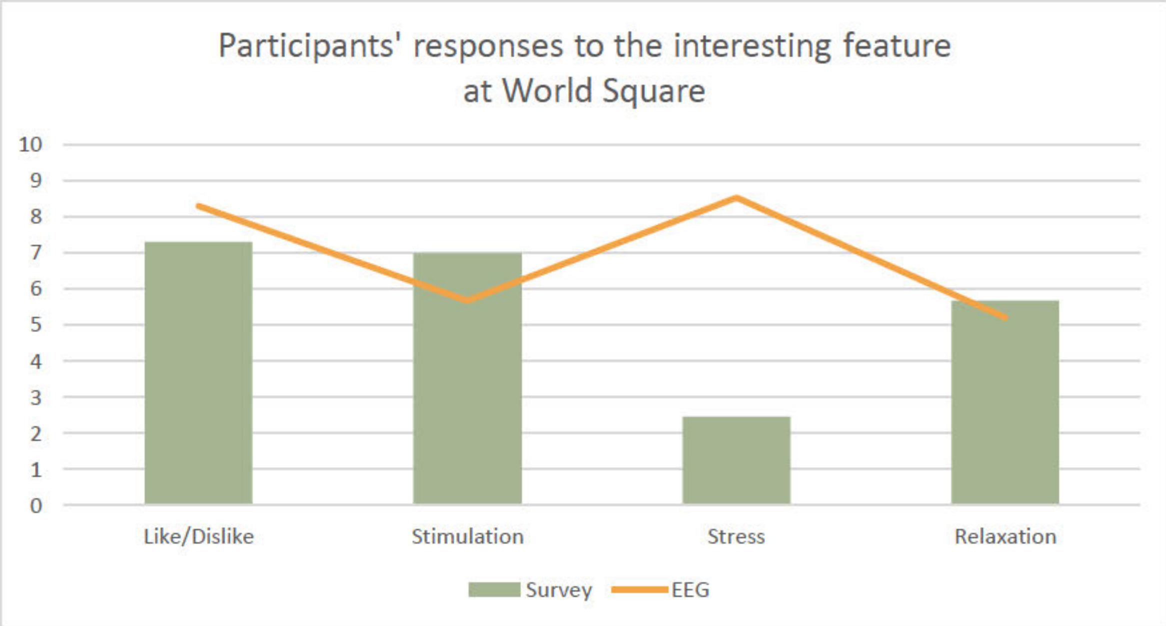


Figure 26. Average of all participant survey and EEG scores for the feature they found most interesting at World Square.

The key data points are:

- Participant survey and EEG scores are similar for like/dislike (survey 7.3, EEG 8.3), stimulation (survey 7, EEG 5.7) and relaxation (survey 5.7, EEG 5.2), while the readings for stress drastically differ (survey 2.5, EEG 8.5).
- Participants' EEG scores for like/dislike are the highest score (8.3), indicating participants were attracted to the feature they found interesting.
- Participants' EEG scores for stimulation (5.7) and relaxation (5.2) are just above neutral (5).

From the survey scores, participants indicated a mid-range score of 7.3 for the degree to which they liked/disliked the interesting feature, while the EEG score recorded a slightly higher reading for positive attraction of 8.3. Participants' survey scores for stimulation were higher (7) than their EEG scores (5.7) for stimulation. Participants reported a very low (2.5) stress response on their survey scores, but the EEG reading for stress was high (8.5). Participants reported levels of relaxation just above neutral for both the survey (5.7) and EEG (5.2).

PARTICIPANTS’ WALKING INTERVIEW RESPONSES TO THE INTERESTING FEATURE AT WORLD SQUARE

Participants had a wide range of like/dislike responses to World Square and its design features, with some participants expressing general enjoyment at being in the space while others responded with a strong dislike. Even in response to the most interesting feature participants identified, there was a mix of results. Regarding the dragon sculpture, some participants expressed positive comments, such as Bobby, who remarked: ‘It’s really cool,’ Neha, who described the sculpture as a ‘beautiful kind of swirl,’ and Harvey, who said they liked ‘the colours and the shape, and it adds to the culture here too.’ Other participants who also identified the dragon as being the most interesting feature were less complimentary, such as Laura, who described the dragon as ‘scary,’ and Elena, who commented, ‘I hate it but it’s interesting… it’s super tacky.’

The second most interesting feature, the dancing pig sculptures, also had a mixed review from participants. Some people enjoyed the pigs. Omar described the dancing pigs as being ‘so funny, it’s so sweet.’ Neha explained her attraction to the pig sculptures, saying ‘it’s very out and proud. Just having a good time.’ Jing commented that ‘pig symbolises prosperity, so it could be that’s why they have it here.’ Other participants were less engaged by the pigs, which Helen explained by saying, ‘I don’t know what they’re meant to symbolise or why they’re here,’ and Bobby, who pointed out that ‘it’s now the year of the rooster… The pigs don’t add anything.’

There were a wide range of comments regarding participants' stimulation responses to the World Square's design. The participants who found the dragon sculpture to be the most interesting feature described various senses of stimulation. Jane made positive comments regarding the stimulation, saying 'I like the colour. I like how it reflect light… It's not your usual square building, boring sculpture that's made of stone. It has the purple and the red and underneath is LED lights. It's just exciting.' Other participants reflected on a sense of movement, such as Natalie, who said 'this is lots of different things to look at in it and you can almost feel movement even though it's static,' and Oliver, who commented that 'it kind of fluid compared with everything being in a rectangle otherwise.'

Participants did not generally make further comment on any stress response elicited from the features they found interesting. Laura found the dragon sculpture interesting but also 'scary' and noted it gave World Square's design a feeling of being 'aggressively Asian futuristic.'

Only two participants chose to comment on their feeling of relaxation in response to the interesting stimuli. Elise, who found the trees to be interesting, noted that they offered 'a bit of seclusion,' and acted as a 'nice and peaceful spot to sit down,' that was somewhat removed from the rest of World Square. Bobby was interested by the dragon sculpture and commented that 'I wouldn't say it was a calming space, maybe an exciting space rather than a calming space.'

DISCUSSION OF PARTICIPANTS' RESPONSES TO THE INTERESTING FEATURE AT WORLD SQUARE

The key points are:

- Participants' mid-range positive attraction and stimulation responses to the feature in terms of both survey and EEG scores was consistent with the expectations of this study. In general, participants identified the central landmark of the square (the dragon sculpture) as being a point of interest, even though many participants (expressed through walking interview responses) noted that the sculpture was not necessarily aesthetically to their taste.

- Participants' stress responses via the survey and EEG varied greatly. It is unclear why participants had such high EEG scores when there were no clear indications via the survey or walking interview what stressors may be eliciting this high EEG score. It may be that there are several contributing factors, including that this the first question being asked under experimental conditions causing some nervousness, and under lying anxiety at wearing the headset in a public place where this usual activity can be observed by other people.

Although participants' interview responses were mixed in regard to whether they liked the features of World Square, the survey and EEG scores are both high at 7.3 and 8.3 respectively. The divide between participants who responded positively to the dragon sculpture and those who were less positively inclined towards it seems to reflect the extent that participants could make sense of the sculpture. For example, Barry thought it may have been a rocket rather than a dragon and was unsure why it was there. In contrast, Jing, who is of a Malay background, interpreted the dragon with a different lens, saying the positioning of the dragon was 'very symbolic' nothing that 'it's like the Chinese way of doing thing, where the dragon stands right where the entrance is. It's supposed to be guarding the entrance, I think.'

Similarly, the mixed responses from participants to the pig sculptures also seems to reflect whether the participants found it easy to interpret them. The confusion experienced by some participants was voiced by Helen above, who was unsure of the symbolism behind the pigs, and Bobby struggled to account for the pig sculptures when it was the year of the rooster. In contrast, Jing was better able to understand the symbolism of the pig sculptures, noting that pigs are a sign of prosperity and therefore fitting to have in among the businesses of World Square.

The ability to interpret the sculptures seems to correlate with a narrative understanding. The ability to make sense through narrative is ‘the inescapable frame of human existence’, according to neurologists Young and Saver (2001, p. 79). However, they also note that existence and experience are influenced by culture, which would elucidate why Jing, who had more experience with Chinese culture, was able to read the sculptures differently to participants with different cultural backgrounds.

The sculptures were also often described with a sense of movement. The dragon sculpture, for example, was described as a ‘swirl’ by Neha, and as being ‘fluid’ in an otherwise static space by Oliver. Natalie also commented that ‘you can almost feel movement even though its static.’ The pig sculptures also were viewed in terms of their perceived movement, even though they were immobile. When deciding which of the pig sculptures they liked best, participants explained their choice based on which dance-like pose most appealed to them.

Returning to the discovery of mirror neurons previously mentioned in the literature review, these neurons are located within the premotor cortex, which activates when planning movement. This means that the process of activating mirror neurons also influences feelings of movement when observing other people, but also in observing objects. This may contribute to the participants’ sense of movement they observed in the dragon and pig sculptures. Wölffin (as cited in Robinson & Pallasmaa 2017, p. 24) directly attributes this sense of movement as an embodied response, nothing that as we form our understanding of the world through our bodily experience moving through life, this is the lens we take in understanding other people’s and objects’ experiences. This empathetic ‘embodied simulation’ does correlate with the descriptions given by participants.

It is less clear whether this embodied simulation was reflected in the participants' survey and EEG scores. Participants reported somewhat high levels of stimulation via the survey at an average of 7 and lower scores for stimulation from the EEG of 5.7. It may be that, as Oliver observed, the sculptures were one of the few stimuli within World Square that evoked a sense of movement and the otherwise static square contributed to lower stimulation scores.

Although participants did not directly comment on feeling stressed in response to the interesting features of World Square, the EEG recorded rather high levels of stress at 8.5. In contrast, the survey scores were low, at 2.5. The potential stressors may have included the confusion involved in interpreting the symbolism of the sculptures, or the responses evoked by the sculptures themselves, as Elena bluntly stated she hated the dragon sculpture, saying it was 'super tacky,' and Laura, who saw the dragon as being 'aggressive' and 'scary.'

Participants did not comment on the interesting features of World Square as being relaxing. This is consistent with their survey and EEG scores, which were relatively comparable mid-range scores of 5.7 for the survey and 5.2 for the EEG. Rather than relaxing, both Jane and Bobby used the word 'exciting' in their descriptions of the interesting features of World Square. The only participants who reflected on a feeling on relaxation were the participants who found the trees were the most interesting feature, noting the appeal of having a secluded place to sit.

PARTICIPANTS' RESPONSES TO THE UNINTERESTING FEATURE AT WORLD SQUARE

THE FEATURES OF WORLD SQUARE PARTICIPANTS FOUND UNINTERESTING

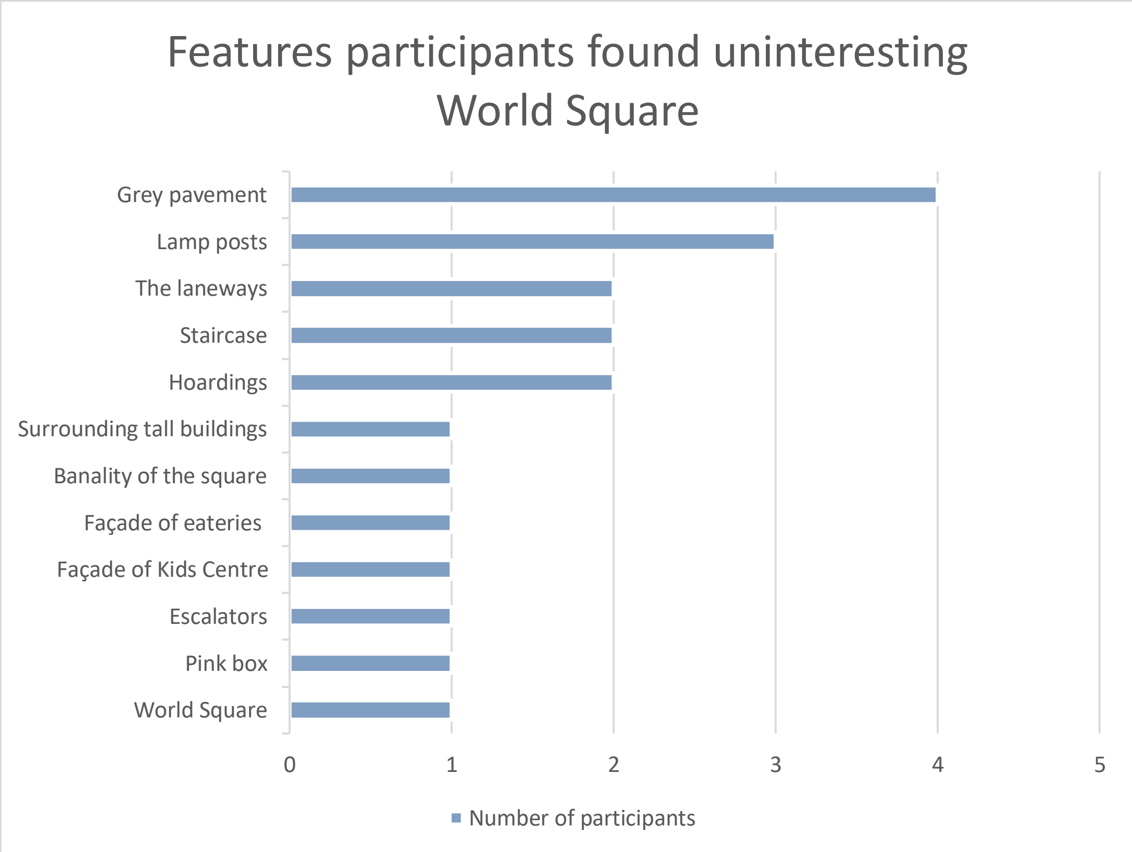


Figure 27. The features of World Square participants identified as being uninteresting.

There was a wider range of features that participants found uninteresting compared to interesting. The features that were identified as being uninteresting were mainly fabricated elements, such as the infrastructure (lampposts, hoardings, grey pavement) and advertisements (facades of businesses, pink box) as well as the overall impression of World Square (the banality of the square and World Square itself).

The feature most (four participants) described as uninteresting was the grey pavement, followed by the lampposts (three participants). The third (two participants) least interesting features were the laneways branching out from the square, the staircase under the dragon sculpture, and the hoardings of a resturants being refurbished. The remaining (seven) participants respectively found the least interesting feature of World Square to be the surrounding tall buildings, the air of banality they decribed feeling, the facades of the various eateries, the facade of the childcare centre on the second level, a pink box that was temporarily installed as advertisement, and World Square as a whole, which the participant descibed as being generally dull.

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE UNINTERESTING FEATURE AT WORLD SQUARE

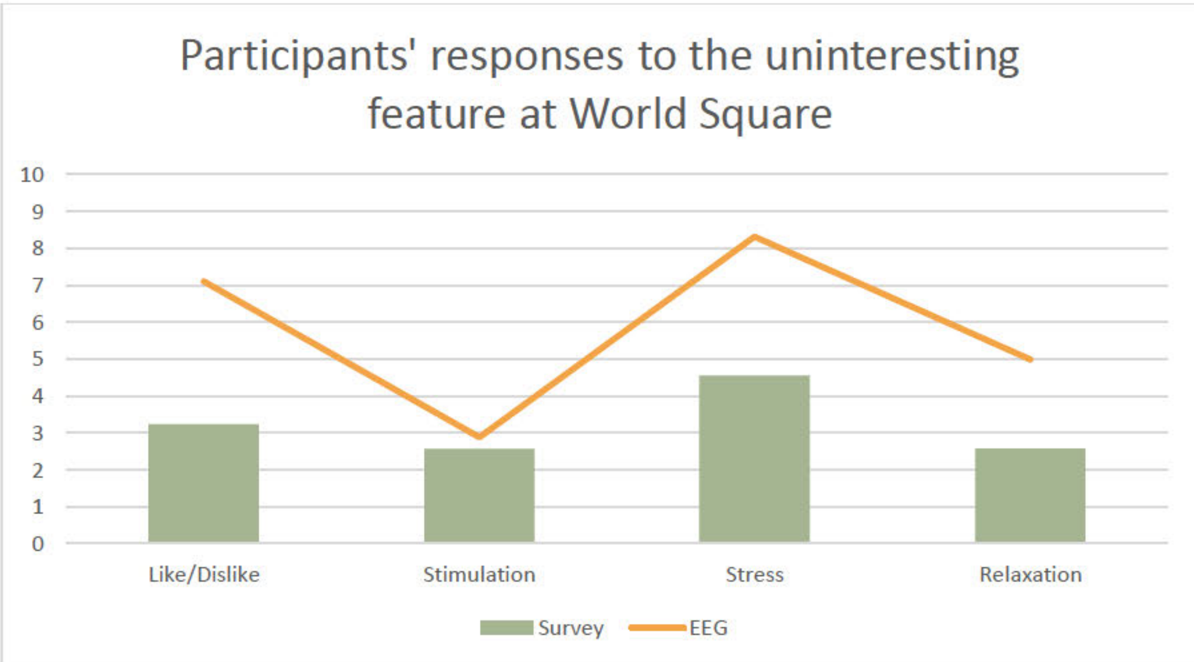


Figure 28. Average of all participant survey and EEG scores for the features they found most uninteresting at World Square.

The key data points are:

- Although participants' like/dislike survey scores were low (3.2), indicating some aversion to the uninteresting features, EEG scores were much higher (7.1), indicating some positive attraction.

- Apart from stimulation, which had relatively similar low levels recorded for both the survey (2.6) and EEG (2.9), there is not consistency between the survey scores and EEG readings for like/dislike (survey 3.2, EEG 7.1), stress (survey 4.6, EGG 8.3) and relaxation (survey 2.6, EGG 5).

There is significant divergence between participants survey scores (3.2) for like/dislike and EEG scores (7.1), while in terms of stimulation there is more consistency between the survey (2.6) and EEG (2.9) scores. Participants reported low levels of stress via the survey (4.6), while the EEG (8.3) recorded much higher stress levels. Participants' survey scores for relaxation were low (2.6) while the EEG score was neutral (5) for relaxation.

PARTICIPANTS' WALKING INTERVIEW RESPONSES TO THE UNINTERESTING FEATURE AT WORLD SQUARE

Participants' comments on the uninteresting features were consistently negative. The feature most participants found uninteresting was the grey pavement, which Josephine described as giving of 'a sterile sort of feeling,' while Noel found the 'bland monochrome' of the pavement drab. The lampposts were identified as being uninteresting and were described by Jane as 'grey. It's a bit tacky. There's sticky tape hanging off of it. Its dirty. It looks very cold and the texture almost looks a bit like cement, and that's just a very boring thing,' and Oliver, who said 'they're trying to make it disappear, right? That's why they've got the same colour as the ground and not have any kind of visible thing. It's more grey like the ground and it kind of disappears into shadows.'

Participants commented on the lack of stimulation the most uninteresting feature provided them. For example, the grey pavement was described as being an 'expanse of nothingness that's just boring,' by Laura, and Kalinda made similar observations, saying, 'it's a bit bare. There's not a lot to attract you. […] a lot of empty space.' Other participants noted the grey colour of the pavement was especially unstimulating, such as Josephine, who remarked that ‘grey is just so bland and depressing as a colour.’

Similarly, participants generally did not feel the uninteresting features were especially stressful, as noted by Josephine, who said, ‘I don’t know if [the grey paving] stresses me out as such… I just don’t like them.’ Elena, who found the lampposts to be uninteresting, noted ‘it [the lamppost] doesn’t overly stress me, but it stresses me out that it’s here and not tucked away.’

The uninteresting features identified by participants did not often inspire much reflection on the sense of relaxation they elicited. Oliver, who found the lampposts uninteresting, commented that he felt ‘maybe a little bit [relaxed], probably more if it was dark, but it isn’t so… a little bit relaxed. I know that they’re there, but they’re not really anything more than nothing.’ No other participants chose to make further comment on the relaxation response to the uninteresting feature.

DISCUSSION OF PARTICIPANTS’ RESPONSES TO THE UNINTERESTING FEATURE AT WORLD SQUARE

The key points are:

- It was anticipated that participants would have not have a positive attraction to design elements they found uninteresting, which is demonstrated through the survey scores. However, the EEG scores show mid-level positive attraction. This outcome was not anticipated and is it unclear why the survey and EEG responses varied so much.
- It was also anticipated that given the participants were asked to identify features that were uninteresting to them, there would be low levels of stimulation. The survey and EEG scores are consistent with this expectation.

- Participants' stress responses via the survey and EEG varied greatly. It is unclear why participants had such high EEG scores when there were no clear indications via the survey or walking interview of what stressors may be eliciting this high EEG score.

The features that participants found uninteresting could be grouped into broad categories, such as:

- Features that provide utility infrastructure, such as pavement, lampposts, stairs and escalators.
- Nonactive facades, such as the hoardings and the enclosed facade of the Kids Centre.
- Advertising, such as the pink box and facades of the eateries.

These broad categories are consistent with Nasar's (1994) theory that human-made elements like infrastructure and advertising are less likely to elicit a positive response than natural stimuli. The fact no participants identified the trees or garden beds as uninteresting further supports this theory. The nonactive facades being identified as uninteresting supports Gehl's (2006) theory that active shopfronts are needed to spark interest. This theory will be discussed further in the following section on participants' responses to orderly design at World Square.

The participants' comments regarding the feature they found uninteresting were consistently negative, which is unsurprising as they were asked to identify a feature that did not appeal to them. In regard to the grey paved area at the centre of World Square, several participants commented that it felt like a void, with Kalinda noting it was 'a lot of empty space,' and Laura describing it as an 'expanse of nothingness.' The somewhat derelict appearance of uninteresting features was also highlighted through participants' comments, which is also consistent with Nasar's (1994) postulations that derelict elements do not engage people. Jane, who found the lampposts uninteresting, observed that 'there's sticky tape hanging off of [the lamp post]. Its dirty. It looks very cold and the texture almost looks a bit like cement, and that's just a very boring thing.'

These low levels of positive attraction are reflected in participants' low survey scores of 3.2. In contrast, however, participants exhibited mid-range positive attraction, with an EEG score of 7.1. This stark variation may be due to participants' multisensory experience of World Square. While participants were asked to focus on the feature they found uninteresting, they were still exposed to a range of other stimuli in World Square.

Participants' stimulation responses were uniformly low on both the survey, with a score of 2.6, and the EEG, with a score of 2.9. These low stimulation scores seem to reflect the fact that participants were focusing on design elements that did not interest them. The colour of the grey pavement was noted by several participants as a key contributor to the lack of stimulation, with Noel describing it as 'bland monochrome,' and Josephine commenting that 'grey is just so bland and depressing as a colour.'

Interestingly, Oliver theorised that it would the intention of the designer to use grey in an attempt to hide uninteresting design elements, such as lampposts, saying designers were 'trying to make it disappear […] Its more grey like the ground and it kind of disappears into shadows.' However, several participants noted irritation regarding the position of the lampposts. Elena commented that she was stressed because 'its here and not tucked away.' Natalie commented that positioning of the lamp post did not fit in the square, saying 'it's not in line with the walls. It's like I want to push that out to be symmetrical... It doesn't feel like it's in the middle.'

This mild irritation expressed by some participants regarding the uninteresting features may be reflected in the high EEG scores for stress, which were 8.3. Participants' conscious experience of stress reported through the survey, however, was much lower, at only 4.6.

Participants did not generally comment on any relaxing elements of the uninteresting features. Participants reported very low relaxation responses via the survey at 2.6 and a neutral relaxation response via the EEG of 5.

PARTICIPANTS' RESPONSES TO THE ORDERLY DESIGN AND PATTERN AT WORLD SQUARE

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE ORDERLY DESIGN AND PATTERN AT WORLD SQUARE

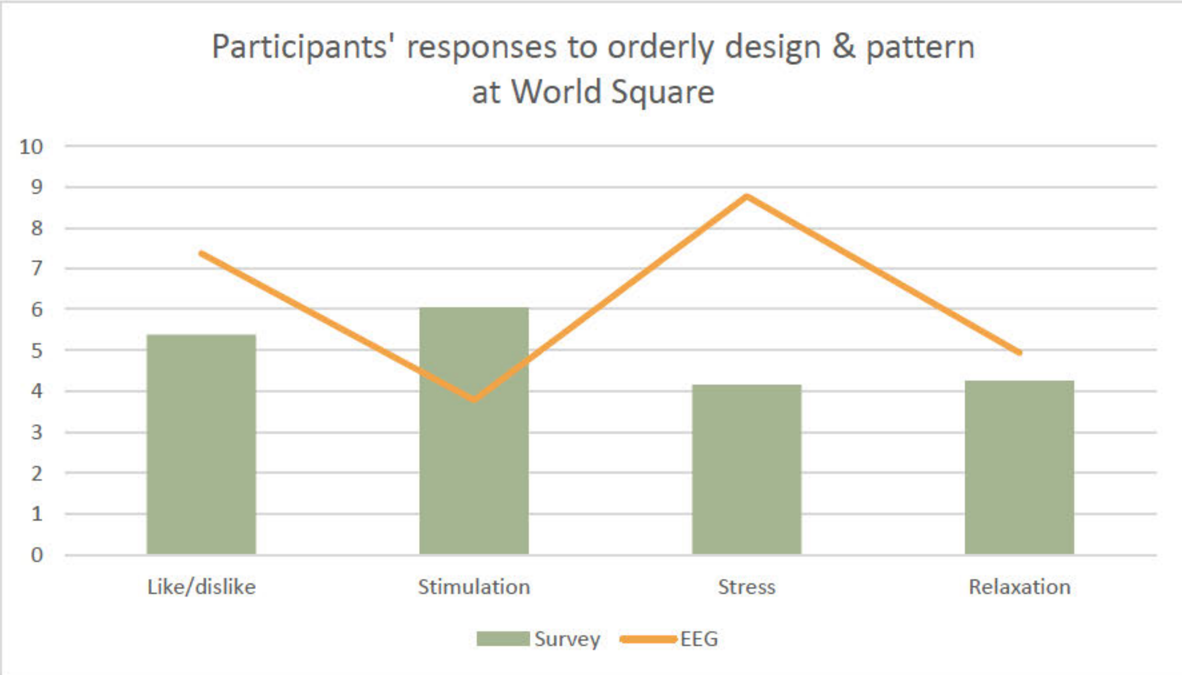


Figure 29. Average of all participant survey and EEG scores for the orderly design and pattern at World Square.

The key data points are:

- While there is some consistency between participants' survey and EEG scores for relaxation (survey 4.2, EEG 5), the survey and EEG scores for like/dislike (survey 5.4, EEG 7.3), stimulation (survey 6, EEG 3.8) and stress (survey 4.2, EEG 8.8) all differ significantly.
- The biggest difference between survey and EEG scores is for stress, where the EEG reading (8.8) is over double the level of stress reported via the survey (4.2).

The survey scores for like/dislike of World Square's design are just slightly above neutral (5.4), while the EEG readings note higher levels of positive attraction (7.3). Participants reported levels of stimulation higher via the survey (6) than the EEG (3.8). Participants showed high levels of stress from the EEG (8.8), while the survey scores showed low levels of stress (4.2). The participants' levels of relaxation were comparable for the survey scores (4.2) and EEG (5).

PARTICIPANTS' WALKING INTERVIEW RESPONSES TO THE ORDERLY DESIGN AND PATTERN AT WORLD SQUARE

Regarding the overall design of World Square, there were again a mix of views from the participants, both positive and negative. Larry described the design of World Square as creating an atmosphere that was 'positive, welcoming, open, relaxing… I think I like the fact it doesn't have a theme 'cos is a little bit of everything.' Ben reflected on the style of World Square's design, saying 'I wouldn't really call it Western or European, I'd just call it blended Sydney style with an Asian influence… They're very different cultures coming together. It's kind of indicative for its namesake, World Square.' There were less favourable comments from other participants, such as Noel, who commented that the style of World Square's design was 'very Sydney,' and that 'this area of town is just a bit showy and bit tacky.' There were also very strongly negative reviews of the design, for example from Elena, who said 'I don't like it because they put all these random features that don't make sense with each other. The [dragon] tail and the pigs don't make sense with the grey concrete, which don't' make sense with this particular style of planting things… If the trees weren't there, it would look like a Soviet f***ing playground.'

Comments from participants on the sense of order to World Square often highlighted two features: the lampposts and hoardings on a Japanese restaurant under renovation. Some participants felt that the position of the lampposts were less than ideal, with Harvey saying, 'they're just in people's way,' and Natalie, who expressed a desire to 'push that [lamppost] out. It's not symmetrical so that's a bit annoying.' The position of the lamppost also stood out to Bobby, who commented, 'the streetlights break the line of view… I think that's part of the reason the steps don't work for Instagram photos, because to get far enough back to take in the dragon and the stairs, that's in the way so I think the street lamps are plonked really badly.' Other participants felt the hoardings were the feature that was most at odds with the design of World Square. This was explained by Jane, who noted 'that looks a bit out of place because everything else seems quite well established and that seems, I don't know, is it jutting out, is it popping out? It's so white.'

The questions on stimulation elicited from the overall design of World Square were met with mixed responses from participants. Josephine commented that

> I don't find the design that stimulating. I find the outdoors stimulating, but not the actual design… Its actually very linear. Lots of criss-crosses and not enough roundness, I would say. In fact, those pigs are probably the most round things and there's nothing much round and I'm a bit more attracted to circle things.

In contrast, Noel found the design more stimulating, saying

> It's more stimulating because you actually have to be engaged in the space about where it is I'm going or what is it that I'm seeing, but not necessarily in a good way, but stimulating because it's not just very user-friendly abut here it is that you're ging around here.

Elena commented succinctly, saying 'it's stimulating. There's s**t everywhere.'

Some participants commented on the overall design of World Square being stressful, such as Noel, who said, 'it's busy because it's got no particular unifying theme, it just sems a bit incongruous so it's a bit stressful.' Oliver commented that 'it's [World Square's design] generally stressful and they're trying to soften it with the curves and beams and pipes and stuff.' The layout of World Square's design was a particular factor that some participants found stressful. Noel said, 'it's a bit chaotic. It's not user friendly. You don't know exactly where you're going. People everywhere, it's a bit noisy, it windy, and its reasonably stressful.' Jing commented, 'if I come here blind and I don't where, and I've got an appointment with somebody, I would find that stressful.'

When reflecting on any sense of relaxation elicited by World Square's design, Josephine said 'I mean I guess I feel relaxed because I'm outside, but again it's the wind that makes me feel uncomfortable.' John felt that some key changes to the design would make it more relaxing, saying

> I'm wondering, can we use some water somewhere? Could we use some smells? Could we make some these [plants] lemon, perhaps? Would it benefit from a little of chimes somewhere? That might be quite relaxing, perhaps a clock that sounds once every quarter hour. Maybe use this to bring some calmness and order rather than keeping flashy stuff.

DISCUSSION OF PARTICIPANTS' RESPONSES TO THE ORDERLY DESIGN AND PATTERN AT WORLD SQUARE

The key points are:

- Given World Square's design features includes may dynamic stimuli, such as flashing staircases, high levels of stimulation were anticipated. This was not reflected in the data as the survey score was at the low end of the positive range and the EEG score dipped below a neutral reading, into a negative response.
- Similarly, mid-range scores for relaxation were not anticipated given the mix of design elements included very few natural features that would offer opportunity for relaxation as described in the attention restoration theory (Kaplan & Kaplan 1989).

- Participants' stress responses via the survey and EEG varied greatly. It is unclear why participants had such high EEG scores when there were no clear indications via the survey or walking interview what stressors may be eliciting this high EEG score.

Participants' mixed responses to liking/disliking the overall design of World Square is reflected in mix of survey, EEG and walking interview responses. The survey response for like/dislike was 5.4, which is just above neutral, and shows very low levels of positive attraction. In contrast, the EEG score was 7.3, which shows mid-range levels of positive attraction. The more positive responses to World Square's design are reflected in comments made by participants such as Larry, who described the design as 'positive, welcoming, open, relaxing.' Less favourable assessments of World Square's design were also made by participants such as Noel, who noted the design was 'a bit showy and a bit tacky.'

The mixed responses might possibly reflect the degree to which participants were able to easily understand a sense of order or appreciate patterns in design. Some participants were able to identify themes, such as Ben, who described the design as 'blended Sydney style with an Asian influence […] It's kind of indicative for its namesake, World Square.' In comparison, the design elicited very negative reviews from participants that did not see a clear sense of order. For example, Elena saw the design elements as being jumbled together, saying 'they put all these random features that don't make sense with each other.'

Gehl recommends having open active facades to elicit interest. Gehl's formula for designing these facades is based on people's bodily experience moving through space. Estimating that pedestrians move at a rate of five kilometres per hour, Gehl recommends that they should be seeing something new to spark their interest every five seconds (Gehl 2006, p. 29–47). Applying this formula to World Square, participants are being exposed to new stimuli at comparable rate to Gehl's recommendation; however, regular new stimuli alone does not seem to be sufficient to elicit positive attraction (or a high like/dislike) score from several participants. As people's experience is multisensory, other factors need to be considered.

Looking at participants' survey and EEG scores for stimulation also shows a high degree of variation. The survey results were at the low end of positive stimulation at 6, while the EEG results showed a mid-range negative response of 3.8. There were also a mix of reflections made by participants in the walking interviews. John noted the lack of positive, relaxing stimuli that natural elements could offer, such as wind chimes, water features, and the scent of plants. Josephine noted that the patterns she observed were mostly harsh linear and angled patterns, rather than soft round shapes.

These reflections from participants' walking interview comments are consistent with theorist previously discussed in the literature review. Noting John's comments on wanting more natural features to create a more calming environment, the ability of natural stimuli to elicit relaxation in consistent with the Kaplan's attention restoration theory. To avoid duplication with the discussion on participants' responses to natural elements in World Square, this will be further discussed later in this chapter.

The preference for patterns with curved shapes is also consistent with studies previously mentioned in the literature, such as MRI studies (Leder, Tinio & Bar 2011) that show people generally have more positive responses to round shapes. Sharp-angled shapes have been found to trigger the amygdala, which processes fearful and threatening stimuli. It is theorised that the fearful response to sharp objects is a deeply ingrained bodily response developed create an innate understanding of the dangers presented by thorns, claws, and teeth (Jasanoff 2018; Leder, Tinio & Bar 2011; Sussman & Hollander 2015).

Participant's responses for stress were also mixed. Participants' survey responses indicated low levels of stress at 4.3, while the EEG scores showed high levels of stress at 8.8. A common stimulus that participants found stressful was the layout of World Square, which has several laneways branching out from the central square. Noel described his impression of World Square as 'chaotic,' given the mix of stimuli he was exposed to, and noted, 'you don't know exactly where you're going.' Similarly, Jing remarked that 'if I come here blind and I don't where, and I've got an appointment with somebody, I would find that stressful.'

Neurological studies on the behaviour of rats and other species in mazes have consistently shown that the paths with high complexity and novelty are preferred (Berlyne 1960). Translating this to human experience in urban environments, Ellard (2015) found similar results in people's responses to urban settings that lacked complexity. Ellard asked participants to walk through bland, featureless urban environments like the walls of mega stores, and participants found this exercise so disengaging that he struggled to retain participants to continue in the study long enough to expose them to a second environment. The second environment that featured more active facades with a mix of open shopfronts elicited considerably more positive responses from participants.

Tthe mixed responses to participants' responses to World Square's design in terms of like/dislike, stimulation and stress above suggests that a balance or order and positive stimuli must be found. Hildebrand (2008, p. 264–265) describes this balance noting that,

> Order alone is monotony, complexity alone is chaos […] there is substantial empirical evidence that we are genetically programmed to respond positively to complexly ordered sound (music) but not to chaotically complex sound (noise). One might argue, similarly, that consciously or unconsciously, we distinguish architecture from 'just buildings' by evident order and complexity of its materials and spaces.

This observation from Hildebrand is generally consistent with the experience of participants in World Square. The negative responses elicited from participants generally reflected on a lack of order and over stimulation by seemingly incongruent design elements. Hildebrand's comment is perhaps echoed by the participant, John, who spoke about what he felt was needed to make World Square a more positive experience. John suggested 'maybe use [some natural elements] to bring some calmness and order rather than keeping flashy stuff.'

PARTICIPANTS' RESPONSES TO THE OPENNESS AND EXPOSURE AT WORLD SQUARE

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE OPENNESS AND EXPOSURE AT WORLD SQUARE

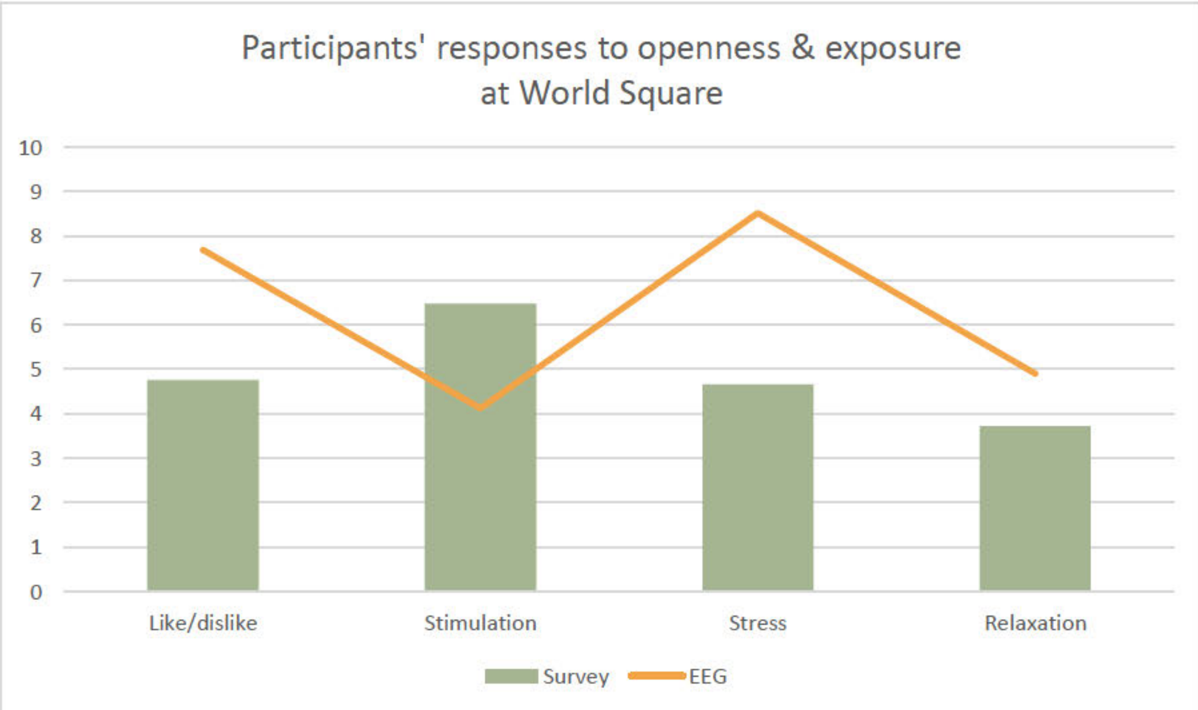


Figure 30. Average of all participant survey and EEG scores for the openness and exposure at World Square.

The key data points are:

- The survey and EEG scores differ significantly for like/dislike, with the survey scores (4.8) dipping just below neutral, into participants disliking being in the open space of

World Square, while the EEG scores (7.7) show positive attraction to being in the open space.

- The biggest difference between survey and EEG scores was for stress, with participants' survey scores showing low levels of stress (4.7) and high EEG readings (8.5).

In regard to liking or disliking being in the open space at World Square, participants survey scores (4.8) indicated mild levels of dislike, while the EEG scores recorded mid-range positive readings (7.7). Participants' survey scores recorded that it was somewhat stimulating (6.5) while the EEG scores (4.1) were below a neutral reading, indicating there was little stimulation. Participants' EEG readings for stress were high (8.5), while the survey results for stress were much lower (4.7). Participants' levels of relaxation were somewhat similar for the survey (3.8) and EEG (4.9), with both measures recording low levels of relaxation.

PARTICIPANTS' WALKING INTERVIEW RESPONSES TO THE OPENNESS AND EXPOSURE AT WORLD SQUARE

Participants' comments when asked to stand in the most open part of World Square revealed a mix of responses. Participants such as Josephine enjoyed the experience, saying 'I love being in the open… Maybe it's the sun because I like to be in the sun.' Elise commented on the experience immediately before being asked any questions, saying simply 'I don't like this.' Harvey said, 'I'm feeling a bit exposed and uncomfortable.'

Standing in the most open area of World Square was a stimulating experience for people. Helen described it by saying, 'it's probably stimulating in a physiological sense, but not in a particularly pleasant way. I'm not rating this as an overall pleasant experience.' Harvey echoed these sentiments, saying 'I guess it's over stimulating, in a bad way though.' While several participants described feeling exposed while standing in the open, Bobby described a feeling of being sheltered, saying 'it feels like you would be sheltered from the elements somewhat. I can't see a lot of the sky […] [I] just don't see past the skyscraper aspect.' Kalinda responded by saying that seeing the tall buildings surrounding the square made her feel 'small,' but also 'with the sun it feels nice… The breeze makes it seem like it's an open space.'

Participants had a range of stress responses when standing in the open space of World Square. John noted, 'the only stress being the occasional person, but otherwise its quite relaxing if it's in the sun.' Jane commented that 'I feel small because the building are so large, and there are people walking around me constantly, the noise, but I do like it. It makes me feel like I'm in a big modern city.' Alexander has a contrasting reaction, describing the experience of standing in the open as 'uncomfortable, unpleasant, unwelcoming. All the un words. Anything opposite to nice.'

When standing in the open space of World Square, Oliver reflected on experience, saying that 'it's warmer and brighter here. We're out of the shadows, and looking up a lot, which is unusual in the space, it feels more open, but that's to be expected.' Neha, who visited the square on an overcast day, noted that 'I think if the wind wasn't here and maybe if the sun was on you, you'd have a different reaction.'

DISCUSSION OF PARTICIPANTS' RESPONSES TO THE OPENNESS AND EXPOSURE AT WORLD SQUARE

The key points are:

- It was anticipated that participants would have low levels of positive attraction and stimulation in response to being asked to stand in the most open part of World Square due to thigmotaxis (wall-hugger preference) (Kallai et al. 2007). However, the EEG scores indicated a mid-range positive attraction to standing out in the open and mid-range responses for relaxation for both the survey and EEG scores.

- High levels of stimulation and stress were anticipated by asking participants to stand in an exposed space. The EEG scores, however, showed a low stimulation response. The stress responses varied greatly between the survey and EEG, and it was anticipated the survey responses to stress would be higher to match the EEG reading.

The mixed responses from participants in terms of like/dislike while standing in the open space of World Square may have contributed to the contrasting survey and EEG scores. In terms of survey scores of 4.8, participants generally had mild dislike of standing in open space. When narrating their experiences, Elise remarked ‘I don’t like this,’ and Harvey noted that ‘I’m feeling a bit exposed and uncomfortable’. This response is consistent with observations from Jacobs (1961, p. 374), who commented that people ‘do not sally out in the middle and glory in being kings of the road at last. They stay to the sides.’ From an embodied cognition perspective, it is also consistent with the thigmotaxis (wall-hugging) behaviour observed.

The EEG score of 7.7, however, indicates a moderate level of positive attraction while standing in the open space. This may demonstrate that people’s experience is multisensory, and the impact of other stimuli elicited a positive response, contributing to a higher reading. This was observed by participants who commented on the impact of natural elements while standing in the open space, such as when Josephine said that ‘maybe it’s the sun because I like to be in the sun,’ and Kalinda, who noted ‘with the sun it feels nice… The breeze makes it seem like it’s an open space.’

In terms of stimulation responses to being in the open at World Square, participants were asked to look up and around. This instruction was a deliberate design in response to Gehl’s (2010, p. 33) point that ‘people are bipedal, they have two feet, and they walk with their eyes facing forward. People rarely look backwards or up. They almost never walk sideways or backwards.’ Asking people to look in a way they may not have otherwise engaged with World

Square sought to maximise their exposure to stimuli to gauge the multifactor sensory experience that might impact participants' stimulation responses.

Participants found this experience to be generally stimulating, rating it via the survey scores as 6.5, while the EEG score showed lower levels of stimulation at 4.1. This contrast in scores may be due a trend observed by Helen and Harvey, who respectively commented that 'it's probably stimulating in a physiological sense, but not in a particularly pleasant way. I'm not rating this as an overall pleasant experience,' and 'I guess it's over stimulating, in a bad way though.' It may be that people consciously felt somewhat bombarded with stimuli and consequently gave a higher survey score while unconsciously not enjoying the experience, which resulted in a lower EEG score.

There was a high degree of variance for participants' stress responses, with a low survey score of 4.7 and a high EEG score of 8.5. Standing in the most open part of World Square also equates to standing in the middle of pedestrian traffic, as there is often a flow of people cutting through World Square to reach the nearby train station. Several participants commented on feeling in the way of others during this part of the research, noting other people as a source of stress, such as when John said, 'the only stress being the occasional person,' and Jane noting, 'there are people walking around me constantly.' It may be that the higher stress EEG readings reflect people's discomfort of being out of step with the flow of pedestrian traffic, or the 'ballet of the good city sidewalk' as Jacobs described it.

The high EEG stress rating may also be related to participants breaking with an innate preference to stay at World Square's edges, as thigmotaxis can be a trigger for fear. Kallai (et al. 2007, p. 28) notes thigmotaxis 'plays an essential preparatory role in the first phase of spatial learning. The use of thigmotaxis helps the individual define the borders of an enclosed space and identify escape routes from that space.' During the earlier stages of the study, where participants were invited to freely explore – as per Lefebvre's rhythmanalysis – to familiarise themselves with the space, this provided an opportunity for participants to acquaint themselves with the layout of World Square's laneways, though many participants chose to only walk down one side of the square and then stop. Additionally, it should be noted that, while fear may be a factor in feeling exposed, the relative safety of World Square's edge was only ever a few steps away, which may also contribute to why participants rated the stress response lower on the survey.

Participants did not generally describe a relaxation response while standing in the open at World Square, and this is reflected in the survey and EEG scores. The EEG score was just below neutral at 4.9, while the survey score was somewhat lower at 3.8. This may reflect that although people might not necessarily have felt comfortable when they stopped in the thoroughfare of World Square's open space, it was nevertheless a relatively safe experience as people generally feel safe cutting through World Square. Sussman and Hollander (2015, p. 19) note that 'people favour risk-free shortcuts, and tend to shun things that require conscious effort and paying extra attention.' It may be that the experience was low risk enough that they were in a state where they felt they only needed mild levels of alert attention.

PARTICIPANTS' RESPONSES TO THE NATURAL AND FABRICATED ELEMENTS AT WORLD SQUARE

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE NATURAL AND FABRICATED ELEMENTS AT WORLD SQUARE

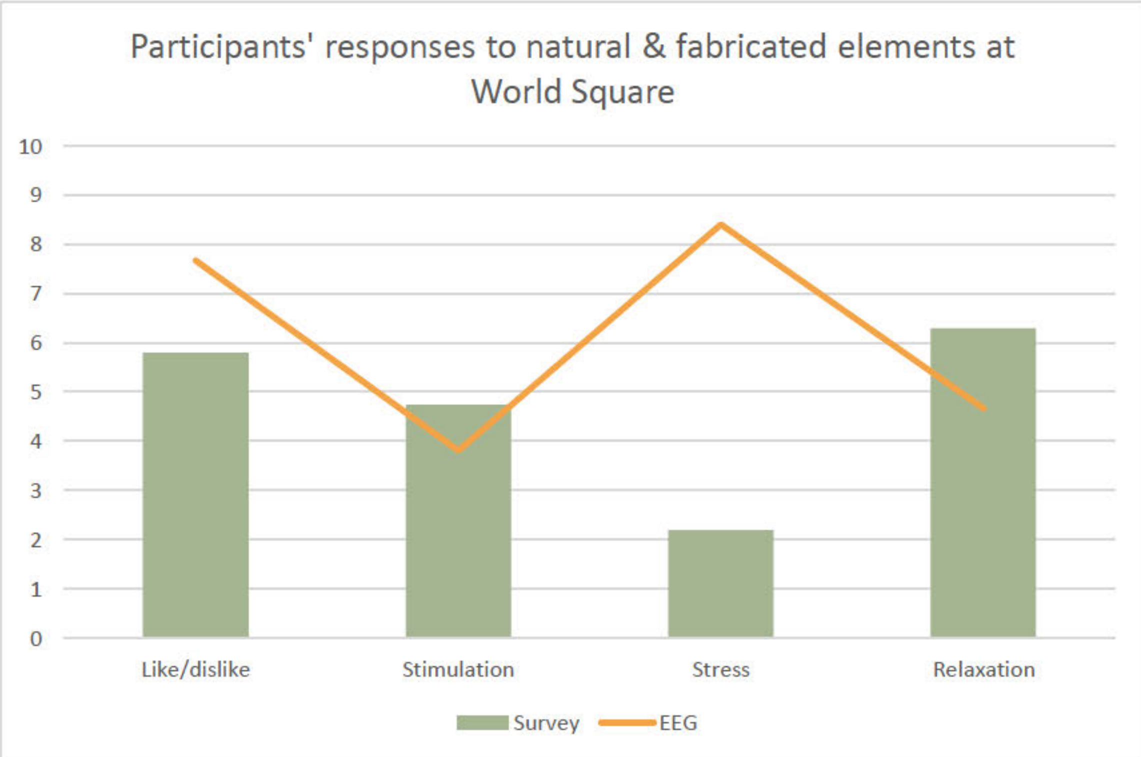


Figure 31. Average of all participant survey and EEG scores for the natural and fabricated elements at World Square.

The key data points are:

- There is very little consistency between the survey and EEG scores, with the closest readings being for stimulation (survey 4.8, EEG 3.8).
- Stress readings show the biggest difference, with high EEG scores (8.4) and low survey scores (2.2).
- Relaxation results are above neutral for the survey (6.3), but dip just below neutral for the EEG (4.7).

Participants reported low levels of positive attraction via the survey (5.8) but higher readings from the EEG (7.7). Participants' levels of stimulation were both below neutral (survey 4.8, EEG

3.8), indicating low levels of stimulation. Participants' levels of stress differed significantly with a very low survey score (2.2) and high EEG score (8.4). Levels of relaxation were recorded higher via the survey (6.3) but lower for the EEG reading (4.7).

PARTICIPANTS' WALKING INTERVIEW RESPONSES TO THE NATURAL AND FABRICATED ELEMENTS AT WORLD SQUARE

The participants responses to the landscaped elements of World Square were, again, quite varied. Some participants responded positively, such as Jane, who said, 'it's shaded, it's green, it's pleasant.' Kalinda, who identified the trees as being the most interesting feature of World Square, commented, 'it's symmetrical. I like that, but they didn't put in a lot of effort.' John reflected on the landscaped elements, saying, 'I find it formulaic and so it lacks a sense of naturalness and randomness that you have with nature. It seems very orthogonal and very orderly and so it lacks creativity… But it's nice there's lots of foliage.'

The landscaped elements of World Square's design elicited polemic responses from participants in terms of stimulation. Laura commented that 'it looks unnatural and really heavily attacked with a machete… It's trying to soften the space but it's not doing a very good job cause everything around it is so hard.' In comparison, Elise commented that the landscaping was 'manicured nicely,' though she also conceded that 'it could be greener. Definitely could be greener.' In reference to the landscape, Bobby commented that having the bins beside the landscaped area was a source of stress, saying 'if you come and sit on these chairs, you'd have this bin right next to you, especially in this Sydney summer heat. So, maybe having the bins over there would be better because it just makes it very refuse-y.' Elena noted some stress standing by the landscaping but qualified her response, saying 'it's not really [the garden bed's] fault really, it's the people.'

Participants generally reported feeling relaxed in response to the landscaping. Harvey commented that ‘I guess landscaping always makes me feel relaxed.’ Elena described the landscaped section, saying ‘it’s the best part of this area because it’s almost like not here. It’s a bit more calm.’ Neha said ‘this is nice. It’s in the sun and you’ve got some trees on both sides and greenery. Somewhere to relax, although I’ve chosen to sit right next to the pig [sculpture].’

DISCUSSION OF PARTICIPANTS’ RESPONSES TO THE NATURAL AND FABRICATED ELEMENTS AT WORLD SQUARE

The key points are:

- Given Nasar’s (1998) theory that human-made elements are less likely to elicit a positive response in comparison to natural elements, it was anticipated that participants would have a low level of positive attraction to World Square. This is not reflected in the EEG score, however, which shows mid-level positive attraction.
- Applying Kaplan and Kaplan’s (1989) attention restoration theory, it was anticipated that participants would have low levels of relaxation in World Square, since the natural elements there are very sparse. Participants reported higher than expected levels of relaxation via the survey.
- Given that there are so few natural elements, high stress levels were expected and this was borne out in the EEG data. It is unclear, however, why the survey scores for stress are so much lower than the EEG readings.

The natural elements of World Square are limited to three matching garden beds that consist of a tree in the centre and some low hedges. Given this low level of natural elements, it was anticipated that there may not be enough natural stimuli for participants to experience the restorative response described in Kaplan and Kaplan’s (1989) attention restoration theory. Indeed, when participants were instructed to stand by the natural elements within World

Square, many participants were confused and sought clarification on whether that meant standing beside the garden beds. In terms of the four characters that the Kaplans theorise as being necessary for attention restoration (which are fascination, extension, being away and compatibility, previously defined in the literature review), the three garden beds in World Square to not meet this definition.

Rather than fascination and awe from the natural elements of design, participants described the garden beds in milder terms, such as ‘pleasant.’ Comments were not always positive regarding the natural elements; Kalinda liked the design but qualified her comment by adding that the designers ‘didn’t put in a lot of effort.’ This low level of positivity is reflected in the survey scores, which were just above neutral at 5.8. The EEG score for like/dislike was higher at 7.7, indicating mid-range positive attraction.

It is unlikely participants experienced the sense of extension as described by the Kaplans (1989), which necessitates a sense of orderly coherence. The maintenance of the garden beds was described by Laura, who said ‘it looks unnatural and really heavily attacked with a machete,’ and by Barry, who observed, ‘I find it formulaic and so it lacks a sense of naturalness and randomness that you have with nature. It seems very orthogonal and very orderly and so it lacks creativity.’ These comments are consistent with the survey score of 4.8, which is just below a neutral level, suggesting a slight level of calming. The EEG score was lower at 3.8.

It is unlikely the garden beds offered participants the feeling of ‘being away’ from the stressors of the city, as described by the Kaplans. The worries of everyday life were noted by participants as intruding on their experience of the natural elements in World Square, with Bobby commenting that sitting by the gardens also meant sitting by the bins and experiencing the smell of hot garbage on a warm summer day. Elena also noted that the stress of having so many people nearby impacted her experience of the natural elements. This mix of experiences may contribute to the wide variation between the survey and EEG scores. The survey score was very low at 2.2, indicating that people did not consciously feel very stressed. In contrast, the EEG score was considerably higher at 8.4, indicating high levels of unconscious stress.

It seems that the garden beds did go some way towards the sense of compatibility referred to by the Kaplans, as it generally met participants' expectations for natural elements within the context of World Square. Elena described the landscaped section as 'the best part of this area… It's a bit more calm,' and Neha noted that the seating between the garden beds provided a place to relax. Participants recorded some positive relaxation responses, with a survey score of 6.3, while the EEG score dipped below neutral to a slightly negative score of 4.7.

It may be that rather than experiencing a restorative effect, the overwhelming prevalence of person-made materials adversely impacted the sensory experience of World Square. Kellert (2012, p. 161) notes that over exposure to concrete jungles can result in 'sensory deprivation, where monotony, artificiality and the widespread dulling of the human senses are the norm rather than the expectation.' This perspective may help explain the mixed responses of participants towards the natural design elements at World Square.

PARTICIPANTS' RESPONSES TO THE UPKEEP AND DERELICT ELEMENTS AT WORLD SQUARE

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE UPKEEP AND DERELICT ELEMENTS AT WORLD SQUARE

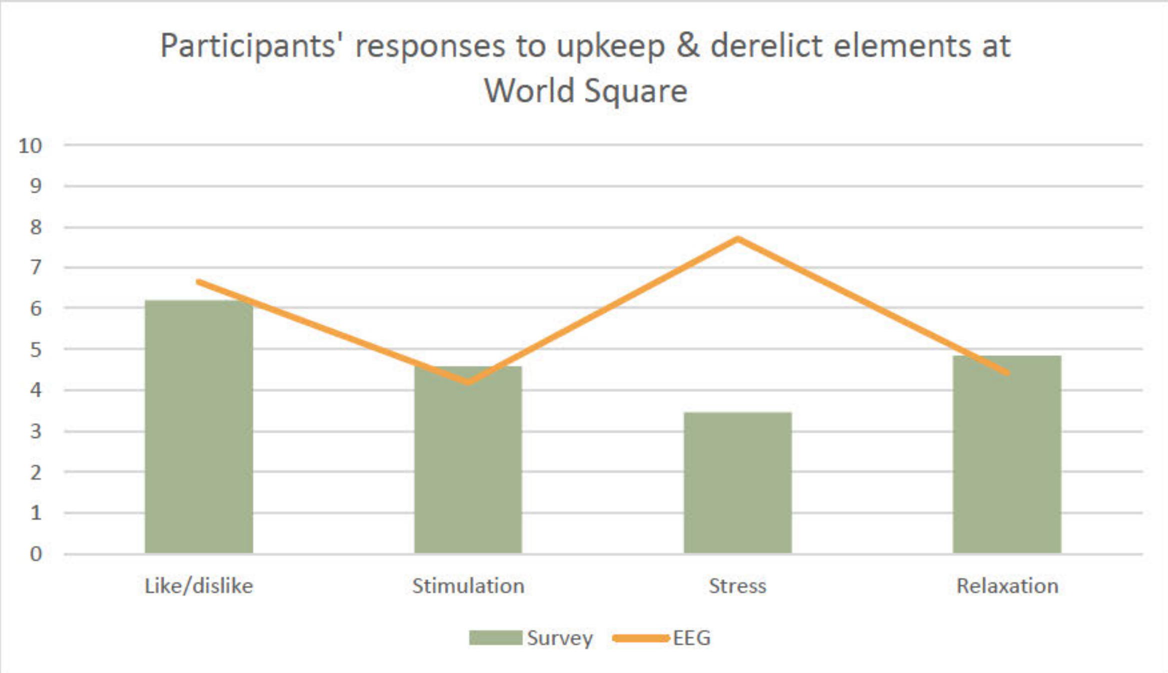


Figure 32. Average of all participant survey and EEG scores for the upkeep and derelict elements at World Square.

The key data points are:

- Although the readings for stress differ (survey 3.5, EEG 7.8), the reading for like/dislike (survey 6.2, EEG 6.7), stimulation (survey 4.6, EEG 4.2) and relaxation (survey 4.9, EEG 4.4) are quite comparable.

Participants' scores for like/dislike towards the upkeep of World Square similarly showed low levels of positive attraction (survey 6.2, EEG 6.7). Participants' survey and EEG scores both show comparably low levels of stimulation (survey 4.6, EEG 4.2). Participants' survey scores reported there were low levels of stress (3.5), while the EEG recorded much higher levels of stress (7.8). Levels of relaxation were low for the survey (4.9) and EEG (4.4) in World Square.

PARTICIPANTS' WALKING INTERVIEW RESPONSES TO THE UPKEEP AND DERELICT ELEMENTS AT WORLD SQUARE

Participants mostly described World Square's upkeep as 'clean,' as they noted a general lack of visible rubbish. However, there were some negative comments. Alexander remarked that 'the wind f***ing clears this place of rubbish and I don't even think those trees are real, so I actually think there's almost zero upkeep to this.' John regarded the upkeep as being 'slightly lacking,' noting that 'I can see what looks like dirt and bit animal you know…droppings over here. Some of this part of the wood is starting to age a bit. Some of this glass could be cleaned a bit regularly.'

While participants did not make many comments on the stimulation of World Square's upkeep, several participants did comment on the stairs they were asked to stand on to observe the upkeep. Elise remarked that 'I'm not happy with the stairs, really. Why would they pick that colour? And the lights, so stressful.' Neha commented that 'I don't like those flashy stairs. I just think they're really ugly, just a bit crass and kind of over the top.' In contrast, Larry responded to the stairs, saying 'it is red. Good red. It's got a nice energy. It's kind of vibrant. Powerful. Stimulating.'

When reflecting on stress related to the upkeep of World Square, Neha described it as being 'sterile' rather than clean, saying 'I guess sterile, partly again, just the steel, with lots of flat facades and steel and lots of angles, and maybe because there's not a lot of people around, it just feelings a bit empty and bare.' John commented that 'it's kind of a typical mismatch of modern things. I find the different shapes, they're reasonably stressful.' Helen remarked, 'I think it's probably upkept really well, but there's something about the design and the environment that just feels dirty... It's not stressing me but it's just not aesthetically pleasing.'

Very few participants commented on having a relaxing response to the upkeep of World Square. Oliver noted, 'I think its slightly relaxing. It's one of those things where you would notice if it wasn't, but you don't notice if it is.' Josephine commented, 'I would say I like it more… I mean if there was rubbish floating around, I wouldn't like it.'

DISCUSSION OF PARTICIPANTS' RESPONSES TO THE UPKEEP AND DERELICT ELEMENTS AT WORLD SQUARE

The key points are:

- As World Square is generally well maintained and typically free of litter, it was anticipated that there would be generally positive responses from participants. This is reflected through both the survey and EEG scores, as the readings are generally consistently mid-level responses for like/dislike, stimulation and relaxation.
- Participants' stress responses via the survey and EEG varied greatly. Further research may be needed to understand the reason for this variation.

When asked to consider the upkeep of World Square, many participants drew an interesting distinction on how they interpreted upkeep. Participants used the term 'clean' to reflect the fact there was little rubbish present and were generally positive in their comments about the lack of rubbish. However, participants also described the upkeep in terms of being 'sterile,' with clear negative connotations in their comments. For example, Helen explained her response saying, 'I think it's probably upkept really well, but there's something about the design and the environment that just feels dirty.' Neha explained her sense of World Square being sterile, saying 'I guess sterile, partly again, just the steel, with lots of flat facades and steel and lots of angles, and maybe because there's not a lot of people around, it just feelings a bit empty and bare.'

These mixed responses show a general positive approval to the lack of rubbish but negative sentiments to the sterile feeling they experienced, which appears to be reflected in the rather low scores for like/dislike. The survey score was 6.2 and the EEG score was only slightly higher at 6.7. Neha's above comment about the design's abundance of steel and angles may also provide some insight into the low stimulation responses from participants. Participants' conscious responses via the survey for stimulation was 4.6 and the EEG score was similar but slightly lower at 4.2.

As was mentioned in the previous section on participants' responses to orderly design at World Square, sharp-angled shapes can trigger the amygdala, which processes fearful and threatening stimuli. This may be an embodied, evolutionary response that has developed in response to the dangers presented from naturally occurring sharp things such as thorns, claws and teeth (Jasanoff 2018; Leder, Tinio & Bar 2011; Sussman & Hollander 2015).

Participants' bodily experiences of the textures and materials used in design may also be contributing to this response. Seeing the texture of surfaces can trigger the memories of past experiences with these stimuli. This has been observed from brain scans that show interconnectivity between the parts of the brain that respond to sound, sight and physical sensations. Seeing a cold or rough surface can unconsciously trigger the sensations of touching these surfaces without actual physical contact (Williams Goldhagen 2017).

In regard to stress, some participants identified the lights of the staircase they were asked to stand on as being stressful. Elise responded that that 'I'm not happy with the stairs really. Why would they pick that colour? And the lights, so stressful.' Neha was similar displeased by the stairs, saying 'I don't like those flashy stairs. I just think they're really ugly, just a bit crass and kind of over the top.' These responses may be reflected in the rather high EEG scores of 7.8 for stress responses. However, the survey scores for stress were much lower at only 3.5. This may reflect the mixed responses by participants as some participants, like Larry, liked the stairs and described the stairs as '…vibrant. Powerful. Stimulating.'

Participants did not report feeling especially relaxed by the upkeep of World Square. This is consistent with both the survey and EEG responses which are just below neutral with a survey score of 4.9 and EEG score of 4.4.

PARTICIPANTS' RESPONSES TO THE LIVELINESS AND PEOPLE AT WORLD SQUARE

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE LIVELINESS AND PEOPLE AT WORLD SQUARE

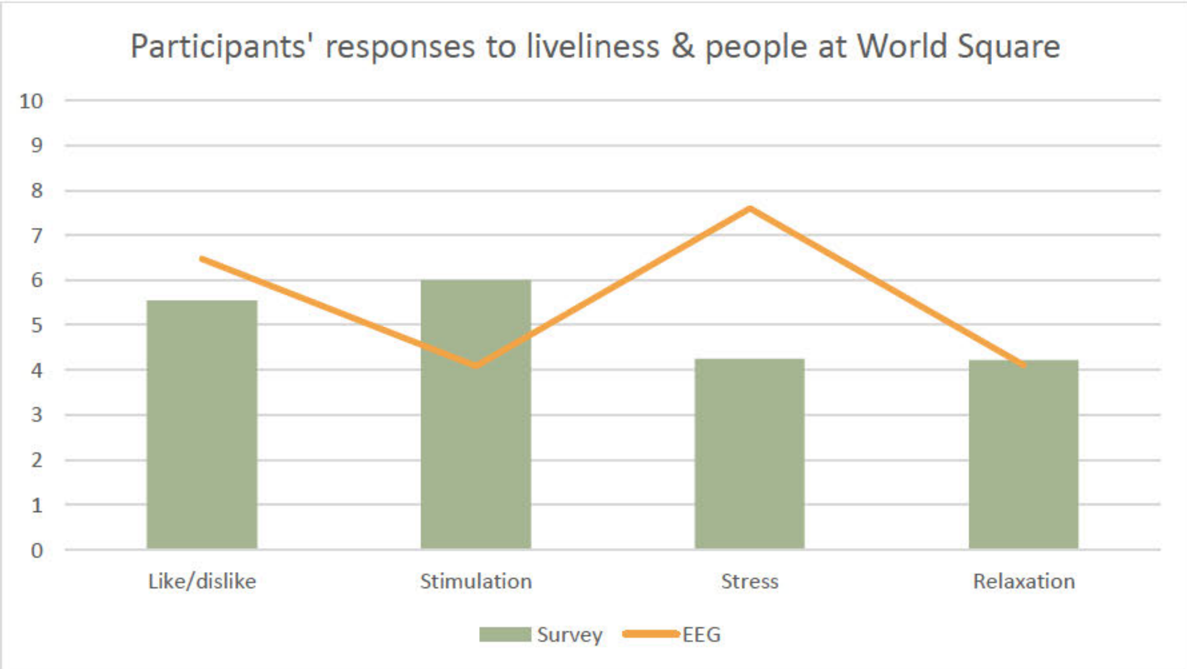


Figure 33. Average of all participant survey and EEG scores for the liveliness and people at World Square.

The key data points are:

- The biggest difference between survey and EEG scores was in participants' levels of stress (survey 4.3, EEG 7.6), while the most consistent scores were for relaxation (survey 4.2, EEG 4.1), followed by participants like/dislike scores (survey 5.6, EEG 6.5).
- In terms of stimulation, participants reported feeling somewhat stimulated by the liveliness of World Square via the survey (6), while the EEG reading (4.1) dipped below neutral into a low reading for stimulation.

Participants' survey and EEG scores both show low levels of positive attraction to the liveliness of World Square (survey 5.6, EEG 6.5). Participants reported higher levels of stimulation via the survey (6) in comparison to the EEG scores (4.1). Participants' survey scores for stress were low (4.3) while the EEG recorded higher stress readings (7.6). Participants' results for relaxation were very similar for the survey (4.2) and EEG (4.1).

PARTICIPANTS' WALKING INTERVIEW RESPONSES TO THE LIVELINESS AND PEOPLE AT WORLD SQUARE

The liveliness of World Square was also responded to with a mix of positive and negative reflections from participants. Josephine was positive regarding the liveliness, saying, 'I like it, it's really nice because it's not too busy,' and Ben, who commented, 'I actually like it, the chillness of it… Its more relaxing that lively.' In comparison, other participants did not like the amount of people patronising World Square, like Elena, who said, 'I just don't like lively places, but I know that society does… It's just too much f***ing liveliness, but as a hermit, I would enjoy it if there were no people.' Similarly, Laura did not like the liveliness, saying, 'gotta get me out of here quick smart. Everyone's using it as a walkway through. No one seems to be hanging around much.'

In terms of World Square's design offering the necessary stimulation needed for liveliness, Laura remarked that it did not seem that people fit in, saying 'the humans need the trees, look, everyone's congregating near the trees but no one's hanging around. […] They just feel like they're not a fit. It doesn't feel like it's been designed for them, it's been designed and they just happen to be here.' Bobby commented that 'it's not a great space to be lively in. Apart from those benches there's not a lot. There's a path between the square and the corridors. It's got almost like the facade of being for human comfort but actually it's just getting you into the next shop.' Alexander said that 'there's no doubt that its stimulating. Its unrelenting, so its stimulating,' though he also emphasised it was not stimulating in a positive sense, saying 'I'm not interested in a post-apocalyptic scenario.'

In response to the questions on stress elicited from liveliness, Helen noted that, 'there's places for people to sit down and talk and have something to eat and drink. You get the feeling that people themselves aren't actually stressed when I look around.' Josephine commented that, 'I don't think it's too lively, so I don't find it stressful.' Elena, however, found the liveliness stressful, saying 'I'm watching people swarm me.'

Some participants expressed a sense of relaxation when focusing on the liveliness of World Square. Ben said, 'I'd say it's more relaxing than lively.' Natalie commented that 'it's not calming… You could visualise people being here or having a party and have like, having some drinks and it's kind of a relaxed sort of relatively happy party sort of atmosphere.' Jane remarked that 'I don't think right now it's very lively. Everyone here is just walking about, going through World Square rather than engaging with World Square. It's such a nice space here […] that we could use for a lot of activities.'

DISCUSSION OF PARTICIPANTS’ RESPONSES TO THE LIVELINESS AND PEOPLE AT WORLD SQUARE

The key points are:

- Applying Gehl’s (2006) theory that the presence of people encourages more people to use a place, the generally well patronised World Square was expected to elicit high positive responses to like/dislike and stimulation. However, participants had relatively low levels of positive attraction to people via both the survey and EEG. The survey scores for stimulation were higher than the EEG readings, but both were lower than anticipated.

The participants had a wide range of views on how many people constituted a sense of liveliness in World Square. Although the number of people and the activities those people were undertaking varied somewhat depending on the time that the interview was conducted, there was little consistency in how participants responded to other people. The mixed responses are reflected in the survey and EEG scores for participants’ like/dislike responses to liveliness, with a rather neutral survey score of 5.6 and slightly higher EEG score of 6.5.

Gehl (2006) emphasises the importance of people using a space to attract others to also use it, creating a self-perpetuating process of people drawing in more people. However, this is not consistent with many of the reflections made by participants. In particular, Elena was very vocal about her dislike of liveliness, saying ‘I just don’t like lively places’ and ‘I’m watching people swarm me,’ even when standing up on the staircase away from the flow pedestrian traffic cutting through the square.

Other participants found the medium-to-low levels of liveliness as a positive trait, observing that it created a more relaxed sort of liveliness, with Ben commenting that the ‘chillness’ was appealing and Josephine saying, ‘it’s really nice because it’s not too busy.’ The lower level of stimulation from not being overcrowded seems to be reflected in the low EEG stimulation score of 4.1, though participants' survey scores were somewhat higher at 6. This variation in scores may also reflect that not all the participants found the liveliness levels especially calming. For example, Alexander described the experience of World Square as being 'unrelenting' in the stimulation it elicited, but in a negative way that bombarded the senses.

In contrast to Gehl's emphasis on the importance of bringing people into a space, it may be that more sedate, less populated spaces also appeal to people. A study conducted by Ellard (2015) compared the physiological responses of participants in sparsely populated public environments, such as carparks and churchyards, with the responses to private environments, like homes and secluded gardens. This study found similar physiological responses that indicated comparable levels of relaxation in both public and private spaces with low numbers of people. Ellard hypothesised that this result suggests that people with chaotic, busy lives may be drawn to less populated spaces as a means of finding respite from social interactions.

Participants also commented on the design of World Square and its impact on the space's potential for liveliness. Laura said that human needs seemed to be an afterthought in the design of the space. These sentiments were echoed by Bobby, who described World Square as offering 'the facade of being for human comfort but actually it's just getting you into the next shop,' and Jane, who also observed that 'everyone here is just walking about, going through World Square rather than engaging with World Square.' It is worth noting that both Laura and Bobby used the word 'human', rather than 'people,' which seems to suggest a level of alienation from the space, noting that World Square operates as a space to pass through rather than one that draws people in to linger and partake in social activities.

The observations from participants that the design of World Square does not facilitate engagement with the place was not anticipated. Part of the rationale for selecting squares as the typology for case study sites was that it met with Gehl's formula for a scale that allowed for social interaction. Gehl (2010, p. 34) notes:

> Only when the distance has been reduced to about 100 meters can we see movement and body language in broad outline. Gender and age can be identified as the pedestrian approaches, and we usually recognise the person at somewhere between 50 and 70 meters […] At a distance of about 22 to 25 meters we can accurately read facial expression and dominant emotions.

The scale of World Square for facilitating social encounters was noticed by Jing, who commented that the benches by the trees offered a useful vantage point to watch for someone approaching from most of the laneways. She said, ‘if I’m waiting for somebody I can see better the person from that end, that end or that end, so I have a bit more control.’

The relatively low levels of liveliness and good visibility of other people may contribute to the low levels of stress reported by participants via the survey, with a score of 4.3. Participants’ stress readings on the EEG was higher at 7.6, though this is not as high as many other stress readings taken throughout World Square. However, given participants’ descriptions of World Square’s liveliness as calming, the levels of relaxation recorded on both the survey and EEG did not directly correlate with these sentiments. For both the survey and EEG, higher scores indicated higher levels of relaxation, but the survey results were 4.2 and the EEG recorded 4.1. Both scores dipped below neutral readings into negative results, which seems somewhat at odds with the interview accounts.

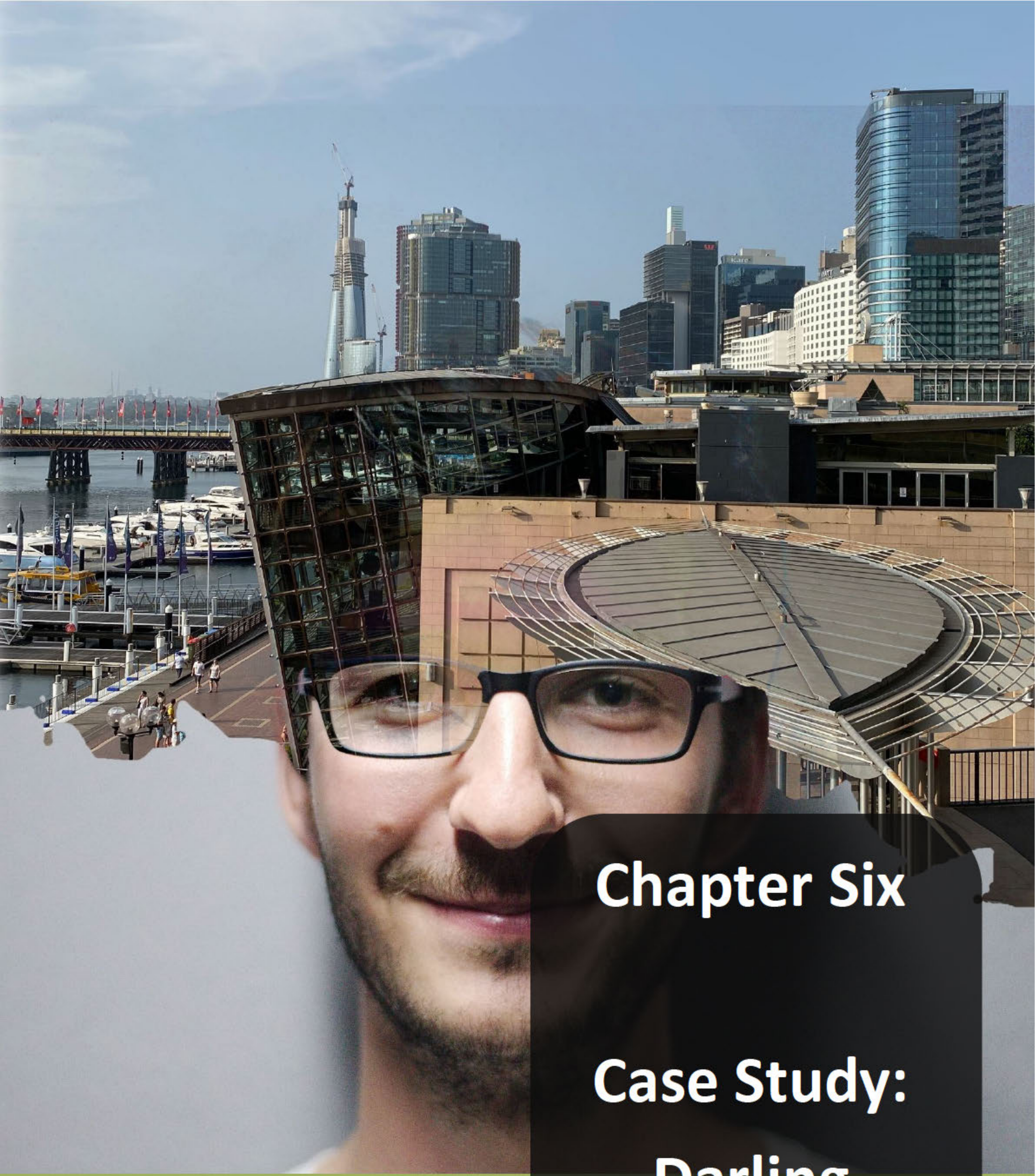
CONCLUSION

This chapter has introduced the first case study site, World Square, Sydney, by providing information on the square’s historical and geographic context and detailing description of the square together with panoramic photographs. The design elements that participants were asked to focus on where identified, described and illustrated with photographs.

The demographic profiles of the participants who engaged in the study were provided. An overview of the process each participant undertook in World Square illustrated how they were engaged for this study.

The key findings were that participants tended to report a wider range of response via the surveys in comparison to the EEG scores, which tended to be fairly stable across all stimuli. In terms of like/dislike participants survey scores ranged between 7.3 and 3.2 while EEG scores were between 8.3 and 6.5. Stimulation responses had the widest degree of difference both between the survey scores, which ranged between 7.0 and 2.6 and EEG scores between 5.7 and 2.9, but also the highest variation between EEG scores. The difference between EEG scores for stimulation has a gap of 2.8 points while the other EEG scores have less fluctuation. There was consistently significantly higher stress readings via the EEG scores (between 8.8 and 7.6) in comparison to the survey responses (between 4.6 and 2.2) across all design elements. Relaxation survey response ranged between 6.3 and 2.6 while EEG scores held quiet stably with a narrow range between 5.2 and 4.1.

The datasets collected through this fieldwork comprised of survey scores, EEG scores and walking interview responses. These datasets were provided for each of the design elements being focused on with graphs, written descriptions and summaries of the responses. The discussion of each design element bought together the datasets collected during fieldwork and the theory explored in the literature review to provide possible rationales for the various responses that participants had to the stimuli of World Square's design elements.



Chapter Six

Case Study: Darling Square

CHAPTER SIX – CASE STUDY: DARLING SQUARE

INTRODUCTION

The second of the two case study sites is Darling Square, Sydney. This chapter provides a context for the site in terms of its history, geography and over all appearance. Written descriptions and photographs of the design elements of Darling Square are provided to show the key stimuli that participants responded to when engaged in the study.

The research methods undertaken at Darling Square are described. The data collected at Darling Square is presented according to each of the design elements being focused on through graphs that show survey scores and EEG sources. A summary of participants walking interview answers are provided to show participants' reflections on their experience at Darling Square.

The discussion of participants' responses to the design elements brings together the datasets collected through fieldwork (namely survey scores, EEG scores and walking interview responses). The discussion also reflects on theory discussed in the literature review to explore possible reasons for the various responses participants had in their experience at Darling Square.

DARLING SQUARE SITE ANALYSIS

This section contextualises Darling Square by outlining the history of the area in terms of both the traditional First Nations knowledge of the place and its postcolonial uses. The geographic context of the site and its relationship to Sydney city is briefly explained. A description of Darling Square is provided, together with panorama images of the four sides of the square. This provides a foundation to understand the environment and key stimuli the research participants encountered during the study.

PRE-COLONIAL HISTORICAL CONTEXT

Darling Square is located on the land of the Gadigal people of the Eora Nation. Prior to colonisation, as mentioned previously, the topography of the land around Darling Harbour was low lying and captured the runoff rain from higher ground, such as the hill where World Square is now situated. The wetlands along the edge of the bays grew medicinal plants, paperbark trees and food.

The bay that has been renamed Darling Harbour was a primary source of food, offering fish and shellfish. The bay was also a launching site for *nawi* (canoes), which the Gadigal people used to travel out of the harbour to the headlands and further inland via the Parramatta River (Personal communication, Education, Culture & Tourism Office, Sydney Metro Aboriginal Land Council, 22/1/20).

Archaeological evacuations in the Darling Quarter have uncovered midden consisting of cockle shells, rock oysters and mud whelks, charcoal from campfires, and Aboriginal tools, which shows evidence of Aboriginal people having sat by the bay to cook seafood and sharpen their tools (Irish & Goward 2012).

POSTCOLONIAL HISTORICAL CONTEXT

In the early 1800s, the Haymarket area was outside the edge of Sydney town and consisted of a low-lying marshy area that drained into Darling Harbour. As Sydney expanded the site was used for a flea market that offered a wide variety of wares, such as fruit and vegetables, grain, clothing, souvenirs.

By the 1870s the Belmore Markets and Paddy’s Market had become firmly established and served as a nucleus for Chinese migration to the area (Karskens 2010). The Belmore Market building was considered inconveniently located in relation to the access to shipping offered at

Darling Harbour and provided the impetus for the construction of the Paddy's Market building in the early 1900s, which still stands today, albeit with the addition of extended refurbishments (City of Sydney Achieves 2016).

The site that has now become Darling Square was formerly used for the Sydney Entertainment Centre, which stood from the early 1980s until its demolition in 2016. The Entertainment centre was Sydney's largest concert venue until the construction of larger venues in Sydney Olympic Park in 2000 (City of Sydney Achieves 2016).

GEOGRAPHIC CONTEXT

Topographically, the area is mostly flat, although there is a slight decline from Darling Square towards the harbour. Darling Square is located within the Darling Quarter, which wraps around Darling Harbour. The Darling Quarter is located very close to the Sydney Central Business District CBD and is only approximately 1 km from Sydney Central Station. Darling Square spreads across a whole block, with Little Pier Street on the north boundary, Harbour Street on the east and Tumbalong Boulevard on the western side. Light rail tracks run across the southern end of the square.

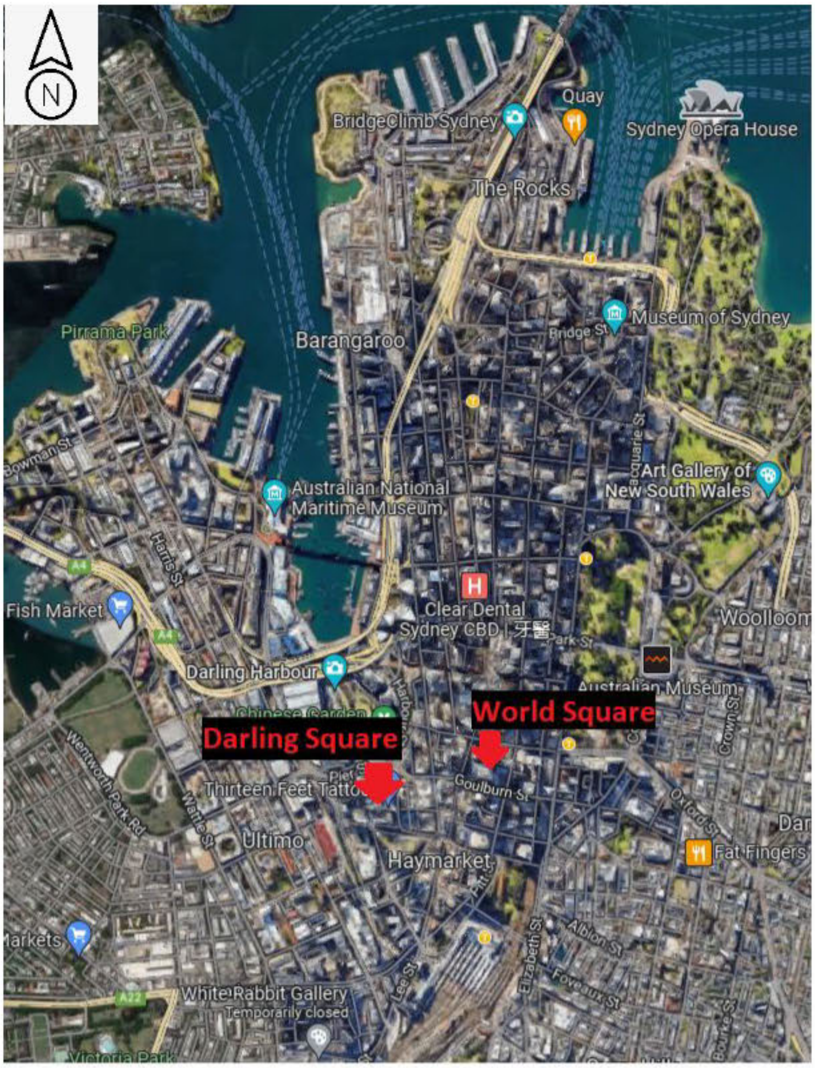


Figure 34. Map showing geographic context of World Square and Darling Square in Sydney's central business district. Image: Google Maps.

DESCRIPTION OF DARLING SQUARE

Darling Square is a newly constructed space that was opened to the public in late 2019. It consists of a mix of retail businesses, eateries, residential apartments and a library. Darling Square is surrounded by buildings that range between five to seven stories in height and are used as residential dwellings and some office spaces. The ground level of these buildings have open facades for customer access to the shops, cafes and restaurants along the edges of the square.

Darling Square attracts larger crowds on weekends compared to weekdays; however, the busiest times on any day are consistently lunch and dinner times. The main pedestrian thoroughfare runs along Tumbalong Boulevard, which runs along the western edge to connect the square to the Darling Quarter. This allows Darling Square to act as a place of refuge off the main thoroughfare.

Figure 35. Photo: Eldridge, T, Panorama of the northern side of Darling Square, 29/9/19.

The northern side of Darling Square, shown in Figure 36, is a clear focal point in the square, with the round, wooden clad library that was designed by Japanese architects Kengo Kuma & Associates. While the internal spaces of the library are outside scope of this study, it is worth noting that the bottom floor of the library offers more eateries and is often the busiest area of the square. There are public chairs and tables for people to use set out along the edge of grassed area.

The eastern side of Darling Square has a line of deciduous trees running along its length, as shown in Figure 37. The bottom level of the buildings operate as restaurants, with al fresco dinning that extends beyond the boundary of the building and into the square. The upper levels of the building are residential apartments.

Figure 36. Photo: Eldridge, T, Panorama of the eastern side of Darling Square, 29/9/19.

The southern end of Darling Square offers more public seating, with tables and chairs set up in between deciduous trees and small garden beds, as shown in Figure 38. Similar to the eastern side, the southern side of the square consists of a building with residential accommodation on the upper floors and retail businesses along on the bottom level.

Figure 37. Photo: Eldridge, T, Panorama of the southern side of Darling Square, 29/9/19.

The wooden facade of the library extends out along the western side of Darling Square to form a pergola over landscaped garden beds and wooden benches for seating, as shown in Figure 39. The garden beds include jasmine, which has been planted at the base of cables to encourage it to creep up the pergola as the garden matures. Native gum trees are planted along the outside of the pergola, lining the pedestrian thoroughfare of Tumbalong Boulevard. The building on the western side had yet to open it bottom level at the time of the study, but the upper levels were in use as residential dwellings.

Figure 38. Photo: Eldridge, T, Panorama of the western side of Darling Square, 29/9/19.

DESIGN ELEMENTS AT DARLING SQUARE

This section identifies, describes and illustrates (through photos) the key design elements in Darling Square that are the focus of this study, namely orderly design and patterns, openness and exposure, natural and fabricated elements, upkeep and derelict elements, and liveliness and people. These descriptions are provided to show the stimuli that participants were asked to focus on during Method 3 Walking interviews and when answering the questions from Method 2 Surveys.

ORDERLY DESIGN AND PATTERNS

LAYOUT

There are two laneways and a large pedestrian thoroughfare that branch off the main square. The two laneways have different designs, with different styles of artwork. One laneway is primarily devoted to retail businesses while the other is primarily focused on dining options.

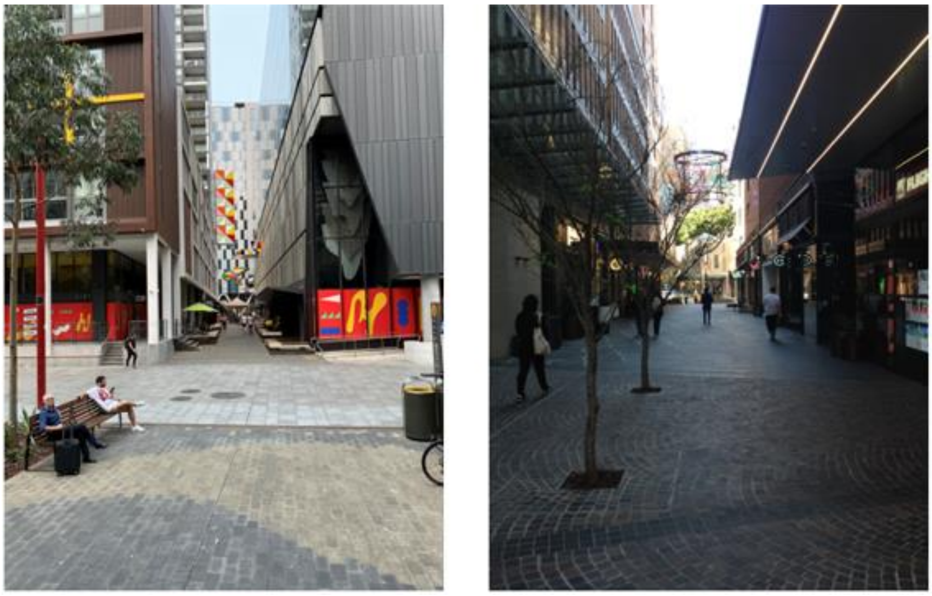


Figure 39. Photo: Eldridge, T, Laneways branching out of the centre of Darling Square, 8/9/19.

THEME

Being part of the Darling Quarter, Darling Square blends into the design of Darling Harbour, which is aimed at a more international audience of tourists. This square also aims to cater for local residents, as it abuts the University of Technology campus and accommodation.

Figure 40. Photo: Eldridge, T, Tumbalong Boulevard connecting Darling Square to the Darling Quarter, 10/1/20.

PATTERNS

Patterns are varied with different styles of rounded pavements used throughout the square. The building facades offer a mix of monotonous and varied patterns. The colour palette is wider, with a mix of warmer hues such as browns and yellows mixed in with beige.

Figure 41. Photos: Eldridge, T, Patterns of the pavement, pergola and benches with long parallel lines, Darling Square, 15/1/20.


Figure 42. Photos: Eldridge, T, Patterns of the building facades with both varied and monotonous designs, Darling Square, 15/1/20.

SHAPES

The wooden facade wraps around the circular library to emphasise the building's roundness. The tables and chairs that are located on pavements with circular patterns also provide rounded shapes. There are also long rectangular wooden features, such as the pergola and wooden slat benches for public seating.

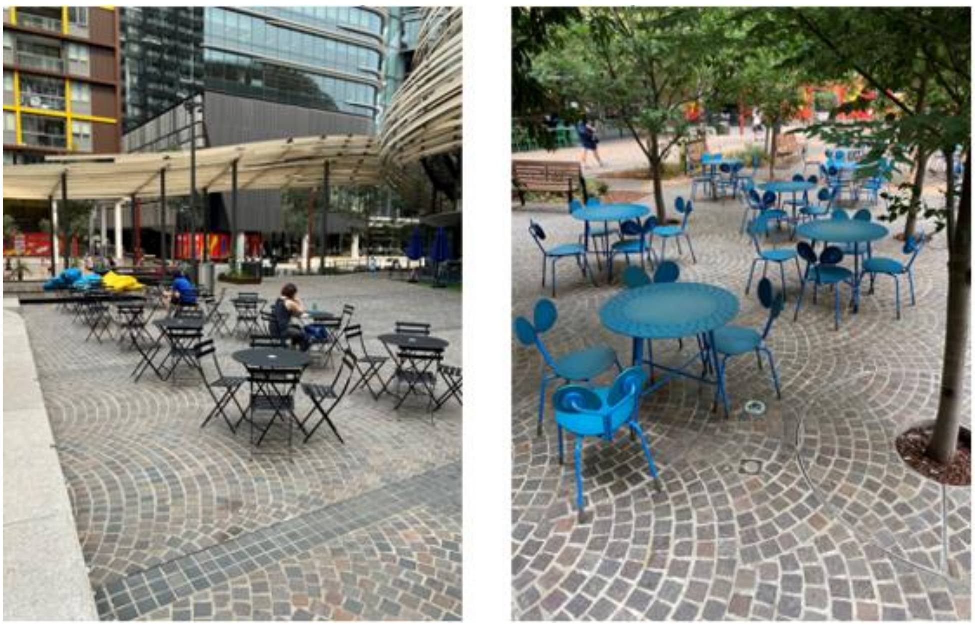


Figure 43. Photos: Eldridge, T, Patterns of the rounded pavement design and curved tables, Darling Square, 15/1/20.

OPENNESS AND EXPOSURE

The surrounding buildings are lower (six to seven stories) in comparison to World Square. The surrounding buildings tend to be residential dwellings in the upper levels. The open space in the centre is grassed and regularly strewn with beanbag chairs to provide space for passive recreation.

Figure 44. Photos: Eldridge, T, Empty open space in the centre grassed area within Darling Square, 15/1/20.

NATURAL AND FABRICATED ELEMENTS

There are numerous garden beds with a mix of different plant species, both native and introduced. There are both flowering plants, such as jasmine, and non-flowering, such as ferns and succulents. There is a mix of deciduous and native evergreen trees, which means that Darling Square became progressively greener during the study as the deciduous trees regrew their leaves. There is also a grassed area in the centre of the square.

Figure 45. Photos: Eldridge, T, Sample of garden beds, Darling Square, 15/1/20.

There are lampposts and surveillance cameras spread throughout the square and numerous bins for recycling and general waste spread throughout the area. There are also bubblers for public use.

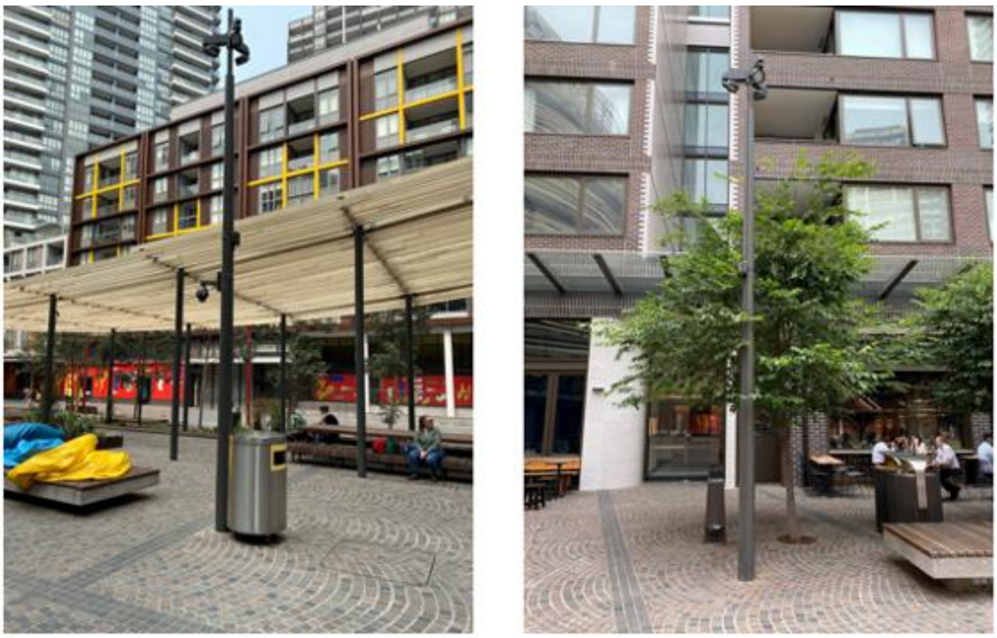


Figure 46. Photos: Eldridge, T, Bins and lampposts, Darling Square, 15/1/20.

UPKEEP AND DERELICT PLACES

At the time of this research, Darling Square had only been open to the public for a matter of weeks, which meant everything was new and in very good condition. The level of litter varied between each participant and in some instances the public tables had litter on them. A maintenance person was often observed at Darling Square removing litter and sweeping bark chips back into the garden beds

LIVELINESS AND PEOPLE

Darling Square is patronised on both weekdays and weekends and is busiest during lunch and dinner times. There are regularly people making use of the ample public seating at all hours of the day for passive recreation, such as meeting friends, reading and relaxing. Bean bags were situated on the grass area at the centre of the square to facilitate people relaxing.

Figure 47.Photo: Eldridge, T, People relaxing at the tables and on benches around the grassed area of Darling Square, 10/1/20.

RESEARCH METHODS AT DARLING SQUARE

This section presents the data gathered from participants in Darling Square. The section is organised to match the approach taken for World Square as it outlines the features participants identified as being the most and least interesting. It then presents the EGG and survey scores via line graphs. Extracts from the walking interviews are used to illustrate the participants' responses to the design features they encountered.

RESEARCH METHODS IN PRACTICE

This section discusses the steps that were taken at Darling Square to collect data for the three methods. This description provides transparency on how this mixed methods approach was executed and how the participants were involved, noting that it was a slightly different process at Darling Square compared to World Square.

All participants were escorted from World Square to Darling Square via the walking route shown in Appendix I.

Once at Darling Square, participants sat at the public seating at the southern end of the square. They were fitted with the EEG headset and, where necessary, small adjustments to the position of the sensors where made to ensure closer contact between the sensors and the participant's scalp. Figures 4 and 5 in Chapter Four illustrate the readings given in the EmotivPRO software to indicate the connectivity of each sensor. As with the previous site, the study commenced when connectivity was at 100%, allowing for the reading to drop to a range of 96%–100% connectivity during the study.

Once the EEG headset was positioned to show 100% connectivity, a baseline reading was taken. This involved having participants relax with their eyes open for 15 seconds and then relax with their eyes closed for 15 seconds. This is a feature of the EmotivPRO software to take into account the impact of participants' eye blinks, which could otherwise impact the accuracy of the measurements.

The audio recording for Method 3 Walking interviews was started when the EmotivPRO software asked participants to relax with their eyes closed for 15 seconds. This synchronised the audio recording and EEG recording so that the EEG readings could be reviewed simultaneously with the audio to track what the participants reported they were experiencing parallel with the EEG data.

Participants were given a cue card with the Method 2 Survey questions (Appendix F) for their reference and then instructed to walk around Darling Square – as per Lefebvre's rhythmanalysis – to familiarise themselves with the space. I walked beside them while holding a laptop with the EmotivPRO software to maintain Bluetooth connectivity with the EEG headset to record the data for Method 1 EEG and to take an audio recording of participants' responses for Method 3 Walking interviews for the entirety of the fieldwork.

Participants were asked semi-structured questions to reflect on their initial experience of Darling Square (Method 3 Walking interview questions are in Appendix G). Participants were then asked to identify the feature of Darling Square's design that they found most interesting and to stand beside it (the locations where each participant choose to stand for each reading is available in Appendix H). After briefly discussing their thoughts on the most interesting feature, participants were asked to refer to the cue card for Method 2 Survey. The questions were also read aloud to them. The point where participants verbally communicated their rating for Method 2 Survey was the same point in time that Method 1 EEG measurements were taken from the recording to synchronise participants' conscious and unconscious data. Participants were then asked to identify the design element of Darling Square that they found least interesting, and the same steps were taken to gather the next dataset.

Participants were next instructed to continue walking around Darling Square and asked to reflect on the design, theme and patterns using semi-structured questions from Method 3 Walking interviews. Method 2 Survey questions were asked, and the Method 1 EEG data was collected through the EEG headset.

Participants were asked to identify the most open part of Darling Square and were directed to stand in the area they felt was most open. While standing in the open, participants were asked semi-structured questions from Method 3 Walking interviews. Method 2 Survey questions were asked and the Method 1 EEG data was collected through the EEG headset.

Participants were instructed to find a space that had the most appealing natural elements and to stand there. While standing next to the natural design elements participants were asked semi structured questions from Method 3 Walking interviews. Method 2 Survey questions were asked and the Method 1 EEG data was collected through the EEG headset.

Participants were next instructed to go to the north-eastern corner of Darling Square and to look out over the square. They were asked to reflect on first the upkeep and order of Darling Square and, finally, on its liveliness using semi-structured questions from Method 3 Walking interviews. Method 2 Survey questions were asked and the Method 1 EEG data was collected through the EEG headset.

Participants were offered a final opportunity to add any further comments and the interviews were ended. The audio record was turned off and the EEG headset was removed. This concluded each participant’s involvement in the study.

DATA AND DISCUSSION ON PARTICIPANT RESPONSES TO DARLING SQUARE

This section provides the results of the fieldwork conducted in Darling Square. The average of the participants' scores are presented side by side via line graphs. The graphs compare the participants' unconscious responses through the EEG measurements and the conscious responses recorded through the survey questions. The participants' results are further illustrated with comments and observations made by the participants during the walking interviews.

Participants' responses in terms of like/dislike, stimulation, stress and relaxation are analysed in the context of each design element (interesting feature, uninteresting feature, orderly design and pattern, openness and exposure, natural and fabricated, upkeep and derelict, liveliness and people). Each of these measures is presented via graphs that show the average participants' EEG and survey scores for each of the key design elements in Darling Square. The results are discussed and further illustrated by extracts of the walking interviews conducted in between the survey questions. Scores are rounded to one decimal place in the commentary for the reader's ease.

UNDERSTANDING THE DATASETS

The data is presented as averages from all participants, grouped to show EEG scores and survey scores side by side. This arrangement is intended to compare and contrast the participants' unconscious responses captured via the EEG and the conscious responses recorded via the survey.

The EEG performance metric for **like/dislike measures the level of attraction or aversion** to a stimuli or environment. High readings indicate strong interest, low readings indicate strong aversion, while mid-range readings indicate the wearer neither likes nor dislikes the stimuli or environment. The survey question mirrors this by asking to what extent the participant likes or dislikes the feature to which they are responding, with 0 being dislike and 10 being like.

The EEG performance metric for **stimulation measures a positive feeling of awareness**, characterised by activation in the sympathetic nervous system. These physiological responses can include pupil dilation, eye widening, sweat gland stimulation, and increased heart rate and muscle tension. The device is tuned to measure short-term changes in excitement over short time periods. The survey question corresponds to this metric by asking participants to rate the extent to which they feel stimulated by the various design elements, with 0 being not at all stimulating and 10 being very stimulating.

The EEG performance metric from **stress measures the wearer's level of comfort** with the situation that they are experiencing. High readings may occur while being confronted with a challenging problem that is not easily solved, or fear of failing to complete a task. The survey question has been synchronised by asking participants to what extent they feel stressed by the design elements encounter in World Square, with 0 being not at all stressed and 10 being very stressed.

The EEG performance metric for **relaxation measures the wearer's ability to recover from intense focus** and switch off their attention in a positive way. The survey questions echo this measure by asking participants to what extent they feel relaxed by the features they are responding to in World Square, with 0 being not at all relaxed and 10 being very relaxed.

Participants' individual scores are available in Appendix N and maps of where each participant was standing when the scores were taken is available in Appendix H.The survey questions used in the study are in Appendix F and the semi-structured walking interview questions are in Appendix G.

PARTICIPANTS' RESPONSE TO THE INTERESTING FEATURE AT DARLING SQUARE

THE FEATURES OF DARLING SQUARE PARTICIPANTS FOUND INTERESTING

As mentioned in the previous chapter, participants were asked to identify the features they found most and least interesting to establish the bounds of their responses to key design elements. These specific features have been identified, as the stimuli to which participants responded varied. The below graphs summarise the specific features participants identified and how many of the participants found these features interesting or uninteresting. These features are the stimuli participants are responding to in Figures 50.

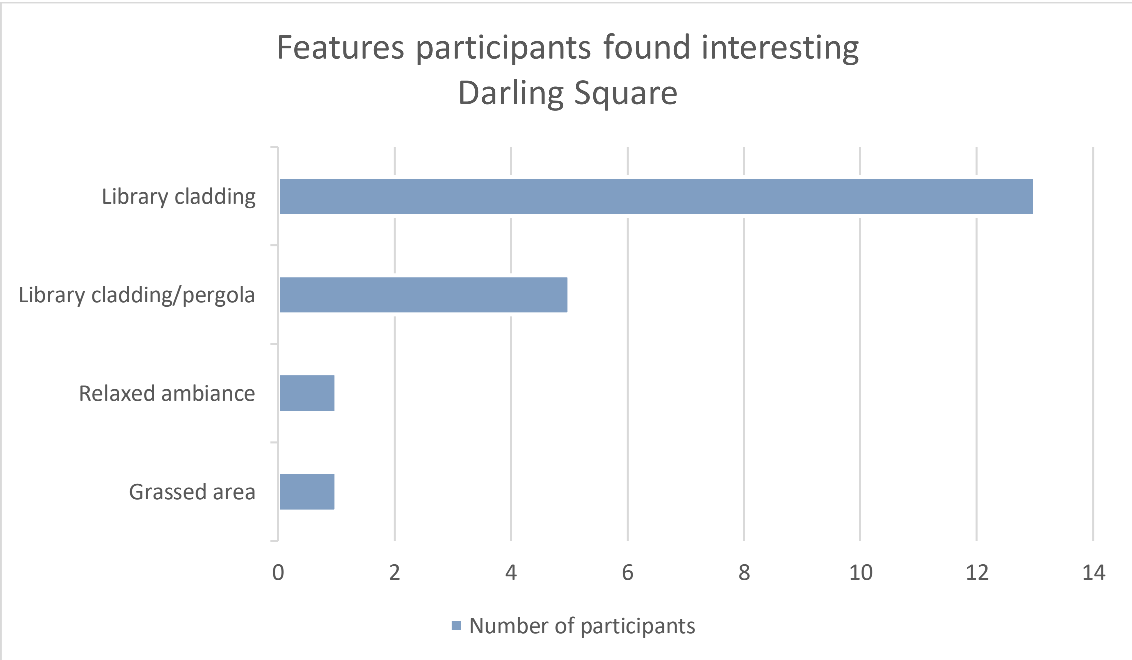


Figure 48. The features of Darling Square participants identified as being interesting.

The vast majority (thirteen) of participants identified the library as being the most interesting feature of Darling Square. Five participants specified that the most interesting aspect was the way the wooden cladding of the library extended out into a pergola. The remaining two participants respectively found the grassed area and general relaxed ambiance of Darling Square to be the most interesting features.

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE INTERESTING FEATURE AT DARLING SQUARE

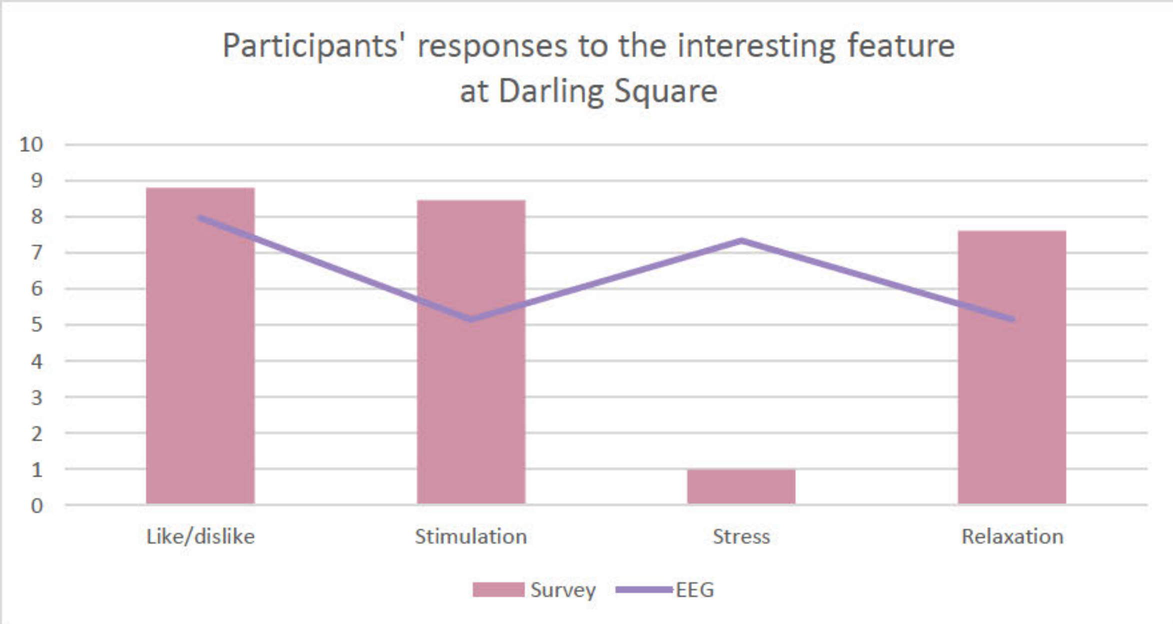


Figure 49. Average of all participant survey and EEG scores for the feature they found most interesting at Darling Square.

The key data points are:

- The participants' scores for stress varied greatly between the survey (1) and EEG (7.3) and also varied significantly for stimulation when comparing the survey (8.5) and EEG (5.1) scores.
- Participants survey responses (7.6) for relaxation were higher than the EEG scores (5.2).

Participants' scores for like/dislike towards the interesting feature at Darling Square were high for both the survey (8.8) and EEG (8). In terms of stimulation, the survey scores (8.5) were much higher than the EEG scores (5.1), which was approximately a neutral reading. Stress scores were very low for the survey (1), but quite high for the EEG (7.3). Relaxation results were higher for the survey (7.6) in comparison to the EEG (5.2).

PARTICIPANTS' WALKING INTERVIEW RESPONSES TO THE INTERESTING FEATURE AT DARLING SQUARE

The feature that the majority of participants found interesting was the design of the library and the way the wooden cladding extended out to form a pergola. Mike described the design, saying, 'I like, in particular just here, first time I've ever been here, but the wonderful curvy shape of the pergola's design, the way it goes past and then wraps itself around this building at the end of the square. I think that's alive.' Jane also spoke positively about the design, saying

> I love how it's round and smooth, but not too smooth. There's texture from whatever that wooden thing is wrapping around it. It doesn't feel perfect, which is what I like about it. It also matches with this [pergola], which is quite nice. It feels like a free-flowing train of thought... It's a journey. It's a process, which I like.

For Oliver, the experience of standing under the pergola was especially interesting, noting that 'The quality of light is nice, kind of soft and dappled as opposed to being all the way in the shadow or all the way in the sun, like dappled.'

Participants who found the library's design interesting commented that it was a stimulating design, such as Bobby, who felt that 'I'm really excited rather than relaxed.' Jing noted that

> I like the library although I don't understand. I don't know what it actually is. It just looks like rattan wrapped around that. It looks like one of those, Chinese people use this kind of thing to steam buns. Because I don't understand it, it's not really that relaxing but it's stimulating.

Josephine commented that 'This [library] is a great building […] It's like bamboo on the outside almost. So, it takes away that kind of concrete-y feeling that you have in a city. I find it very stimulating because it makes my eyes move around the building.'

The participants only commented on a few sources of stress while at Darling Square and often noted the lack of stress at various point of the interview. For example, when asked to assess her level of stress while focusing on the design of the library as the most interesting feature, Jing replied, 'oh no, not at all.'

When focusing on the design of the library as the interesting feature, participants noted it was relaxing. John described a sense of calm, saying

> It feels good, and it will be different again when the light changes, perhaps in the morning when the light's over this part. And I like the natural wood circling above. Yes. It feels much more thought through and consistent […] and I'm circling around this and it leads me in, so I feel that it's more welcoming, because it's a natural flow to here rather than crisscrossing to go to buildings.

DISCUSSION OF PARTICIPANTS' RESPONSES TO THE INTERESTING FEATURE AT DARLING SQUARE

The key points are:

- The central landmark of Darling Square, the library and its wooden cladding, was expected to be a focal point for participants. This was consistent with the results, which showed high positive attraction from both the survey and EEG scores.
- The rounded shaped and wooden materials used in the library's design was anticipated to be relaxing for participants. This is reflected in the survey response for relaxation, but the EEG results were lower and it is unclear why there is such a difference.
- Given that it was anticipated that the library's design would be relaxing, it is unclear why there are high stress responses via the EEG. The low stress readings via the survey are in line with the expected responses from participants.

The majority of participants identified the cladding on the library as the most interesting feature of Darling Square's design. The strong positive attraction was reflected in high survey scores of 8.8 and an EEG score of 8. Participants were unanimously positive in their comments regarding the library cladding. Comments ranged from simple approval, such as Harvey, who said, 'that [library] is cool. I like it,' to other participants who spoke about what imagery the design evoked in them, such as Bobby, who said, 'I like the shapes, it's like a lot of movement. It could be like a whirlwind or noodles or like how the eye goes like that [drawn along from the library out into the square].' Several participants described the library's cladding in terms of a feeling of movement, natural elements, and food. Both Bobby and Jing noted the design reminded them of noodles and steamed buns. Harvey, Bobby, Larry and Neha all described a sense of movement in terms of wind, with Larry describing the cladding as a 'swirly breeze,' and Harvey calling it a 'hurricane building.'

The metaphors used by participants suggest they were carrying over meaning from other experiences to understand the design of the library. This phenomenon is observed by Williams Goldhagen (2017, p. 75) who explains that 'we imbibe such metaphors out of our experiences of living in the kinds of bodies humans have, in environments both natural and constructed. That's why they are embodied.' Wooden textures are often present in home furnishings and may contribute towards the connections being drawn to domestic experiences, such as steaming buns and noodles. Design that stimulates the imagination is also observed by Robinson and Pallasmaa (2017, p. 146), who succinctly note that 'texture invites life.' This was true for Barry's experience of the library's design, as he commented that 'the wonderful curvy shape of the pergola's design, the way it goes past and then wraps itself around this building at the end of the square. I think that's alive.'

While participants were attracted and interested in the library's design, there was a mixed response in terms of stimulation. The survey response was high at 8.5 but the EEG showed neutral levels of stimulation at 5.1. It is possible that this mixed response may reflect both participants' conscious stimulation in terms of the imaginative metaphors that emerged and the unconscious calming response to round wooden shapes. The roundness was noted by several participants, such as Helen, who commented, 'I can see more circles rather than all those really sharp angles back at World Square.' Josephine echoed these sentiments, saying, 'compared to [World Square] it's a lot more round, there's curves, there's colours. This is a great building with the – well it's almost like bamboo on the outside, so it takes away that concrete-y feeling you have in the city.'

Human preference for round shapes has been well documented and goes as far back as psychologist Kate Gordon's (1909, p. 169) seminal work, *Esthetics*, where she observed 'curves are in general felt to be more beautiful than straight lines. They are more graceful and pliable, and avoid the harshness of some straight lines,' and 'the most simple abstract line […] may have an emotional effect and meaning of its own,' (p. 160). As has been previously noted in this research, neurological studies have since added evidence in support of this by showing the amygdala in the brain is triggered by sharp angles; however, the same fear response is not triggered by curved shapes. It may be that the round, plump shape of the library is unconsciously comforting after the angular environment of World Square.

Participants reported feeling very low levels of stress, with a survey score of 1, but the EEG score was much higher at 7.3. There was also a mixed response for relaxation, with a survey score of 7.6 and an EEG score of 5.2. It is unclear why there was such variation in these scores. Based on participants' comments, there were no stressful elements that participants identified as impacting their experience. The observations made by participants focused on the relaxing response of the natural elements of the design, for instance, John said:

> It feels good, and it will be different again when the light changes, perhaps in the morning when the lights over this part. And I like the natural wood circling above. Yes.

> It feels much more thought through and consistent [...] and I'm circling around this and it leads me in, so I feel that it's more welcoming, because it's a natural flow to here rather than crisscrossing to go to buildings.'

Ben also expressed general approval of his experience of the library's design, commenting 'it's nice, I don't know. It's where the design intersects. It's where the slats from [the pergola] meet up with the very nicely designed library. It feels like a focal point, or at least that how I interpret it. It feels like its where everything converges.'

PARTICIPANTS' RESPONSES TO THE UNINTERESTING FEATURE AT DARLING SQUARE

THE FEATURES OF DARLING SQUARE PARTICIPANTS FOUND UNINTERESTING

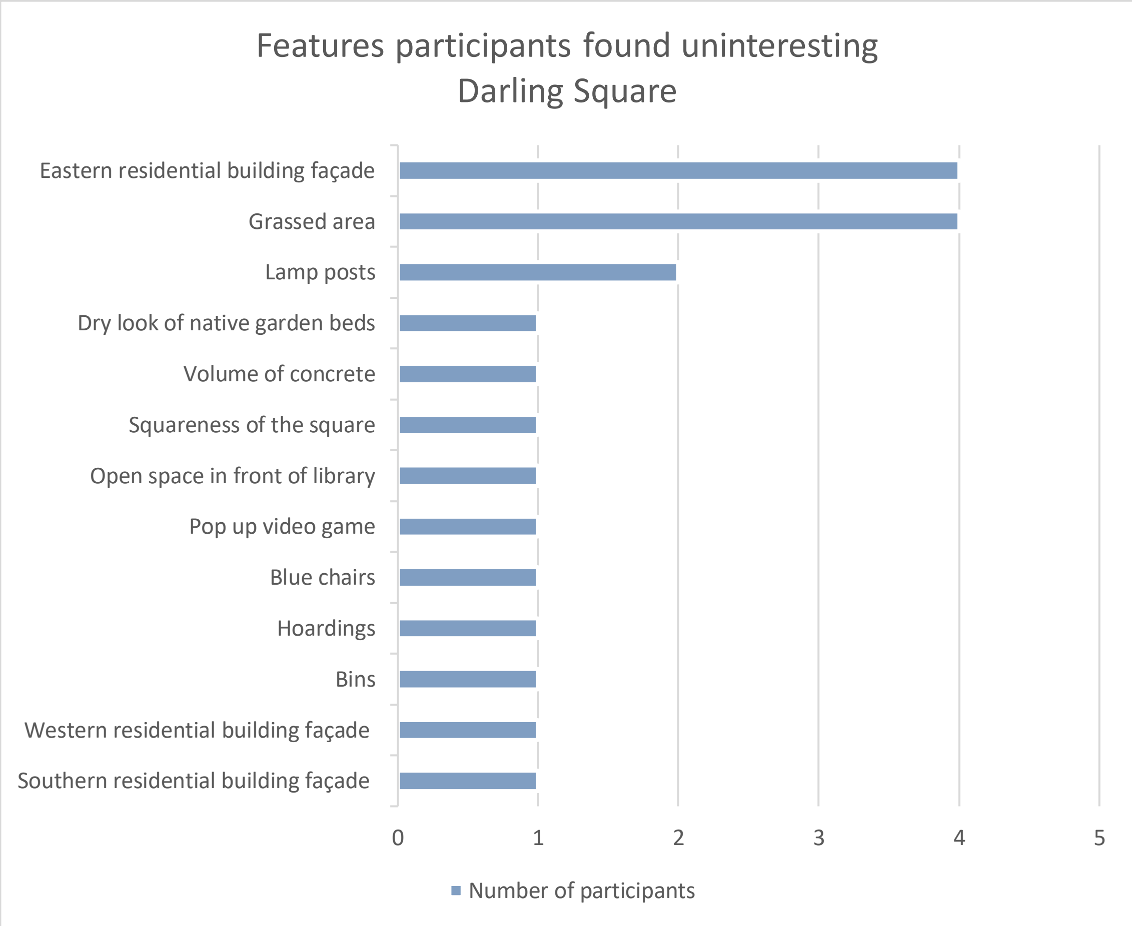


Figure 50. The features of Darling Square participants identified as being uninteresting.

The participants identified a wider range of features that they found uninteresting. The features most people (four) found uninteresting were the facade of the residential apartments on the eastern side of the square and the grassed open space in the centre of the square. Two participants identified the lampposts as being the most uninteresting feature. The remaining uninteresting features were the dry look of the native garden beds, the volume of concrete used in Darling Square's design, the open space in front of the library, a pop-up video game that was installed for one weekend, the blue chairs for public seating, the hoardings of shopfronts that had not yet opened, the bins, and the facades of the residential apartments on the western and southern sides of the square. Each of these features was identified by one participant as being the most uninteresting.

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE UNINTERESTING FEATURE AT DARLING SQUARE

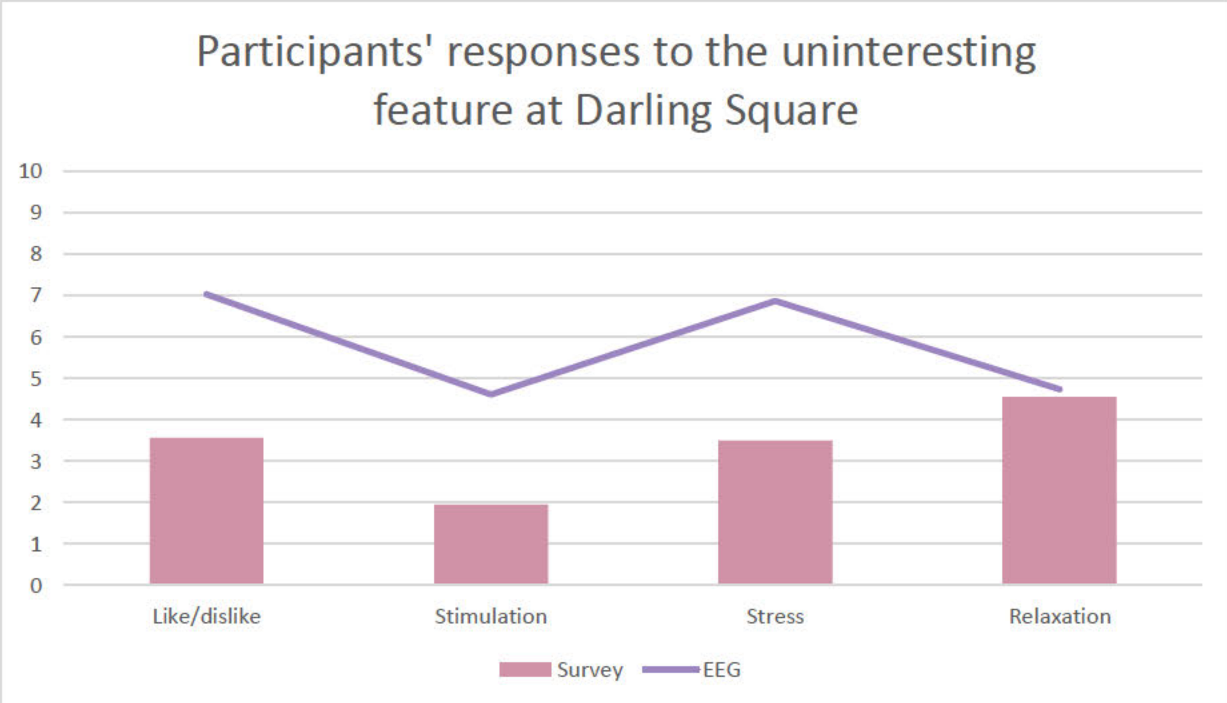


Figure 51. Average of all participant survey and EEG scores for the feature they found most uninteresting at Darling Square

The key data points are:

- The EEG scores are higher than the survey scores across all responses from the uninteresting feature at Darling Square, with the highest EEG score being for like/dislike (7), followed by stress (6.9), then relaxation (4.7) and stimulation (4.6).
- The survey scores are all quite low. Even the highest survey score, which is for relaxation (4.6), is comparable to the EEG (4.7), and the survey scores for like/dislike (survey 3.6, EEG 7), stimulation (survey 2, EEG 4.6) and stress (survey 3.5, EEG 6.9) are all much lower when compared to the EEG results.

Participants’ survey scores (3.6) indicated a level of aversion towards the uninteresting feature at Darling Square, while the EEG scores (7) showed some positive attraction towards the uninteresting feature. Stimulation scores were very low for the survey results (2) and somewhat low for the EEG (4.6). Participants’ survey scores for stress were low (3.5), but higher in the EEG results (6.9). Relaxation scores were comparably low for both the survey (4.6) and EEG (4.7).

PARTICIPANTS’ WALKING INTERVIEW RESPONSES TO THE UNINTERESTING FEATURE AT DARLING SQUARE

When asked to find the least interesting feature of the Darling Square’s design, some participants found this request somewhat challenging. Harvey asked, ‘Least interesting? I think you're going to have to search for the least interesting thing.’ The grassed area in the centre of the square was identified as being uninteresting by some participants, yet despite this, participants such as Oliver still noted that they liked the feature, saying, ‘I quite like it, the big patch of grass in the middle feels kind of wasted I guess, no one's really using it, but it's nice to have.’ John also had a mixed response to the grassed area, saying, ‘it just feels like it's used to fill a space and to mark an area, it's all uniform. Perhaps, you know, there's pros and cons to that.’ John elaborated on how he felt the grassed area could be improved by providing more natural stimuli, explaining ‘I know what you could have, could have done a scent garden with it. I've seen some really good ones where they do that, and then you've got lavenders or rosemary, really simple stuff, grows crazily and then it's, you know, lovely scents.’ Neha, who found the facade of the residential buildings uninteresting, made a similar observation that more natural elements would improve the design, saying ‘Maybe something like that would have been good or something creeping or something hanging. Just something to make it tie in a little bit. This does look like it's just sort of been plonked compared to the other stuff around.’

The features participants found uninteresting were those described as lacking stimulation. For Laura, who found the grass unstimulating, she commented that ʻit's an experience of nothingness. Doesn't really engage me.' Elena also found the grass unstimulating, saying 'I think what the interesting thing about this is that bold design is that because it really interesting, so then like something that would have maybe been cool in World Square with that grass is actually really dull here because everything's so like, whoa.' Jane, who found the lamppost uninteresting, commented that it 'blends in. It's very grey. I do like that it's newer than the World Square lamppost. It does look a bit like it's dirty, but it's just, it's here for a function, I guess, and not to stimulate you.' While Helen found the facade of the residential buildings uninteresting, she also noted that a lack of stimulation could be a positive thing, observing that

> I'm not finding that stressing, I'm finding that actually stimulating in a relaxed way. I actually like the colours, but it's more because of the context, it's just more pleasant. Yeah, but once again, the very tall buildings, but that's just having to say, if I had to pick something that I didn't like, but really it's just a very different space, it's genuinely more inviting and relaxing.

When focusing on features that they found uninteresting, participants such as Laura noted that her stress level was more directly related to stimuli outside the design elements, saying 'that's really the multitude of children that is making me stressed.' Mike explained that his low stress reaction to the grassed area as an uninteresting feature was 'because it's boring, it's an empty space.'

There were no comments on relaxation in response to the uninteresting feature.

DISCUSSION OF PARTICIPANTS' RESPONSES TO THE UNINTERESTING FEATURE AT DARLING SQUARE

The key point is:

- It was anticipated that as participants were asked to identify and reflect on a feature they found uninteresting there would be low levels of positive attraction and stimulation from participants. This is consistent with the survey scores for like/dislike and stimulation; however, the EEG scores for these responses is much higher and it is unclear why this is the case.

There was a wider range of features that participants found uninteresting compared to interesting in Darling Square. Many of the features participants found uninteresting, such as lampposts, bins, and hoardings, were consistent with Nasar’s (1994) observation that these objects of human-made infrastructure and advertisements were generally unappealing to people. However, Nasar (1994) also postulated that natural elements were generally appealing, yet the grassed area was identified by several participants as being uninteresting. The comments from the walking interviews demonstrate mixed feelings towards the grassed area, such as Oliver, who noted, ‘it's nice to have,’ but also that it perhaps was not the best use of this space. Similarly, John commented that he saw both positive and negative aspects to the grassed area. This mixed response may contribute to the variation between the low survey score of 3.6 indicating low positive attraction, but a higher EEG score of 7 indicating mid-range positive attraction to the uninteresting feature.

The facade of the apartments on the eastern side of Darling Square were also identified as a uninteresting feature. The lack of appeal was generally described by participants in terms of a sense of monotony, such as when Mike said, ‘it’s mainly the colour and that is very regular. I can see they’d actually be pretty nice apartments, but I think they have a bland look for me because of the colour.’ Larry described the facade as ‘just plain brick, square, boring apartments.’ The lack of engagement in the uninteresting feature is reflected in the low stimulation scores of 2 on the survey and 4.6 on the EEG.

Taking both the grassed area and facade of the eastern apartments together, the comments from the walking interviews have a common thread: the uniformity of the design did not spark interest for participants. Looking at this from an embodied cognition perspective, it is theorised that people generally have a preference for patterns as they allow the brain to easily predict what comes next and to swiftly make sense of the surroundings. However, a degree of complexity or variation is also needed to avoid monotony (Alexander 1977; Robinson & Pallasmaa 2017; Sussman & Hollander 2015). This phenomenon is evident in the participants' comments, such as when John noted some more variety in the grassed area would provide a more engaging sensory experience, suggesting a scent garden as an option. Neha noted that the facade of the eastern apartments could be improved by introducing some different features into the design, like climbing plants. Additionally, while there are apartments on three of the four sides of the square, fewer participants identified the apartment facade on the western side of Darling Square as uninteresting. This may be partly due to a more varied design that included a mix of colours and an alternating crosshatch design.

The participants did not report any significant stressors when observing the uninteresting features. This seems to be reflected in the low survey scores for stress of 3.5, yet the EEG score was higher at 6.9. The reason for this divergence score is unclear.

Participants similarly did not report anything relaxing about the uninteresting features, yet the survey and EEG scores were very similar. The survey score was 4.6 while the EEG score was 4.7.

PARTICIPANTS' RESPONSES TO THE ORDERLY DESIGN AND PATTERN AT DARLING SQUARE

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE ORDERLY DESIGN AND PATTERN AT DARLING SQUARE

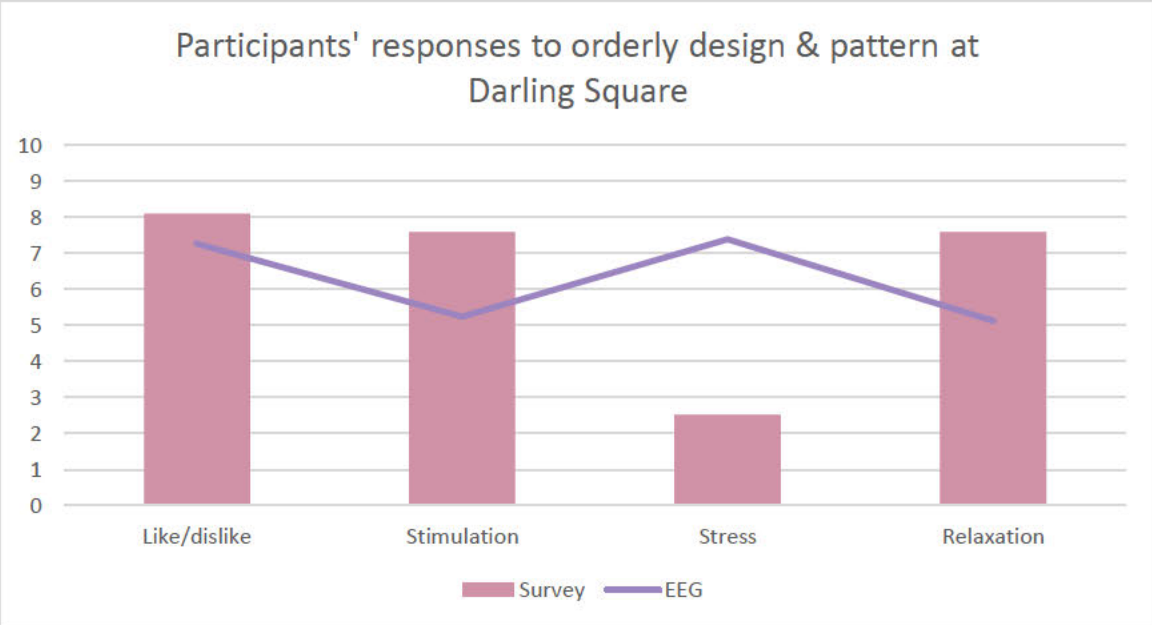


Figure 52. Average of all participant survey and EEG scores for the orderly design and pattern at Darling Square.

The key data points are:

- Participants' survey and EEG scores for Darling Square's overall design show relatively similar levels of positive attraction (survey 8.1, EEG 7.3).
- There is not a high degree of consistency between the survey and EEG scores for stimulation (survey 7.6, EEG 5.2), stress (survey 2.5, EEG 7.4) and relaxation (survey 7.6, EEG 5.1).
- The biggest difference between survey and EEG scores is for stress (survey 2.5, EEG 7.4).

There were similar results for like/dislike across both the survey (8.1) and EEG (7.3). There were higher survey scores (7.6) for stimulation compared to the EEG (5.2). Stress recorded higher readings from the EEG (7.4), while relaxation results were higher in the survey (7.6) than the EEG results (5.1).

PARTICIPANTS' WALKING INTERVIEW RESPONSES TO THE ORDERLY DESIGN AND PATTERN AT DARLING SQUARE

Of the 20 participants, only one disliked Darling Square. Alexander described it as a 'fair attempt at a relaxing space,' but found it 'concrete centric, cramped, shady and overbearing.' In contrast, the other participants spoke very positively about Darling Square, such as Ben, who remarked that

> It exudes what a city aspires to be like. I feel like this is what the whole of Sydney should feel like. New buildings, new designs, very well planned out. Those aren't the sort of terms that you would associate with the majority of the Sydney city landscape. If the entire city was like this, then we'd be rated as one of the most beautiful cities in the world.

When describing their impressions of the overall design of Darling Square, many participants remarked that they liked the relaxed atmosphere of the square. Natalie described it as

> a contemporary garden, but it's by the ocean. You've got this wave pattern by [the design of the pergola] when the waves come in and you've got the smell of the sea. And you know when you've got the waves on the sand? And that's what this [pavement pattern] bit reminds me of.

Kalinda had a similar response, saying, 'this is just a nice place to come and relax and sit down. Like I can imagine sitting here and just eating lunch on the grass, put out a blanket. You know, have the little ones running around.'

Participants noted a range of patterns and shapes that they liked. Both Bobby and John compared the square shapes of the design by comparing it to works of art by Piet Mondrian. Other participants, like Harvey, noted the mix of round and straight patterns. He said

> I can see the pattern of the rotating wood around the library and then it kind of comes out into some sort of ribbon wrapping sort of pattern. Again, it felt like the squares and the parallel running lines throughout the paving, as well as the lines running across the buildings. It's all very parallel and square.

The rounded shapes drew the attention of other participants, with Elise commenting that ‘Other than the wooden pattern and then the circles, there's a fair bit of circles in the way that the floors are fanning and the tile formation, circles around the library, circle tables, even those chairs are kind of circle.’

In terms of stimulation from Darling Square’s design, participants spoke about the use of materials, juxtaposing the experience of metal and wood. Omar commented that ‘I don't like the metal stuff. Chair is very useful, but not the metal one. You can get cold, you can get hot, hot metal. That's the thing.’ Bobby also expressed concern over the use of metal for seating, saying,

> Mainly, the rest of your square looks natural and flowy. Those blue metal chairs kind of stand out and they don't fit. They should be like either a neutral black or wood or something like that… I also worry that all the metal chairs will just burn you to cinders in here in the summertime.

Jane remarked that

> I like how everything's wooden.... It's a homely feel. It's not steel, it's not concrete, where they're quite harsh and cold. And wood just makes you feel warm, and it makes me want to sit out. If it was a concrete slab, I wouldn't want to sit on it, because it's a hot day, and concrete soaks up so much heat.

When responding to the overall design of Darling Square, Natalie noted some stress but qualified it was not primarily in response to the design, saying ‘When there's people walking right behind me, I feel a bit stressed, but otherwise good.’ When reflecting on any stress responses, Helen remarked that the design of Darling Square

> isn't as noisy, and actually there's more visible signs of people relaxing rather than hurriedly going about their business... Relaxed, relaxed. The colours actually are much nicer, I think. The yellow, the green, even those rather more striking, stronger colours here, for some reason in the scene, in their context, they just seem bright and happy rather than alarming or stressing.

Participants spoke about relaxation at many points of the interview, describing the site as being more relaxing compared with World Square. For example, Natalie said, ‘It's a lot more relaxing here, you can smell the sea,’ and Jane remarked that ‘if I was stressed at World Square, which I wasn't, I am less stressed now.’ Jing observed that ‘I can imagine sitting down here [in Darling Square] and looking at people. People seems a little bit more relaxed. They’re all sitting down rather than walking, walking, walking like in World Square. Whereas most people here just sit, and people are relaxed.’

The design as a whole was often commented on by participants. Harvey noted that ‘It's a very calming sort of design,’ and Josephine commented, ‘I find it very relaxing with that big grass patch in the middle there. And there's not even a lot of people, it's so great.’ Josephine said that the interplay of shapes and patterns was relaxing:

> The swirl of the library and how it loops around. And there's less symmetry but it's more balanced somehow, does that make sense? I think the other pattern is there's more vertical elements that are natural, you've got the grass trees and the tree trunks but it's a wonky verticalness, which is nicer to look at, like a wonky tree trunk is more relaxing to look at and more comfortable.

DISCUSSION OF PARTICIPANTS' RESPONSES TO THE ORDERLY DESIGN AND PATTERN AT DARLING SQUARE

The key points are:

- Participants were expected to have a positive attraction to Darling Square's design. This has been reflected in participants' survey and EEG scores, both of which show positive attraction.
- As Darling Square is positioned within the Darling Quarter as an area to relax from the busier, more tourist-focused areas of Darling Harbour, high relaxation responses were expected. This was consistent with the survey data but the EEG responses for relaxation were lower and it is unclear why.
- The numerous natural elements in Darling Square's design were also expected to lower participants' stress responses, as per Kaplan and Kaplan's (1989) attention restoration theory. The survey scores show low levels of stress, but the EEG levels are much higher and it is unclear why there is such variance between the datasets.

The positive attraction to Darling Square's design is reflected in the high survey and EEG scores of 8.1 and 7.3 respectively. Participants' walking interviews align with this positive response, as participants offered a range of praise, for example, when Ben commented that the design 'exudes what a city aspires to be like. I feel like this is what the whole of Sydney should feel like.'

Participants identified a range of patterns in Darling Square's design. A common theme to the patterns that stood out to participants were natural elements. Some participants identified the pattern simply as 'wood', given the extensive use of timber in the design. Other participants, like Natalie, drew parallels to natural elements that the design evoked, such as comparing the way the library cladding merged into the pergola as a wave and the pattern of the pavement as reminding her of the waterline on sand at the beach. These comments suggest a high degree of consistency with attention restoration theory, as the natural elements and imagery reminded participants of nature and were identified by participants as contributing to their positive attraction to Darling Square's design.

Regarding stimulation, participants had a mixed response. The survey score of 7.6 suggests participants had a mid-range positive experience of stimulation. The EEG score of 5.2, however, suggests that unconsciously the stimulation was more neutral. This may, in part, be influenced by the different uses of shape in the patterns of Darling Square. As previously mentioned, sharp angles can trigger the amygdala, which is a part of the brain that processes danger, eliciting a negative response. Rounded shapes do not trigger the amygdala in this way (Jasanoff 2018; Leder, Tinio & Bar 2011; Sussman & Hollander 2015). The angular elements of the design, however, were not perceived as aggressive. Bobby and John compared the square design of the apartments on the western side of Darling Square to art by Peit Mondrian. Similarly, Helen noted that the use of colours that could be off putting in other contexts was appealing in the ways they were used in Darling Square. She said, 'The colours actually are much nicer, I think. The yellow, the green, even those rather more striking, stronger colours here, for some reason in the scene, in their context, they just seem bright and happy rather than alarming or stressing.'

The appeal of the rounded shapes was noted by serval participants as a positive pattern. The extensive use of circles in the Darling Square was summarised by Elise, who said, 'there's a fair bit of circles in the way that the floors are fanning and the tile formation, circles around the library, circle tables, even those chairs are kind of circle.' It may be that the calming effect of the rounded design impacted participants' experience of stress. Participants reported low levels of stress via the survey at 2.5. The EEG results were higher, however, at 7.4. The reason for this divergence is unclear.

Relaxation was regularly remarked on by participants. The participants' own positive experiences of relaxation is reflected in a survey score of 7.6. The EEG score was 5.1, indicating more neutral levels of relaxation. Given that participants viewed Darling Square's design as facilitating relaxation and they perceived the people using Darling Square as relaxed, further research is needed to understand the variations in the data.

PARTICIPANTS' RESPONSES TO THE OPENNESS AND EXPOSURE AT DARLING SQUARE

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE OPENNESS AND EXPOSURE AT DARLING SQUARE

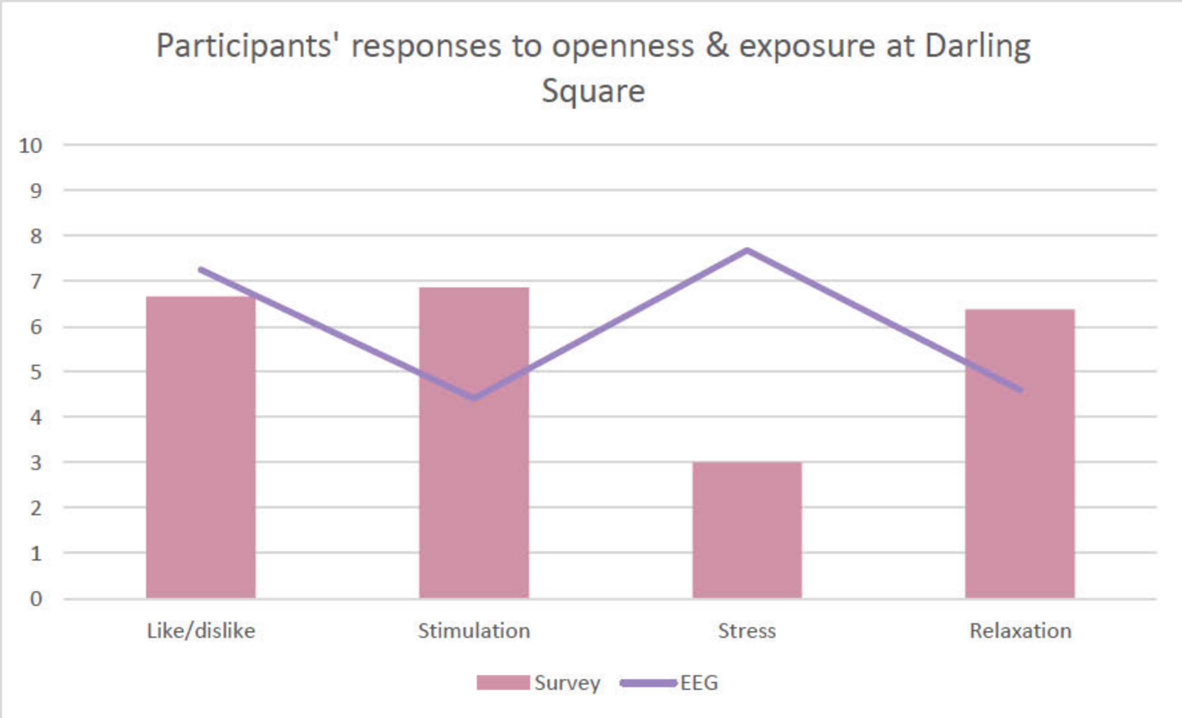


Figure 53. Average of all participant survey and EEG scores for the openness and exposure at Darling Square.

The key data points are:

- There are fairly similar levels of positive attraction to the open space in Darling Square between the survey (6.7) and EEG (7.3) scores.
- There is not a high degree of consistency between the survey and EEG scores for stimulation (survey 6.9, EEG 4.4), stress (survey 3, EEG 7.7) and relaxation (survey 6.4, EEG 4.6).
- The biggest difference between survey and EEG scores is for stress (survey 3, EEG 7.7).

Participants' survey and EEG scores for like/dislike were relatively consistent (survey 6.7, EEG 7.3), while levels of stimulation were much lower via the EEG (4.4) compared to the survey (6.9). Stress recorded by the EEG was the highest reading of any score (7.7), while also being the lowest of any score via the survey (3). Relaxation scores were higher through the survey (6.4) when compared to the EEG (4.6).

PARTICIPANTS' WALKING INTERVIEW RESPONSES TO THE OPENNESS AND EXPOSURE AT DARLING SQUARE

Standing in the most open part of Darling Square was an experience that elicited a mix of like and dislike responses from participants. Laura responded positively to being asked to stand in the open, noting

> There's more sky, so it feels more free and open. Most of the sides are all not matching each other. They have got more regularity in the scale of the buildings and the patterning. There's squares here, and then, there's curve there which matches the curve there. And there's no angry pointiness like the other place... It feels like it's meant to be an open space, that it's not being forced upon us.

In contrast, when Helen was asked to look up and around to get a sense of being in the open, she responded by saying 'Eek! There's more I didn't see when I was standing there. I still like it, but I was more comfortable over under the trees.'

Standing in the middle of the open space at the centre of Darling Square was a stimulating experience for many participants, as they noted it afforded them an opportunity to take in the design of the square. Harvey noted that 'I guess it is stimulating because you've got to get a view of the architecture here,' and Laura felt that 'it's quite exciting to be in amongst here. So, in a positive stimulation.' Jing described standing in the open, saying 'it's stimulating in the sense that I can't seem to get, like, how you know sometimes some buildings are rows and rows of the same thing.... It's unique.' When looking up and around while standing in the open, Elena noted that while she felt dizzy: 'it not stimulating, oh but looking at this stuff is nice.'

The main instance of the interview where participants spoke about feeling stress was when they were asked to stand in the most open part of Darling Square. Participants described a range of stressful influences, which included a sense of exposure. Bobby commented that ‘I feel very exposed. And that sun’s quite bright… in World Square it was like office type things, but here you've got people's homes and now it feels a little bit voyeuristic looking in.’ Elise also noted a sense of exposure, saying ‘it just feels exposed. I just don't think anyone likes to stand in the middle of any sort of space, to be honest. And there's no trees or cover. It just feels like you're in the middle of a big patch of ugly half dying, dead grass.’ Several participants also spoke about feeling more self-conscious about wearing the EEG headset when asked to stand in the open. Josephine noted that ‘I might find myself feeling a little stressed standing in the middle because people might look at me. They might like, "Oh, what's she doing with that thing on her?"’ Alexander noted the EEG headset impacted his response, saying ‘if I wasn’t wearing this? I’d be alright with it.’ Larry commented that ‘it just feels a little bit more imposed upon. I'd be more self-conscious of maybe, of people being around you, and above you, looking down upon you.’ There was also some concern from Harvey and John on whether it was permissible to stand on the grass. John felt that some signage may be helpful, saying ‘there's might be subtle ways to say it's okay to go on the grass. Like for example, "Please don't leave anything on the grass." Which says, "Oh, you're allowed on there, just don't leave anything there."’

Although some participants felt stressed being in the open space, other participants found it relaxing. Kalinda said

> It's actually a nice walk up and look at the apartment and buildings, the sky. You don't get that feeling of being overwhelmed with the tall buildings. It's nice and airy you've got the breeze coming through, but it’s not a wind tunnel. Just a nice light one. Yeah, it just feels light.

Jane described standing in the middle of Darling Square as being ‘relaxing. I want to read a book here. It's very warm. I think I like the liveliness of it […] This isn't like a passing point to where their actual destination is, it feels like this is a destination onto itself.’ Neha described a sense of ‘wellbeing’ while standing in the open, saying

> standing on grass and being surrounded by greenery, it feels like there's less, well there's definitely less kind of steel and less sort of angles and things kind of jumping out at you. Like these trees blocked sort of what's behind it, whereas the other place it was just right in your face. There’re no flashing lights here. Yeah, it has more outdoor feel.

DISCUSSION OF PARTICIPANTS’ RESPONSES TO THE OPENNESS AND EXPOSURE AT DARLING SQUARE

The key points are:

- Given the aforementioned thigmotaxis (wall-hugger preference) (Kallai et al. 2007), it was anticipated that participants would dislike being exposed at the centre of Darling Square and find the experience stressful. However, the survey and EEG scores for like/dislike show that participants had a positive attraction to standing in the open area of Darling Square.
- The high level of stress reported via the EEG is in line with expected results for thigmotaxis, yet it is unclear why the survey data for stress is much lower and relaxation responses for via the survey are surprisingly high.

The participants exhibited a wide range of responses to being asked to stand in the most open space of Darling Square. There were some positive associations to being in the middle of Darling Square, with mid-range like/dislike results on the survey, with a score of 6.7, and an EEG score of 7.3. When looking up, participants commented on the surrounding facades of the residential apartments and natural elements, such as the grass they were standing on and the open sky above them. While not all participants noted the height of the surrounding buildings before being told to look up, it is notable that no participants commented on feeling loomed over by the buildings. This may be partly due to the apartments being limited to roughly six or seven stories. At this height, the apartments are at a scale that fits within the sensory scope of the human body. It has been observed as far back as Vitruvius, who wrote *De Architecture* in circa 15 BCE, that the height and scale of buildings should be designed with the bodily experience of these structures in mind. Anything much higher than the apartment buildings in Darling Square would risk being perceived as too imposing and looming over people, and therefore would likely elicit a more negative response.

There were a range of responses to the stimulation of standing in the openness of Darling Square. There were moderate levels of stimulation reported by participants on the survey, with a score of 6.9; however, the unconscious EEG reading of 4.4 suggests stimulation was just below a neutral level. It may be that the relaxing natural elements participants experienced while standing in the open, such as the open sky and sunshine observed by Laura and the airy breeze that Kalinda commented on, reduced the sense of stimulation participants experienced due to the natural stimuli. The higher levels of stimulation experienced consciously via the survey results may be from the facades of the buildings, as participants commented that the designs and patterns did capture their attention.

Participants' levels of stress were reported to be low, with a survey result of 3. The EEG result was much higher at 7.7. The main stressor identified by participants was a feeling of self-consciousness at wearing the EEG headset in public. This was not a comment that was raised in any other part of the study, other than when participants were asked to stand in the most open space of Darling Square. Interesting, this concern was noted at several points in World Square. At Darling Square Bobby noted, being surrounded by residential apartments and people who had stopped to relax, rather than busily focused on their own activities, seemed to exacerbate a sense of exposure for participants. However, although the exposure may have increased participants' levels of discomfort, it is unlikely that it was increased by a significant degree as no participants were unwilling to walk into the open wearing the headset. One participant, Noel, felt comfortable enough to explain to some nearby children why he was wearing the headset.

The responses for relaxation were also mixed, with a survey score of 6.4, indicating some sense of relaxation, while the EEG score was 4.6, suggesting participants were slightly unrelaxed. Although it may be somewhat stressful to move into an exposed part of Darling Square, the refuge of the sides of the square were close by at all times. As noted by participants throughout their observations of Darling Square, the design affords many places to sit and relax away from busy, exposed areas. Having the option of relaxing places as a refuge close by may have limited the impact of stress on the otherwise relaxing experience participants described having at Darling Square.

PARTICIPANTS' RESPONSES TO THE NATURAL AND FABRICATED ELEMENTS AT DARLING SQUARE

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE NATURAL AND FABRICATED ELEMENTS AT DARLING SQUARE

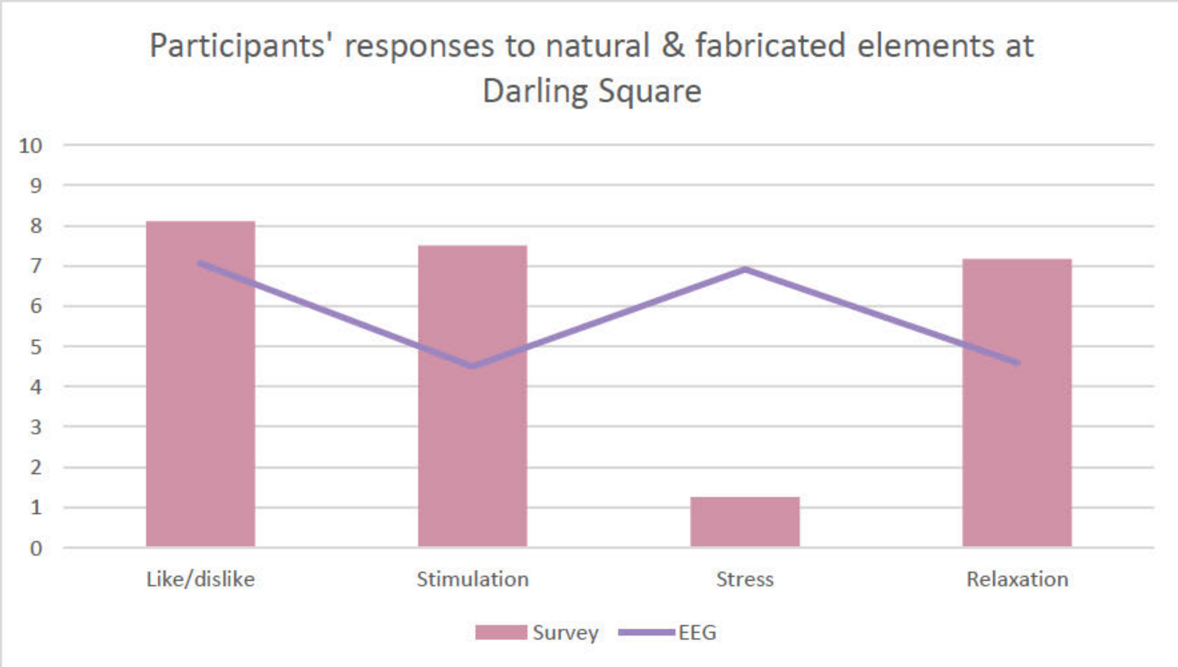


Figure 54. Average of all participant survey and EEG scores for the natural & fabricated elements at Darling Square.

The key data points are:

- While Darling Square's natural design elements elicited relatively comparable levels of positive attraction from participants (survey 8.1, EEG 7.1), there is little consistency between survey and EEG scores for stimulation (survey 7.5, EEG 4.5), stress (survey 1.3, EEG 6.9) and relaxation (survey 7.2, EEG 4.6).
- The greatest deviation between survey and EEG scores is for stress (survey 1.25, EEG 6.9), followed by relaxation (survey 7.2, EEG 4.6).

Survey scores (8.1) for like/dislike were the highest score recorded for participants' responses to the natural elements at Darling Square, with EEG scores that were also high (7.1). Participants reported relatively high levels of stimulation via the survey (7.5), but EEG scores were much lower (4.5). The lowest score by a significant margin was the survey score for stress

(1.3), which had a much higher EEG score (6.9). Participants' survey scores were quite high for relaxation (7.2) but much lower in the EEG result (4.6).

PARTICIPANTS' WALKING INTERVIEW RESPONSES TO THE NATURAL AND FABRICATED ELEMENTS AT DARLING SQUARE

Participants unanimously liked the landscaped elements of Darling Square. Of particular interest to several of the participants was the use of native Australian plants. Harvey said:

> I like the landscaping, it's different. It's not something that you would usually see in the city. There's been a lot of thought put into this. Yeah, I think actually they're trying to capture a real elegant Australian culture. Yeah. Not Australian culture, but a natural element of Australia in urban hands.

Kalinda had a similar response, saying

> I like that it's bringing some of the native traditional plants that used to be here. I like native, like you know, you saw the Kangaroo Paw over there. I love waratah, so anything that I see that's native I just… It's Australia, it feels like they're meant to be there.

John was also drawn to the Kangaroo Paw, explaining that he was originally from Western Australia, which has adopted that Kangaroo Paw as the state's flower, saying 'it makes you feel more welcome, and I like the plants in that they're tasteful.' Only Ben commented that he did not like the use of native Australian plants, saying 'the choice of greenery is dry. Whereas, across the garden, I can see much more lush greenery […] I think it's a bit of a disconnect.'

The landscaping of Darling Square was described stimulating by Natalie and Larry. Natalie commented that 'I find walking around the garden area with the different types of plants more stimulating, I think it's more interesting. I want to take my shoes off and feel the grass between my toes.' Larry also experienced a positive sense of stimulation, saying 'It just feels nice kind of being amongst the trees. You can still see out. You can still see everything that you need to kind of see and get... It kind of opens up more stimulation visually.'

The only comment on stress in relation to the landscaped elements within Darling Square was from Helen, who observed that 'Actually, even the trees don't look as stressed here.' While participants noted the natural, landscaped elements as being relaxing as part of other responses, there were also comments about the landscaping itself when participants spoke about relaxation. Josephine commented that 'it just feels so good. It makes me feel very relaxed,' and Laura mentioned that 'the nature feels more natural here.' However, the upkeep of the grass area that has patches of significant wear was seen as a detractor to relaxation by both Ben and Josephine. Josephine said, 'I don't find a stressful. I don't like these non-grassy patches though.'

DISCUSSION OF PARTICIPANTS' RESPONSES TO THE NATURAL AND FABRICATED ELEMENTS AT DARLING SQUARE

The key points are:

- As Darling Square has many natural design elements, it was anticipated that participants would show strong positive attraction and relaxation responses, and low levels stimulation, as per attention restoration theory. The survey and EEG data for like/dislike are consistent with this expectation. However, the datasets for stimulation and relaxation are inconsistent between the survey scores, which showed high stimulation and relaxation scores, and the EEG data showed much lower scores for stimulation and relaxation.
- The stress responses also show significant variation between the survey and EEG and it is unclear as to why this is the case.

The natural elements of Darling Square elicited positive attraction from the participants. The survey and EEG scores of 8.1 and 7.1 respectively both show that participants liked the natural design elements. Comments from the walking interviews further support this finding, for example, Laura said that 'the nature feels more natural here.'

This positive response to natural elements is consistent with the central premise of attention restoration theory: that people are predisposed to prefer natural environments. This tendency is summarised by Kellert and Wilson (1993, p. 23) who identify the key elements of biophilic design:

> [people] prefer open savanna-like terrain with scattered trees and copses, and they want to be near a body of water, such as a river or lake, even if all these elements are purely aesthetic and not functional. They will pay enormous prices to have this view.

Darling Square is located near Darling Harbour, which is a focal point within Sydney Harbour. Darling Square contains a mix of open space, such as the grassed area in the centre, and copses of trees along the eastern and southern edges. The variety of elements is also described by Josephine, who said, 'I think the other pattern is there's more vertical elements that are natural, you've got the grass trees and the tree trunks but it's a wonky verticalness which is nicer to look at, like a wonky tree trunk is more relaxing to look at and more comfortable.' Using this measure, the landscaping of Darling Square largely meets the key criteria for engaging natural design.

Several participants found that the natural elements elicited a sense of connection from the use of native plants. This response was described by Kalinda, who said, 'It's Australia, it feels like they're [the plants] meant to be there.' She also reflected on how she enjoyed seeing waratahs, which are the state flower for New South Wales; John, who was from Western Australia, was drawn to Kangaroo Paw as it made him feel welcome seeing his state's flower.

The survey and EEG scores for stimulation vary, with a survey score of 7.5 and EEG of 4.5. It may be that the restorative effect of the natural elements lowered participants' stimulation unconsciously, which contributed to a lower EEG score, while their positive attraction to natural elements increased their conscious stimulation measured by the survey. For example, Natalie described the stimulation of Darling Square's natural elements in terms of a bodily response: 'I want to take my shoes off and feel the grass between my toes,' while Larry found being immersed in a variety of plants stimulating.

Participants reported very low levels of stress on the survey, with a score of 1.3. The EEG score is much higher at 6.9. Although there is a significant variation between these scores, the stress reading is the second lowest taken to any stimuli at Darling Square. This may reflect the positive restorative effect of the natural elements. The data for relaxation is also mixed, with a survey score of 7.2 and EEG result of 4.6. The high survey score for participants' conscious experiences of relaxation is consistent with comments from the walking interviews, where participants made frequent reference to feelings of relaxation. It is unclear why the EEG does not also reflect this experience.

PARTICIPANTS' RESPONSES TO THE UPKEEP AND DERELICT ELEMENTS AT DARLING SQUARE

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE UPKEEP AND DERELICT ELEMENTS AT DARLING SQUARE

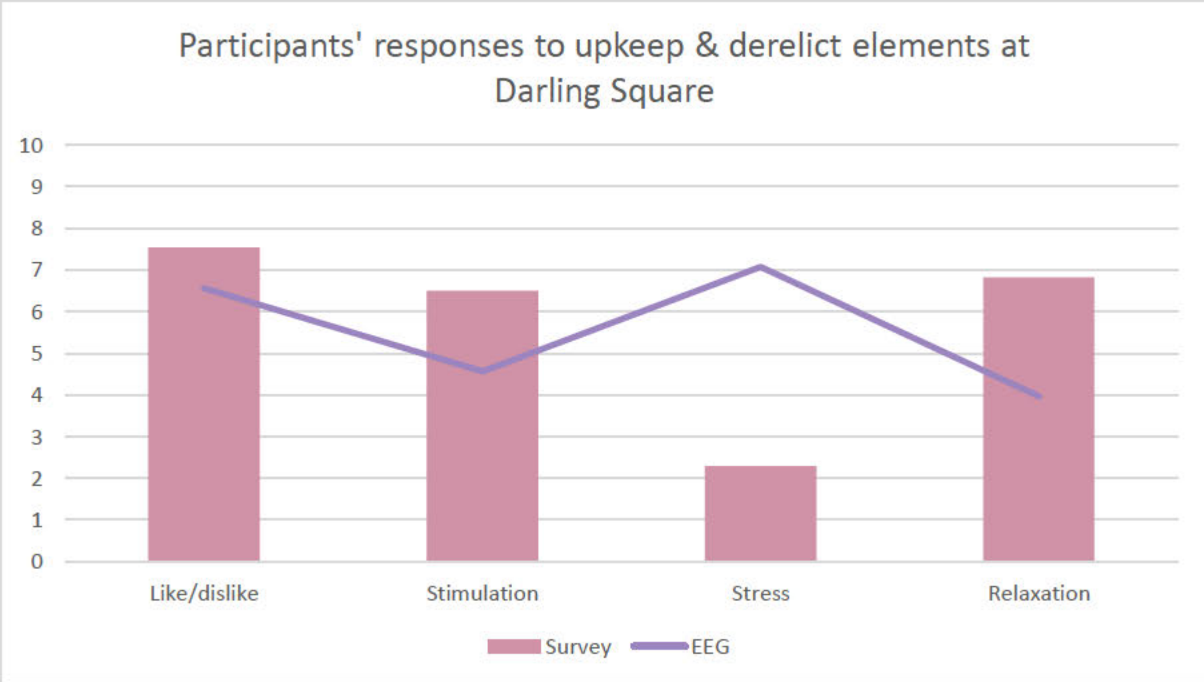


Figure 55. Average of all participant survey and EEG scores for the upkeep and derelict elements at Darling Square.

The key data points are:

- There is some consistency between the levels of like/dislike recorded via the survey (7.6) and EEG (6.6), but little consistency between the survey and EEG scores for stimulation (survey 6.5, EEG 4.6), stress (survey 2.3, EEG 7.1) and relaxation (survey 6.8, EEG 4).
- The greatest difference between survey and EEG scores is for stress (survey 2.3, EEG 7.1), followed by relaxation (survey 6.8, EEG 4).

In response to the upkeep of Darling Square, there were similar levels of positive attention in the survey (7.6) and EEG (6.6). While participants reported that upkeep was somewhat stimulating via the survey (6.5), the EEG score (4.6) showed it was somewhat unstimulating. The responses to stress varied greatly, with a very low survey score (2.3) but a higher EEG (7.1) score. The levels of relaxation were reported to be higher via the survey (6.8) compared to the EEG (4).

PARTICIPANTS’ WALKING INTERVIEW RESPONSES TO THE UPKEEP AND DERELICT ELEMENTS AT DARLING SQUARE

Participants generally liked the upkeep of Darling Square, although several participants noted that there was some rubbish. Laura said, ‘I think good nick. Everything's neat and tidy. There's a little bit of rubbish here and there. But I'd say that's indicative of the fact that people are spending time here.’ The upkeep and sense of order was stimulating for Harvey, who commented, ‘Stimulating, the upkeep. Yeah, I would say, because it's done well, it's aesthetically pleasing,’ while Noel described his experience differently, saying ‘I don't know if the upkeep is stimulating per se, but it does make it a place you'd be happy to spend.’

There was only one comment regarding any stress in response to Darling Square’s upkeep, which was made by Elise. She said that it was ‘Not very stressful, even though right now I do, just because I'm in the walkway. I could be in people's way, so it always stresses me out a little bit, but in general, I feel less stressed than I did in the last place [World Square].’

DISCUSSION OF PARTICIPANTS’ RESPONSES TO THE UPKEEP AND DERELICT ELEMENTS AT DARLING SQUARE

The key points are:

- As Darling Square was newly constructed and opened to the public only a few weeks before the participants visited the site; the high level of upkeep was anticipated to elicit positive responses from participants. This was reflected via the survey scores, which showed participants liked the level of upkeep, low levels of stress, and positive relaxation responses. The EEG data, however, was not always consistent as there was much higher stress readings and lower relaxation responses in comparison to the survey data.

Participants' responses to the upkeep at Darling Square were most consistent in terms of positive attraction. The survey score and EEG score were both positive, with a survey score of 7.6 and a slightly lower EEG score of 6.6. The general approval of the upkeep was reflected in short, simple comments from the walking interviews such as when Larry observed, 'Yep, its fine,' and when Kalinda affirmed, 'Looks alright to me.'

A trait of Darling Square that several participants commented on was that it was an appealing place to spend time sitting and relaxing. To use embodied cognition as a lens to consider this reoccurring comment, Goffman (as cited in Montgomery 2014) notes that environments present cues and triggers for behavioural responses. The hippocampus, which processes memory based on previous experience with the environment, can prompt the hypothalamus to produce hormonal responses to signals before we can consciously register the stimuli we respond to. In practice, this can manifest as self-regulating our behaviour without us realising it. This was illustrated through an experiment by Ellard (2015), who set up cars to look broken down. One car was positioned in a well-cared for area of town while the other was set up in a derelict area. The car positioned in the derelict area was vandalised almost before the researchers had a chance to set up the surveillance equipment. In contrast, the car in the well-maintained area of town actually received some measure of care from passers-by, who lowered the bonnet to protect the engine on a rainy day. This suggests that the generally well-kept environment of Darling Square may signal to people that there is a sufficient level of social order to make it a safe space to sit and relax.

In terms of the participants' responses to stimulation, stress and relaxation, the results between the survey and EEG seem to show little correlation. For stimulation, participants reported low levels of positive stimulation, with 6.5 on the survey, yet the EEG results dropped just below neutral at 4.6. Responses for stress were also inconsistent, with a very low survey score of 2.3 indicating very little conscious stress was experienced, yet the EEG recorded stress levels of 7.1. Relaxation responses were also mixed, with a survey score of 6.8, which indicates low levels of conscious relaxation, but the EEG results dipped below neutral to 4.

It is unclear why there is such divergence between these scores and the comments from the walking interviews do not suggest any clear cause for the contrasting readings. It is possible that a contributing factor may be where the participants were standing when the recordings were taken. Although participants were asked to move from the area of Darling Square with the natural elements that most appealed to them, several participants did not want to leave the place they had chosen. The participants that did agree to move were asked to stand in a corner farthest away from the natural elements of Darling Square. It may be that the multisensory experience of these different parts of Darling Square influenced the mixed results (full details on where each participant was located within the Square when their readings were taken is available at Appendix H).

PARTICIPANTS' RESPONSES TO THE LIVELINESS AND PEOPLE AT DARLING SQUARE

SURVEY AND EEG RESULTS FOR PARTICIPANTS' RESPONSES TO THE LIVELINESS AND PEOPLE AT DARLING SQUARE

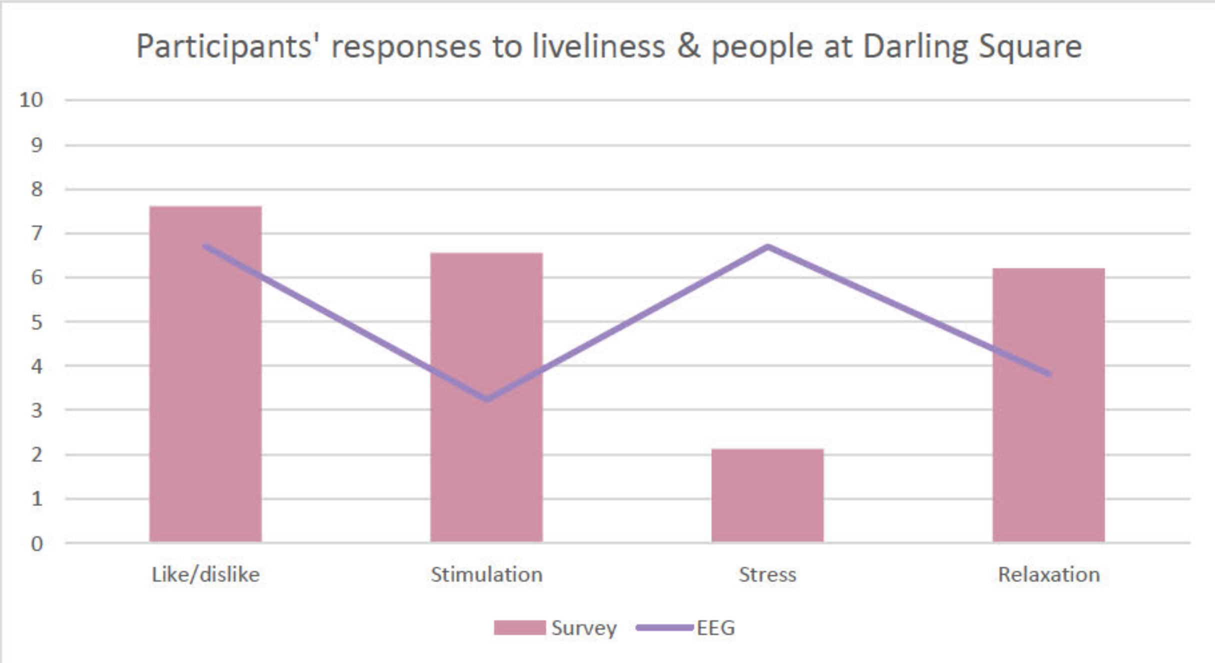


Figure 56. Average of all participant survey and EEG scores for the liveliness and people at Darling Square.

The key data points are:

- Participants' survey scores are higher than EEG scores for like/dislike (survey 7.6, EEG 6.7), stimulation (survey 6.6, EEG 3.2) and relaxation (survey 6.2, EEG 3.8) but for stress the EEG score (6.7) is significantly higher than the survey score (2.1).
- There is significant difference between the survey and EEG scores for stress (survey 2.1, EEG 6.7) and stimulation (survey 6.6, EEG 3.2).

There were mid-range positive results for like/dislike responses for both the survey (7.6) and EEG (6.7) scores. Participants' stimulation responses varied greatly for stimulation with survey score (6.6) that is over double the reading from the EEG (3.2). There was an even larger divergence between survey and EEG scores for stress, with a very low survey result (2.1) and significantly higher EEG reading (6.7). Levels of relaxation were also quite different, with a higher survey score (6.2) compared to the low EEG score (3.8).

PARTICIPANTS' WALKING INTERVIEW RESPONSES TO THE LIVELINESS AND PEOPLE AT DARLING SQUARE

Participants generally liked the liveliness of Darling Square. Jing commented that she liked the fact that were 'people just sitting round enjoying the sun. Yeah. Kids playing. I think it's a place where people feel that they can just sit around.' Josephine also observed 'a lot of people, families, kids sitting around enjoying the space. There's quite a lot of people with prams. There's people with bicycles. Obviously, it's like a meeting place for people… I like it because it's not overly hectic.'

The liveliness of Darling Square elicited a stimulation response from Jing, who noted that 'well, it's not relaxing-relaxing because it's hyped up and I want to be on the move kind of thing as well. It has things that I would like to explore.' Helen, in contrast, described a relaxed kind of stimulation, saying 'it's obviously not as physically lively, but there is liveliness. People are relaxed but they're still, they look stimulated and engaged at the same time, again.'

There was a mix of comments on stress in response to liveliness. Natalie noted that 'there's a bit of anxiety, but I think I'm actually focusing on the crowd a bit more […] I'm not-not stressed, I feel a little bit stressed.' In contrast, Noel commented that 'it's not stressful here. It's the right type of liveliness.' Elena noticed a general sense of tension, describing it as 'not unwelcome. No one's looked at me wrong or anything like that. It just feels like I've stumbled upon something that wasn't necessarily made for me… It feels like there's a catch to it. It's too perfect.'

Mike commented that 'It's relaxed rather than lively. It's for people coming to rest and relax rather than to go to do things, from the look of it, and from what I get the layout of the whole square to be, it's just to recharge.' John reflected on the liveliness, saying, 'It seems rather relaxed, but people, I feel contented by it, so that's a liveliness. And people are enjoying the grass… From those people here, they feel quite comforted and relaxed.'

DISCUSSION OF PARTICIPANTS' RESPONSES TO THE LIVELINESS AND PEOPLE AT DARLING SQUARE

The key points are:

- Using Gehl's (2006) theory that people attract more people to use a place, the generally high levels of liveliness in Darling Square was expected to elicit high positive responses to like/dislike and stimulation. This is consistent with participants' like/dislike responses for the survey and EEG; however, the EEG data for stimulation was significantly lower than the survey scores. It is unclear why this difference occurred.
- Participants' stress responses varied greatly, with high EEG scores and low survey scores.

There was general agreement from participants that the liveliness of Darling Square was a positive trait. The liveliness was commonly described as a relaxing sort of liveliness that involved a good number of people using the square in mostly passive recreation. Participants like Jing and Josephine noted the mix of people – adults and young children – who were making use of the space. As Josephine commented, Darling Square offers affordances as a meeting place for people to pause and enjoy being outdoors. The participants' general approval of the relaxed style of liveliness is reflected in the like/dislike scores of 7.6 via the survey and 6.7 on the EEG.

The responses for stimulation are not consistent between the survey and EEG. The survey score of 6.6 indicates low levels of positive stimulation, while the EEG score of 3.2 suggests a general lack of stimulation. The source of this mixed result may be illustrated by the comment made by John, who observed that 'it seems rather relaxed, but people, I feel contented by it, so that's a liveliness. And people are enjoying the grass… From those people here, they feel quite comforted and relaxed.' John's comment highlights both a positive response to the liveliness of having people around engaging with the square, while also experiencing a sense of relaxation as he perceived the other people in the square to be relaxed and comfortable. This empathic response to other people in Darling Square may be the related to the role of mirror neurons, previously mentioned in this thesis. Mirror cells can trigger a similar response in people who are observing others engaging in an action. In practice, observing someone walking up some stairs, riding a bike, or relaxing can trigger an embodied response in the observer who is not preforming the action. Having the participants observing the passive recreation in Darling Square may be triggering an empathic response (Robinson & Paalasmaa 2017).

In terms of stress responses, participants reported very low levels of stress on the survey, with an average score of 2.1. The EEG score was much higher at 6.7, though this score is lower than the other stress readings from the EEG throughout Darling Square. Several participants described themselves as introverts who did not enjoy crowded places and found being in the city provoked anxiety. Natalie indicated that encountering other people was a stressor when she said, 'There's a bit of anxiety, but I think I'm actually focusing on the crowd a bit more.' In an EEG study conducted by Karandinou and Turner (2017), who used the same EEG headset as in this study, they found spikes in brain activity whenever their participants encountered other people. Karandinou and Turner hypothesised that given the high levels of theta and alpha activity in these encounters, participants were unconsciously assessing people to see if they were familiar or not. This is consistent with Gehl's hypothesis that the scale of the built environment is important to facilitate the body's sensory experience of urban life. The small scale of Darling Square was chosen to facilitate the ability for participants to engage with the liveliness of the space. Gehl (2010, p. 34) notes that

> Only when the distance has been reduced to about 100 meters can we see movement and body language in broad outline. Gender and age can be identified as the pedestrian approaches, and we usually recognise the person at somewhere between

> 50 and 70 meters […] At a distance of about 22 to 25 meters we can accurately read facial expression and dominant emotions.

Combining the neurourbanist study by Karandinou and Turner with Gehl's theory suggests that, while the scale of the urban environment may facilitate sensory and neural processes for recognising people, individuals' preferences for quiet, less busy places may also be a factor. For these individuals, the presence of other people would be a stressor.

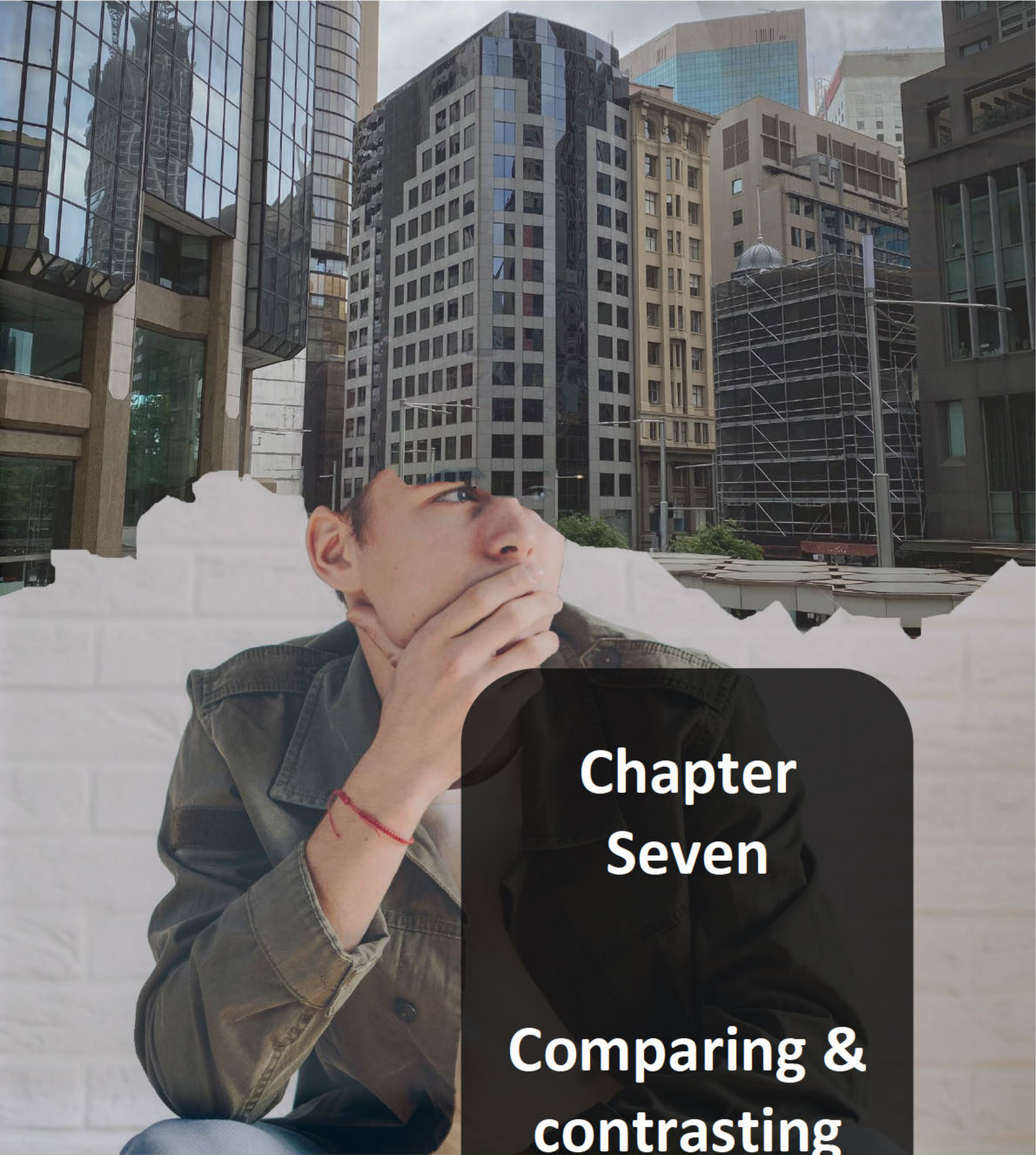
This trend was observed by Montgomery (2014, p. 127) who writes, 'We tolerate other people more when we know we can escape them.' In order words, being able to find refuge in busy environments can make the experience less stressful. Darling Square's position as being tucked to the side of a main pedestrian thoroughfare of Tumbalong Boulevard does offer a place away from the busier sections of Darling Harbour, which is a popular tourist destination within Sydney. This may contribute to the relaxation responses from participants who reported feeling generally relaxed. The survey score was 6.2 while the EEG score was 3.8. It is unclear why there was divergence between these scores.

CONCLUSION

This chapter has introduced the second case study site, Darling Square, Sydney, by providing information on the square's historical and geographic context and providing a detailed description of the square together with panoramic photographs. The design elements that participants were asked to focus on where identified, described and illustrated with photographs. The demographic profiles of the participants who engaged in the study were provided. An overview of the process each participant undertook in Darling Square illustrated how they were engaged for this study.

The key findings of this case study were that participants had a greater range of responses recorded by the survey in comparison to the EEG recordings, across all stimuli. Participants positive attraction to the design elements of Darling Square ranged between 8.8 and 3.6, while EEG scores were fairly stable, ranging between 8 and 6.6. The widest degree of difference for both survey and EEG responses was for stimulation. Stimulation survey responses ranged between 8.5 and 2 while EEG scores ranged between 5.2 and 3.2. Participants stress response were consistently very low through the survey, ranging between 3.5 and 1, while the EEG scores stayed at a stable but much higher reading, between 7.4 and 6.7. Conversely, participants recorded higher rates of relaxation via the survey (between 7.6 and 4.6) while EEG scores were more stable and lower (between 5.2 and 3.8).

The datasets collected through this fieldwork comprised of survey scores, EEG scores and walking interview responses. These datasets were provided for each of the design elements, illustrated with graphs, written descriptions and summaries of the responses. The discussion on each design element bought together the datasets collected during fieldwork and the theory explored in the literature review to provide possible rationales for the various responses that participants had to the stimuli of Darling Square's design elements.



Chapter Seven

Comparing & contrasting case study sites

CHAPTER SEVEN – COMPARING AND CONTRASTING CASE STUDY SITES

INTRODUCTION

Building on the data and analysis from Chapters Five and Six, this chapter brings World Square and Darling Square side by side. Firstly, the key design elements are compared. This is done both as a summary in this chapter and also by drawing from Chapters Five and Six. The anticipated responses to each feature based on literature presented in Chapters Two and Three are presented to highlight how this thesis has expanded on previous knowledge by providing a new dataset to consider.

Secondly, the survey and EEG data from World Square and Darling Square are presented in terms of the participants' responses to each element, that is: like/dislike, stimulation, stress and relaxation. By comparing and contrasting participants' responses to the design elements at World Square and Darling Square, this approach informs the answer to sub question four: **What new data can electroencephalography (EEG) provide on how people experience and respond to design elements in public space?**

The data collected in this study was in line with anticipated responses for participants' positive stimulation in Darling Square and higher levels of stress in World Square. However, it was expected that participants would have a higher positive attraction and higher relaxation at Darling Square, and this was not the case.

The participants' responses provide a mix of new and interesting insights that warrant further investigation, such as the levels of stimulation that speak to the bodily responses of participants and the surprisingly high levels of stress recorded in the EEG. There is also data that conflicts with anticipated findings in terms of positive attraction and relaxation. It is unclear why these results deviated from the expected outcomes, and further investigation would be needed to understand why this is the case.

SIMILIARITIES AND DIFFERENCES BETWEEN WORLD SQUARE AND DARLING SQUARE

This section compares and contrasts World Square and Darling Square in terms of their key design elements. This will illustrate the differences between these design elements and the anticipated response to each, based on theory previously explored in the literature review. There are numerous similarities between World Square and Darling Square that allow for the two sites to be easily compared. Namely:

- Both sites are located in the Sydney CBD and are in close proximity to Chinatown.
- Both sites have a mix of businesses offering retail and dining.
- Both sites are a similar size.
- Both sites are open air, outdoor spaces.
- Both sites provide an open area in the middle.
- Both sites are surrounded by taller buildings.
- Both sites have several laneways running off the centre square.
- Both sites are privately owned public spaces, although it should be noted that the impact of this is largely outside the scope of this study.

The key differences between these two sites are in age, the style and character of their design, outlined in Table 3 with a description and photographs to illustrate the various design elements. While both sites have both positive and negative attributes in their respective designs, Darling Square has more design features that should be appealing to people as per the theories presented in Chapter Two.

Table 3. Comparison of key design elements in World Square and Darling Square

	World Square	Darling Square
Theme	There is a strong Asian influence in the design of the square, with a Chinese-style dragon sculpture and regular pop-up events that cater to Asian celebrations, such as Chinese New Year and the Cherry Blossom Festival. Nasar (1998) predicted that there would be a preference for a clearly understood, uniform style that fostered a sense of order. While there is a unifying theme to World Square, cultural knowledge is needed to understand the nuance of its theme. Given the varied levels of familiarity of participants with the necessary cultural knowledge, it was anticipated that the theme would be less easy to grasp and therefore more likely to elicit stress responses.	Being part of the Darling Quarter, Darling Square blends into the design of Darling Harbour, which is aimed at a more international audience of tourists. This square also aims to cater for local residents as it abuts the University of Technology campus and accommodation. Given Darling Square's location in a more tourist-focused area, the theme is more generalised to cater to a wider audience. This simplicity of order was expected to elicit a stronger positive attraction among participants (Nasar 1998).
Layout	There are seven laneways that extend out from the centre square on the ground level and more laneways on the lower level. Not all of these laneways have a distinctive style or theme, with a diverse selection of businesses in each. Some laneways offer shopping and dining while others serve as access points to corporate offices. Based on Lynch's *The Image of the City* (1960), the more challenging wayfinding presented through the numerous laneways was anticipated to negatively impact participants' stress responses and be less likely to elicit positive attraction to navigating through World Square.	There are two laneways and a large pedestrian thoroughfare that branch off the main square. The two laneways have different designs with different styles of artwork. One laneway is primarily devoted to retail businesses while the other is primarily focused on dining options. Applying Lynch's *The Image of the City* (1960), the easily identifiable laneways and clear route to Darling Harbour (a node within the City of Sydney) was anticipated to elicit a more positive attraction from participants and make it less likely to be a source of stress.

Pattern	Patterns are used minimally as the facades are generally dominated by the branding styles of the respective businesses that occupy the square. The patterns that are present tend to be monotonous rectangular shapes in a palette of whites, greys and beiges, such as the facades of buildings and the paved floors. It was anticipated that the monotonous pattern and neutral colour scheme would elicit a less positive attraction and less stimulation among participants (Williams Goldhagen 2017).	Patterns are varied with different styles of rounded pavements used throughout the square. The building facades offer a mix of monotonous and varied patterns. The colour palette is wider, with a mix of warmer hues such as browns and yellows mixed in with beige. It was anticipated that the higher prevalence of rounded shaped would be less likely to elicit stress responses while the use of natural design elements like the mossy breaks in the pavement and wooden seating and pergola would be more likely to elicit relaxation responses from participants (Jasanoff 2018; Leder, Tinio & Bar 2011; Sussman & Hollander 2015).
Shapes	The dragon sculpture is the main round shape that dominates the design of the square. There is a sharp angle protruding into the square at the western side. The vast majority of other shapes are square and rectangular. The extensive use of angler shapes in World Square was expected to elicit higher stress responses from participants in comparison to Darling Square (Leder, Tinio & Bar 2011; Sussman & Hollander 2015).	A wooden facade wraps around the circular library to emphasise the building's roundness. The tables and chairs that are located on pavements with circular patterns also provide rounded shapes. There are also long rectangular wooden features, such as the pergola and wooden slat benches for public seating. The high use of rounded shapes in Darling Square was expected to elicit lower levels of stress compared to World Square (Leder, Tinio & Bar 2011; Sussman & Hollander 2015).
Openness & exposure	There are multiple high-rise buildings surround the square that often leave the open area in shadow. World Square often functions as a thoroughfare for office workers cutting through the space to access Town Hall Station. It was anticipated that the exposure of being asked to stand in the most open part of the plaza would elicit a stress response due to inherent thigmotaxis and observations from theorists such as Jacobs (1961), who notes people tend to	The surrounding buildings are lower (six to seven stories) in comparison to World Square. The surrounding buildings tend to be residential dwellings in the upper levels. The open space in the centre is grassed and regularly strewn with beanbag chairs to provide space for passive recreation. While it was anticipated that being exposed to the most open area of Darling Square would elicit a stress response, it was anticipated to be lower

	stay to the edges of a place (Sussman & Hollander 2014).	than in World Square. This is because the grassed area in the middle of Darling Square is used for passive recreation and less overlooked, given that the surrounding buildings are considerably less tall compared to World Square (Sussman & Hollander 2014).
Natural elements	There are three garden beds with matching designs: a tree in the centre and short shrubs along the edges. The shape of the trees and shrubs have been pruned to match. The minimal use of natural elements in World Square's design fails to meet the characteristics that the Kaplans (1989) outlined as being necessary for attention restoration theory. It was anticipated that this would result in either a low impact or no impact at all on participants' relaxation responses.	There are numerous garden beds with a mix of different plant species, both native and introduced. There are both flowering plants, such as jasmine, and non-flowering plants, such as ferns and succulents. There is a mix of deciduous and native evergreen trees. There is also a grassed area in the centre of the square. As Darling Square's use of natural elements in its design is much closer to meeting the requirements for attention restoration theory (Kaplan & Kaplan 1989), it was anticipated that participants would have a higher relaxation response in Darling Square compared to World Square.
Fabricated elements	There are free-standing lampposts off centre along the northern side. The bins are primarily located in between the seating on the southern side. There is an abundant amount of advertising in the square to signpost the various businesses and their locations. Based on Nasar's (1998) prediction that people typically prefer natural design elements to human-made elements, it was anticipated that participants would be less likely to show positive attraction to these features in both World Square and Darling Square.	There are lampposts and surveillance cameras spread throughout the square. There are numerous bins for recycling and general waste spread through the area. There are also bubblers for public use. As previously mentioned, based on Nasar's (1998) prediction that people typically prefer natural design elements to human-made elements, it was anticipated that participants would be less likely to show positive attraction to these features in both World Square and Darling Square.

Liveliness & people	While there are generally always people in World Square, it is busiest during weekdays during business hours when the offices surrounding the square are being used. World Square is a popular place for lunch breaks. A steady flow of people using it as a thoroughfare can be observed in the mornings as people arrive at work and in the early evening, when people are leaving for the day. As Gehl (2006) strongly advocated, the presence of people is key to attracting more people and thereby creating a lively place. The constant patronage of people was anticipated to elicit a positive attraction from participants to this aspect of World Square.	Darling Square is patronised on both weekdays and weekends and is busiest during lunch and dinner times. There are regularly people making use of the ample public seating at all hours of the day for passive recreation, such as meeting friends, reading and relaxing. Beanbags have been introduced to help facilitate people relaxing in the grassed area at the centre of the square. As Darling Square is also well patronised and people often spend longer lingering in Darling Square in comparison to World Square, using Gehl's (2006) theory, it was anticipated that there would be a higher positive attraction to the liveliness of Darling Square.

RESULTS AND DISCUSSION ON THE SIMILARITIES AND DIFFERENCES IN PARTICIPANTS' RESPONSES TO DESIGN ELEMENTS IN WORLD SQUARE AND DARLING SQUARE

This section will directly contribute to answering sub-question four: **What new data can electroencephalography (EEG) provide on how people experience and respond to design elements in public space?**

This section compares and contrasts the survey and EEG scores at World Square and Darling Square. Based on the previously discussed literature from embodied cognition and urban theorists, the survey and EEG scores are analysed against the responses that participants were anticipated to have. The data is arranged to compare the performance metrics produced by the EEG (like/dislike, stimulation, stress and relaxation) across all the key design elements investigated in this thesis. This allows the analysis to delve into where the participants' unconscious responses recorded via EEG results were consistent with the participants' conscious responses, which were reported via survey scores.

VARIATIONS IN LIKE/DISLIKE RESPONSES BETWEEN WORLD SQUARE AND DARLING SQUARE

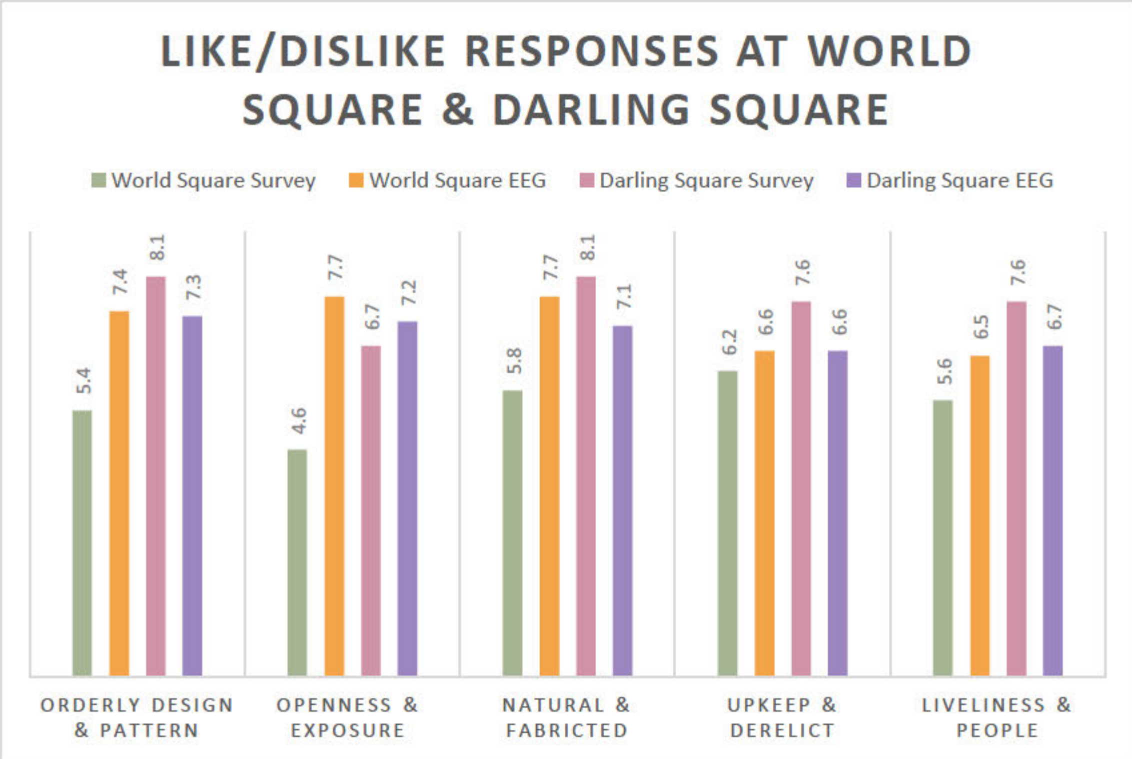


Figure 57. Average of all participant survey and EEG scores for like/dislike at World Square and Darling Square.

The key themes observed from Figure 57 are:

- Survey scores show participants liked every design element at Darling Square more than at World Square.
- EEG scores tend to be similar or rate World Square slightly higher than Darling Square in terms of positive attraction.
- The lowest like/dislike survey scores for both World Square and Darling Square were for openness and exposure.

Survey results for like/dislike at World Square are consistently low across all design elements. The scores for orderly design and pattern, natural and fabricated elements, and liveliness and people are all just above a neutral reading, while openness and exposure dipped below neutral, showing mild dislike. In comparison, the survey scores for Darling Square tend to show mid-level positive attraction to the design elements. Positive attraction to orderly design and pattern, and natural elements were equally high at 8.1, while upkeep and liveliness were slightly lower at 7.6.

The EEG scores are very consistent between World Square and Darling Square in response to all design elements. The EEG scores were the same for upkeep, and only a few decimal points of difference in response to the other design elements.

In comparing survey and EEG scores, World Square has a larger difference between the two sets of data. The biggest difference is for openness and exposure, which had a survey score of 4.6 compared to an EEG score of 7.7. The most similar readings for like/dislike at World Square were for upkeep, with a survey score of 6.2, and the EEG score of 6.6.

The survey and EEG scores for Darling Square were more consistent with each other. For participants' responses to all design elements, the readings for the survey and EEG are roughly within one data point of each other.

DISCUSSION OF PARTICIPANTS' LIKE/DISLIKE RESPONSES AT WORLD SQUARE AND DARLING SQUARE

The key point is:

- World Square and Darling Square were deliberately selected (in accordance with urban theorists previously discussed in the literature review) as World Square's design elements were expected to elicit less positive attraction in comparison to Darling Square's design elements. This is true of the survey scores but not the EEG scores.

When comparing the survey scores of each design element from World Square with Darling Square, there is a clear preference for the design elements at Darling Square. Participants' survey scores for orderly design and pattern, and the natural elements of Darling Square showed much higher positive attraction than World Square. This result was anticipated as, following Nasar (1998) and the Kaplans' (1989) theories, the more extensive use of natural elements (both in terms of plants and natural materials used) would be preferred by participants. The use of rounded shapes and the variations in pattern used in Darling Square were also expected to elicit a stronger preference from participants, which is consistent with the survey results. Based on Gehl's (2009) research, Darling Square was anticipated to be preferred in terms of liveliness, as people were more likely to linger in Darling Square, whereas World Square was more frequently used as a thoroughfare. Although Darling Square was described as a place to relax rather than a lively place by participants, the survey scores showed a clear preference (7.6) for Darling Square while World Square was just above a neutral score (5.6).

Openness and exposure elements were not expected to elicit strong positive attraction due to thigmotaxis (wall-hugging) tendencies described in embodied cognition research (Sussman & Hollander 2015). This is reflected in the survey scores, which were the lowest of any design element for both World Square and Darling Square. However, there is still a stronger positive attraction to openness in Darling Square. This is consistent with Nasar (1998), who theorised that the tall buildings, such as those surrounding World Square, would be less appealing than the shorter buildings, as there are around Darling Square.

Unexpectedly, however, the EEG scores were not consistent with the anticipated positive attraction that the survey scores showed. It was expected that the EEG scores would show higher positive attraction across all design elements, yet this was only true for participants' responses to liveliness and people. Even then, there is only a slight preference at Darling Square (6.7) in comparison to World Square (6.5). The EEG scores were equivalent for upkeep and derelict features, which is surprising as Darling Square was only a matter of weeks old when participants engaged in the study, and every part of Darling Square was new and well maintained.

The higher positive attraction in World Square's EEG scores for orderly design and pattern, openness and exposure, and natural and fabricated elements were a surprising result. Although the EEG like/dislike scores at World Square were only slightly higher than Darling Square in response to these design elements, it is unclear why the EEG is showing stronger positive attraction which is inconsistent with the participants' reported responses through the survey scores, walking interview comments, and anticipated results based on the literature review. Further investigation is needed to better understand the participants' responses.

VARIATIONS IN STIMULATION RESPONSES BETWEEN WORLD SQUARE AND DARLING SQUARE

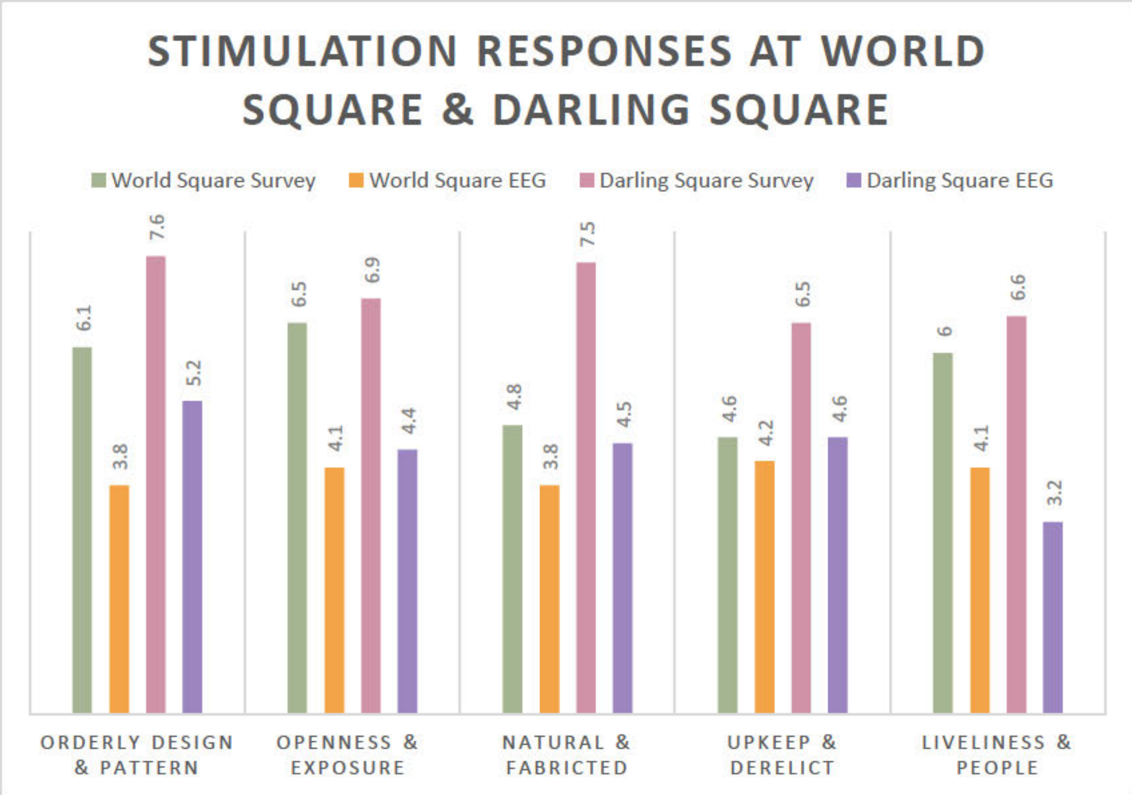


Figure 58. Average of all participant survey and EEG scores for stimulation at World Square and Darling Square.

The key themes observed in Figure 58 are:

- Stimulation readings were higher at Darling Square across both survey and EEG scores apart from EEG responses to liveliness.
- The EEG scores for both World Square and Darling Square show similar readings for stimulation across all stimuli.
- The survey scores are similar for both World Square and Darling Square for orderly design and pattern, openness and exposure and liveliness, but for natural elements and upkeep elements of World Square were reported as being much less stimulating in comparison to Darling Square.

Participants consistently reported higher experiences of stimulation on the survey than is shown via the EEG scores. Participants' survey scores reported mid-range positive stimulation for most design elements, with the only exceptions being natural elements and upkeep at World Square, which were both just below a neutral reading. For the design elements of orderly design and pattern, openness and exposure and liveliness, the survey scores are relatively consistent for both World Square and Darling Square.

The EEG scores for stimulation are almost all below a neutral reading for both sites. The only EEG reading that shows positive stimulation is for orderly design and pattern at Darling Square. All other EEG readings for both World Square and Darling Square show mild negative stimulation responses to all other design elements.

Stimulation survey scores at Darling Square were higher than all survey scores for World Square. The stimulation EEG scores for Darling Square were nearly all higher than at World Square, with the exception of liveliness and people.

DISCUSSION OF PARTICIPANTS' STIMULATION RESPONSES AT WORLD SQUARE AND DARLING SQUARE

The key points are:

- It was anticipated that Darling Square's design elements would elicit higher positive stimulation responses in comparison to World Square. This was true of almost all the readings for both the survey and EEG scores apart from EEG scores for liveliness and people, where World Square showed a higher positive response.
- Participants' conscious responses via the survey tended to be higher than the unconscious EEG scores and it is unclear why this has occurred.

In terms of orderly design and pattern, it was anticipated that World Square would elicit a less positive response than Darling Square because the assorted businesses along the edges are rather eclectic and the sculptures sparked some confusion from participants, who expressed through their comments in the walking interviews uncertainty as to why the sculptures were there. The patterns at World Square tend to be more monotonous repetitions of rectangle shapes, expressed by the building facades and paving. There also tends to be more hard surfaces, with very little natural elements to soften the design. The landmark features of the light-up stairs and dragon sculpture that arches above the stairs were also described by some participants as being overly stimulating.

The anticipated negative response to these features is reflected in the EEG scores for World Square. The EEG readings for all design elements at World Square dipped below neutral and into a negative stimulation response. The participants' EEG scores ranged between 4.1–3.8 for the duration of the study, showing a generally consistent mild level of negative stimulation. In comparison, however, the survey scores for World Square were higher for orderly design and pattern (6.1), openness and exposure (6.5), and liveliness and people (6). The participants reported mixed comments based on their conscious experience in the walking interviews. It is possible that this influenced these higher survey scores.

Darling Square was expected to elicit a higher positive stimulation responses from participants compared to World Square. While this is true for all design elements except liveliness and people, it must be noted that the EEG scores for Darling Square were only marginally higher. The EEG score for orderly design and pattern (5.2) was the only reading that rose above a neutral reading and showed very mild positive stimulation. The EEG scores for openness and exposure, natural and fabricated, and upkeep and derelict elements were just below neutral, ranging from 4.6–4.4.

It may be that the low levels of stimulation from Darling Square's design elements reflects that the square was seen as a relaxing place by participants, as was frequently commented on during the walking interviews. It may also be the higher prevalence of rounded shapes, like the paving design and looping cladding on the library and soft materials (such the extensive use of wood and garden beds), slightly relieved the anxiety inducing response to sharp angles and hard surfaces (Jasanoff 2018; Leder, Tinio & Bar 2011; Sussman & Hollander 2015). The preference for patterns that have an appealing level of variation without being too complex tend to occur in nature, such as woodgrain. Taylor et al. 2011, p. 18) showed that patterns in this idea range 'generated the maximal alpha response in the frontal region, consistent with the hypothesis that they are most relaxing.' Although the participants' EEG scores in Darling Square were not indicating positive stimulation, these scores may be reflecting a level of relaxation.

There is considerable contrast between participants' survey and EEG scores for both World Square and Darling Square. To determine the EEG performance metric for stimulation, unconscious measures, including pupil dilation and eye widening, are measured. Other bodily stimulation responses that people may be aware of, such as sweat gland stimulation, increased heart rate and muscle tension, are also included; however, it may be that the stimuli of urban design elements are too similar to demonstrate consciously different levels of stimulation from participants (Emotiv.com n.d). It is possible that a more thrilling environment, such as an amusement park, would be more likely to elicit bodily stimulation that is more closely aligned with conscious stimulation.

VARIATIONS IN STRESS RESPONSES BETWEEN WORLD SQUARE AND DARLING SQUARE

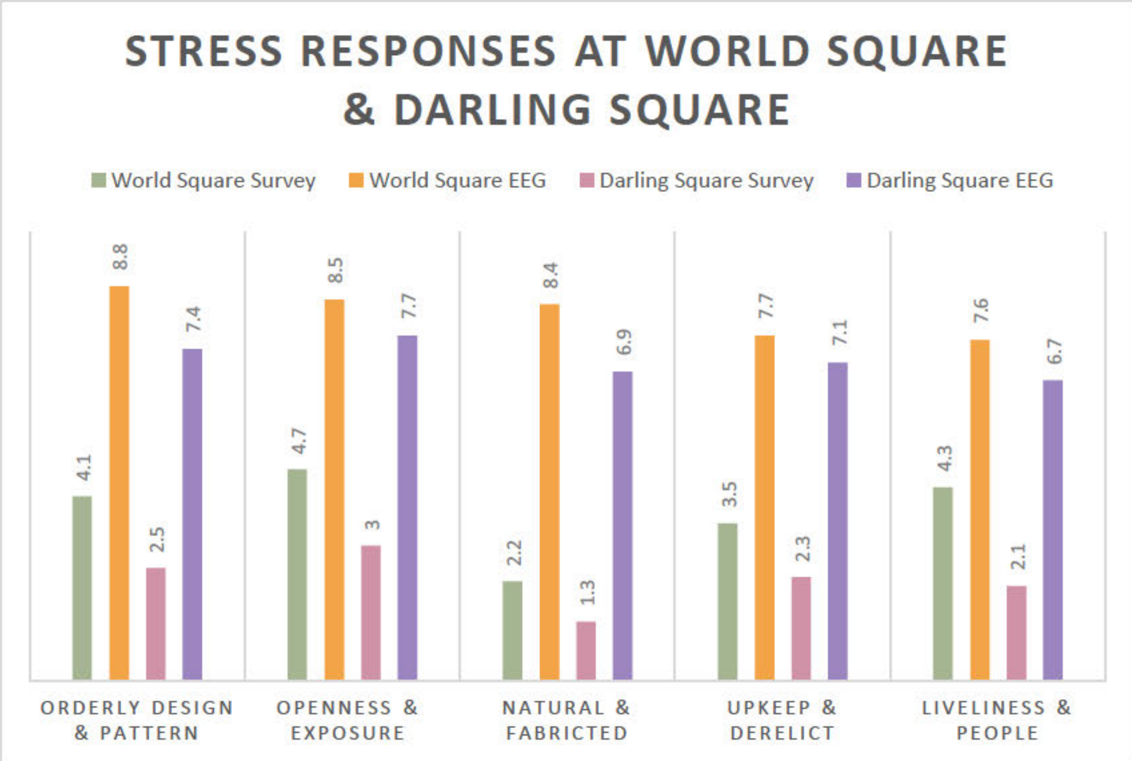


Figure 59. Average of all participant survey and EEG scores for stress at World Square and Darling Square.

The key themes observed in Figure 59 are:

- Participants' survey scores reported low stress responses to all design elements for both World Square and Darling Square.
- In comparison to the survey scores, participants' EEG scores showed significantly higher stress responses across all design elements for both World Square and Darling Square.
- Stress responses in both survey and EEG scores were higher at World Square for all design elements in comparison to Darling Square.

Participants reported experiencing low stress responses for World Square that were generally just below neutral levels. In comparison, the survey scores for Darling Square show even lower stress responses, with very low scores in response to all design elements. The lowest stress survey scores for both World Square and Darling Square are in response to natural design elements.

EEG scores showed consistently high stress responses for all design elements in both World Square and Darling Square. The World Square EEG readings were all higher than Darling Square for all design elements. The EEG readings at World Square progressively dropped over the course of the experiment, but only slightly. The Darling Square EEG readings showed mostly mid-level stress responses that remained more or less stable across the participants' experience at Darling Square.

While the stress responses for both survey and EEG scores were consistently higher at World Square, there was generally a similar difference between scores for all design elements at Darling Square. The World Square survey and EEG scores were typically one or two points away from the survey and EEG scores at Darling Square.

DISCUSSION OF PARTICIPANTS' STRESS RESPONSES AT WORLD SQUARE AND DARLING SQUARE

The key points are:

- It was anticipated that participants would have a higher stress response in World Square compared to Darling Square. This was found to be the case for both survey and EEG scores, which were consistently higher at World Square than Darling Square.
- It was not anticipated that there would be such a stark difference between the survey and EEG scores. EEG scores for both World Square and Darling Square were significantly higher than the survey scores across all design elements.

Participants' stress responses reported via the survey were in line with the expected results. As previously mentioned, World Square has numerous features that, as previously discussed, are more likely to elicit stress responses. The prevalence of hard surfaces and angular design elements coupled with the very low levels of natural design elements were predicted to negatively impact participants' stress levels. Additionally, its often used as a thoroughfare rather than a space to stop and relax. Darling Square's design was anticipated to be less stressful as it makes use of more rounded shapes, softer materials such as extensive use of wood, and garden beds that have a mix of trees and shrubs. Darling Square's position to the side of a main pedestrian thoroughfare on Tumbalong Boulevard has resulted in it being used as a place of refuge to relax and linger rather than simply pass through.

This is reflected in survey scores, where there very low levels of stress were reported by participants in Darling Square. The lowest levels of stress were in response to the natural design elements in both World Square (2.2) and Darling Square (1.3), which is consistent with the Kaplan's (1989) attention restoration theory. The more extensive use of garden beds and natural materials in Darling Square are likely to have contributed to the very low levels of stress reported by participants.

The highest levels of stress reported by the survey for both World Square and Darling Square were in response to openness and exposure. This was in line with expectations, as according to thigmotaxis (wall-hugging preference) (Kallai et al. 2007), participants would feel somewhat exposed standing in the most open area of the square. This feeling was deliberately provoked as participants were asked to look up and around at the surrounding buildings. As the buildings around World Square are very tall, this was anticipated to exacerbate stress. While the buildings around Darling Square are not as tall in comparison to World Square, the buildings along the edges of Darling Square tend to be residential apartments. During the walking interview responses, participants reported feeling more observed when standing in the open area of Darling Square. It may be that the lower height of the buildings and use of the buildings as residential homes correlated with a sense that people could more easily observe the participants while standing in the open, thereby exacerbating a sense of exposure.

The EEG scores are consistent with the survey scores in terms of World Square's design eliciting a higher stress response than Darling Square. However, it is unclear why the EEG scores are so much higher across all design elements. There seems to be a general trend where stress levels slightly drop across the length of the experiment, from 8.8 to 7.6. Participants in Darling Square held a steadier level of stress, which also dropped by the end of their experience in the study (7.7–6.7). Ellard (2015) noted that frequent exposure to a stressor may result in normalising the experience and, therefore, reducing the conscious response. As the design elements being observed in this study are commonly found in urban environments all over the world, it may be that the stress-inducing nature of urban design has become largely unconscious through normalisation, but more research is needed to better understand this trend.

VARIATIONS IN RELAXATION RESPONES BETWEEN WORLD SQUARE AND DARLING SQUARE

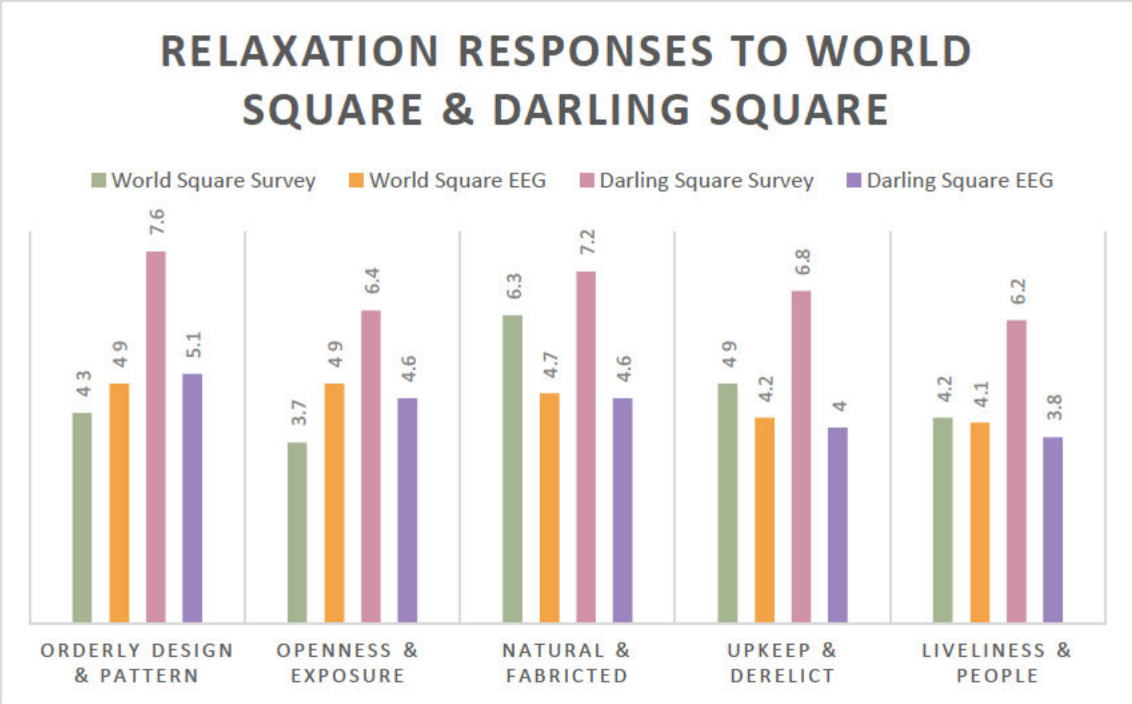


Figure 60. Average of all participant survey and EEG scores for relaxation at World Square and Darling Square.

The key themes observed in Figure 60 are:

- Participants reported high levels of relaxation via the Darling Square survey scores in comparison to the other readings for all design elements.
- The EEG readings for both World Square and Darling Square are similar across all design elements.
- Aside from the survey responses in Darling Square, most other readings were just below a neutral level.

The participants' survey and EEG scores at World Square are generally fairly similar across all design elements with the exception of natural design elements, where participants' survey scores were higher than any other relaxation response. In comparison, there is a much greater level of difference between the Darling Square survey and EEG scores. All design elements in

Darling Square elicited much higher relaxation responses via the survey than the EEG scores, which were several points lower.

The level of relaxation experienced by participants in World Square varied somewhat across the design elements, with a low survey response to openness and exposure but a much higher relaxation response to natural design elements.

While there were difference between the levels of relaxation reported via the survey and EEG in Darling Square, the level of relaxation shown through the survey and the level of relaxation shown through the EEG remained fairly consistent throughout participants experience of Darling Square.

DISCUSSION OF PARTICIPANTS' RELAXATION RESPONSES AT WORLD SQUARE AND DARLING SQUARE

The key points are:

- It was anticipated that participants would experience higher levels of relaxation at Darling Square than World Square (Kellert 2012), and while this was the case with the survey scores, it was not the case for the EEG scores.
- There are generally comparable levels of stress recorded between EEG scores in World Square and Darling Square. While the World Square survey scores are more or less in line with the EEG scores, Darling Square's survey responses are much higher than the other readings.

Previously cited urban design literature hypothesises that increased use of natural elements in urban design softens the hard elements of the build environment and contributes to a more aesthetically pleasing local character. World Square's natural elements are limited to three planter boxes with heavily manicured trees and some small shrubs. In comparison, Darling Square makes use of numerous garden beds and lines two of the sides with trees, as well as having an open grassed area in the centre. Given the stark contrast in the number of natural elements between the two squares, it was anticipated that Darling Square's design would be more relaxing.

The survey scores are consistent with this expectation as the relaxation levels reported by participants are much higher at Darling Square for all design elements. The only design element where the survey scores between World Square and Darling Square are somewhat close is in response to natural elements. In response to all other elements, Darling Square elicited a more relaxing conscious response from participants.

In contrast, the EEG scores for World Square are typically slightly higher than Darling Square. The only instance where Darling Square's design elicited a higher relaxation response than World Square was in relation to orderly design and pattern. Darling Square's orderly design elicited a marginally higher EEG reading of 5.1 compared to World Square's score of 4.9. This was the only instance of any EEG reading for relaxation going over a neutral reading. All other EEG scores showed negative levels of relaxation.

The EEG performance metric for relaxation measures the wearer's ability to recover from intense focus and switch off their attention in a positive way. This approach complements the Kaplans' (1989) attention restoration theory as the theory predicts the ability of natural elements to have a restorative effect on people. For this reason, it was anticipated that the scores for relaxation would most closely align between the survey and EEG. It is not clear why this has not been the case. Further research is needed to understand why there is such significant difference between the Darling Square survey scores in comparison to the EEG readings.

REFLECTIONS ON USING EEG TO GAIN GREATER INSIGHT INTO PEOPLE'S EXPERIENCES AND RESPONSES TO URBAN DESIGN

This section summarises the data and analysis explored in this chapter in answer to sub-question four: **What new data can electroencephalography (EEG) provide on how people experience and respond to design elements in public space?**

The data collected in this study has produced a range of insights, some of which are consistent with the expected results and some of which will require further study to fully understand.

There are several areas of investigation where the survey scores and EEG data have been consistent with each other, thereby suggesting that EEG can be used to create a more detailed understanding of people's responses to urban design elements. The areas where the survey and EEG data have been consistent include the stimulation responses. Using embodied cognition literature and urban theory, Darling Square was predicted to elicit higher positive stimulation than World Square. This was largely the case, apart from participants' responses to liveliness, where there was a more positive response to World Square than Darling Square in terms of EEG scores.

An interesting trend noted in terms of stimulation is that participants tended to rate their level of stimulation higher in the survey than was shown by the EEG. As the EEG measures unconscious levels of stimulation based on bodily responses and the survey scores reflect conscious awareness of stimulation, it may be that these divergent scores reflect a difficulty in being consciously aware of bodily responses, like pupil dilation and eye widening. Alternatively, it may be that the bodily responses that the EEG stimulation performance metric measures may be more consciously noted, such as sweat gland stimulation, increased heart rate and muscle tension, both which influence participants' conscious responses. To investigate this aspect of the study further, improved insights may be gained by including other biometric monitoring devices in future studies. Heart rate monitors and GSR measures can provide additional information on emotional arousal, which may help explain the difference between participants' conscious and unconscious responses to design elements (Boucsein 2012; Critchley 2002).

In comparing the participants' stress levels at World Square and Darling Square it was anticipated that as World Square's design included more stressors, participants would have higher stress levels there than Darling Square. This was true of both the survey and EEG data, as participants' levels of stress were higher in World Square in response to all design elements.

An additional interesting trend that emerged from this dataset was that participants' conscious experience of stress reported via the survey was significantly lower across all measures in both case study sites. The EEG data showed much higher levels of stress in response to all design elements at both World Square and Darling Square. It may be that constant exposure to stressors in urban design have normalised the level of stress people are experiencing and, therefore, they are not as consciously aware of it as one might assume. Given that much of neurourbanism focuses on the impact of stressors in the public realm, this is a finding that warrants further investigation within the field (Fitzgerald & Callard 2015; Adli et al. 2017). It is an especially challenging area of investigation, as noted by Knöll et al. (2018), there is currently no criteria or framework for describing stress perception of pedestrians using environmental properties (Gong et al. 2016, Yang & Matthews 2010).

There were instances where the data collected was inconsistent with the anticipated findings. In terms of positive attraction, it was expected that participants would experience a lower level of positive attraction to the design elements of World Square compared to Darling Square, based on the theory explored in the literature review. While the survey scores showed that consciously, participants had a more positive response to Darling Square, the EEG results showed World Square as eliciting stronger positive attraction. It is unclear why this is the case. Additional data collected through the walking interviews supported the view that the participants consciously showed a much more positive response to Darling Square than World Square. Further investigation is needed to understand why this divergence between conscious and unconscious responses has occurred.

With respect to participants' relaxation responses, the collected datasets are not in line with expected results. Given that Darling Square's design has a much higher use of natural elements, it was anticipated that this would elicit a higher relaxation response from participants (Kellert 2012). Participants consciously reported higher levels of relaxation in Darling Square than World Square, yet the EEG scores showed higher levels of relaxation in World Square than Darling Square. This was especially surprising as, during the walking interviews, participants made frequent reference to Darling Square eliciting relaxation. Additionally, given World Square consistently showed higher levels of stress in response to all design elements, it is unclear how World Square can simultaneously be both more stressful and more relaxing according to the EEG data. Further study is needed to understand why participants' responses did not align with the anticipated results.

FURTHER OPPORTUNITIES TO USE EEG TO GAIN GREATER INSIGHTS INTO PEOPLE'S EXPERIENCES AND RESPONSES TO URBAN DESIGN

The original contribution of this thesis is two-fold; to provide a new mix of theories and to introduce a new mix of methods to better understand people's experiences and responses to urban design. To augment the contribution of introducing a new mix of methods, possible amendments to the experiment are suggested for further researchers to consider when recreating this study.

Noting that this experiment produced some unanticipated results, it is clear further study is needed to refine the /use of EEG in urban studies. There are possible adjustments to the research methods that might be made to in future studies that could enhance the quality of the data collected.

Increased sample size. The unanticipated results may be partly due to the small sample size used in this study. This thesis was intended to pilot this mix of methods and it was envisaged that the study would not draw any conclusive results. It may be that if the study were expanded to use a larger group of participants, the data may produce different trends by capturing a wider sample of people's experiences and responses to urban design. Further study is needed to understand if this could be the case.

Conducting the study as a single group. Due to the practical restrictions of only having a single researcher conducting this experiment, participants visited the case study sites one at a time on different days with different conditions (Appendices C and D detail variables observed during each participants' experience in the case study sites). If future research is better resourced, it may be possible to coordinate all research participants to attend the experiment on the same day to reduce the number of variables impacting their experience. It is recommended that each participant should be interviewed separately to reduce the risk of participants influencing each other through conversation or other interactions.

Case study sites with more comparable uses. Although World Square and Darling Square are comparable in many ways, the two squares have different uses. World Square is primarily a shopping mall and often used a transitionary space to pass through to access public transport, whereas Darling Square is used as a place to relax and is positioned as a refuge to the side of the busy tourist area of Darling Harbour. It is possible that the quality of data collected may be improved by comparing the design of two or more shopping malls for greater consistency.

This study was restricted to using case study sites that were located in close proximity due to the logistical concerns in organising participants. If future studies were better resourced and able to provide transportation then there would be greater flexibility in choosing case study sites.

Cultural expectations. The scope of this study has focused on the physiological responses of participants to highlight the importance of bodily experiences. Within the embodied cognition literature, some researchers consider the way cognitive anthropology examines the interaction between language, thought, and cultural models (Kronenfeld 2011; Jourdan et al. 2006; Bennardo & de Munck 2020). Participants' comments during the walking interviews showed that their experience was positioned within a cultural framework that impacted their responses to place. This was especially notable in World Square, where the strong Asian influence in the design resulted in confusion from some participants. Including cognitive anthropology as part of the focus of embodied cognition may also help provide deeper insights into people's experiences and responses to public space.

CONCLUSION

The range of key design elements at World Square and Darling Square were expected to elicit different responses from participants; however, the data collected does not always show participants responding as anticipated. It was expected that participants would feel a stronger positive attraction and be more relaxed in response to the design of Darling Square over World Square, yet this was not true of the EEG data. The research developed interesting findings in terms of participants' stimulation and stress responses via the EEG, although further research is needed to fully understand their responses. The data reflects the potential impact and importance of more EEG studies to further understand people's experiences and response to the design of public space.

Chapter Eight

Conclusion

CHAPTER EIGHT – CONCLUSION

INTRODUCTION

This thesis has been inspired by the desire to better understand how we as humans respond to urban environments in order to improve the quality of public spaces. The built environment is a mix of natural elements and mostly human-made buildings and infrastructure. It is therefore well within our sphere to influence how it is shaped. This is an especially important consideration as, according to embodied cognition theory, our experience and interactions with the world shape us and our perception (Varela, Thompson & Rosch 1991). If we accept this tenet of embodied cognition theory as true, then it is an important realisation that should be acted upon; we should be constructing environments best suited to our needs and the experiences we want to have in the public realm.

While there have been many investigations that focus on person-centred design, technological and scientific advances are opening up new avenues to understand ourselves and the world around us. This provides opportunities to delve further into research to understand the people–place relationship.

This research has focused on bringing together existing urban theory and research methods with the theory and methods of embodied cognition as a means to gain new insights into how people respond to the design of the public realm. The data collected shows that there is some promise in combining these fields as interesting insights have been gained. In particular, the comparison of conscious survey data with unconscious EEG data for stimulation and stress have uncovered areas that warrant further investigation. However, there are also other areas, such as the datasets around positive attraction and relaxation that suggest further empirical research within cognitive sciences is needed to fully understand the collected data.

ACADEMIC SIGNIFICANCE

This thesis represents two central original contributions to academia:

- A new combination of theory by combining embodied cognition with urban theory.
- A new mix of research methods that couples unconscious data collection via EEG and conscious responses recorded via surveys and walking interviews.

In terms of a theoretical contribution, the literature review has explored the burgeoning research studying the overlap of cognitive sciences and urban literature. This includes cognitive mapping, attention restoration theory and rhythmanalysis, which have increasingly incorporated learnings from cognitive science research using EEG.

This research takes a step further by starting to show how embodied cognition can be used to gain new insights into people's relationship with space by understanding their responses to specific design elements. The versatility of having a mobile EEG headset that produces reliable data has opened the opportunity to take cognitive science outside of lab conditions and into every day urban places to better understand people's multisensory experience of public spaces.

The data collected through this innovative mix of methods has revealed interesting results as well as shown this area of investigation is still in its early stages. Continuing to combine unconscious data collected via EEG together with conscious participant responses recorded through surveys and walking interviews has allowed a more detailed dataset of how people respond to key design elements that can be encountered in everyday life.

RESEARCH STATEMENT

This research has posed a central question:

> ***To what extent can embodied cognition be used to better understand how people respond to the design of the public realm?***

The central research question was addressed through four sub-questions. Namely:

1. What is embodied cognition and how has it previously been used to understand the relationship between people, the mind and the environment
2. How have urban theorists predominantly studied people's responses to place and what are the limitations of theorists' current understandings of space?
3. What are the key design features of public plazas, as an example of public space, which we understand as eliciting positive and negative responses?
4. What new data can EEG provide on how people experience and respond to design elements in public space?

To take each sub-question in turn, this thesis has explained embodied cognition as the theory that mind, body and environment is inextricably linked with each aspect influencing the other. As such, the way we perceive the world is determined by our bodily experience in the world (Carsetti 2010). Through the literature, this thesis has explored how embodied cognition has built on phenomenology and extended into cognitive science. The integration of this approach into urban literature with neurourbanism emerging, an emerging area of study (Adli et al. 2017).

In response to the second sub-question, this thesis has presented literature that shows how phenomenological research methods have been traditionally used to understand people's responses to place, but also how the cognitive sciences are starting to be incorporated into urban studies to grow the evidence base on this topic. The three main areas where this trend has been noted are:

- Cognitive mapping, which has begun to incorporate EEG to better understand the decision-making aspects of wayfinding (Moser, Kropff & Moser 2008; Save et al. 2000).
- Attention restoration theory and EEG studies that have added evidence of increased relaxation when participants are exposed to natural environments (Pitchford & Arnell 2019; Hopman et al. 2020).
- Rhythmanalysis and EEG headsets used to collect data on unconscious experiences in the city (Karandinou & Turner 2017).

This has shown there is an emerging foundation for increased inclusion of the cognitive sciences in urban studies, which this thesis has expanded on by focusing on people’s responses to design elements in public space.

The third sub-question has been addressed by identifying key design elements synthesised from the literature of a range of theorists, particularly Nasar (1998), Alexander (1977), Gehl (2006), and Jacobs (1962). This resulted in a focus on the key design elements:

- Orderly design and pattern.
- Openness and exposure.
- Natural and fabricated elements.
- Upkeep and derelict elements.
- Liveliness and people.

Sub-question four was the central focus of Chapters Five, Six and Seven, which discussed in detail the results of combing EEG with the typical urban research methods of surveys and walking interviews. Participants’ conscious responses collected through the surveys and walking interviews were compared with the unconscious data collected via the EEG; the literature provided anticipated responses to each case study site design features, and the results were unpacked in reference to these expectations. Then World Square and Darling Square were compared to show participants' overall responses to each design element.

The findings of this experiment have answered sub-question four by collecting interesting new data. The EEG data shows that it is effective at collecting useful data reflecting participants' stimulation through bodily responses to design elements that they were otherwise unconscious of. This research also found that the impact of stressors in design was considerably higher than participants were consciously aware. There was also new data collected in terms of participants' positive attraction to design elements and the levels of relaxation experienced by participants; however, this data was not in line with the anticipated results. This suggests that, as an emerging field of study, further research is needed to properly explain the data.

Each of these sub-questions have contributed to a final answer to the central question:

Embodied cognition can be used to some extent to better understand how people respond to the design of the public realm, but further research is needed to fully understand the person/place relationship.

Chapter Seven has showed that there are promising areas of investigation as the stimulation and stress responses have collected interesting data that can be explored through more research. However, the datasets collected in regard to positive attraction and relaxation show that it may be too soon for neurourbanism to explain some aspects of the person/place relationship.

CONCLUSION

This thesis has explored what embodied cognition is and how it can be combined with urban theory to gain new insights into how people experience public space. This has occurred through an extensive review of existing literature and theory on urban literature, highlighting areas where the inclusion of cognitive science theory and methods has opened pathways for an improved understanding of people's responses to the public realm.

This thesis has also demonstrated new and innovative ways to research design. By using two case study sites in Sydney, Australia, this research has tested to what extent EEG data reflects the anticipated responses to the mix of key design elements predicted through urban literature. In terms of participants' stimulation and stress responses, interesting findings were uncovered that warrant further investigation. However, the data from participants' positive attraction and relaxation responses was less clear and further research is needed to understand why there was not greater alignment between the anticipated results and data collected.

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Appendix

APPENDIX A – ETHICS APPROVAL

UNSW
SYDNEY

12-Sep-2019

Dear Associate Professor Nancy Marshall,

Project Title	Urban Design Governance: How can Embodied Cognition Theory be used to improve the outcomes of urban design?
HC No	HC190698
Re	HC190698 Notification of Ethics Approval
Approval Period	12-Sep-2019 - 11-Sep-2024

Thank you for submitting the above research project to the **HREAP E: Built Environment** for ethical review. This project was considered by the **HREAP E: Built Environment** at its meeting on **03-Sep-2019**.

I am pleased to advise you that the **HREAP E: Built Environment** has granted ethical approval of this research project. The following condition(s) must be met before data collection commences:

Conditions of Approval:
N/A

Conditions of Approval - All Projects:

- The Chief Investigator will immediately report anything that might warrant review of ethical approval of the project.
- The Chief Investigator will seek approval from the **HREAP E: Built Environment** for any modifications to the protocol or other project documents.
- The Chief Investigator will notify the **HREAP E: Built Environment** immediately of any protocol deviation or adverse events or safety events related to the project.
- The Chief Investigator will report to the **HREAP E: Built Environment** annually in the specified format and notify the **HREAP E: Built Environment** when the project is completed at all sites.
- The Chief Investigator will notify the **HREAP E: Built Environment** if the project is discontinued before the expected completion date, with reasons provided.
- The Chief Investigator will notify the **HREAP E: Built Environment** of his or her inability to continue as Coordinating Chief Investigator including the name of and contact information for a replacement.

The **HREAP E: Built Environment** Terms of Reference, Standard Operating Procedures, membership and standard forms are available from https://research.unsw.edu.au/research-ethics-and-compliance-support-recs.

If you would like any assistance, or further information, please contact the ethics office on:
P: +61 2 9385 6222, + 61 2 9385 7257 or + 61 2 9385 7007
E: humanethics@unsw.edu.au

Kind Regards,

[redacted]

Mr Russell Lowe
Convenor HREA Panel E: Built Environment

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)*. The processes used by this HREC to review multi-centre research proposals have been certified by the National Health and Medical Research Council.

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APPENDIX B – LIST OF PARTICIPANT INTERVIEWS TIMES

Number	Pseudonym	Day	Date	Time
1.	Laura	Saturday	5 October 2019	14:30 to 15.30
2.	Natalie	Sunday	6 October 2019	12.30 to 14.30
3.	Omar	Sunday	6 October 2019	12.30 to 14.30
4.	Bobby	Sunday	13 October 2019	11.00 to 12.00
5.	Elise	Wednesday	16 October 2019	11.30 to 12.30
6.	Harvey	Wednesday	16 October 2019	17.00 to 18.00
7.	Elena	Friday	18 October 2019	17.30 to 18.00
8.	Kalinda	Saturday	19 October 2019	10.30 to 11.30
9.	Oliver	Sunday	20 October 2019	11.00 to 12.00
10.	Mike	Wednesday	23 October 2019	10.30 to 11.30
11.	John	Wednesday	23 October 2019	14.30 to 15.30
12.	Larry	Thursday	31 October 2019	10.00 to 11.00
13.	Josephine	Saturday	2 November 2019	12.30 to 13.30
14.	Jing	Saturday	2 November 2019	14.30 to 15.30
15.	Jane	Sunday	3 November 2019	11.00 to 13.00
16.	Ben	Sunday	3 November 2019	11.00 to 13.00
17.	Alexander	Thursday	7 November 2019	17.00 to 18.00
18.	Helen	Friday	8 November 2019	13.30 to 14.30
19.	Neha	Sunday	10 November 2019	10.00 to 11.00
20.	Noel	Thursday	14 November 2019	16.00 to 17.00

APPENDIX C – PHOTOS OF VARIABLES AT THE CASE STUDY SITES

Figure 61 Photo: Eldridge, T, Dancing pig with stickers on the pavement and pink box advertising a promotional event, World Square, 6/10/19.

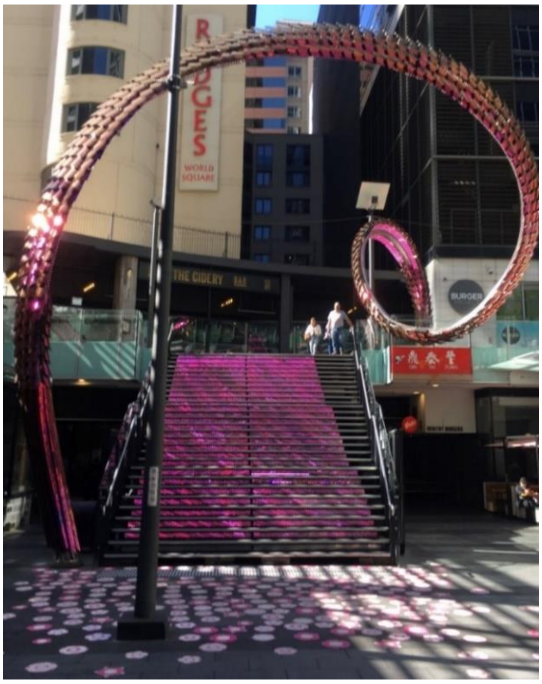


Figure 62 Photo: Eldridge, T, Stairs with lighting and stickers on the pavement as part of the Cherry Blossom Festival, World Square, 6/10/19.

Figure 63 Photo: Eldridge, T, Deciduous trees in early spring, Darling Square, 2/10/19.

Figure 64 Photo: Eldridge, T, hoardings on Yayoi restaurant, World Square, 16/10/19.

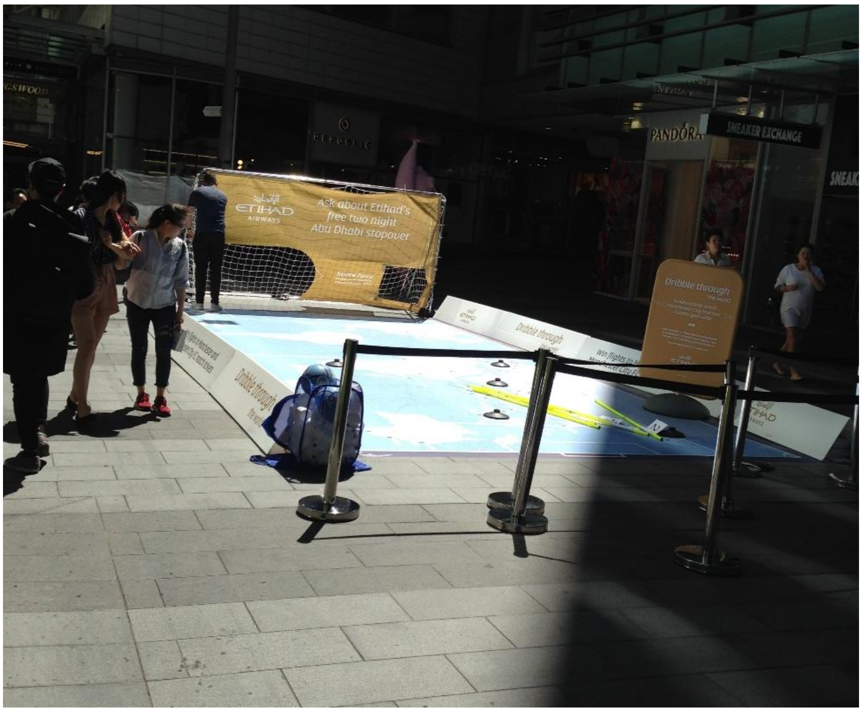


Figure 65 Photo: Eldridge, T, Pop-up soccer game, World Square, 23/10/19.

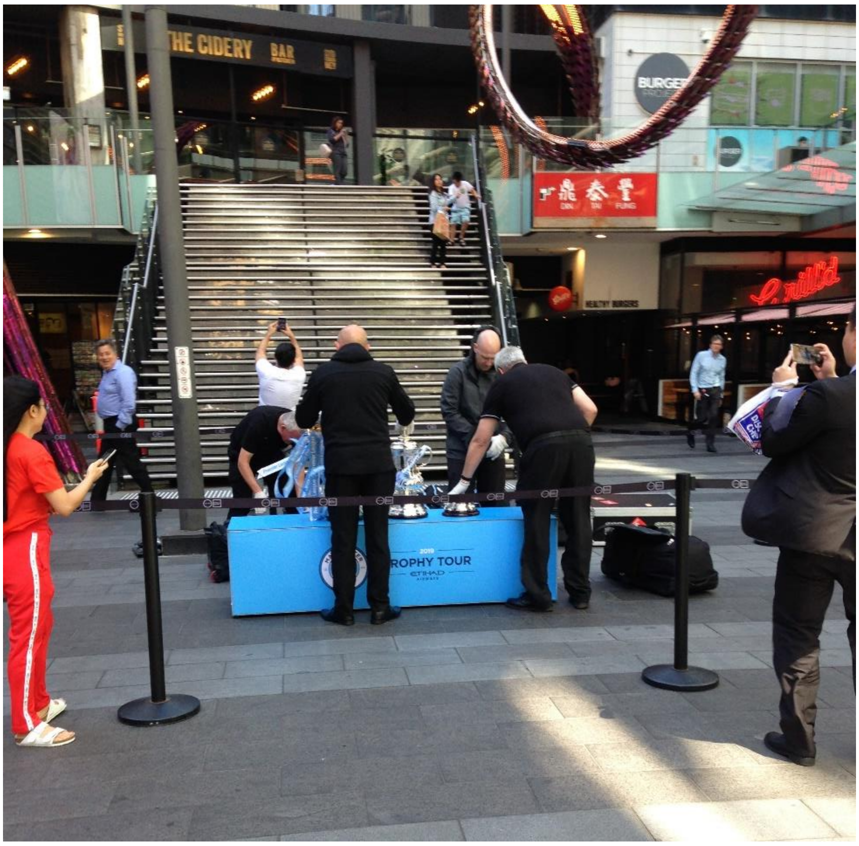


Figure 66 Photo: Eldridge, T, Pop-up trophy table, World Square, 23/10/19.

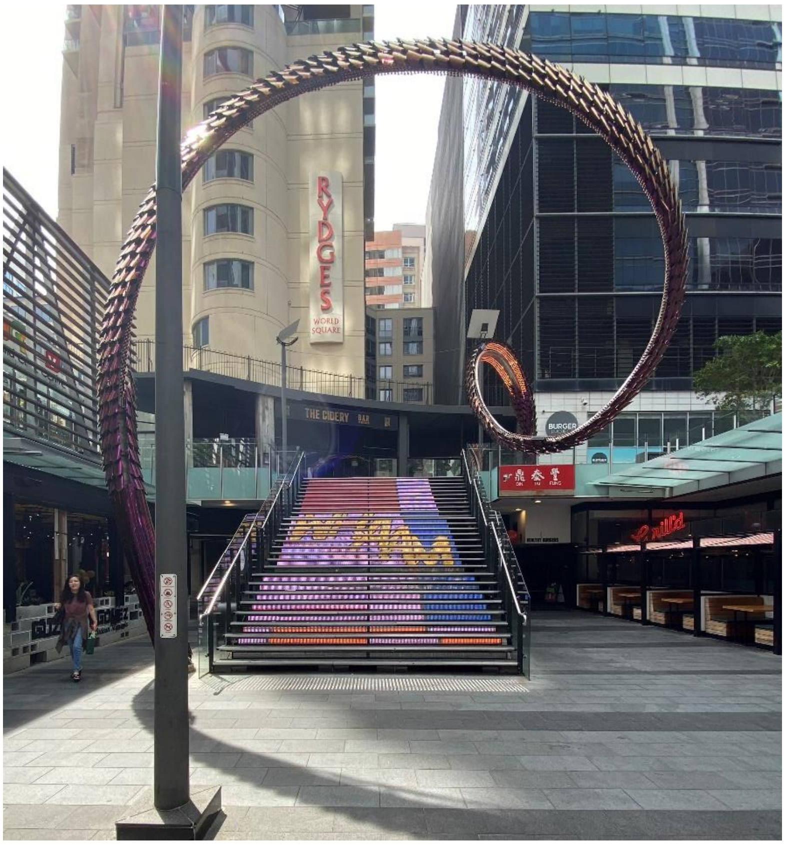


Figure 67 Photo: Eldridge, T, Stairs showing a loop of various pop art style animations, World Square, 2/11/19.

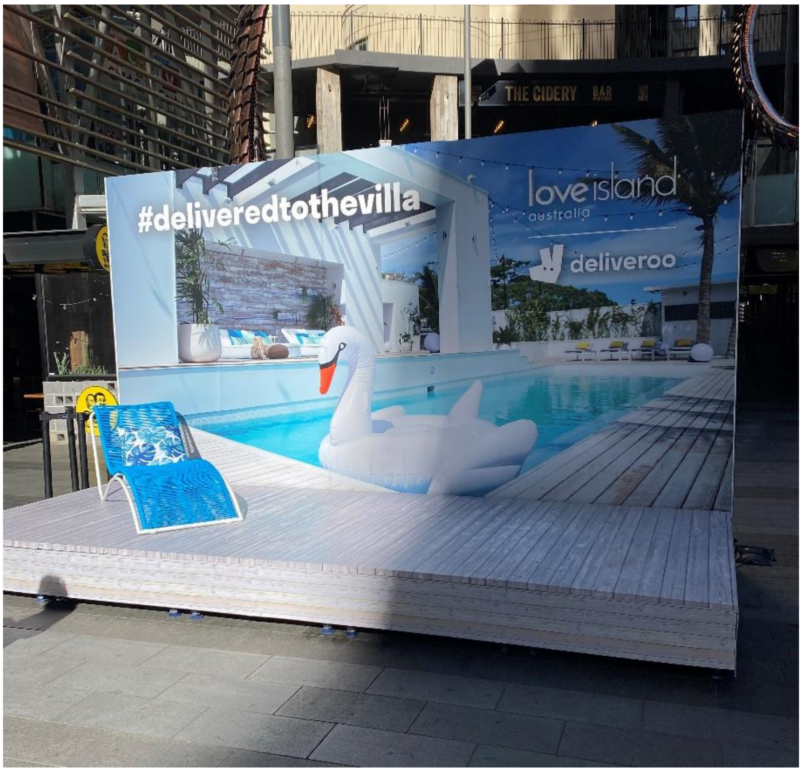


Figure 68 Photo: Eldridge, T, Deliveroo advertising event, World Square, 7/11/19.

Figure 69 Photo: Eldridge, T, 'Fire Pop,' the pop-up food stall, World Square, 7/11/19.

Figure 70 Photo: Eldridge, T, People using the bean bags available on the grassed area, Darling Square, 7/11/19.

Figure 71 Photo: Eldridge, T, 'Fire Pop,' the pop-up food stall relocated position in front of the stairs, World Square, 8/11/19.

Figure 72 Photo: Eldridge, T, Yayoi restaurant with the hoardings removed, open for business, World Square, 8/11/19.

Figure 73 Photo: Eldridge, T, Christmas bauble pop-up art installation, World Square, 14/11/19.

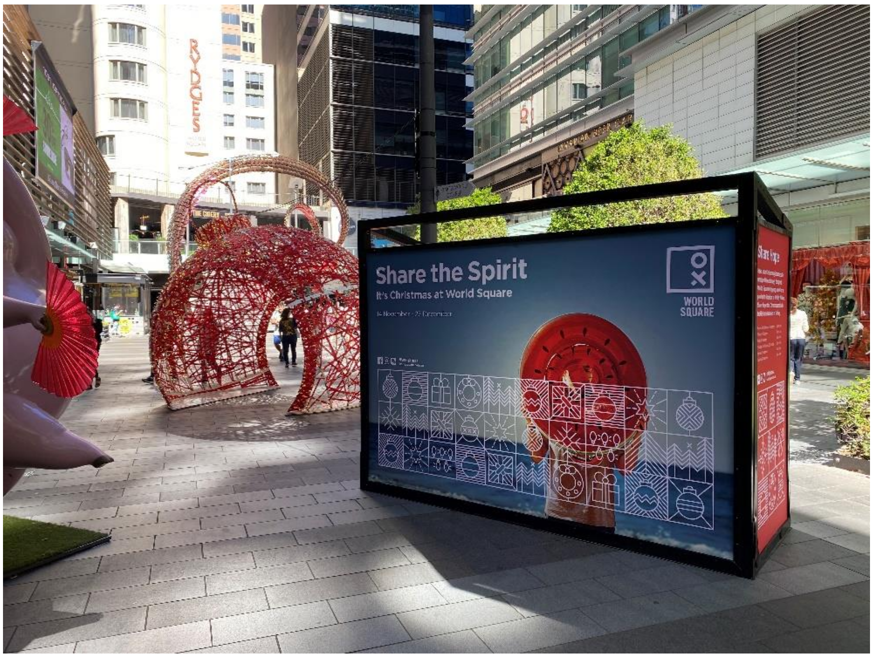


Figure 74 Photo: Eldridge, T, Advertising box installed to promote the Christmas season, World Square, 14/11/19.

APPENDIX D – INTERVIEW REFLECTIONS

Pseudonym:	Laura
Date and time:	5 October 2019, 14.30–15.30
Weather:	Overcast, 19°C. World Square: slightly windy
World Square variables:	• Three dancing pig statures with pink stickers on the pavement around them. • Pink stickers on the pavement in front of the light-up stairs. • Big pink box advertising a promotion for the cherry blossom promotion. • Hoardings up on Yayoi restaurant.
Darling Square variable:	• A large TV screen as set up with a "Snake" style video game available for people to play. • The deciduous trees still growing back their leaves.
Participant notes:	Participant expressed some low anxiety about looking silly with the EEG headset at the beginning of the study. Also some concerns that the wet sensors would make her hair gross. This was the only participant who had been to Darling Square before the interview as she worked nearby and enjoyed coming here for lunch breaks.

Pseudonym:	Natalie
Date and time:	6 October 2019, 12.30-14.30
Weather:	Overcast, 21°C
World Square variables:	• Three dancing pig statures with pink stickers on the pavement around them. • Pink stickers on the pavement in front of the light-up stairs. • Big pink box advertising a promotion for the cherry blossom promotion. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• A large TV screen as set up with a "Snake" style video game available for people to play. • The deciduous trees still growing back their leaves.
Participant notes:	This participant had used an EEG device before for medical reason. She also strongly reacted to gardens. She was noticeably calmer in the garden area and commented that it took the edge of her social anxiety. Her low rating of upkeep in Darling Square was influenced by a person nearby littering at the time we were discussing the topic.

Pseudonym:	Omar
Date and time:	6 October 2019, 12.30-14.30
Weather:	Overcast, 21°C
World Square variables:	• Three dancing pig statures with pink stickers on the pavement around them. • Pink stickers on the pavement in front of the light-up stairs. • Big pink box advertising a promotion for the cherry blossom promotion. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• A large TV screen as set up with a "Snake" style video game available for people to play. • The deciduous trees still growing back their leaves.
Participant notes:	The participant seemed a bit shy at first but gradually warmed up as he was really interested in his EEG readings. At World Square he seemed very cold, putting on two jumpers while his wife and I were in T-shirts. It was difficult to pull his attention away from the pig sculptures in World Square. He had a very strong negative reaction to the children playing in Darling Square.

Pseudonym:	Bobby
Date and time:	13 October 2019, 11.00-12.00
Weather:	Scatted showers, 19°C
World Square variables:	• One of the dancing pig sculptures was removed and the two remaining sculptures changed locations. • The promotional stickers on the pavement and pink box were removed for the remaining interviews. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• A large TV screen as set up with a "Snake" style video game available for people to play. • The deciduous trees still growing back their leaves.
Participant notes:	The participant arrived in a rush as they were running late. Some extra time was taken before the study began in give him a chance to settle so that this wouldn't influence the stress or relaxation measures. The participant self-identified as a "real city boy" who loved the "energy" of metro areas. Discussed growing up in the UK and that Sydney was much more relaxed than London.

Pseudonym:	**Elise**
Date and time:	16 October 2019, 11.30-12.30
Weather:	Sunny, 22°C
World Square variables:	• The light-up stairs under the dragon sculpture weren't switched on. • Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• There was a constant low grinding sound from maintenance work being carried out around the corner. • The deciduous trees had mostly grown their leaves.
Participant notes:	The participant grew up in regional NSW on the Far North Coast and mentioned that she avoided coming into the city as much as possible as she didn't like it. When asked to stand in the most open area of World Square, she seemed somewhat agitated, and this section of the questioning was rushed through to reduce her discomfort.

Pseudonym:	**Harvey**
Date and time:	16 October 2019, 17.00-18.00
Weather:	Overcast building into scatted showers, 23°C
World Square variables:	• Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• Given the overcast skies the lights in the sitting areas and the fairy lights in the deciduous trees came on towards the end of the interview. • The deciduous trees had mostly grown their leaves.
Participant notes:	The participant noted that they hoped their social anxiety would impact the readings and commented that he hoped he didn't look weird wearing the EEG. Towards the end of the interview, he expressed that he was worried about whether the timed parking might have run out so the final questions were wrapped up a little quicker.

Pseudonym:	Elena
Date and time :	18 October 2019, 17.30-18.30
Weather:	Sunny, 20°C. World Square: windy
World Square variables:	• Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• There was Friday night markets in Little Hay Street, Chinatown which we walked through to access Darling Square. The smells and noise somewhat drifted into Darling Square. I may also have resulted in more people being in Darling Square. • The deciduous trees had mostly grown their leaves.
Participant notes:	Participant flagged that they were taking lithium for bipolar, which impacted their stress reading. The participant's political view negatively impacted their perception of Darling Square in particular when they learned it was a privately owned space rather than public ownership.

Pseudonym:	Kalinda
Date and time:	19 October 2019, 10.30-11.30
Weather:	Sunny, 26°C. World Square: windy
World Square variables:	• Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• The deciduous trees had mostly grown their leaves.
Participant notes:	The participant arrived with their mother, who had a coffee while she waited in World Square and then entered a travel agent at Darling Square.

Pseudonym:	Oliver
Date and time:	20 October 2019, 11.00-12.00
Weather:	Overcast, 21°C.
World Square variables:	• Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• The deciduous trees had grown their leaves.
Participant notes:	Due to the shape of the participants head, I had to pull the EEG down relatively low. This meant that the grounding sensors pressed in very firmly and by the end of the interview he was in mild discomfort.

Pseudonym:	Mike
Date and time:	23 October 2019, 11.00-12.00
Weather:	Sunny, 24°C. World Square: windy
World Square variables:	• A pop-up soccer game was set up as a promotion for Etihad airlines. • There was a table of trophies set up in front of the light-up stairs as part of the promotion. • The square was considerably more lively compared to other interview times.
Darling Square variables:	• A group of new parents had set up on the grass for story time with their children. • The deciduous trees had grown their leaves.
Participant notes:	In contrast to some other participants who worried about people looking at them wearing the EEG, he asked me to take a photo of him wearing it so he could show his friends. The Bluetooth connection between the laptop and EEG dropped out twice in World Square. It was restarted immediately and an audio cue was recorded so that the EEG measures could be re-synchronised with the audio recording.

Pseudonym:	John
Date and time:	23 October 2019, 14.30-15.30
Weather:	Sunny, 24°C
World Square variables:	• The above-mentioned pop-up soccer game was being slowly packed up at the time of interview. • The table of trophies was almost completely packed up. • Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• The deciduous trees had grown their leaves.
Participant notes:	While the participant had grown up in Australia and spent over ten years living in Sydney, he had only recently returned from five years living in the UK. Many of his responses juxtaposed the design of UK places with Australian conventions.

Pseudonym:	Larry
Date and time:	31 October 2019, 10.00-11.00
Weather:	Sunny, 21°C
World Square variables:	• Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• The deciduous trees had grown their leaves.
Participant notes:	The participant regularly forgot that he was wearing the EEG headset and would try to scratch his head. This meant interviews were often paused momentarily to double check connectivity.

Pseudonym:	Josephine
Date and time:	2 November 2019, 12.30-13.30
Weather:	Sunny, 25°C. World Square: windy.
World Square variables:	• The light-up stairs were showing a loop of pop art images. • Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• The deciduous trees had grown their leaves.
Participant notes:	The participant mentioned that she was an artist who painted for local markets. This may be reflected in her responses that often focus on colours and shapes.

Pseudonym:	Jing
Date and time:	2 November 2019, 14.30-15.30
Weather:	Sunny, 25°C. World Square: very windy.
World Square variables:	• The light-up stairs were showing a loop of pop art images. • Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• The deciduous trees had grown their leaves.
Participant notes:	There was a significant height difference between the participant and I that, when factoring in the windiness of World Square, meant that I often had to bend down to ensure I heard her correctly and the audio recording was positioned at her level.

Pseudonym:	**Jane**
Date and time:	3 November 2019, 11.00-13.00
Weather:	Sunny, 26°C. World Square: windy. Darling Square: breezy.
World Square variables:	• The light-up stairs were showing a loop of pop art images. • Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• The deciduous trees had grown their leaves.
Participant notes:	The participants were a married couple who arrived together. Their partner waited at the place where we set up while interviews were conducted. Both conducted their interviews at World Square before moving to Darling Square where we repeated the same process.

Pseudonym:	**Ben**
Date and time:	3 November 2019, 11.00-13.00
Weather:	Sunny, 26°C. World Square: windy. Darling Square: breezy.
World Square variables:	• The light-up stairs were showing a loop of pop art images. • Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• The deciduous trees had grown their leaves.
Participant notes:	The participants were a married couple who arrived together. Their partner waited at the place where we set up while interviews were conducted. Both conducted their interviews at World Square before moving to Darling Square where we repeated the same process.

Pseudonym:	**Alexander**
Date and time:	7 November 2019, 17.00-18.00
Weather:	Sunny, 27°C. World Square: windy.
World Square variables:	• A large billboard was set up in front of the light-up stairs promoting deliveroo. • There were also people around the billboard handing out free gifts with deliveroo branding. • There was pop-up store called "Fire Pop" set up in front of CUE with setting for its patrons. • Two dancing pig statues. • Hoardings up on Yayoi restaurant.
Darling Square variables:	• Bean bags set up on the grassed area for general use. • The deciduous trees had grown their leaves.

Participant notes:	The Bluetooth connection between the laptop and EEG dropped out twice in World Square. It was restarted immediately, and an audio cue was recorded so that the EEG measures could be re-synchronised with the audio recording.

Pseudonym:	**Helen**
Date and time:	8 November 2019, 13.30-14.30
Weather:	Sunny, 27°C. World Square: *very* windy.
World Square variables:	• "Fire Pop" had relocated to sit in front of the light-up stairs. • Two dancing pig statues. • Yayoi restaurant removed the hoardings and opened for business.
Darling Square variables:	• Bean bags set up on the grassed area for general use. • The deciduous trees had grown their leaves.
Participant notes:	The Bluetooth connection between the EEG headset and laptop was impacted by the high winds. To maintain a steady connection we were forced to stand in sheltered corners of the square rather than moving freely around to interact with different elements of the design. Additionally, the participant had injured their knee so routes were chosen to minimise inclines that might jar her injury.

Pseudonym:	**Neha**
Date and time:	10 November 2019, 10.00-11.00
Weather:	Sunny, 22°C. World Square: slightly windy.
World Square variables:	• The light-up stairs were showing a loop of pop art images. • Two dancing pig statues. • Yayoi restaurant removed the hoardings and opened for business.
Darling Square variables:	• Interview originally planned for Saturday 9/11/19 however it was pushed back a day to avoid events set up for the official opening of the library. • Bean bags set up on the grassed area for general use. • The deciduous trees had grown their leaves.
Participant notes:	The participant flagged that they had a bad headache the day before and noted that they were still feeling a bit delicate and recovering; however, they assured me that they felt fine to participate.

Pseudonym:	**Noel**
Date and time:	14 November 2019, 16.00-17.00
Weather:	Sunny, 25°C. World Square: windy. Darling Square: breezy
World Square variables:	• A large, shiny Christmas bauble pop-up was installed. • There was also a large box advertising the Christmas season. • The light-up stairs were showing a loop of pop art images. • Two dancing pig statues. • Yayoi restaurant removed the hoardings and opened for business.
Darling Square variables:	• Bean bags set up on the grassed area for general use. • The deciduous trees had grown their leaves.
Participant notes:	The Bluetooth connection between the laptop and EEG dropped out three times in World Square. It was restarted immediately, and an audio cue was recorded so that the EEG measures could be re-synchronised with the audio recording.

APPENDIX E – SAMPLE OF EEG RAW DATA

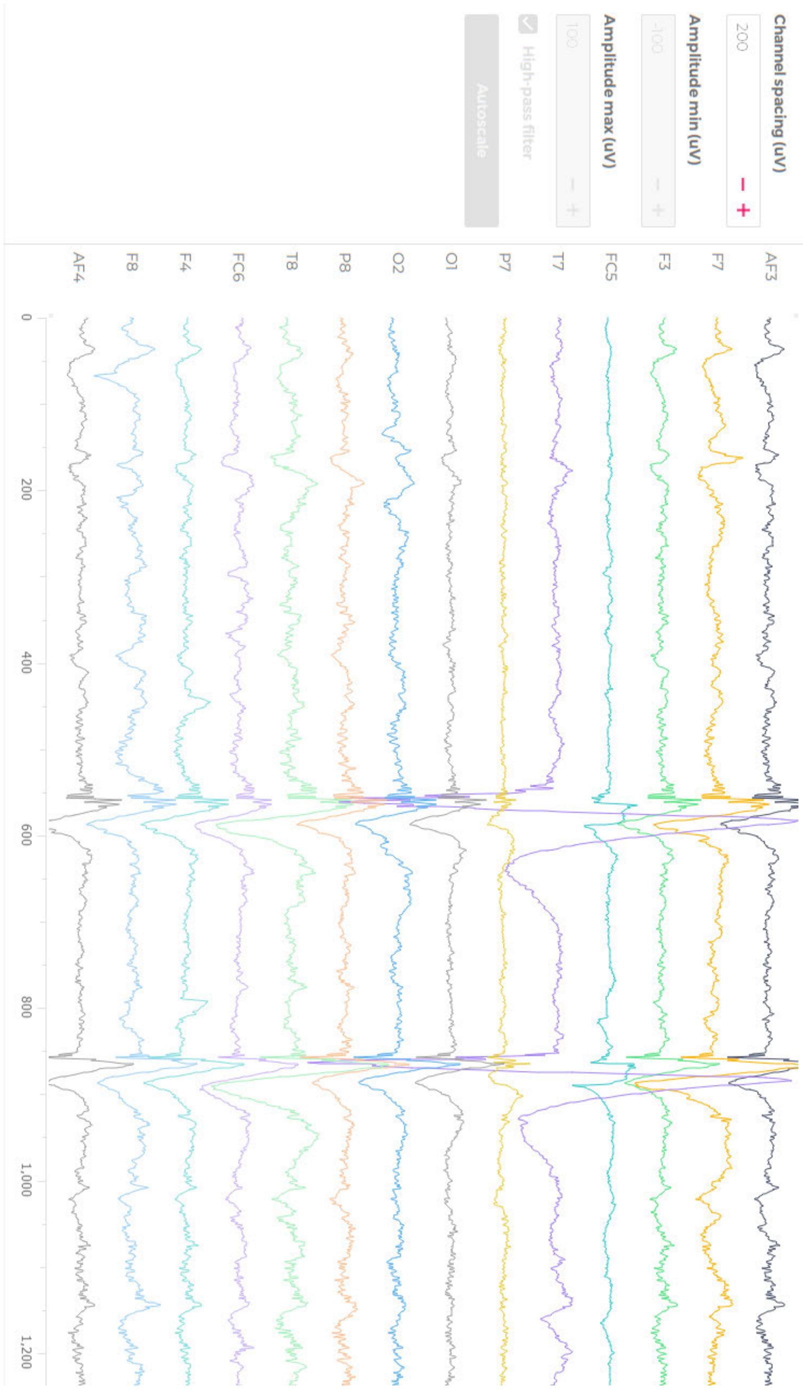


Figure 75. Sample of raw EEG data collected via the Emotiv EPOC headset, presented via the EmotivPRO software.

APPENDIX F – SURVEY QUESTIONS

Please note that the same questions were used for both World Square and Darling Square.

1. To what extent do you like/dislike this aspect of the space you're experiencing?

0=Dislike | *5= Neutral* | *10= Like*

0	1	2	3	4	5	6	7	8	9	10

2. To what extent do you find this aspect of the space you're experiencing stimulating.

0=Not at all stimulating | *5= Neutral* | *10=Very stimulating*

0	1	2	3	4	5	6	7	8	9	10

3. In relation to this aspect of space, to what extent do you feel stressed?

0=Not at all stressed | *5= Neutral* | *10=Very stressed*

0	1	2	3	4	5	6	7	8	9	10

4. In relation to this aspect of space, to what extent do you feel relaxed?

0=Not at all relaxed | *5= Neutral* | *10=Very relaxed*

0	1	2	3	4	5	6	7	8	9	10

APPENDIX G – SCHEDULE OF QUESTIONS

World Square

Instructions: Walk through the square however you like.

1. **How would you describe walking through the square?**
2. **What was the most interesting thing?**

EEG Survey 1

3. **What was the least interesting thing?**

EEG Survey 2

Instructions: Walk around the perimeter of the square

4. **How would you describe the style of this square's design?**
5. **Does this square have a theme? If so, describe it.**
6. **Are there any patterns that stand out to you?**

EEG Survey 3

Instructions: Walk to the most open part of the square, look up and around the layout of the square.

7. **How would you describe being out in the middle of the square?**

EEG Survey 4

Instructions: Walk to the garden beds and have a look at the landscaping.

8. **What do you think of the landscaping of the square?**
9. **What stands out to you?**

EEG Survey 5

Instructions: Standing on the first landing of the stairs.

10. **What do you think of the upkeep of the square?**
11. **Does anything look like it doesn't fit in this square?**

EEG Survey 6

Instructions: Looking around the whole square

12. **In your opinion, what makes a place lively?**
13. **Would you describe the square as lively?**

EEG Survey 7

Darling Square

Instructions: Walk through the square however you like.

1. **How would you describe walking through the square?**
2. **What was the most interesting thing?**

EEG Survey 1

3. **What was the least interesting thing?**

EEG Survey 2

Instructions: Walk around the perimeter of the square.

4. **How would you describe the style of this square's design?**
5. **Does this square have a theme? If so, describe it.**
6. **Are there any patterns that stand out to you?**

EEG Survey 3

Instructions: Walk to the most open part of the square, look up and around the layout of the square.

7. **How would you describe being out in the middle of the square?**

EEG Survey 4

Instructions: Walk to the garden and have a look at the landscaping.

8. **What do you think of the landscaping of the square?**
9. **What stands out to you?**

EEG Survey 5

Instructions: Walk to the side with the open shop fronts

10. **What do you think of the upkeep of the square?**
11. **Does anything look like it doesn't fit in this square?**

EEG Survey 6

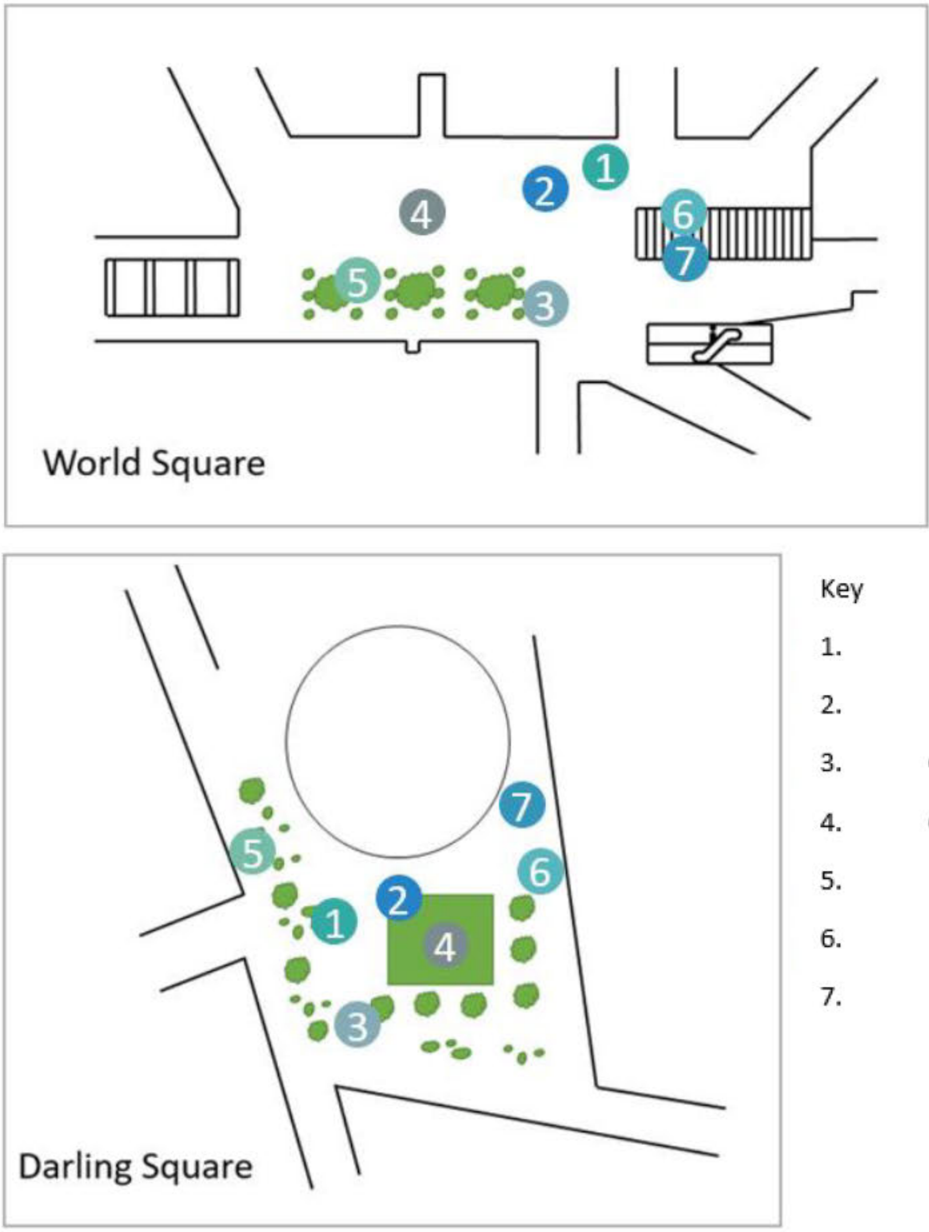
Instructions: Looking around the whole square

12. **In your opinion, what makes a place lively?**
13. **Would you describe the square as lively?**

EEG Survey 7

APPENDIX H – LOCATIONS FOR EACH PARTICIPANTS' SCORES

PARTICIPANT 1 "LAURA"



Key

1. Interesting feature
2. Disinteresting feature
3. Orderly design & pattern
4. Open & exposed
5. Natural elements
6. Upkeep & derelict
7. Liveliness & people

Figure 76. Map of locations where Participant 1 recorded their responses across World Square and Darling Square.

PARTICIPANT 2 "NATALIE"

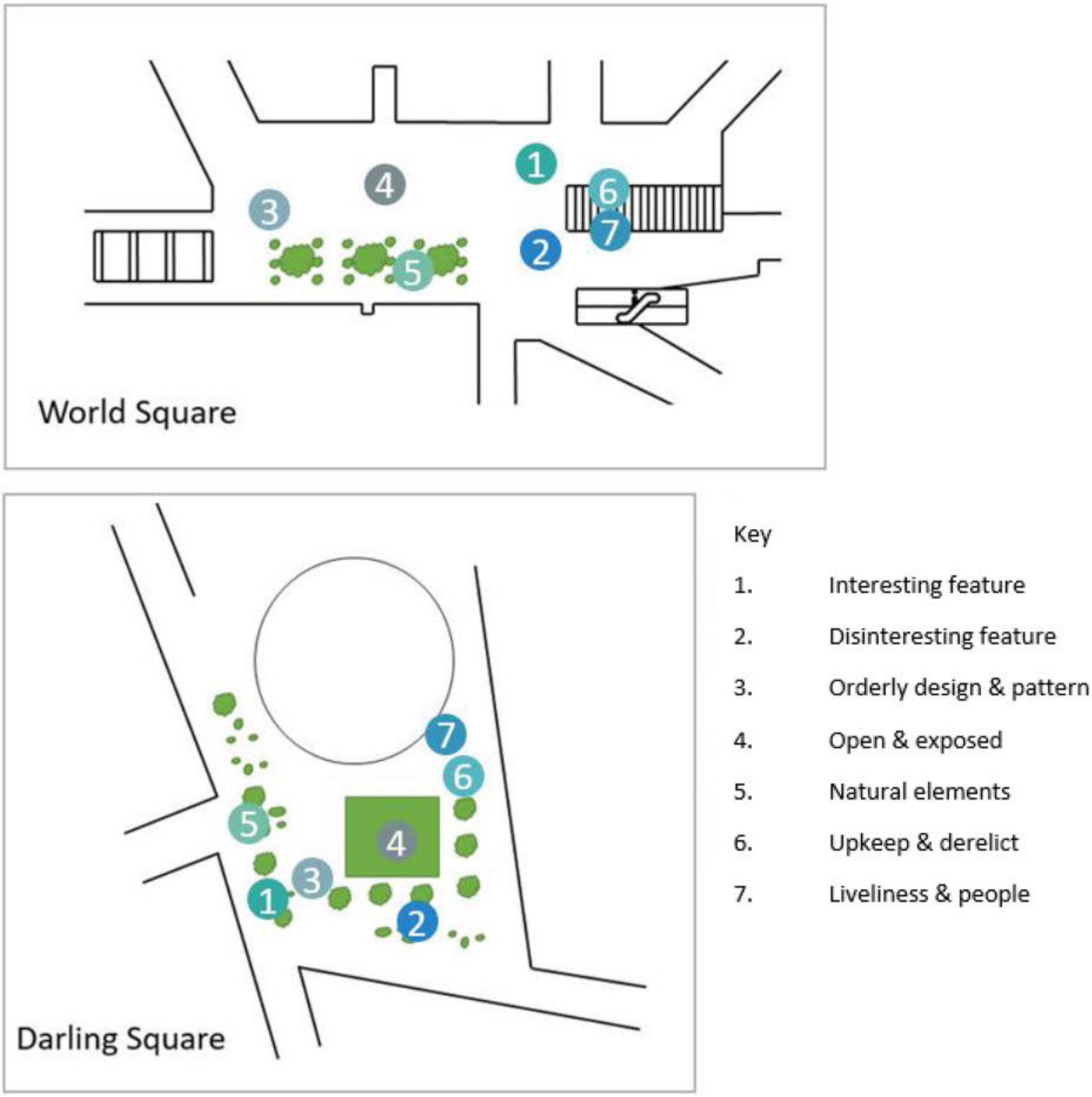
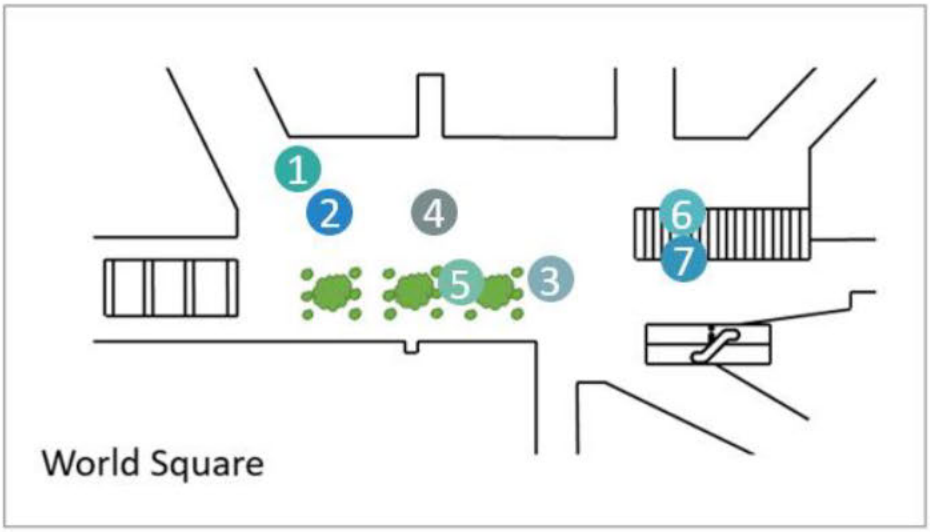


Figure 77. Map of locations where Participant 2 recorded their responses across World Square and Darling Square.

PARTICIPANT 3 "OMAR"



Key

1. Interesting feature
2. Disinteresting feature
3. Orderly design & pattern
4. Open & exposed
5. Natural elements
6. Upkeep & derelict
7. Liveliness & people

Figure 78. Map of locations where Participant 3 recorded their responses across World Square and Darling Square.

PARTICIPANT 4 “BOBBY”

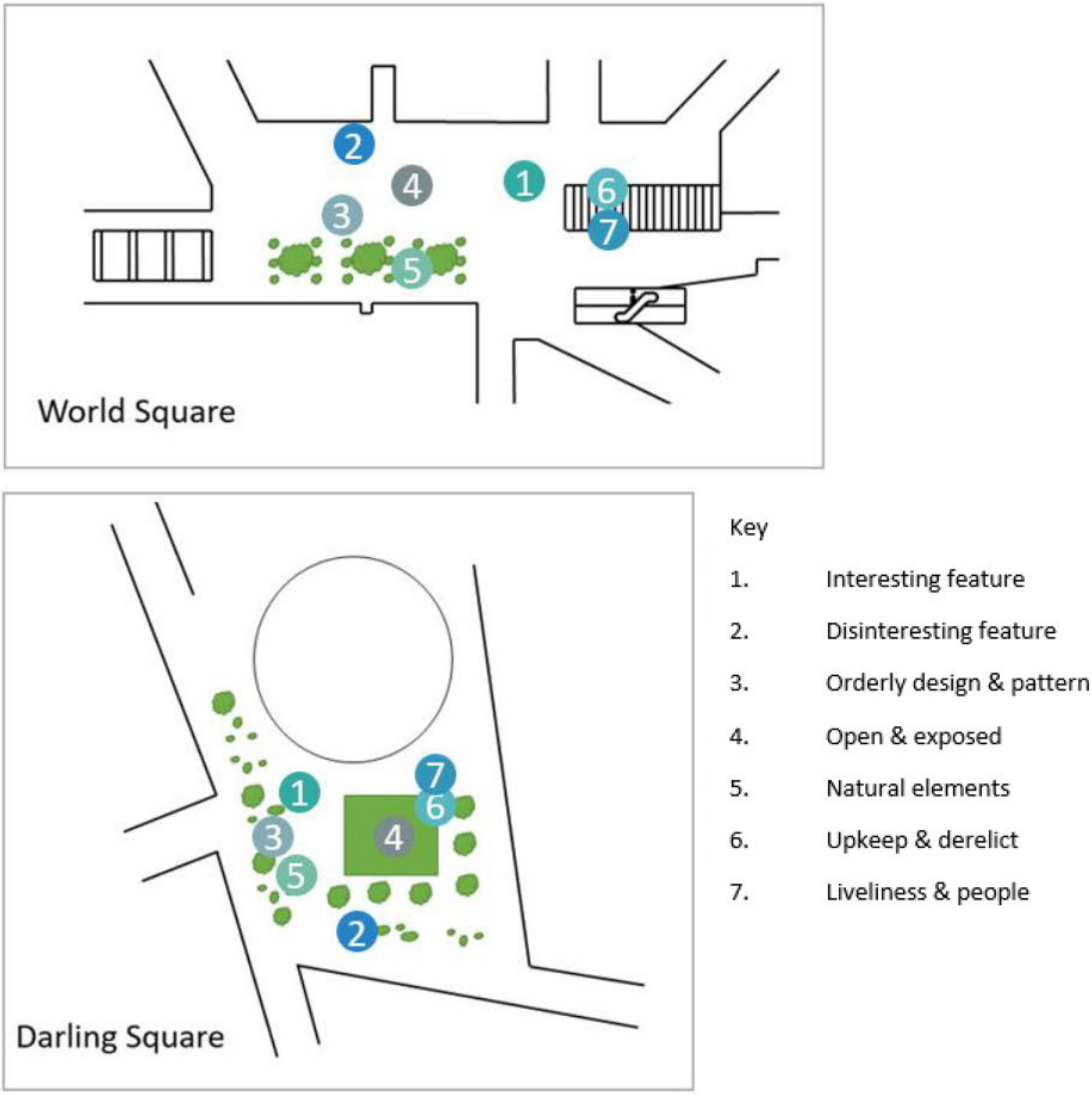


Figure 79. Map of locations where Participant 4 recorded their responses across World Square and Darling Square.

PARTICIPANT 5 "ELISE"

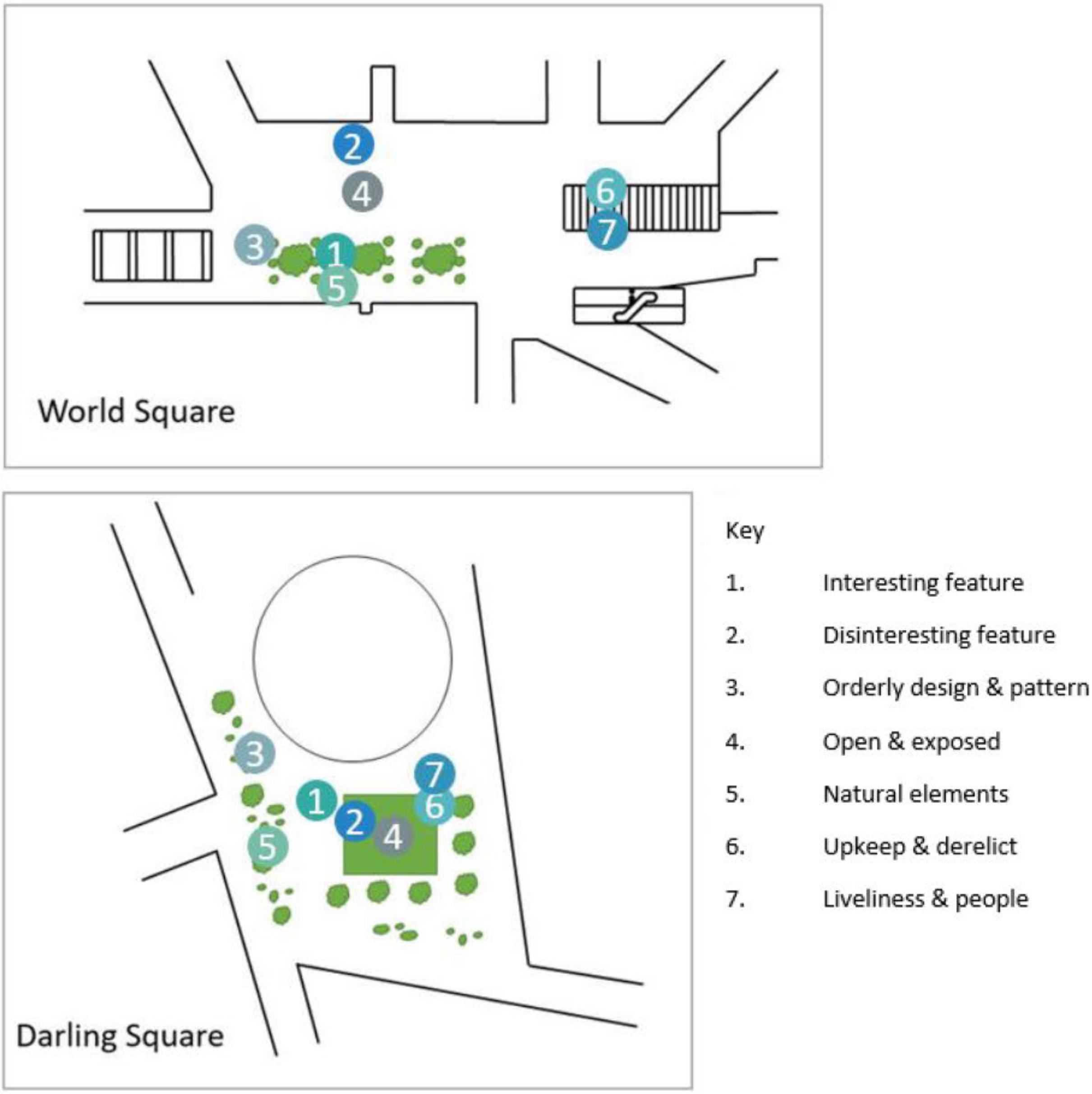


Figure 80. Map of locations where Participant 5 recorded their responses across World Square and Darling Square.

PARTICIPANT 6 "HARVEY"

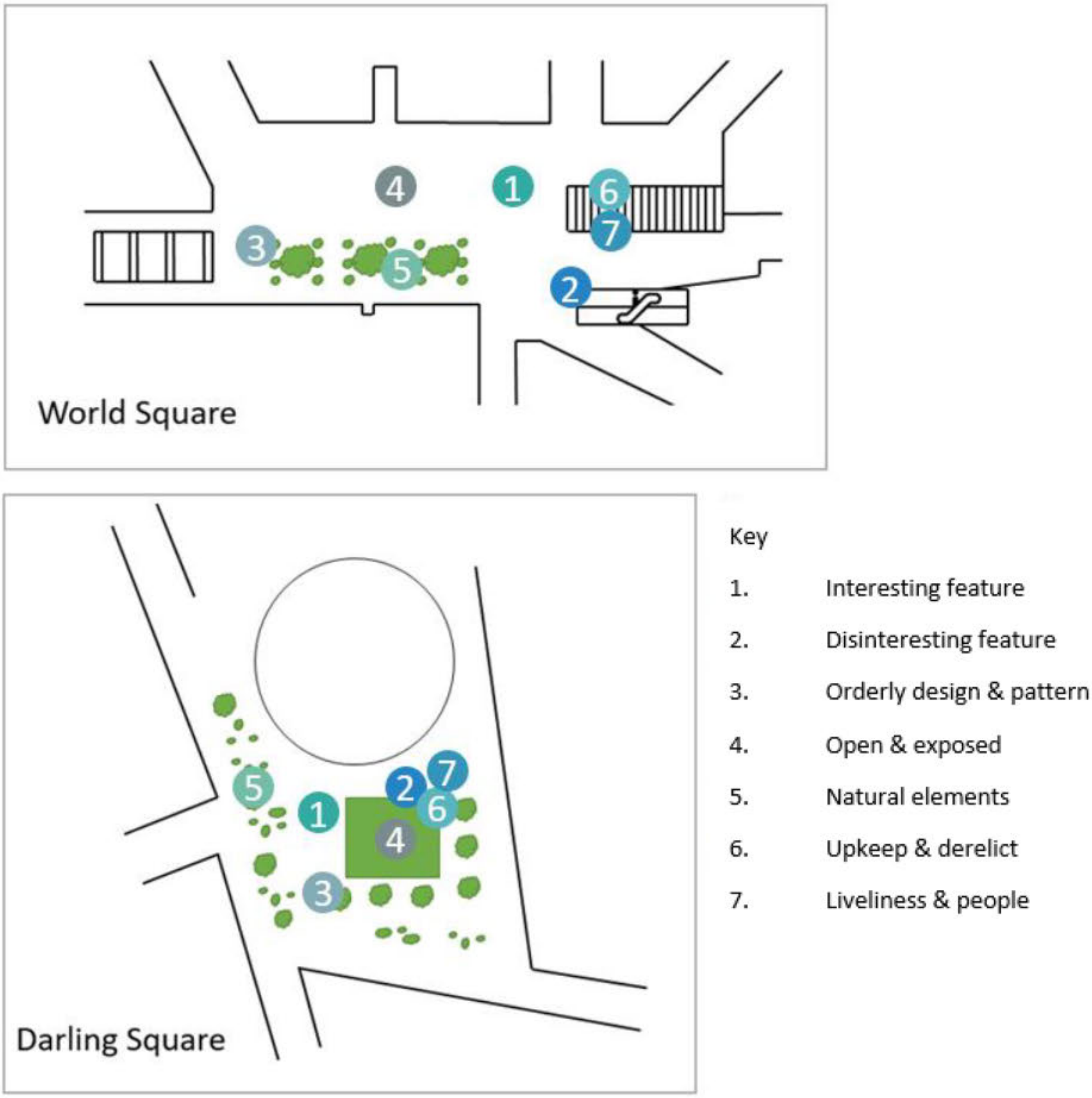


Figure 81. Map of locations where Participant 6 recorded their responses across World Square and Darling Square.

PARTICIPANT 7 “ELENA”

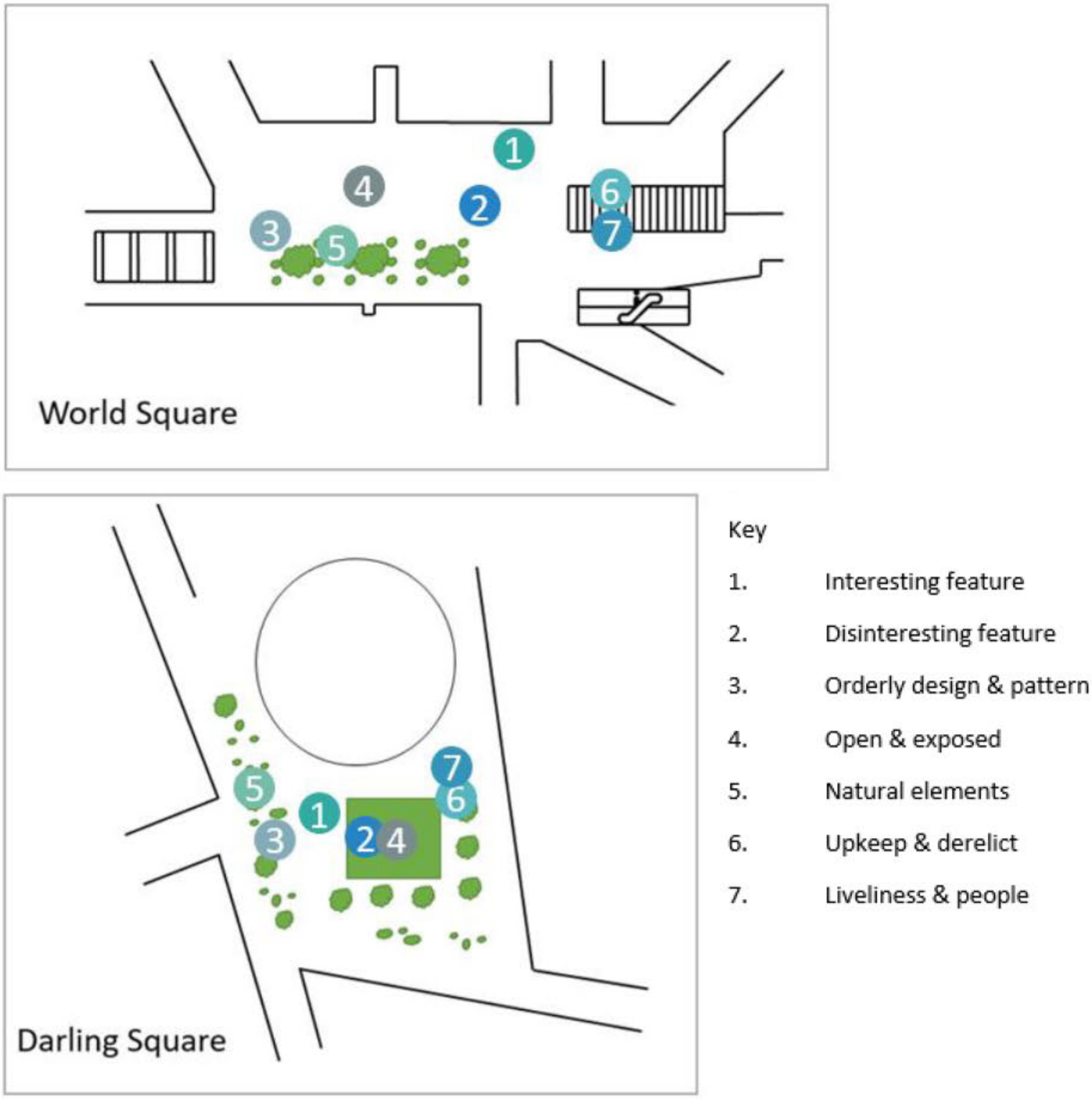


Figure 82. Map of locations where Participant 7 recorded their responses across World Square and Darling Square.

PARTICIPANT 8 "KALINDA"

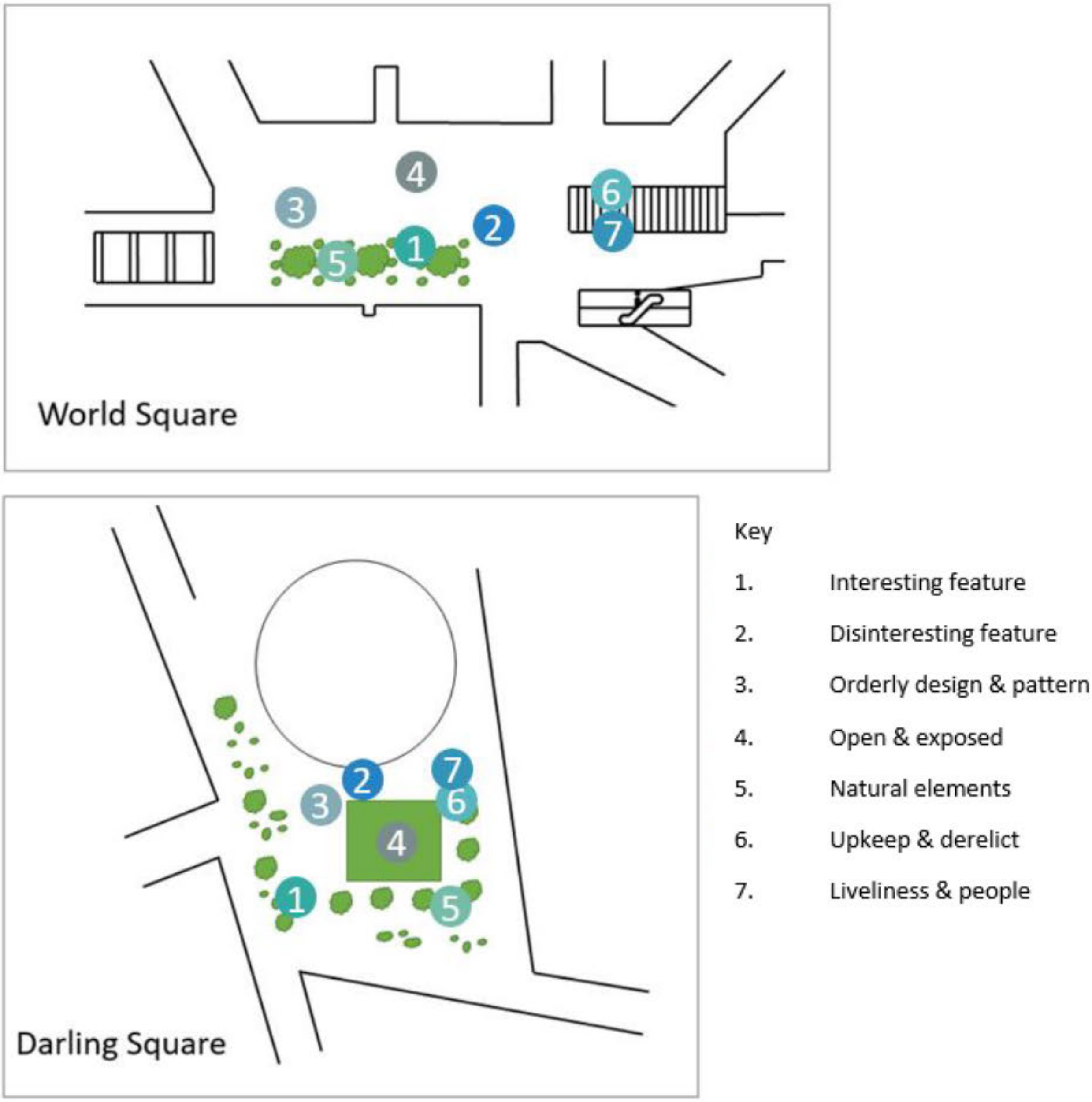
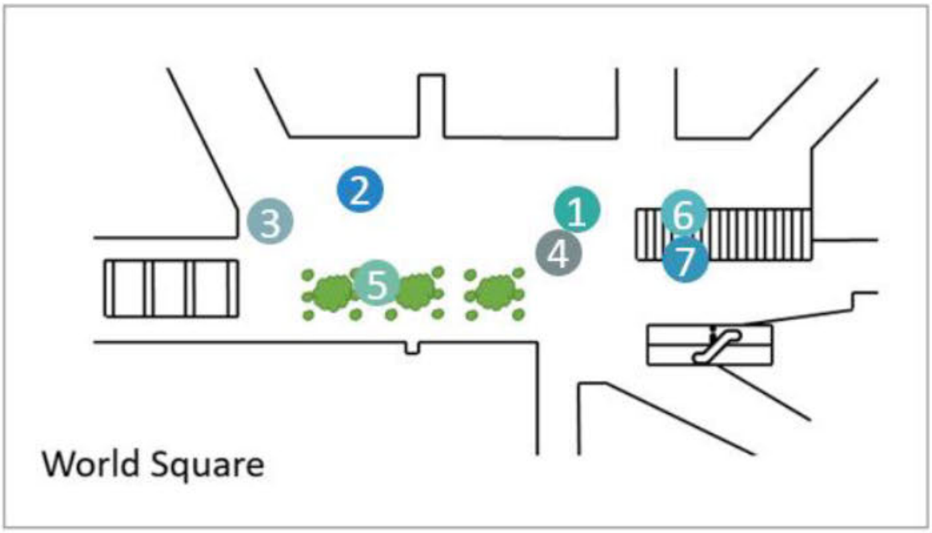


Figure 83. Map of locations where Participant 8 recorded their responses across World Square and Darling Square.

PARTICIPANT 9 "OLIVER"



Key

1. Interesting feature
2. Disinteresting feature
3. Orderly design & pattern
4. Open & exposed
5. Natural elements
6. Upkeep & derelict
7. Liveliness & people

Figure 84. Map of locations where Participant 9 recorded their responses across World Square and Darling Square.

PARTICIPANT 10 "MIKE"

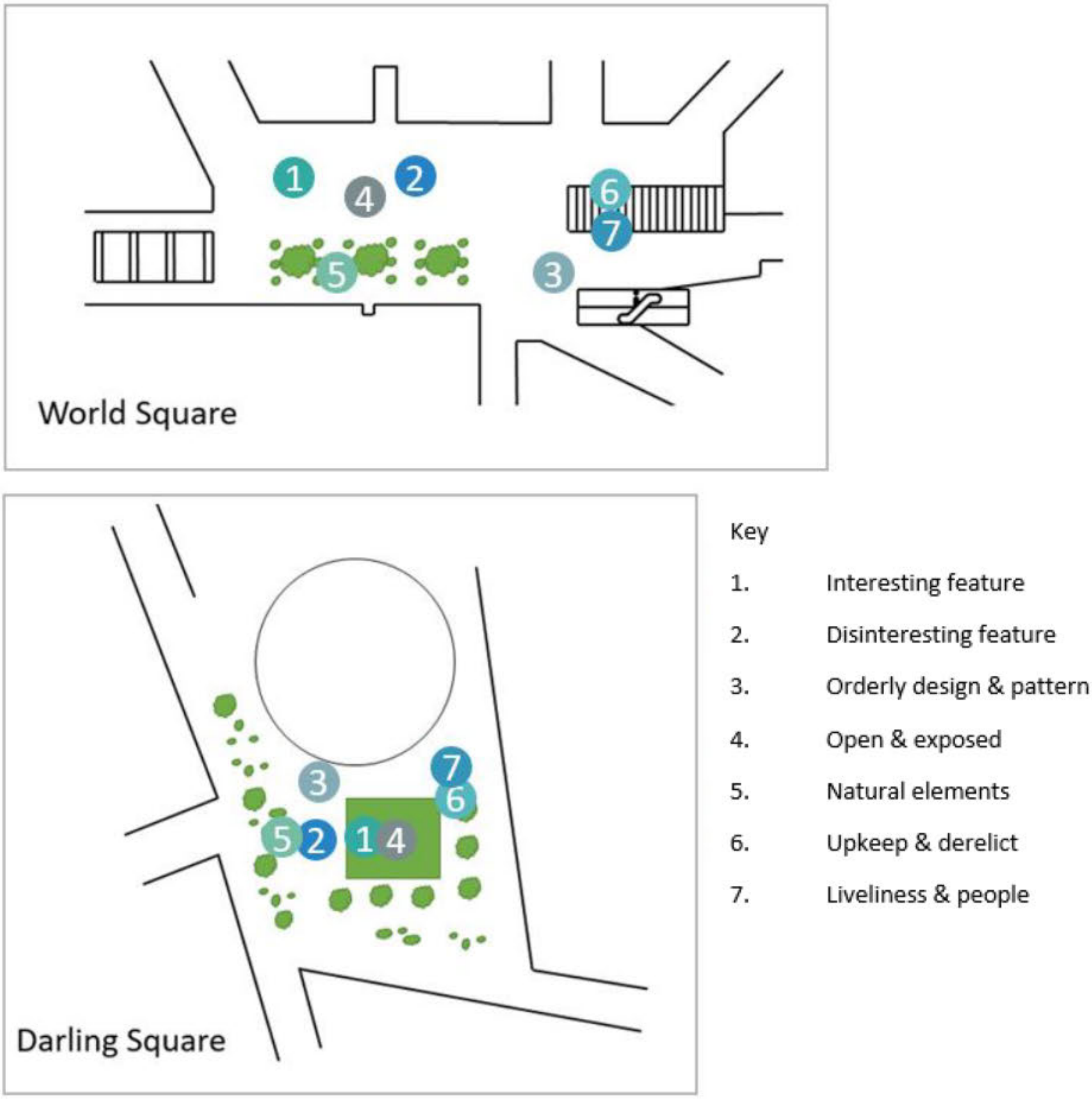


Figure 85. Map of locations where Participant 10 recorded their responses across World Square and Darling Square.

PARTICIPANT 11 "JOHN"

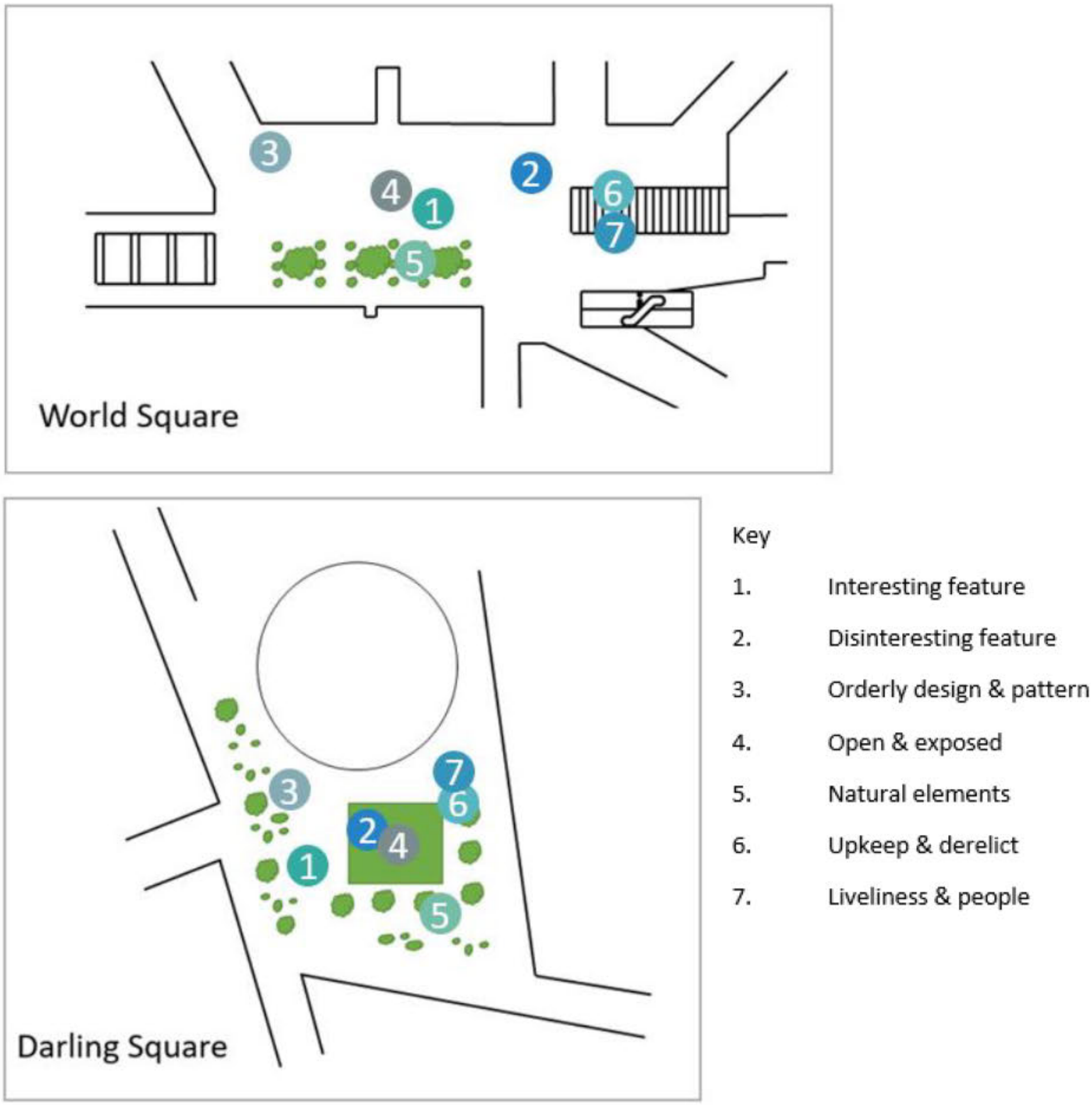
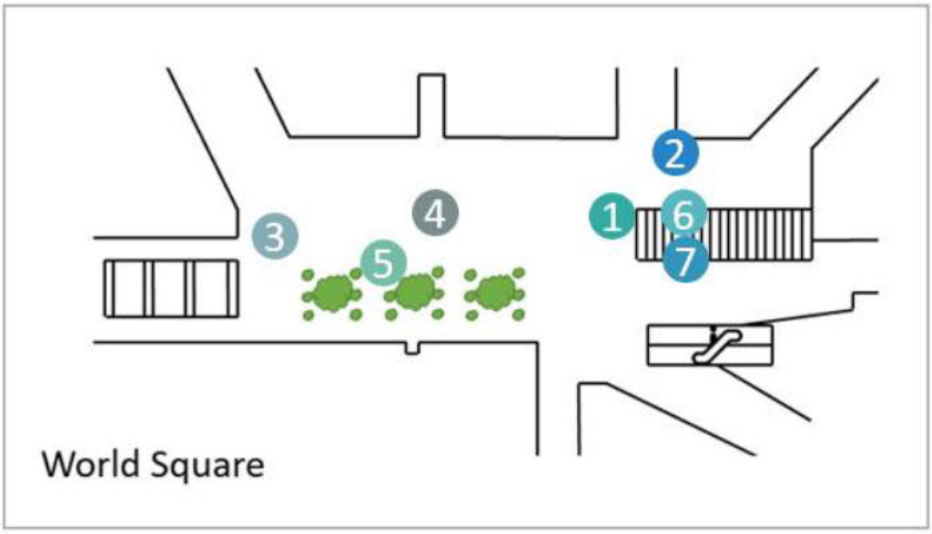


Figure 86. Map of locations where Participant 11 recorded their responses across World Square and Darling Square.

PARTICIPANT 12 "LARRY"

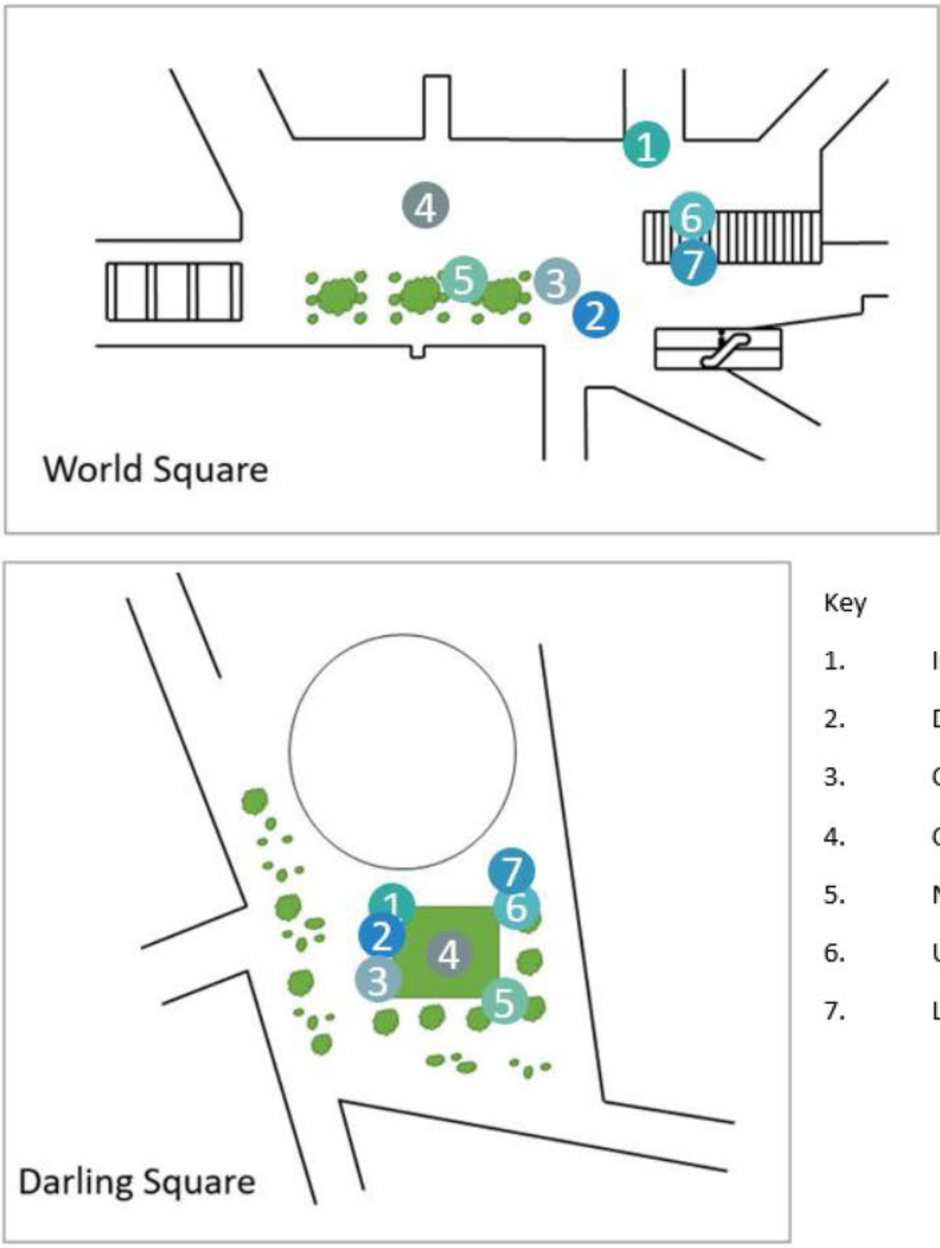


Key

1. Interesting feature
2. Disinteresting feature
3. Orderly design & pattern
4. Open & exposed
5. Natural elements
6. Upkeep & derelict
7. Liveliness & people

Figure 87. Map of locations where Participant 12 recorded their responses across World Square and Darling Square.

PARTICIPANT 13 "JOSEPHINE"

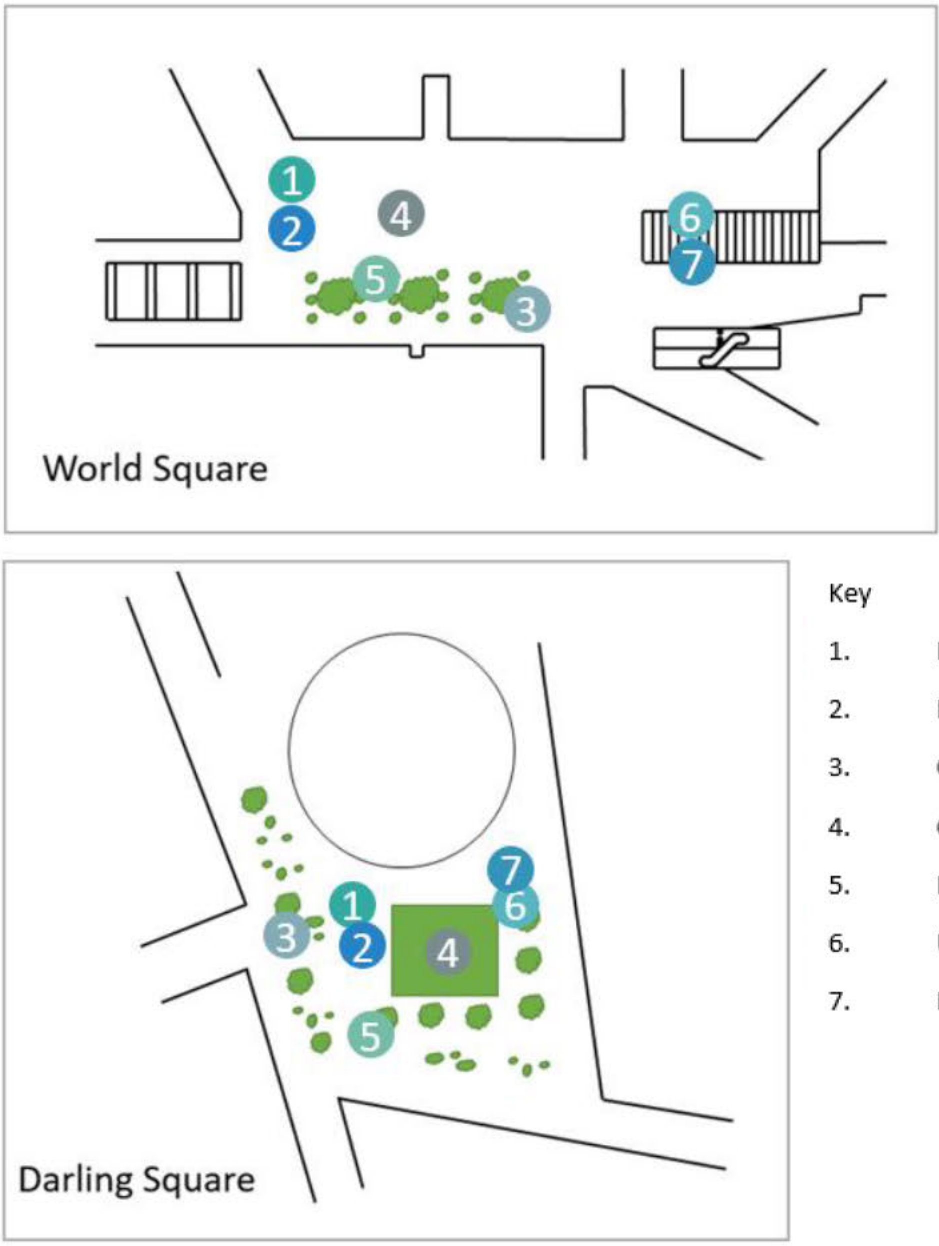


Key

1. Interesting feature
2. Disinteresting feature
3. Orderly design & pattern
4. Open & exposed
5. Natural elements
6. Upkeep & derelict
7. Liveliness & people

Figure 88. Map of locations where Participant 13 recorded their responses across World Square and Darling Square.

PARTICIPANT 14 "JING"

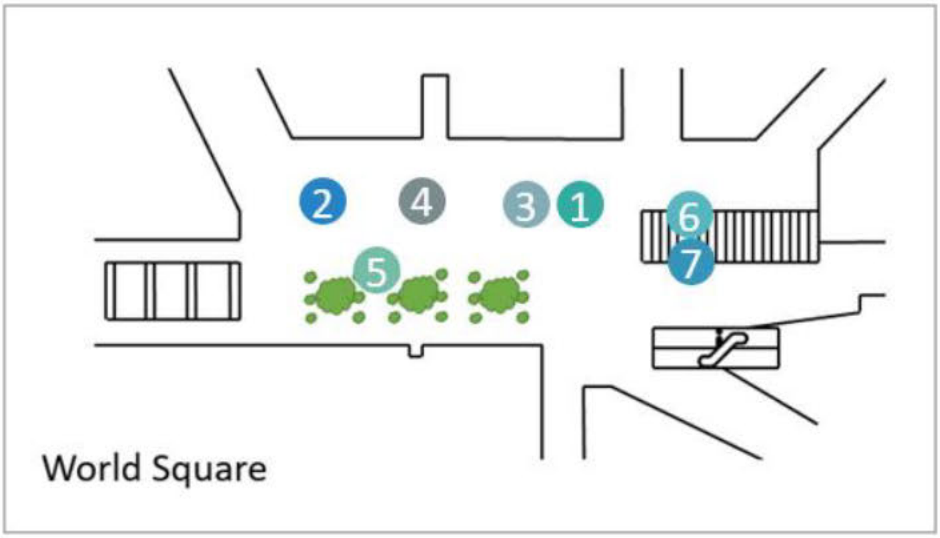


Key

1. Interesting feature
2. Disinteresting feature
3. Orderly design & pattern
4. Open & exposed
5. Natural elements
6. Upkeep & derelict
7. Liveliness & people

Figure 89. Map of locations where Participant 14 recorded their responses across World Square and Darling Square.

PARTICIPANT 15 "JANE"



Key

1. Interesting feature
2. Disinteresting feature
3. Orderly design & pattern
4. Open & exposed
5. Natural elements
6. Upkeep & derelict
7. Liveliness & people

Figure 90. Map of locations where Participant 15 recorded their responses across World Square and Darling Square.

PARTICIPANT 16 "BEN"

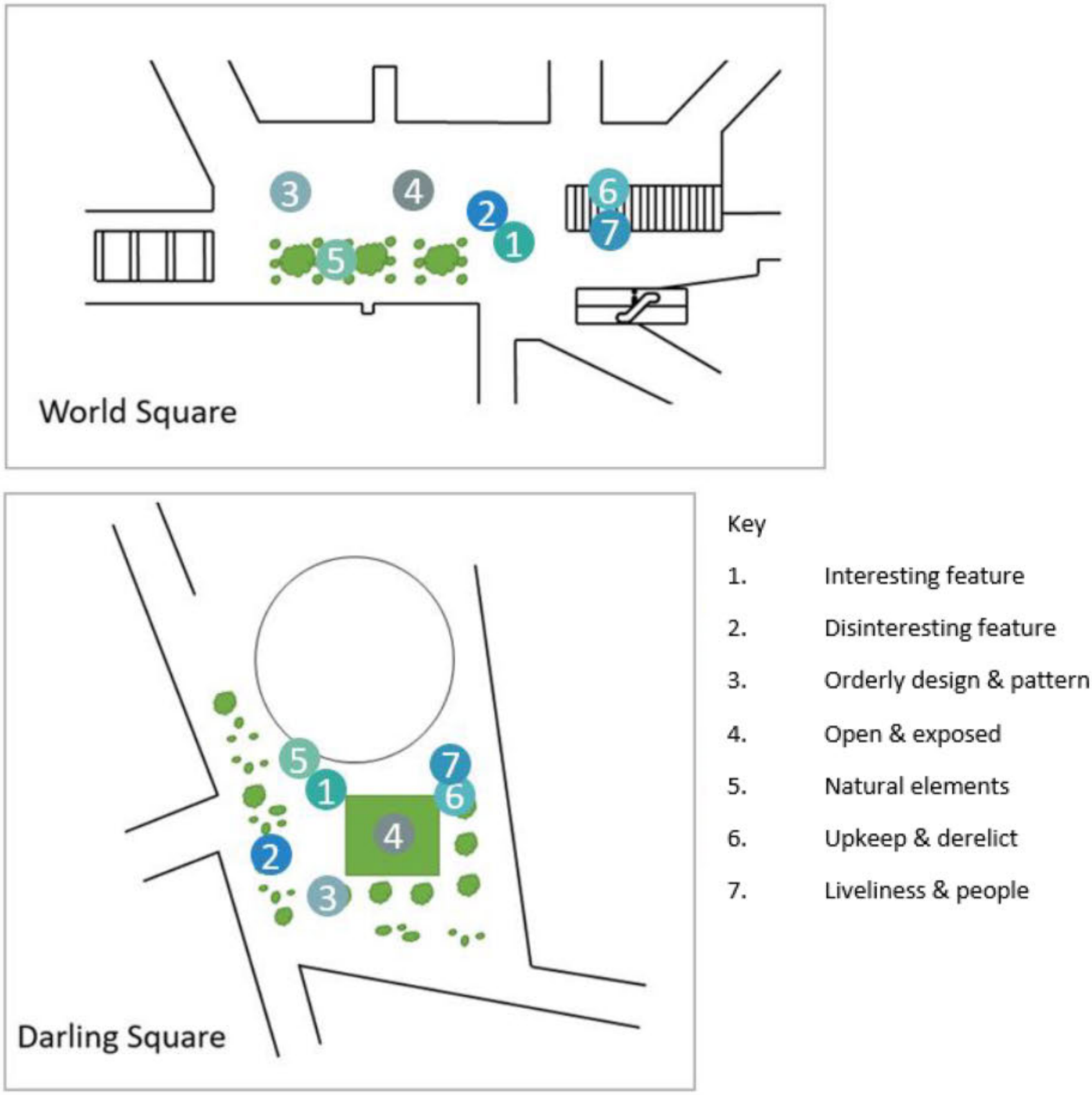


Figure 91. Map of locations where Participant 16 recorded their responses across World Square and Darling Square.

PARTICIPANT 17 "ALEXANDER"

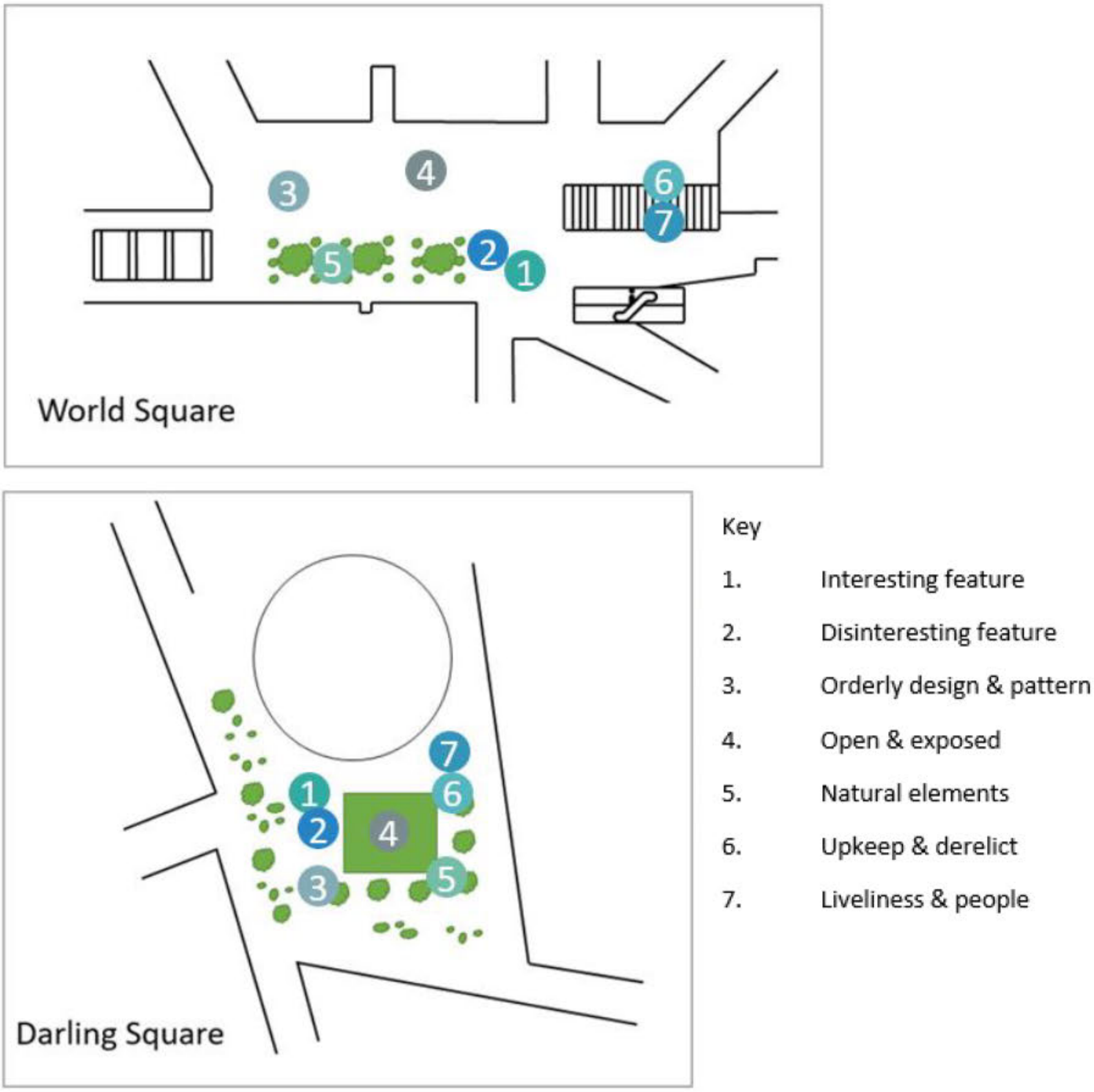
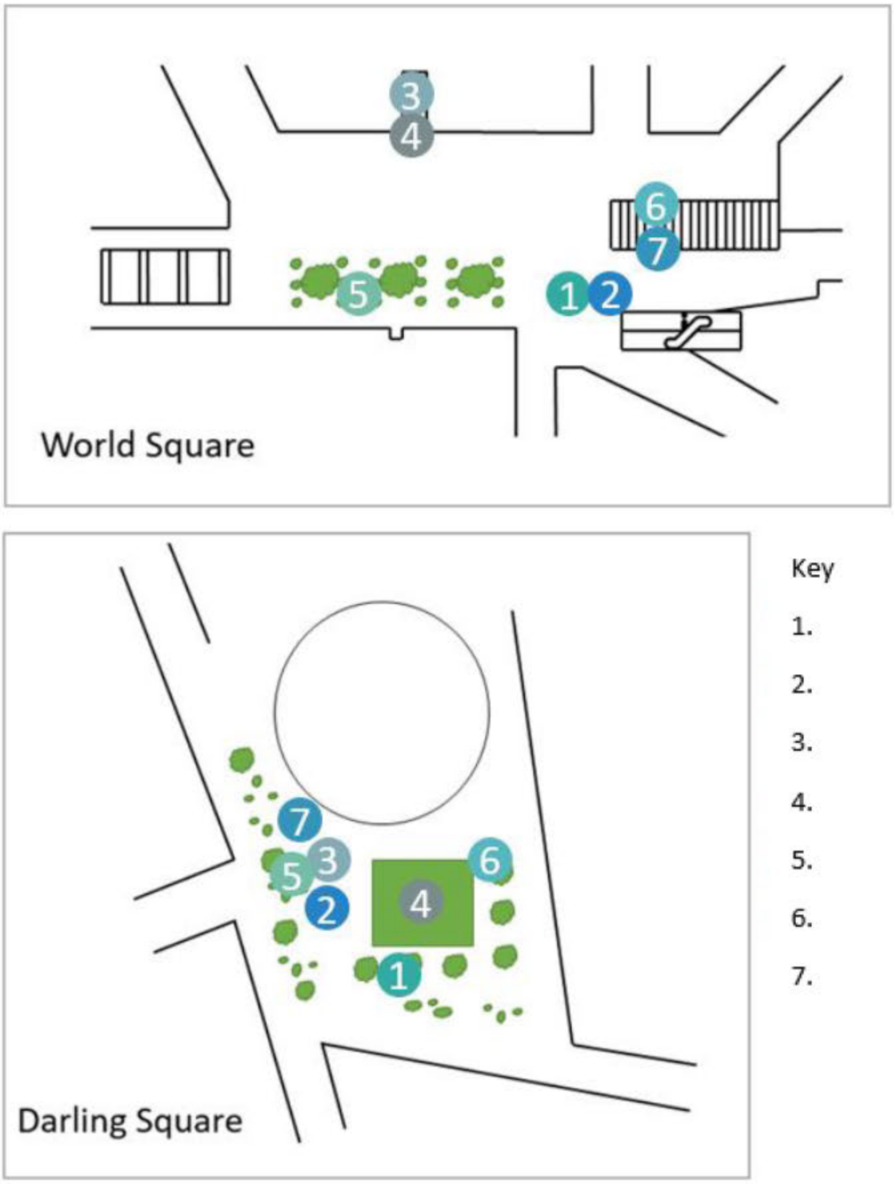


Figure 92. Map of locations where Participant 17 recorded their responses across World Square and Darling Square.

PARTICIPANT 18 "HELEN"

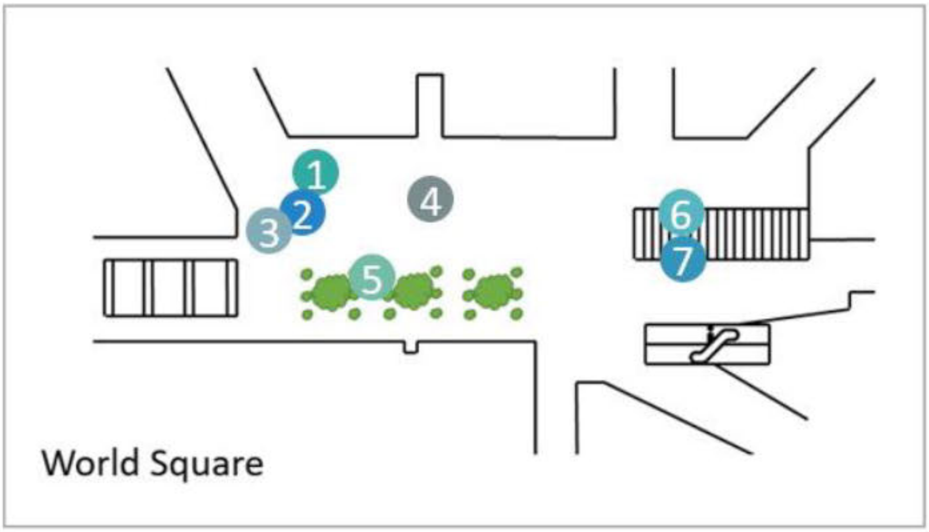


Key

1. Interesting feature
2. Disinteresting feature
3. Orderly design & pattern
4. Open & exposed
5. Natural elements
6. Upkeep & derelict
7. Liveliness & people

Figure 93. Map of locations where Participant 18 recorded their responses across World Square and Darling Square.

PARTICIPANT 19 "NEHA"



Key

1. Interesting feature
2. Disinteresting feature
3. Orderly design & pattern
4. Open & exposed
5. Natural elements
6. Upkeep & derelict
7. Liveliness & people

Figure 94. Map of locations where Participant 19 recorded their responses across World Square and Darling Square.

PARTICIPANT 20 "NOEL"

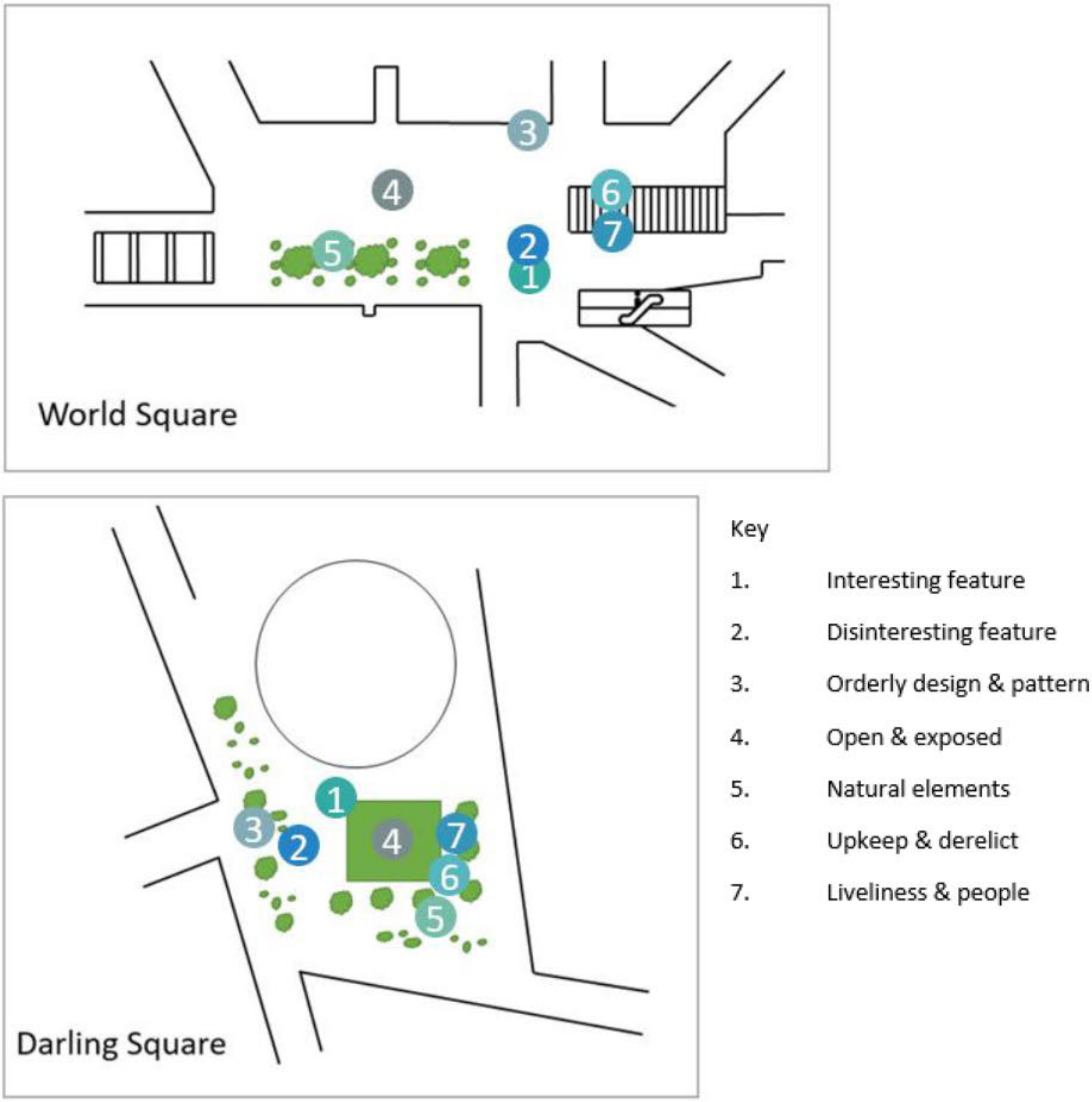


Figure 95. Map of locations where Participant 20 recorded their responses across World Square and Darling Square.

APPENDIX I – WALKING ROUTE BETWEEN CASE STUDY SITES

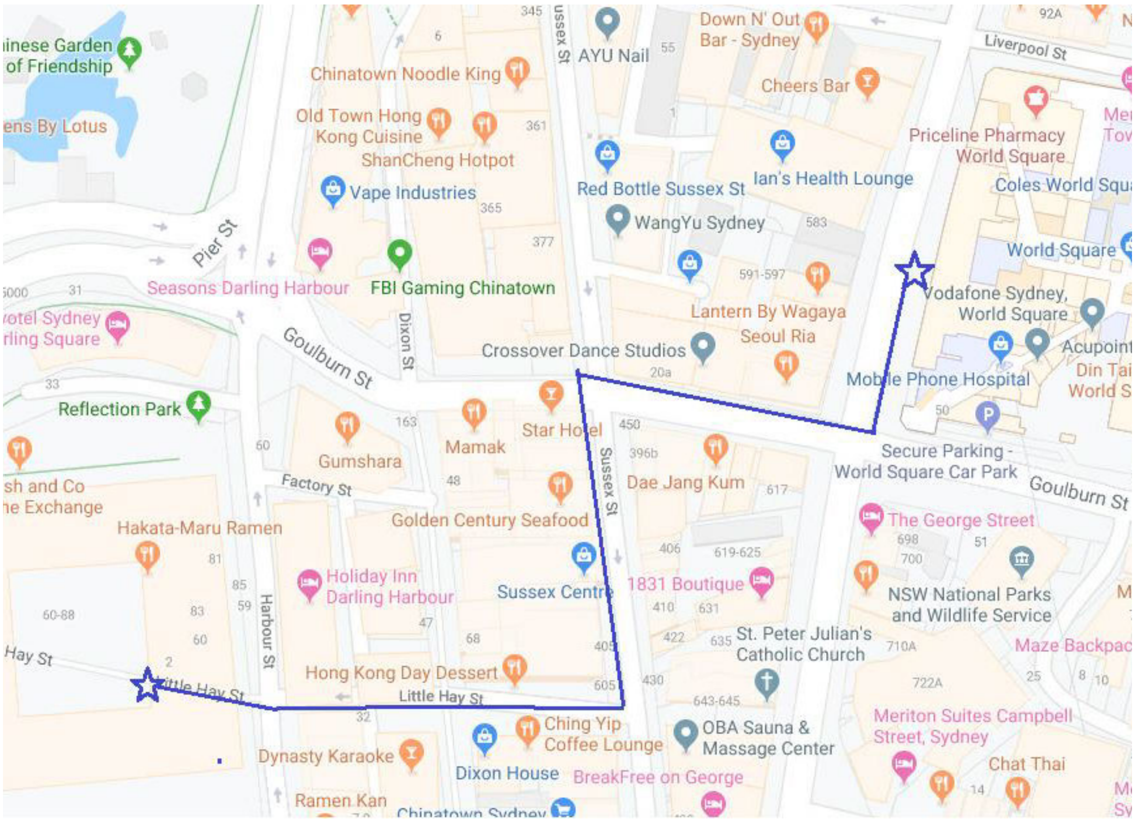


Figure 96. Map of walking route participants were taken on to cross from World Square to Darling Square. Image: Google Maps. Accessed 14/10/2019.

APPENDIX J – SAMPLE EXTRACT FOR PARTICIPANT TRANSCRIPT

TE: All right. So now we're going to have a bit of a walk around, get a feel for the place.

“Josephine”: Just anywhere?

TE: Yeah, I will follow you. We're sticking to the open-air parts because the connection drops out in the alleyways.

“Josephine”: Oh really? Okay. I like the sun here, it's nice.

TE: All right. So what's your impressions of the experience of World Square?

“Josephine”: Well, I like the open space, but you know what these tiles they're so grey.

TE: Which tiles?

“Josephine”: The tiles on the floor, on the ground. Which kind of gives it that, sort of, I don't know, that sterile or feeling. Just really colourful. Actually as I look around me I see a lot of grey and a few colourful things to break it up like that.

TE: Do you mean the sculpture?

“Josephine”: Yeah, the lights, colourful like this. Which generally it's a kind of clinical or a sterile experience [too windy 01:25]. Yeah just a grey experience, and I think I generally respond to colours and feel quite connected to colours and I feel their impact. Yeah.

TE: So what's the most interesting thing about the design of World Square?

“Josephine”: Design? Probably the open space with all the alleyways coming off it. So that you can get to certain sections of the city really easily.

TE: So the layout of it?

“Josephine”: The layout yeah-

TE: Okay.

“Josephine”: Is that kind of what you were after?-

TE: It's whatever your experience. I can't lead you one way or another on this.

“Josephine”: Yeah. Okay, I get you.

TE: So if that's what you find most interesting, we'll reflect on that.

“Josephine”: Yeah, okay.

TE: What is it that interests you about the alleyways?

“Josephine”: I guess there's always little pathways of meet, little places to sit in the alleyways. Reminds me a little bit of Melbourne and all the little alleyways down there. Which I just find that it would be nice living by the sea, to get away from the world sometimes.

TE: Ok, we’ll go to the cue card and keep focusing on the alleyways.

“Josephine”: Yes.

TE: Using the a scale of zero being dislike and 10 being like, to what extent do you like the alleyways?

“Josephine”: I really like them. Ten. Because actually, when I look at that alleyway there [*Liverpool lane*] I can see lights and things. I just, I feel like there's more character in the open space.

TE: Okay so on to question two. To what extent do you find the alleyway stimulating with zero being not at all stimulating and 10 being very stimulating?

“Josephine”: I think if I walked through there I'd be quite a lot more stimulated then standing here. Because it's probably less windy in the alleyways too. So when there's gusts of wind I feel a little cold when that happens. Did I give you a number though?

TE: Not yet.

“Josephine”: I'm going to go another ten. Is that too strong though. Really I should scale it back a little bit. No, I'm going to be, I'm going to be on the extreme.

TE: So that's fine. So thinking about the alleyways still, to what extent do you find them stressful with zero being not at all and ten being very?

“Josephine”: So if I was to walk through and it was really, really crowded, say during lunch time or something, I'd probably find that a little stressful. So maybe a seven.

TE: And to what extent would you find the alleyways relaxing with zero being not at all relaxing and 10 being very?

GC “Josephine”: So the opposite of that, I guess if I walked through and it wasn't too crowded, with the pretty lights and everything and I think I would be very relaxed. I would give it a ten.

APPENDIX K – PARTICIPANT INFORMATION AND CONSENT FORM

PARTICIPANT INFORMATION STATEMENT AND CONSENT FORM

Urban Design:
How can embodied cognition theory be used to improve the outcomes of urban design?

Associate Professor Nancy Marshall

1. What is the research study about?

You are invited to take part in this research study. The research study aims to investigate how people respond to different styles of urban design. This study involves asking people to walk through World Square and Darling, which are located 5-6 minutes' walk of each other in the city, and asking people to reflect on what they experience. The data collected will be used to determine whether people have similar responses to the design of these places. You have been invited because you meet the eligibility criteria of the study and are willing to volunteer.

2. Who is conducting this research?

The study is being carried out by the following researchers:
Associate Professor Nancy Marshall, faculty of the Built Environment
Dr Joshua Zeunert, faculty of the Built Environment
Tanya Eldridge, PhD Candidate, faculty of the Built Environment.
Research Funder: This research is being funded by UNSW.

3. Inclusion/exclusion criteria

Before you decide to participate in this research study, we need to ensure that it is ok for you to take part. The research study is looking recruit people who meet the following criteria:

- Between 25 – 45 years of age.
- Lived in urban areas of Sydney for at least 5 years.
- Able to walk 2 km unassisted.
- Free of any visual or auditory impairments.

4. Do I have to take part in this research study?

Participation in this research study is voluntary. If you do not want to take part, you do not have to. If you decide to take part and later change your mind, you are free to withdraw from the study at any stage.

If you decide you want to take part in the research study, you will be asked to:

- Read the information carefully (ask questions if necessary);
- Sign and return the consent form if you decide to participate in the study;
- Take a copy of this form with you to keep.

5. What does participation in this research require, and are there any risks involved?

If you decide to take part in the research study, the research team will ask you to wear an EEG monitor and walk through two places in the city. EEG monitors place sensors on your scalp to record the electrical information of your brain. There is no risk to the wearer. The sensors only detect electrical activity already present and do not send electricity into the wearer.

You will be asked to walk to specific design features to match your response to the place that you experience. We will ask you to complete a survey at key points during this walk. The survey will ask you about how you felt while being in each place. We will be making an audio recording of you during this time to record your thoughts about each place. In total it should take approximately 30 minutes to complete the task in each of the case study sites.

If you experience discomfort or feelings of distress while participating in the research and you require support, you can stop participating at any time. You can also tell a member of the research team and they will provide you with assistance or alternatively a list of support services and their contact details are provided below.

6. What are the possible benefits to participation?
We hope to use information we get from this research study to benefit urban design of the public spaces. The findings of this research will be used to inform the development of evidence-based policy decisions. The research will expand on the existing evidence base that supports the effectiveness of people-centred urban design theory.

7. What will happen to information about me?

By signing the consent form you consent to the research team collecting and using information about you for the research study. Your data will be kept for 5 years after the project's completion. We will store information about you in a non-identifiable format electronically with password protection, at the UNSW OneDrive. Your information will only be used in a de-identified form only and you will be given a pseudonym in any instances that the collected data is used.

The information you provide is personal information for the purposes of the Privacy and Personal Information Protection Act 1998 (NSW). You have the right of access to personal information held about you by the University, the right to request correction and amendment of it, and the right to make a complaint about a breach of the Information Protection Principles as contained in the PPIP Act. Further information on how the University protects personal information is available in the **UNSW Privacy Management Plan**.

8. How and when will I find out what the results of the research study are?

The research team intend to publish and present at conferences using the data collected from volunteers. All information published will be done in a way that will not identify you. If you would like to receive a copy of the results you can let the research team know by including your details in the space provided in the consent form.

9. What if I want to withdraw from the research study?
If you do consent to participate, you may withdraw at any time. You can do so by completing the 'Withdrawal of Consent Form' which is provided at the end of this document. Alternatively you can ring the research team and tell them you no longer want to participate. Your decision not to participate or to withdraw from the study will not affect your relationship with UNSW Sydney. If you decide to leave the research study, the researchers will not collect additional information from you. Any identifiable information about you will be withdrawn from the research project.

10. What should I do if I have further questions about my involvement in the research study?
The person you may need to contact will depend on the nature of your query. If you require further information regarding this study or if you have any problems which may be related to your involvement in the study, you can contact the following member/s of the research team:

Research Team Contact Details

Name	Dr Nancy Marshall
Position	Associate Professor
Telephone	9385 4212
Email	n.marshall@unsw.edu.au

Support Services Contact Details

If at any stage during the study you become distressed or require additional support from someone not involved in the research please call:

Organisation	Life Line
Telephone	13 11 14
Website with online chat	www.lifeline.org.au

What if I have a complaint or any concerns about the research study?

If you have a complaint regarding any aspect of the study or the way it is being conducted, please contact the UNSW Human Ethics Coordinator:

Complaints Contact

Position	UNSW Human Research Ethics Coordinator
Telephone	+ 61 2 9385 6222
Email	humanethics@unsw.edu.au
HC Reference Number	HC190698

PARTICIPANT INFORMATION STATEMENT AND CONSENT FORM

Urban Design Governance:
How can embodied cognition theory be used to improve the outcomes of urban design?

Associate Professor Nancy Marshall

Consent Form – Participant providing own consent

Declaration by the participant

☐ I understand I am being asked to provide consent to participate in this research study;

☐ I have read the Participant Information Sheet or someone has read it to me in a language that I understand;

☐ I understand the purposes, study tasks and risks of the research described in the study;

☐ I understand that the research team will audio/video record the interviews; I agree to be recorded for this purpose;

☐ I understand that the research team will collect data on the electrical patterns of my brain; I provide my consent for this to happen;

☐ I provide my consent for the information collected about me to be used for the purpose of this research study only;

☐ I have had an opportunity to ask questions and I am satisfied with the answers I have received;

☐ I freely agree to participate in this research study as described and understand that I am free to withdraw at any time during the study and withdrawal will not affect my relationship with any of the named organisations and/or research team members;

☐ I would like to receive a copy of the study results via email or post, I have provided my details below and ask that they be used for this purpose only;

Name: ______________________________________

Address: ____________________________________

Email Address: _______________________________

☐ I understand that I will be given a signed copy of this document to keep.

Participant Signature

Name of Participant (please print)	
Signature of Research Participant	

Date	

Declaration by Researcher*

- ☐ I have given a verbal explanation of the research study, its study activities and risks and I believe that the participant has understood that explanation.

Researcher Signature*

Name of Researcher	**Tanya Eldridge**
Signature of Researcher	
Date	

+An appropriately qualified member of the research team must provide the explanation of, and information concerning the research study.

Note: All parties signing the consent section must date their own signature.

PARTICIPANT INFORMATION STATEMENT AND CONSENT FORM
Urban Design Governance: How can embodied cognition theory be used to improve the outcomes of urban design?
Associate Professor Nancy Marshall

Form for Withdrawal of Participation

I wish to **WITHDRAW** my consent to participate in this research study described above and understand that such withdrawal **WILL NOT** affect my relationship with The University of New South Wales. In withdrawing my consent I would like any information which I have provided for the purpose of this research study withdrawn.

Participant Signature

Name of Participant (please print)	
Signature of Research Participant	
Date	

The section for Withdrawal of Participation should be forwarded to:

CI Name:	Dr Nancy Marshall
Email:	n.marshall@unsw.edu.au
Phone:	02 9385 4212
Postal Address:	UNSW, Faculty of the Built Environment, Sydney NSW 2052

APPENDIX L – RECRUITMENT FLYER

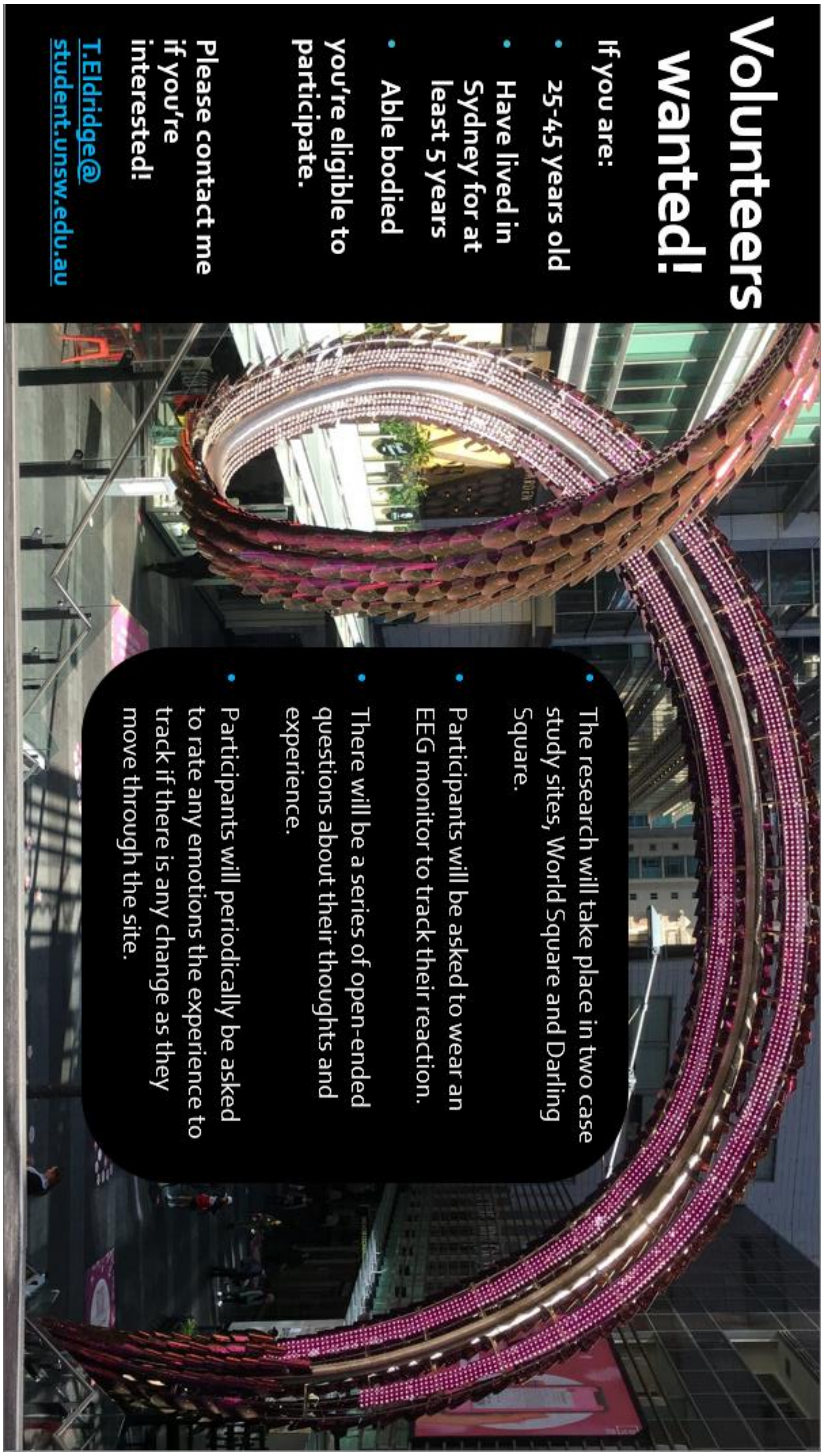


Figure 97. Recruitment flyer designed by Eldridge, T. Photo: Eldridge, T, World Square, 29/9/19.

APPENDIX M – PARTICIPANT THANK YOU LETTER

Dear

Thank you again for participating in my research investigating people's experience of the city. Your contribution of your insights and observations are an invaluable addition to my research. I greatly appreciate your generosity in taking time out of your day and coming into the city to participate.

It was great to meet you and if there's anything that you'd like to get in touch with me about, my email address is t.eldridge@student.unsw.edu.au.

With sincere thanks,

[redacted]

APPENDIX N – INDIVIDUAL PARTICIPANT SURVEY AND EEG SCORES

PARTICIPANT 1 "LAURA"

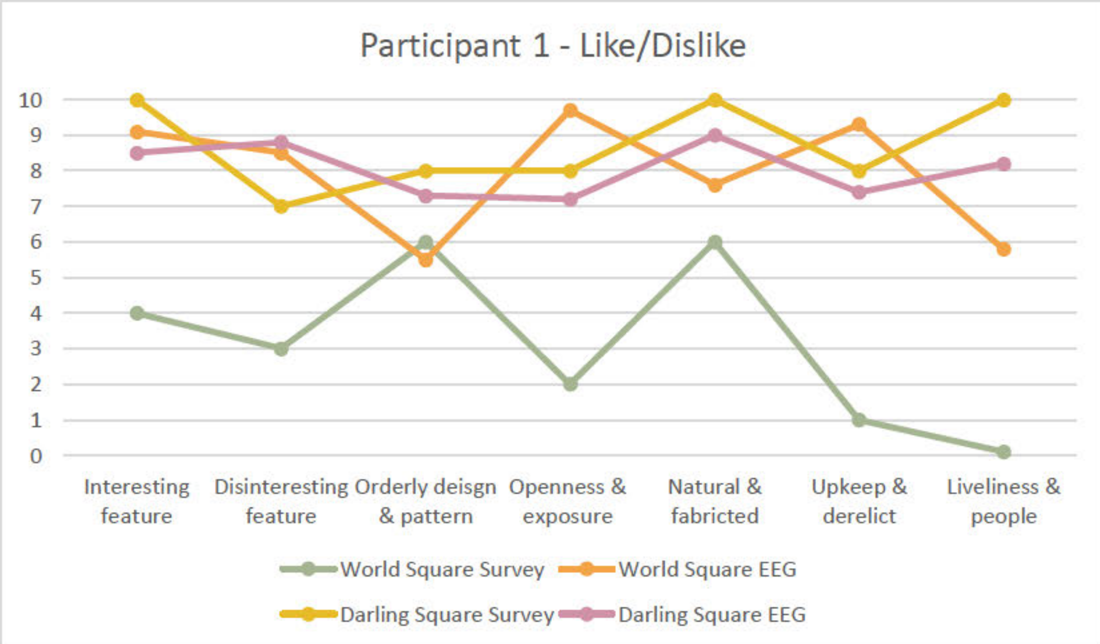


Figure 98. Graph of Participant 1's survey and EEG scores for like/dislike at World Square and Darling Square.

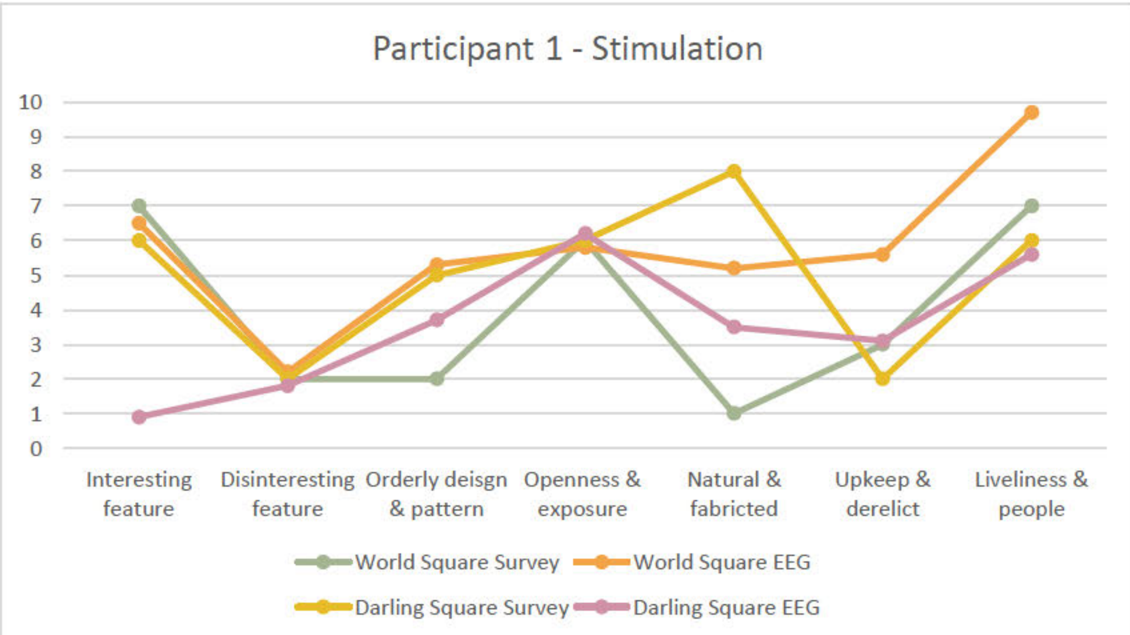


Figure 99. Graph of Participant 1's survey and EEG scores for stimulation at World Square and Darling Square.

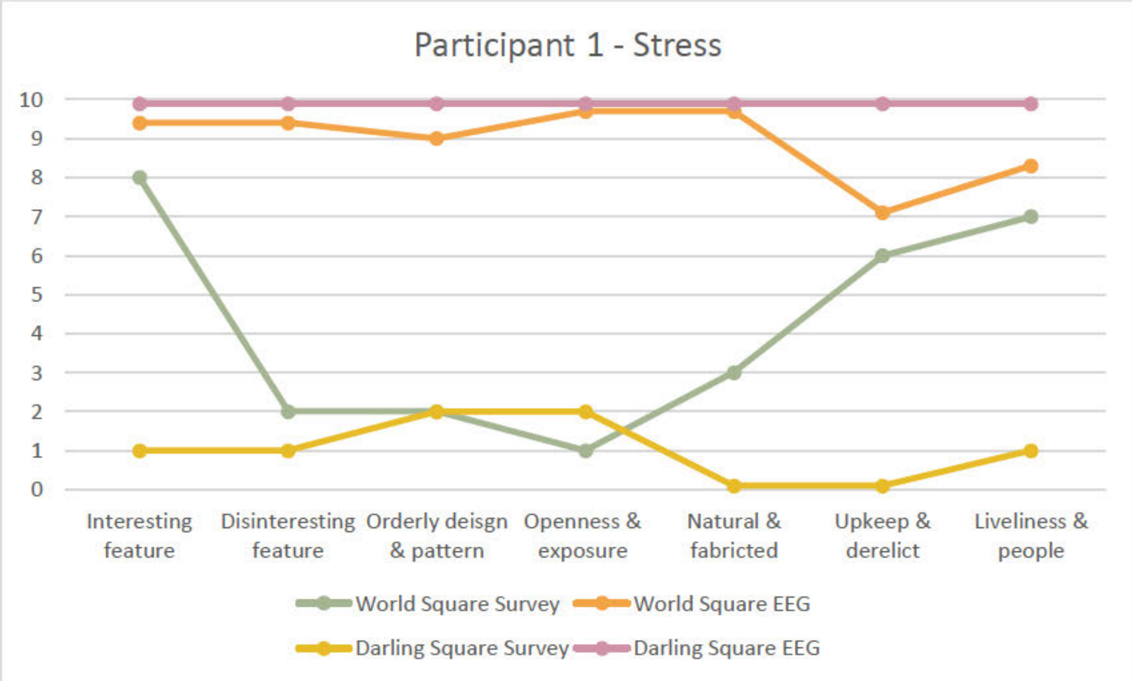


Figure 100. Graph of Participant 1's survey and EEG scores for stress at World Square and Darling Square.

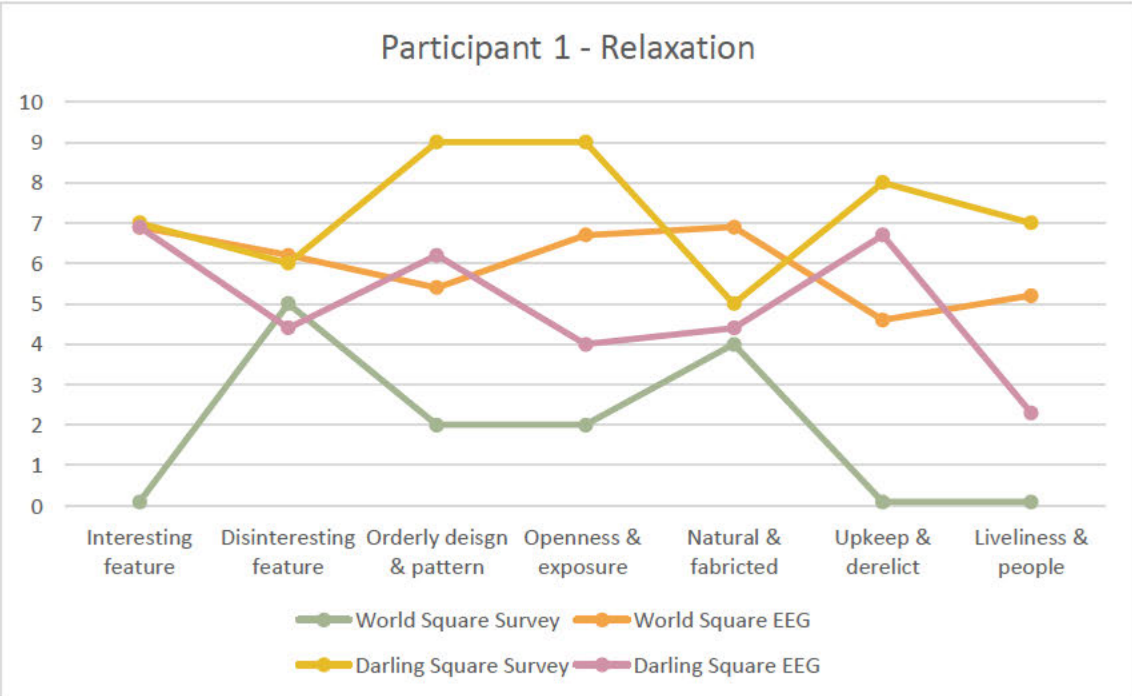


Figure 101. Graph of Participant 1's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 2 "NATALIE"

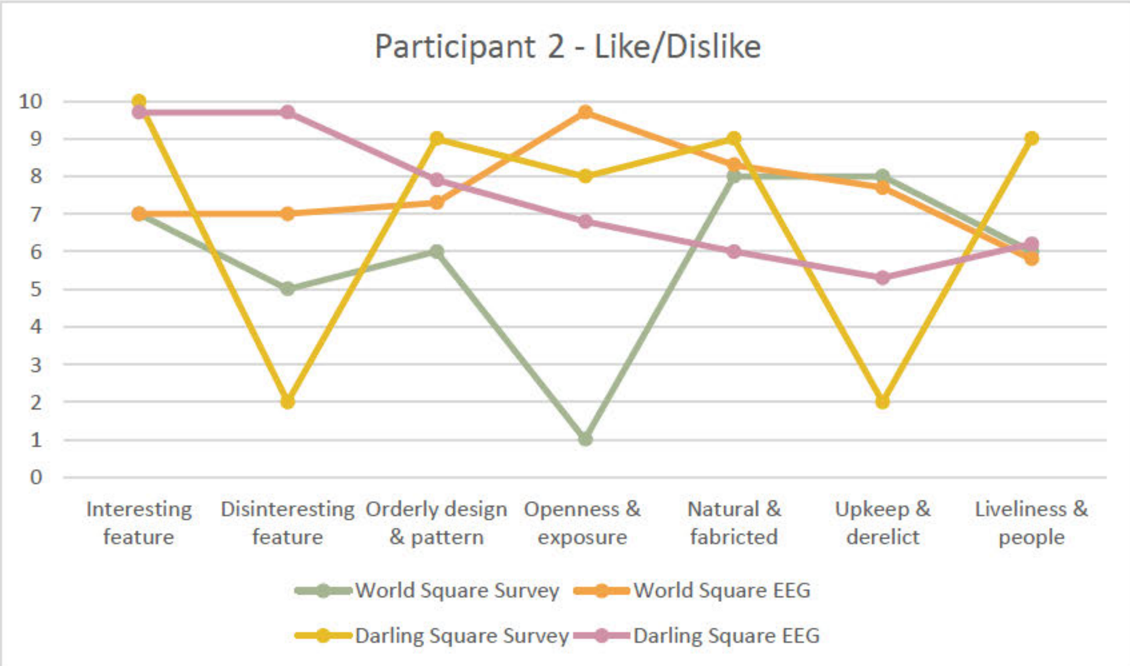


Figure 102. Graph of Participant 2's survey and EEG scores for like/dislike at World Square and Darling Square.

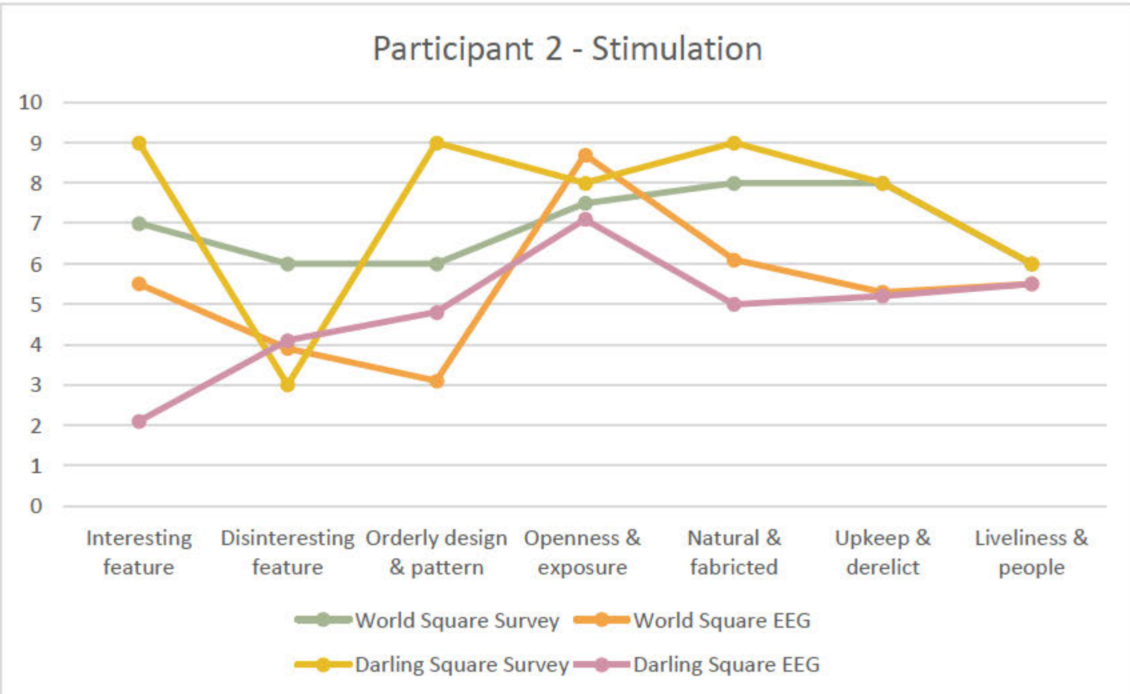


Figure 103. Graph of Participant 2's survey and EEG scores for stimulation at World Square and Darling Square.

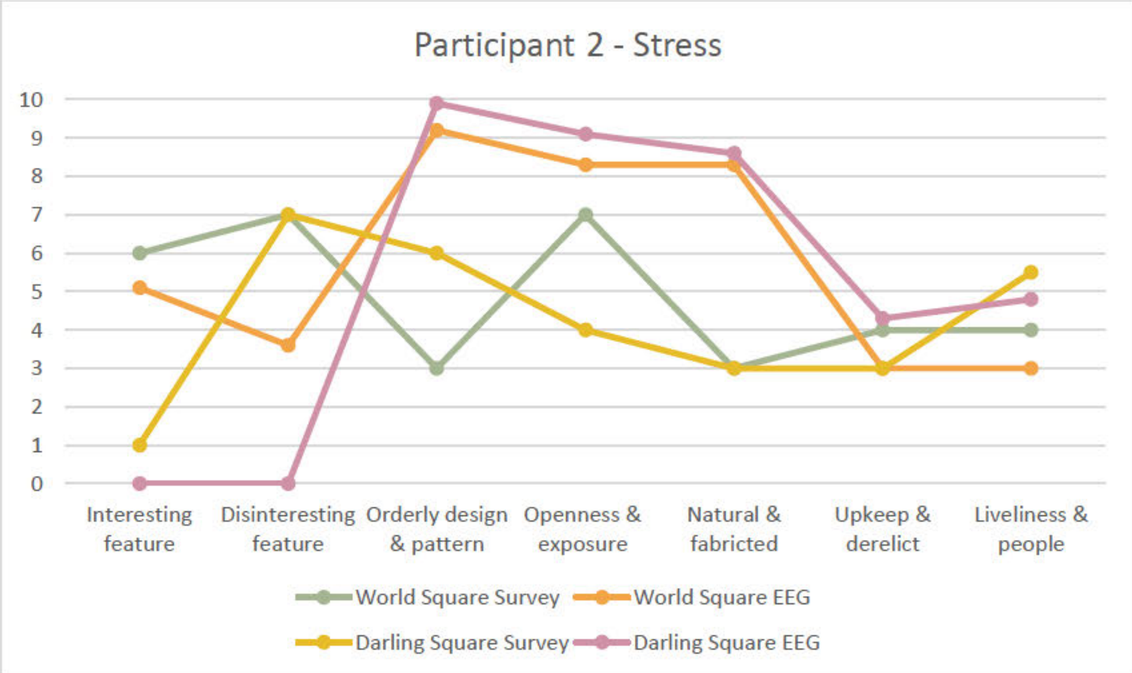


Figure 104. Graph of Participant 2's survey and EEG scores for stress at World Square and Darling Square.

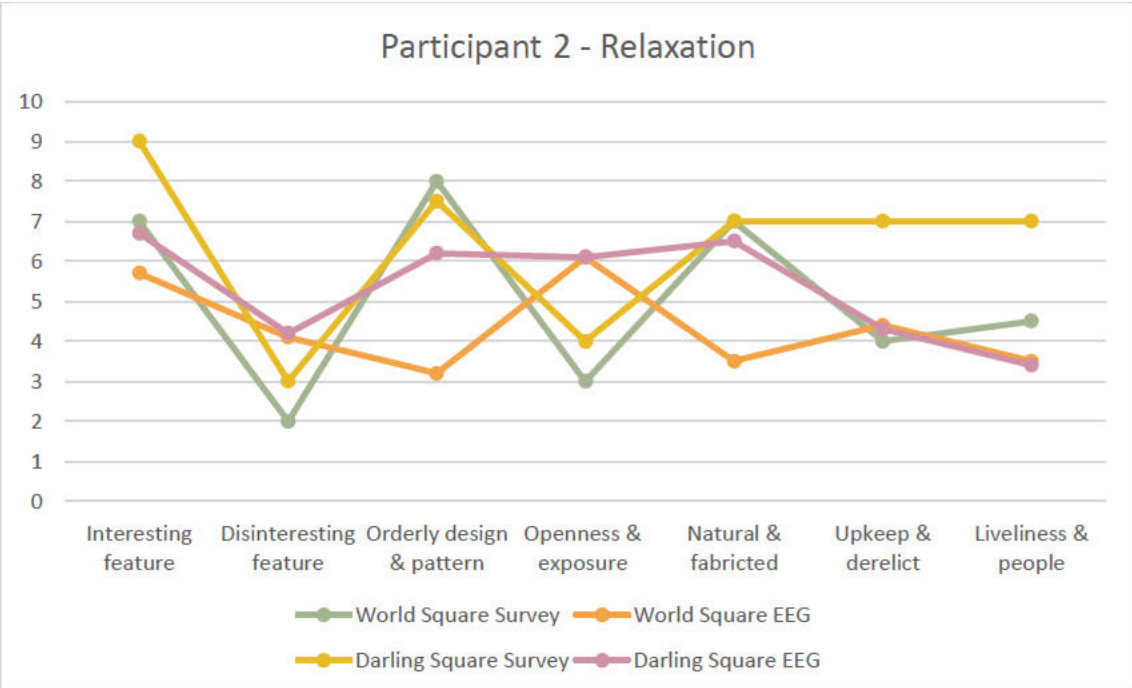


Figure 105. Graph of Participant 2's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 3 "OMAR"

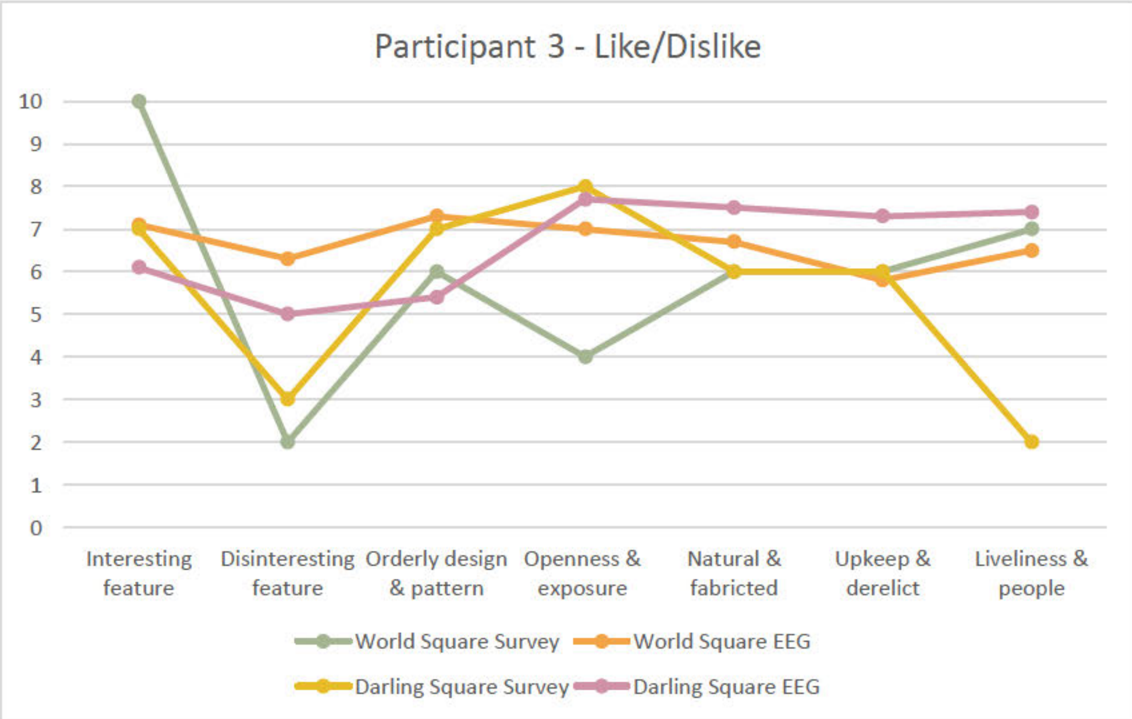


Figure 106. Graph of Participant 3's survey and EEG scores for like/dislike at World Square and Darling Square.

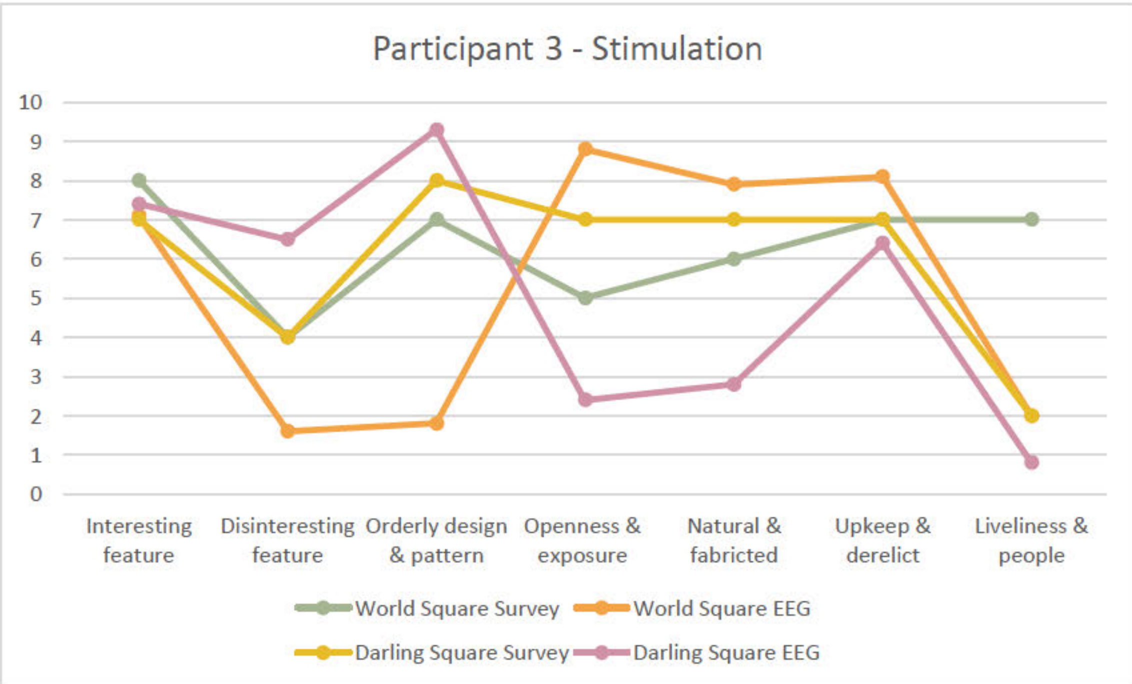


Figure 107. Graph of Participant 3's survey and EEG scores for stimulation at World Square and Darling Square.

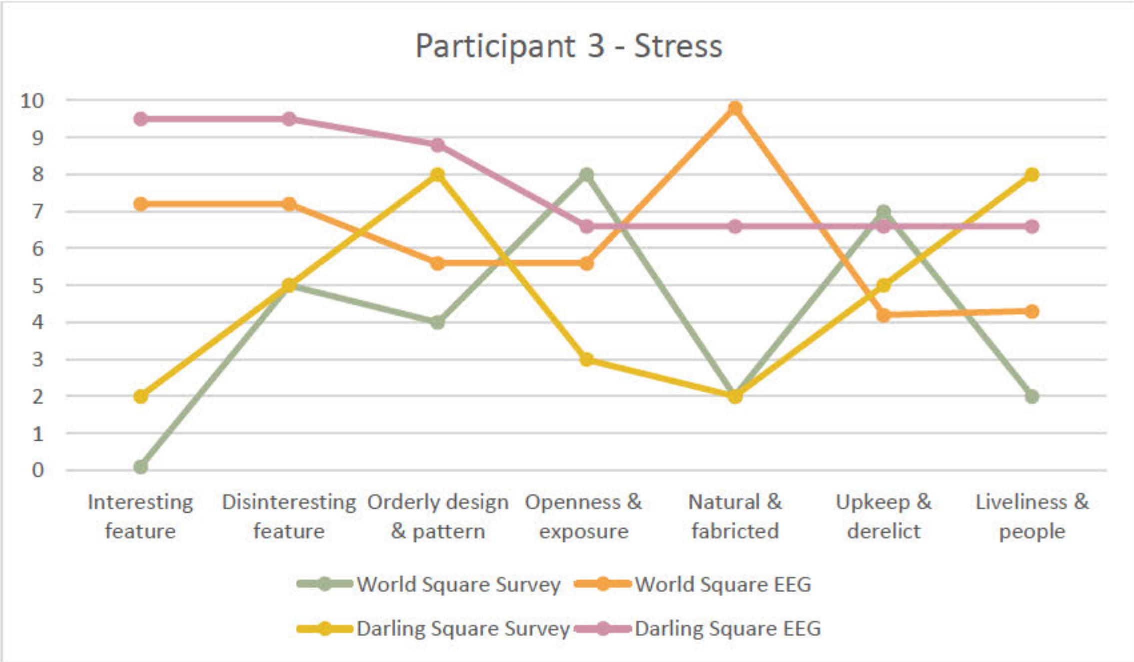


Figure 108. Graph of Participant 3's survey and EEG scores for stress at World Square and Darling Square.

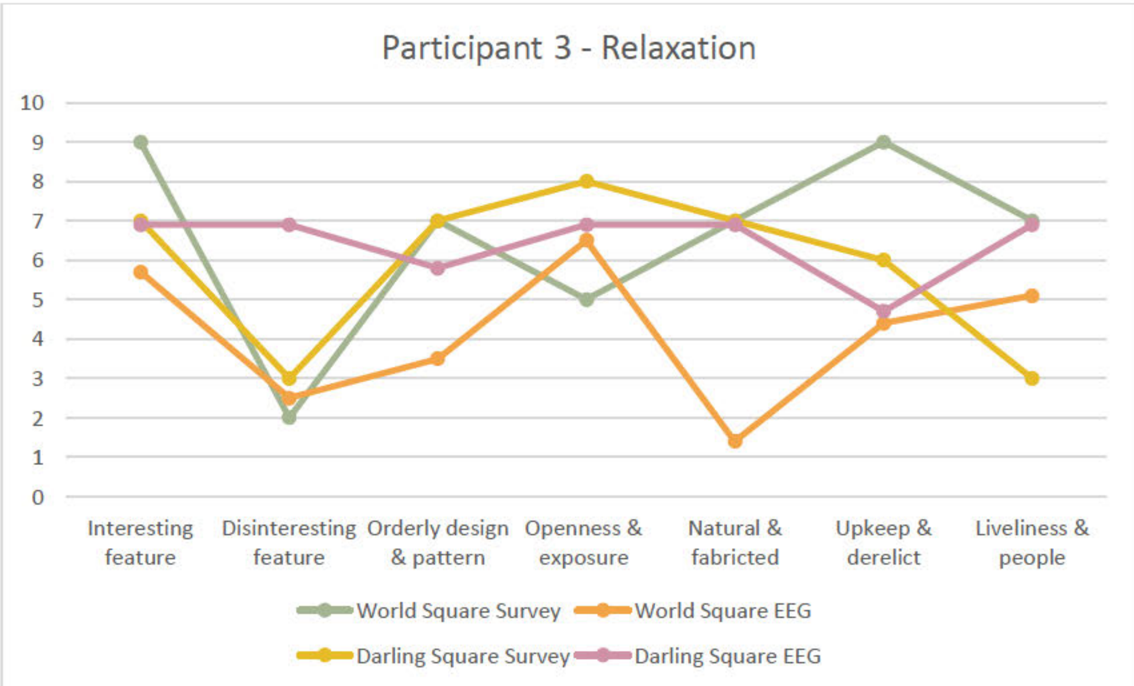


Figure 109. Graph of Participant 3's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 4 "BOBBY"

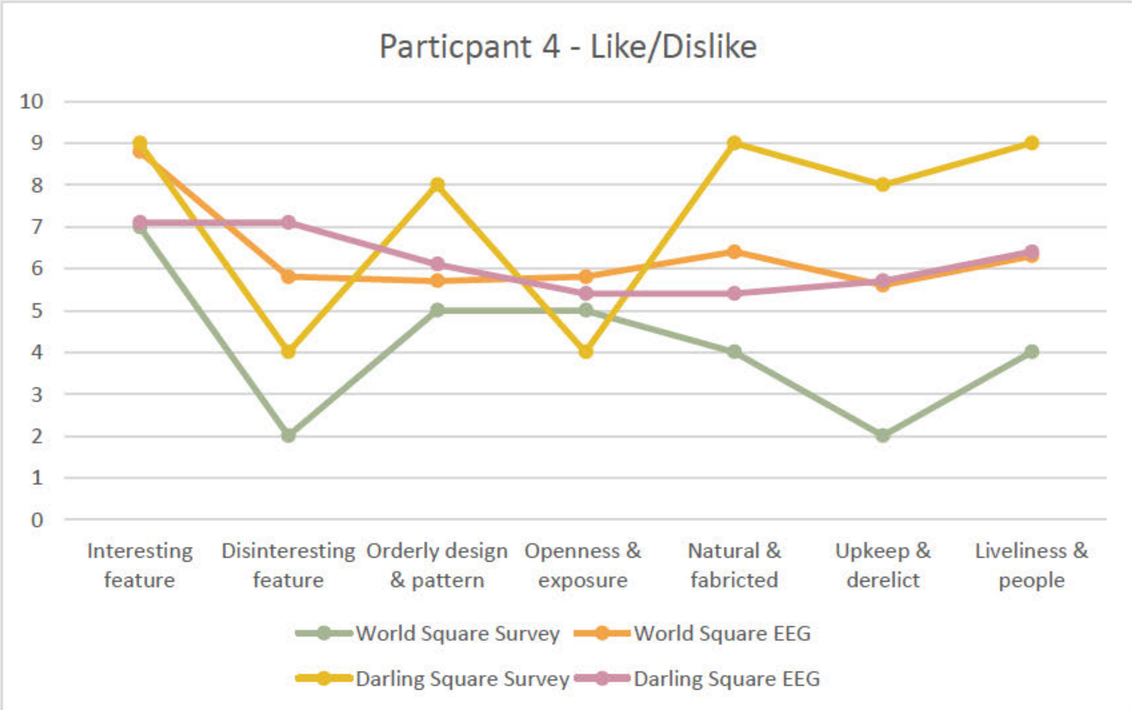


Figure 110. Graph of Participant 4's survey and EEG scores for like/dislike at World Square and Darling Square.

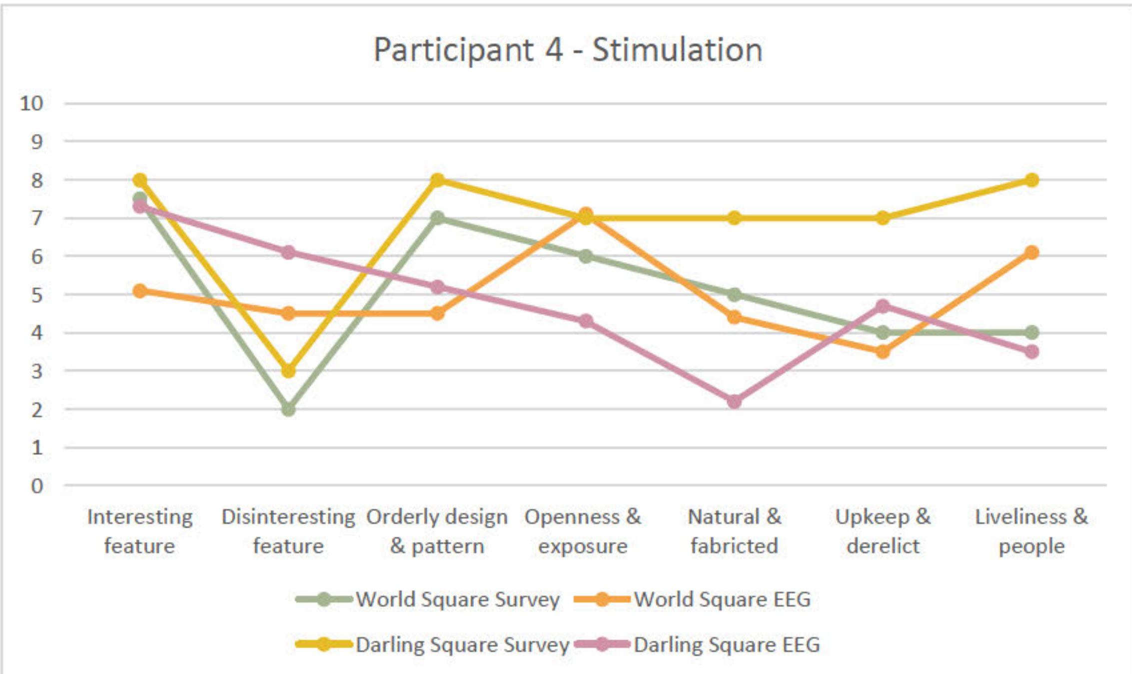


Figure 111. Graph of Participant 4's survey and EEG scores for stimulation at World Square and Darling Square.

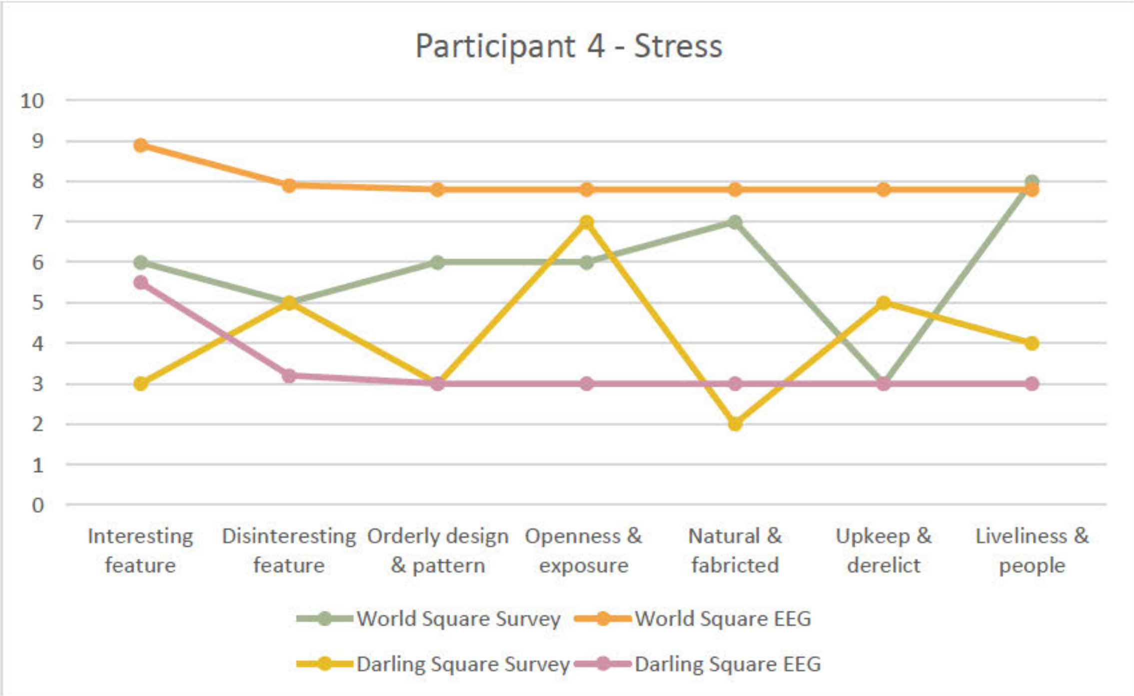


Figure 112. Graph of Participant 4's survey and EEG scores for stress at World Square and Darling Square.

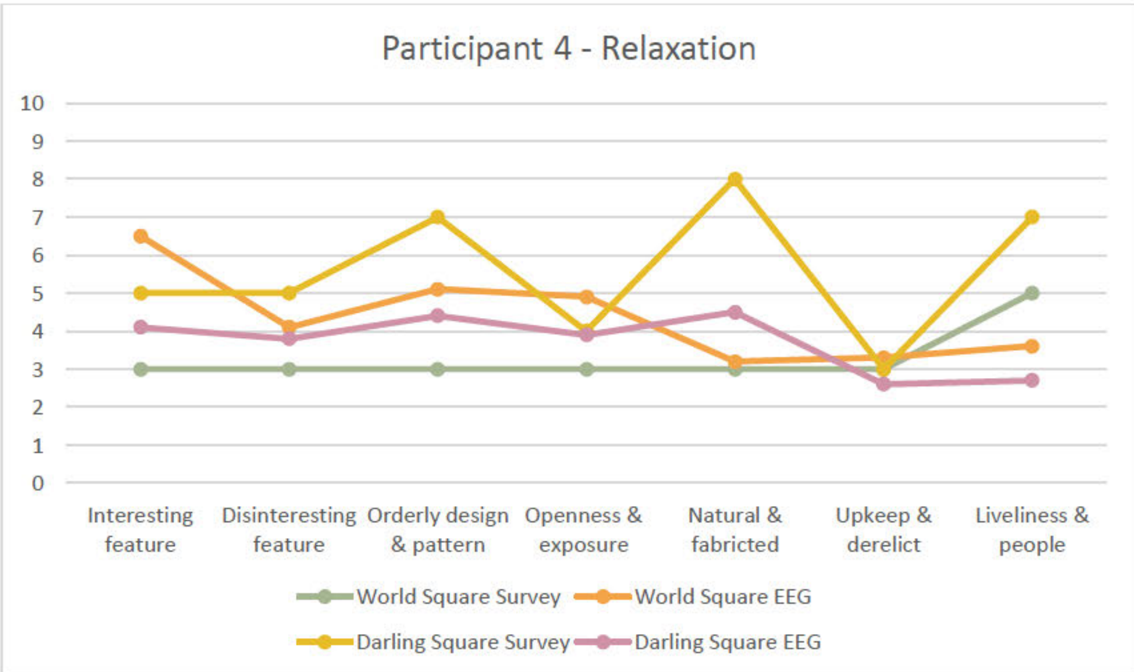


Figure 113. Graph of Participant 4's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 5 "ELISE"

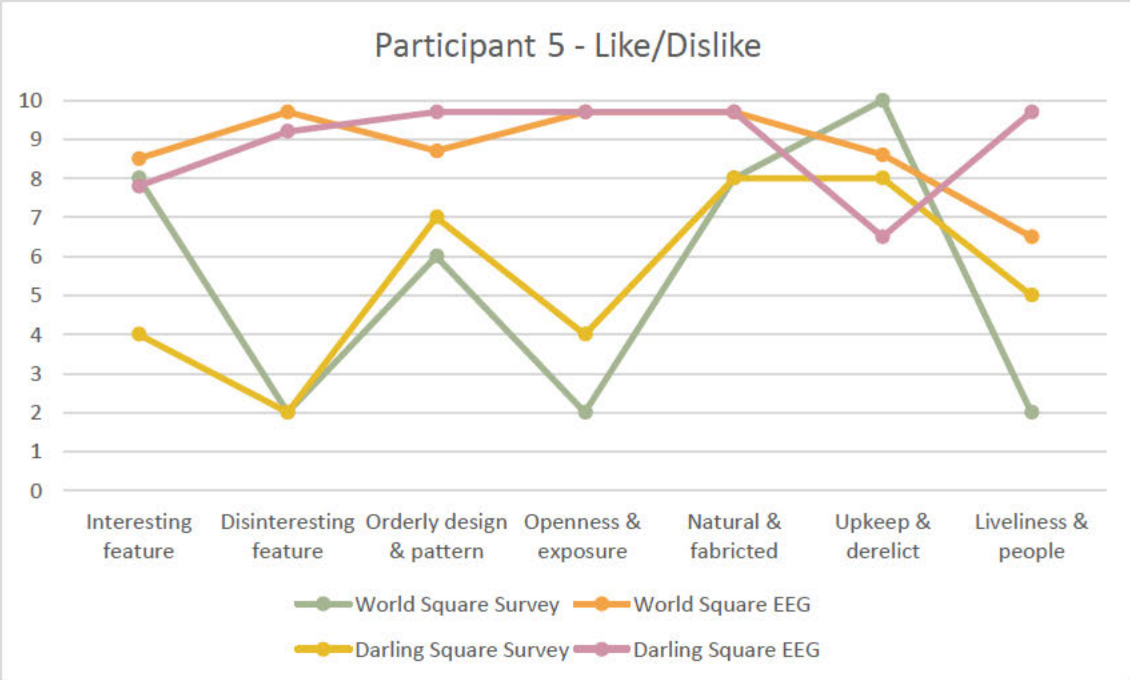


Figure 114. Graph of Participant 5's survey and EEG scores for like/dislike at World Square and Darling Square.

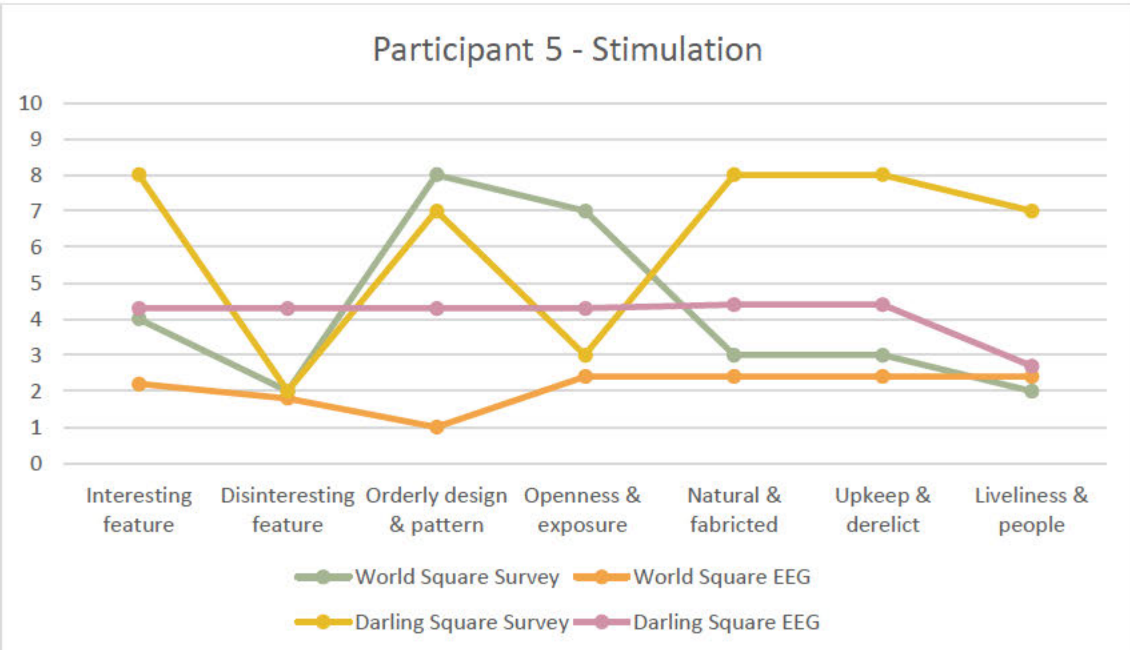


Figure 115. Graph of Participant 5's survey and EEG scores for stimulation at World Square and Darling Square.

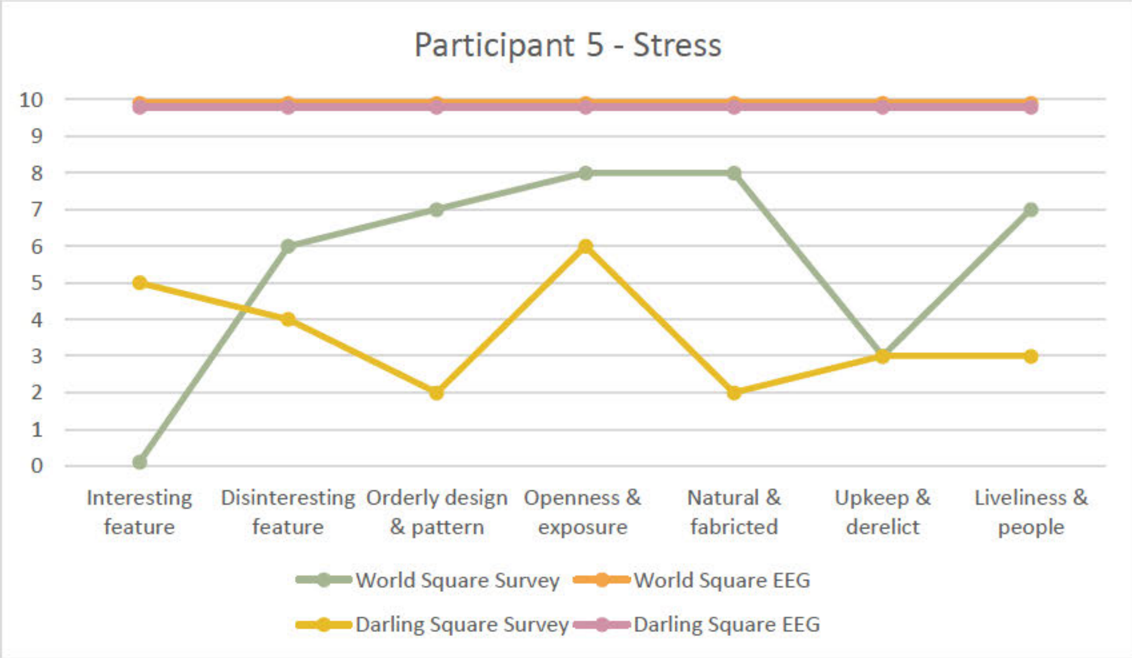


Figure 116. Graph of Participant 5's survey and EEG scores for stress at World Square and Darling Square.

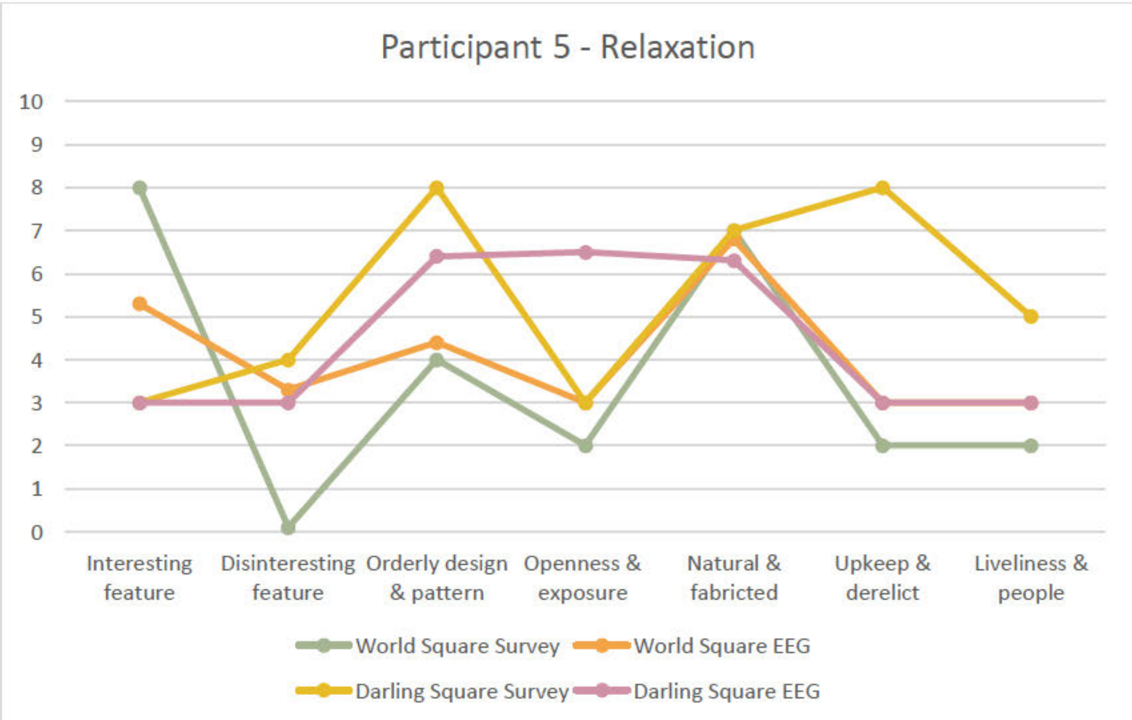


Figure 117. Graph of Participant 5's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 6 "HARVEY"

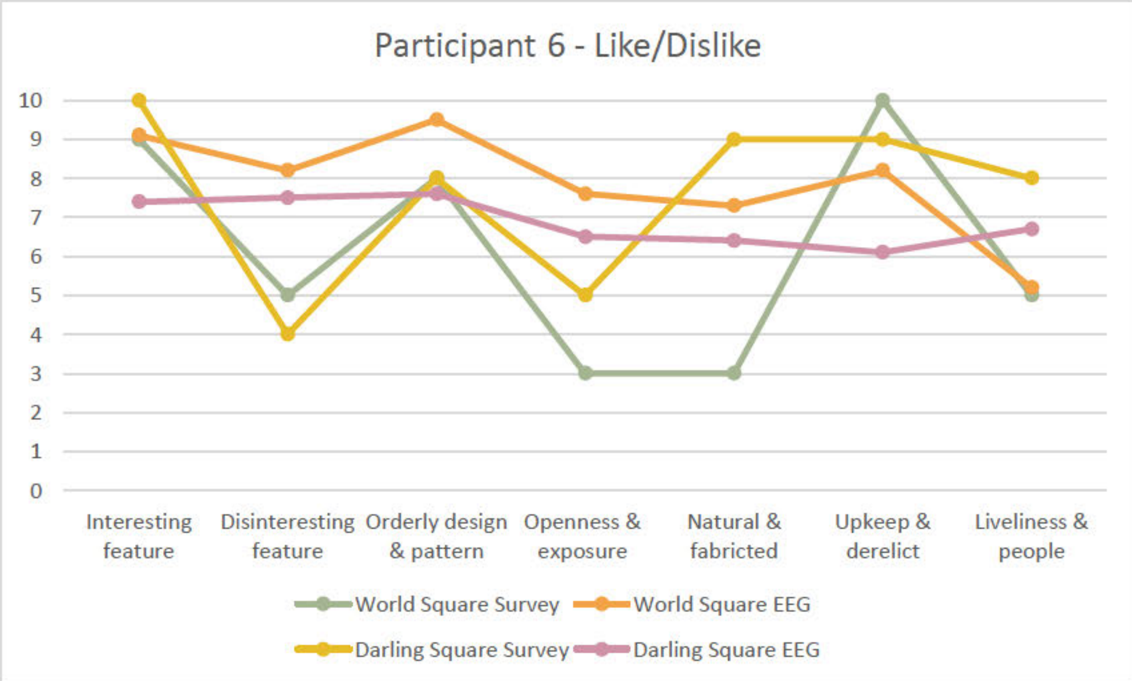


Figure 118. Graph of Participant 6's survey and EEG scores for like/dislike at World Square and Darling Square.

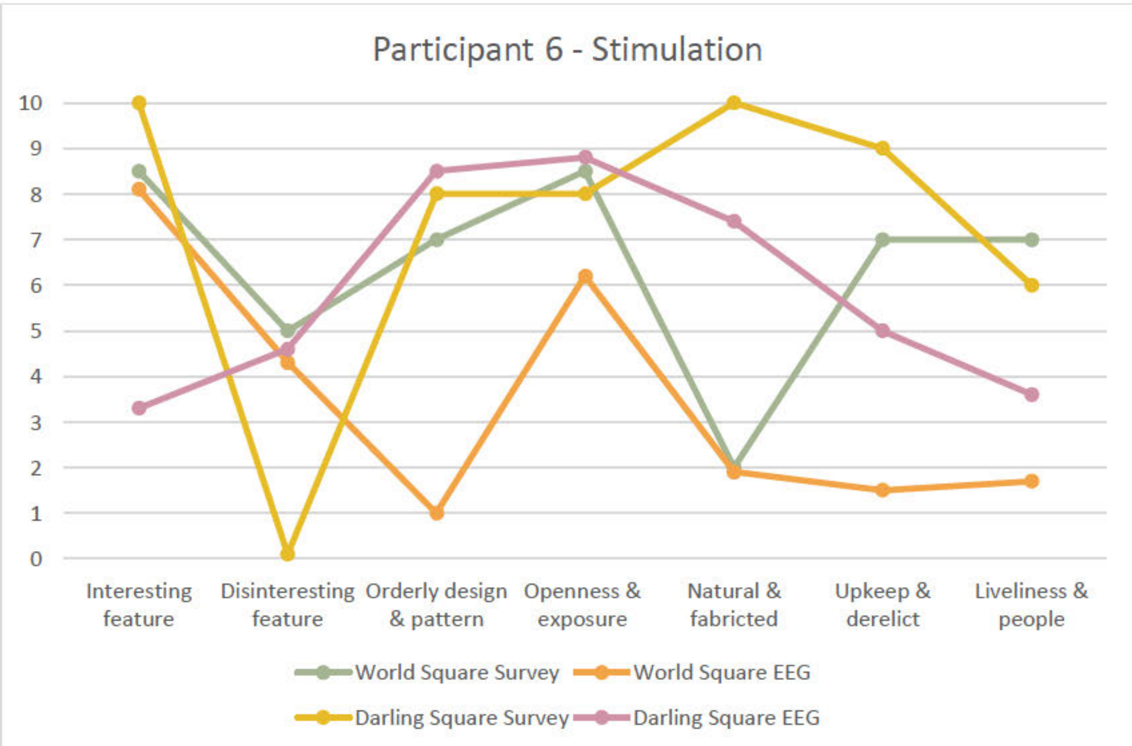


Figure 119. Graph of Participant 6's survey and EEG scores for stimulation at World Square and Darling Square.

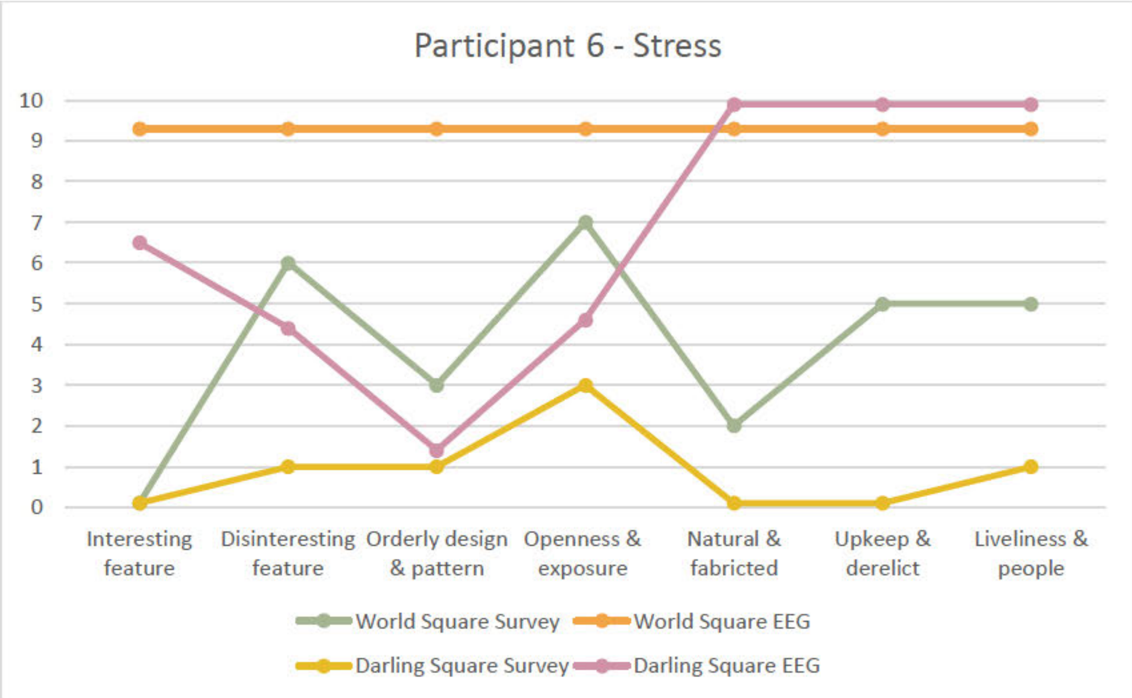


Figure 120. Graph of Participant 6's survey and EEG scores for stress at World Square and Darling Square.

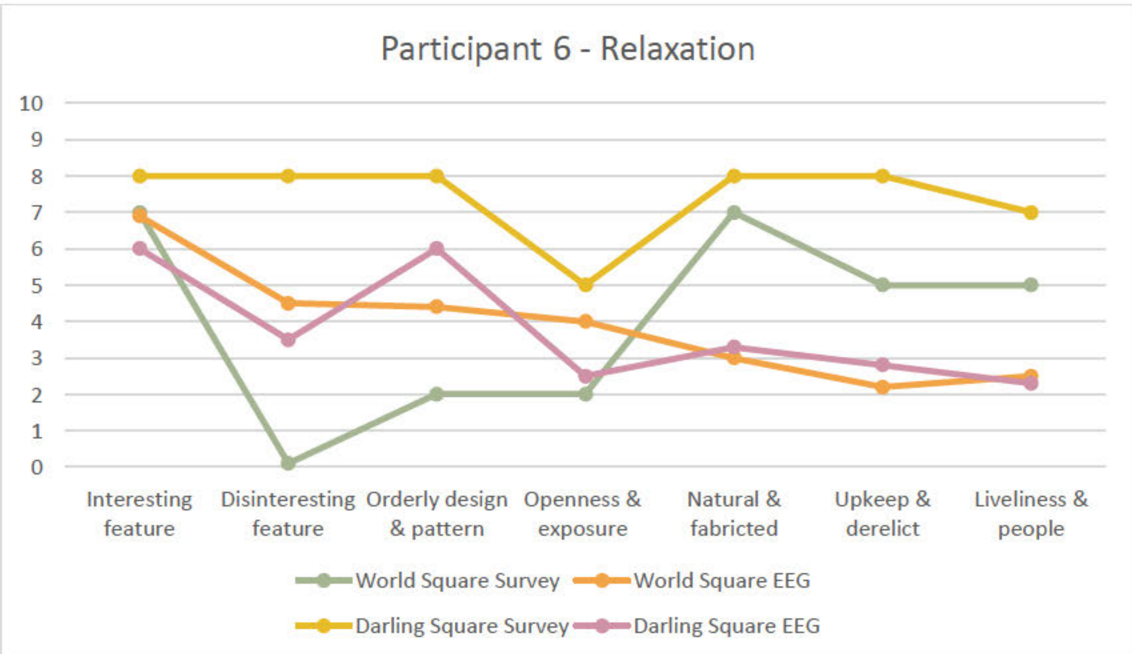


Figure 121. Graph of Participant 6's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 7 "ELENA"

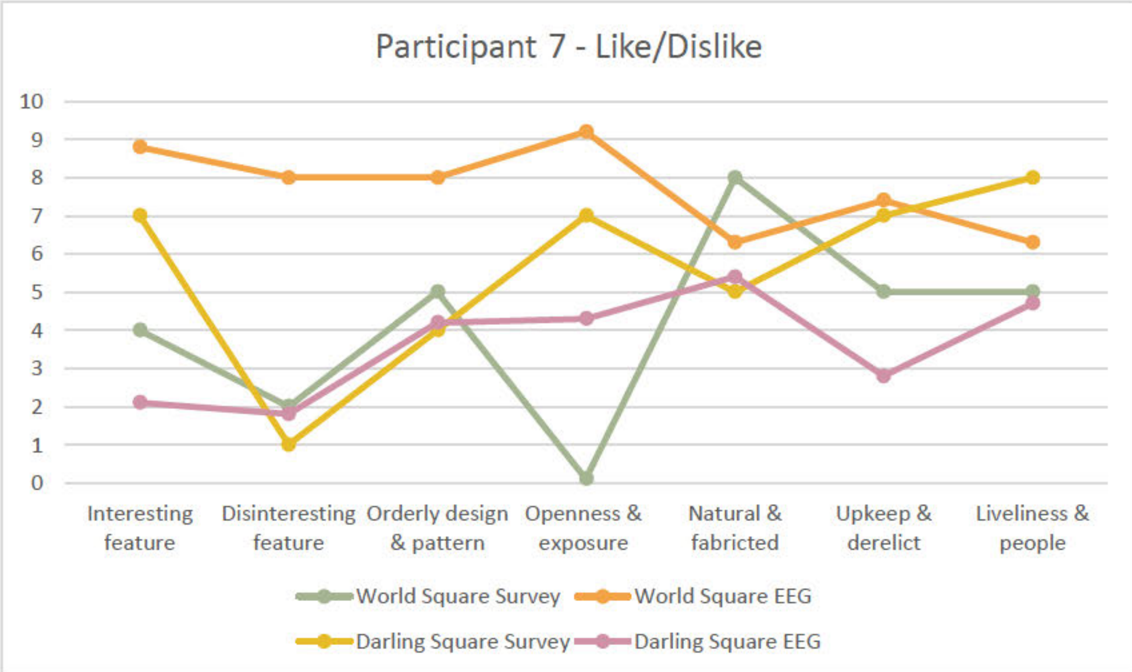


Figure 122. Graph of Participant 7's survey and EEG scores for like/dislike at World Square and Darling Square.

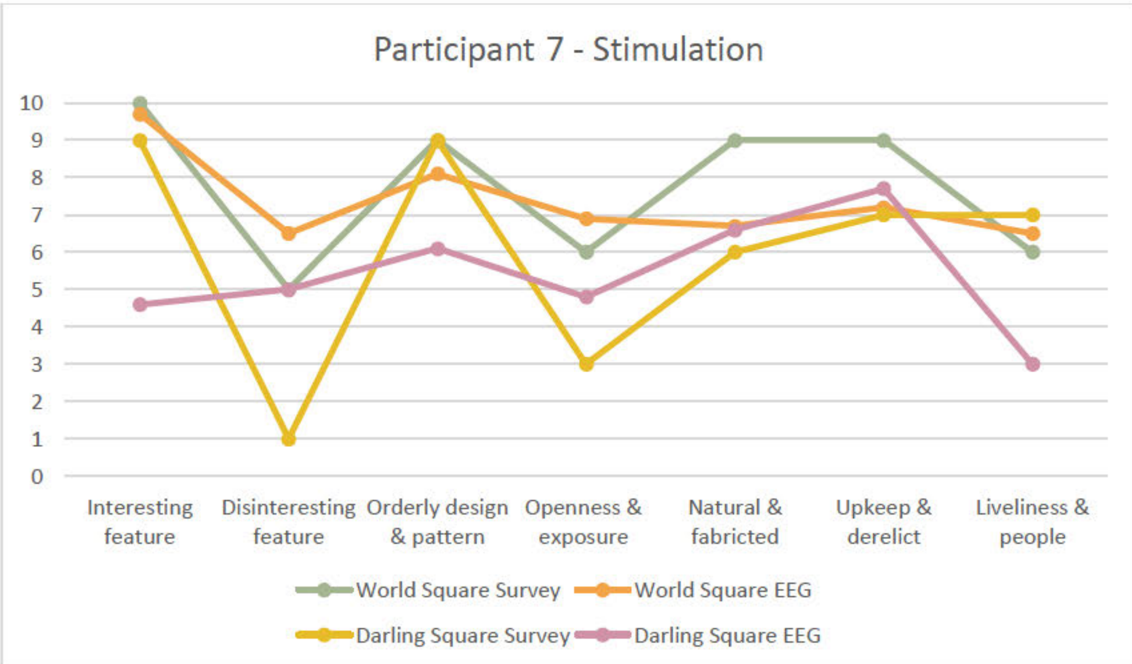


Figure 123. Graph of Participant 7's survey and EEG scores for stimulation at World Square and Darling Square.

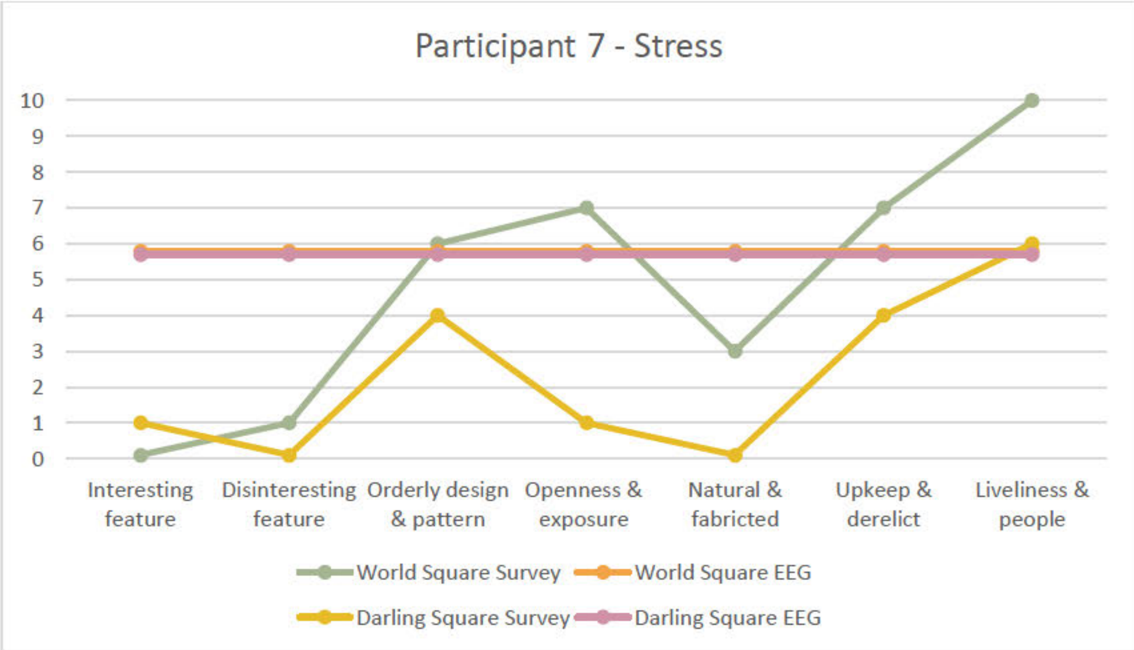


Figure 124. Graph of Participant 7's survey and EEG scores for stress at World Square and Darling Square.

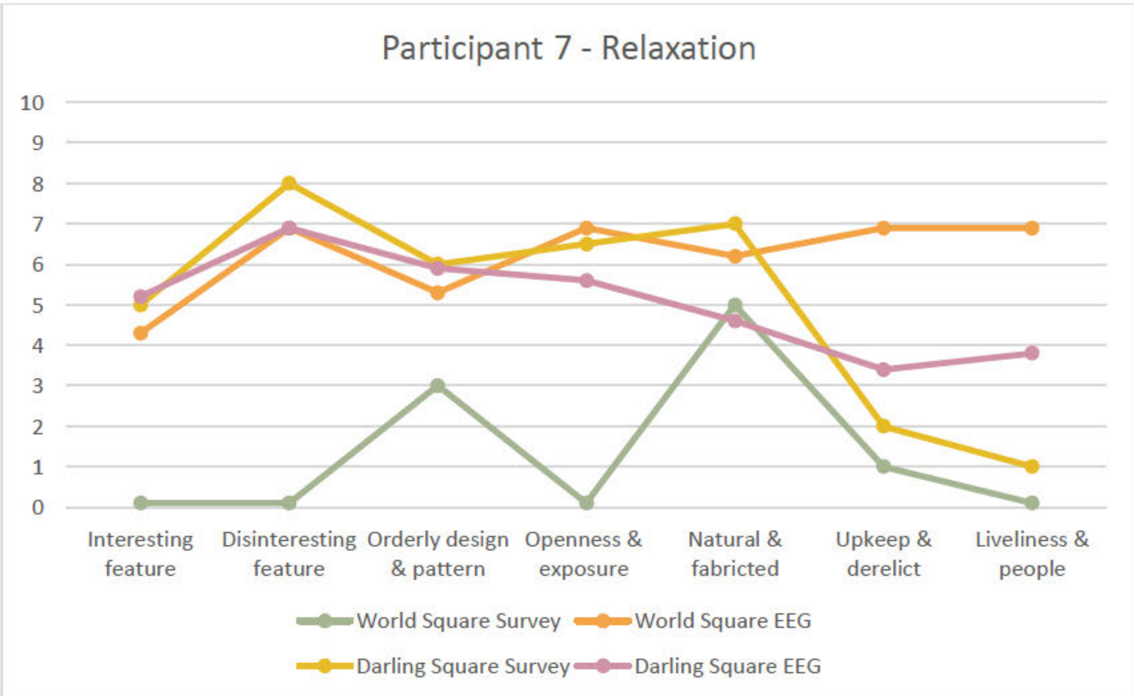


Figure 125. Graph of Participant 7's survey and EEG scores for relax at World Square and Darling Square.

PARTICIPANT 8 "KALINDA"

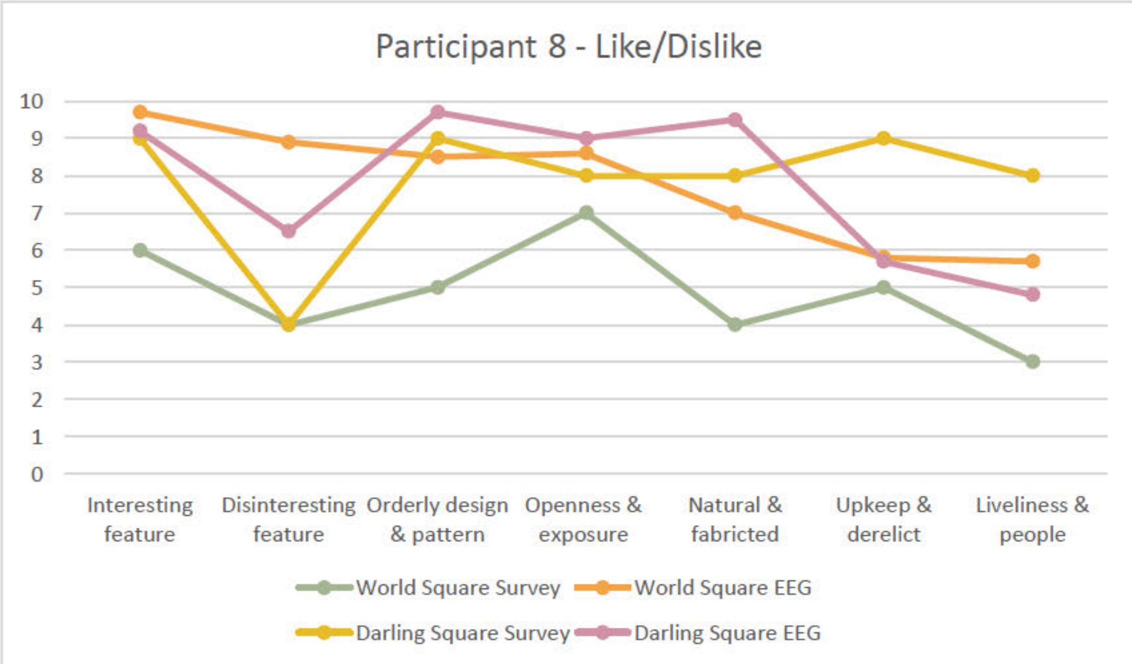


Figure 126. Graph of Participant 8's survey and EEG scores for like/dislike at World Square and Darling Square.

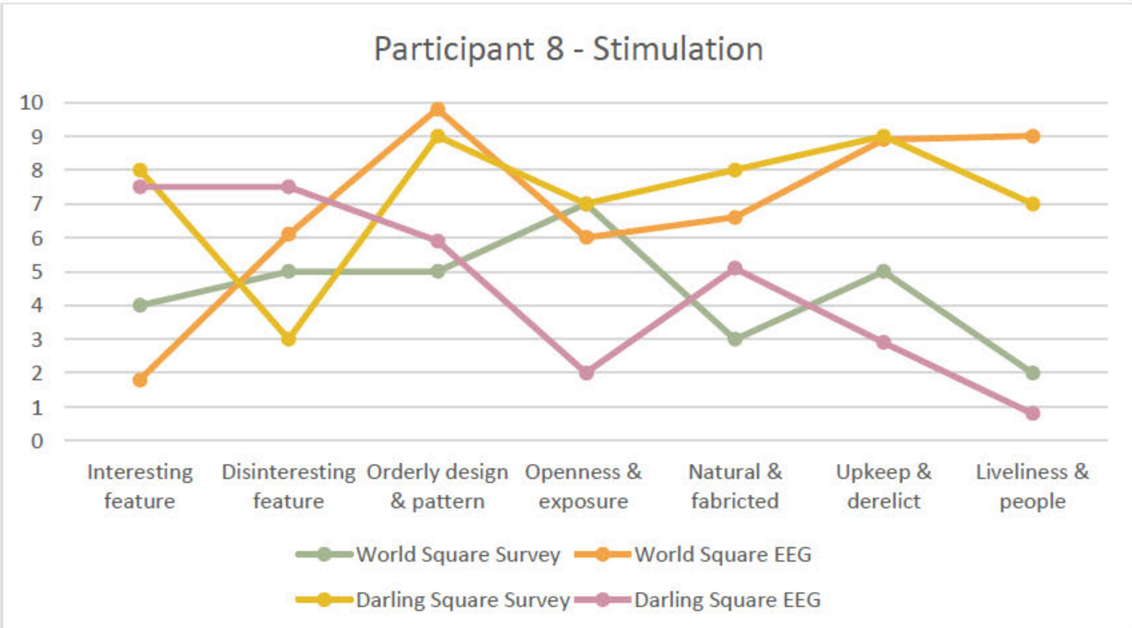


Figure 127. Graph of Participant 8's survey and EEG scores for stimulation at World Square and Darling Square.

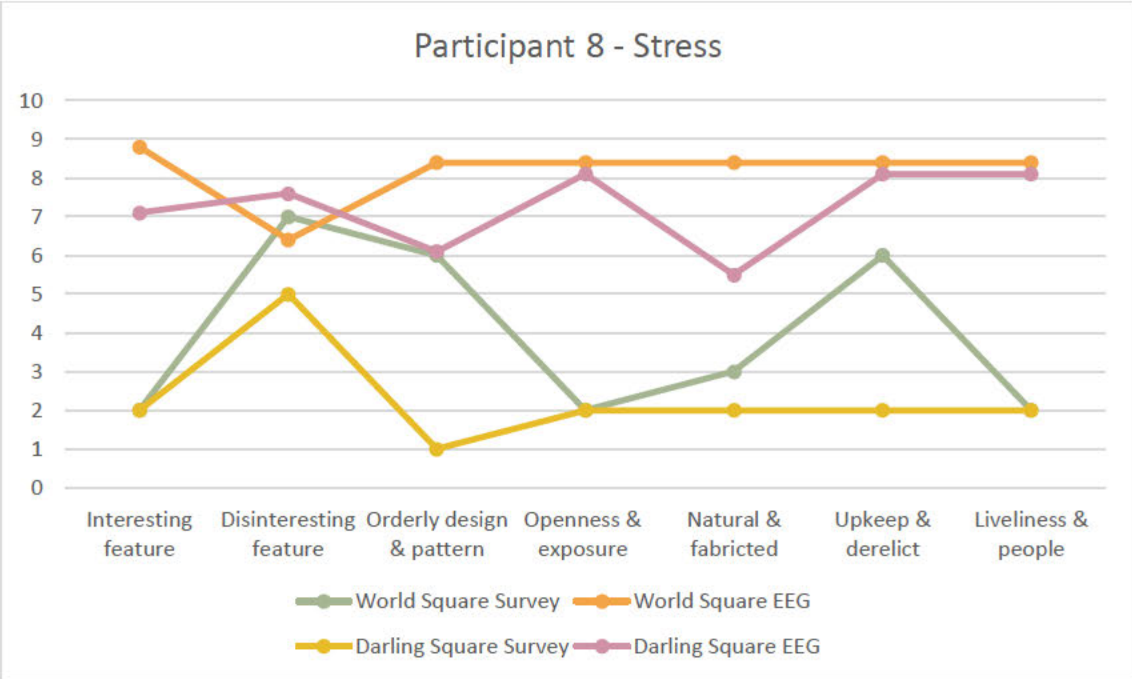


Figure 128. Graph of Participant 8's survey and EEG scores for stress at World Square and Darling Square.

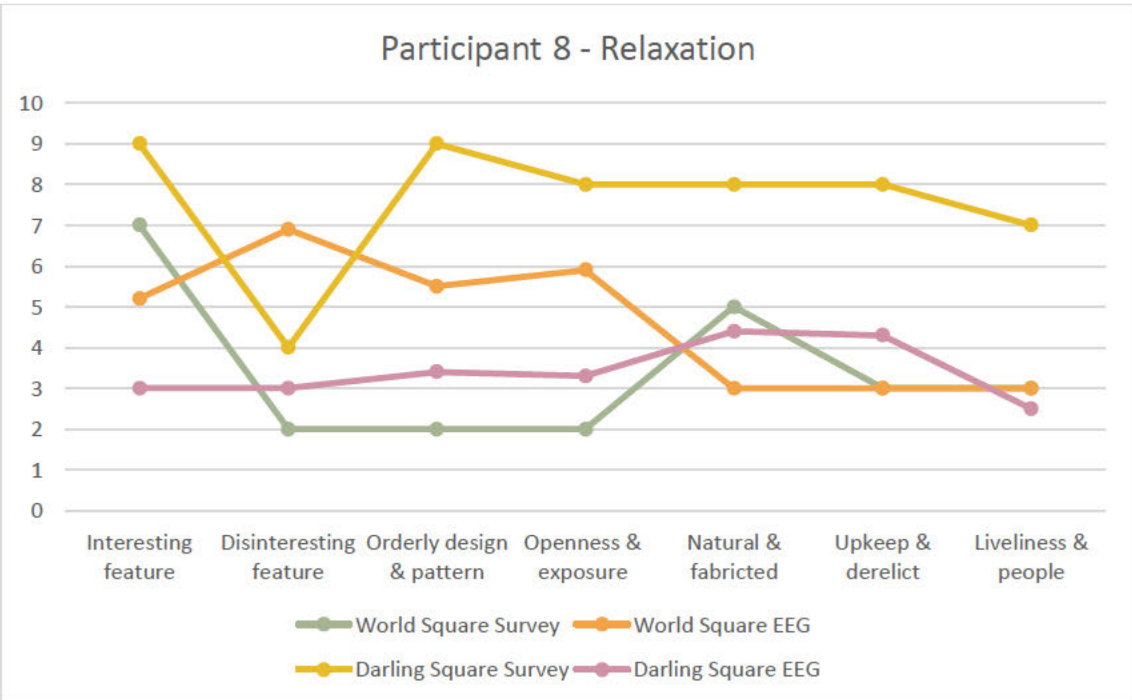


Figure 129. Graph of Participant 8's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 9 "OLIVER"

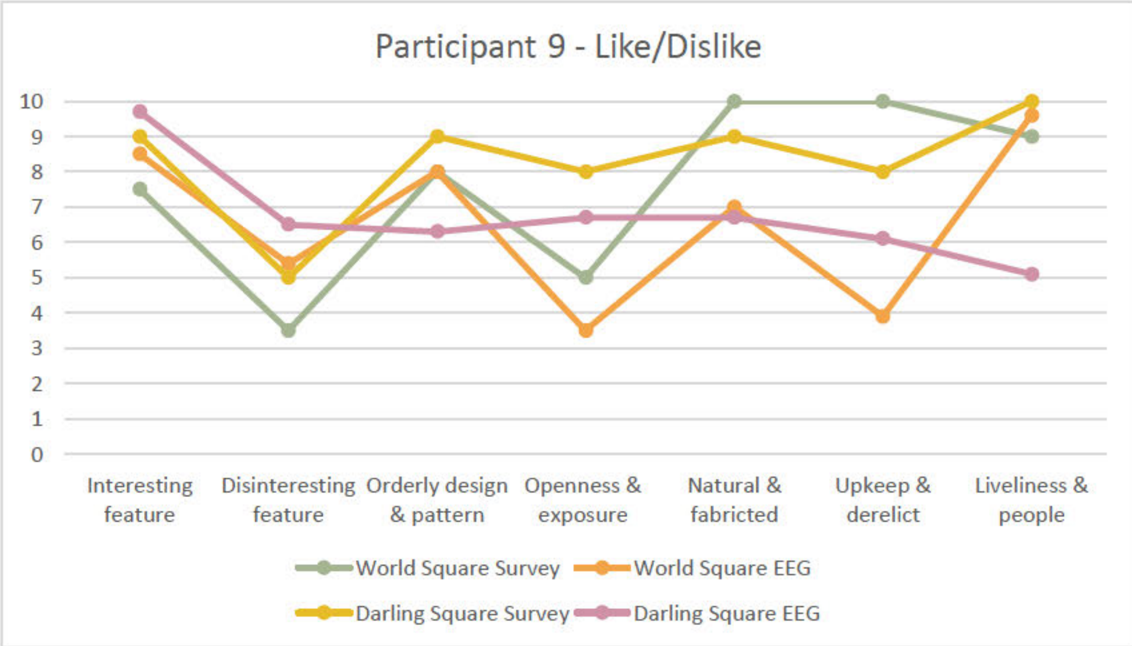


Figure 130. Graph of Participant 9's survey and EEG scores for like/dislike at World Square and Darling Square.

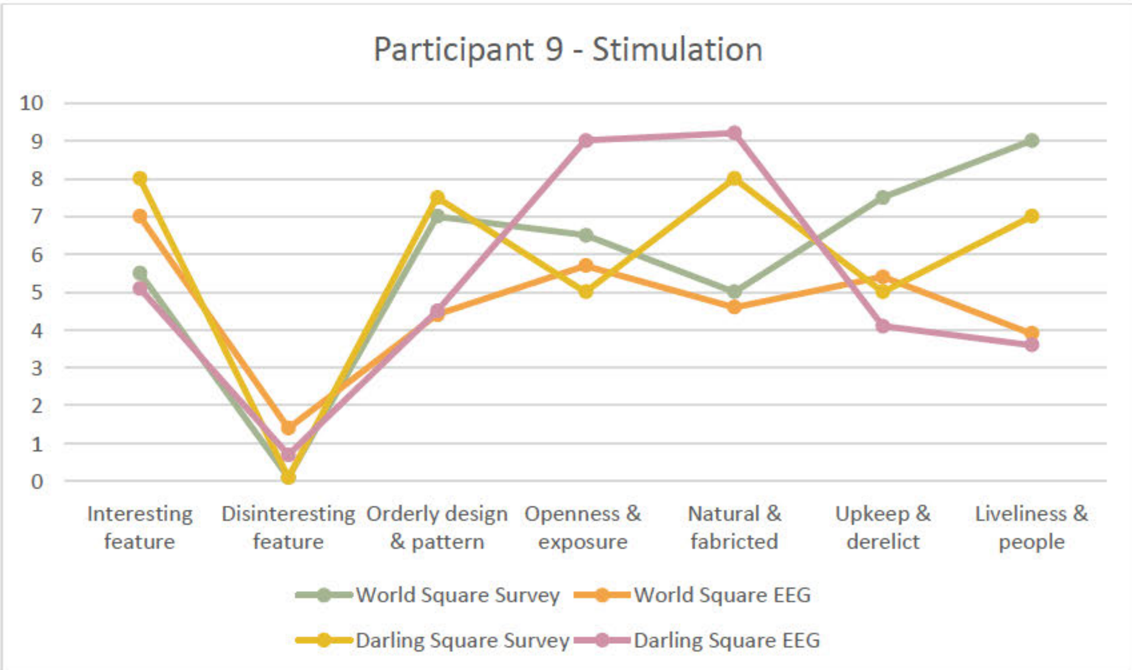


Figure 131. Graph of Participant 9's survey and EEG scores for stimulation at World Square and Darling Square.

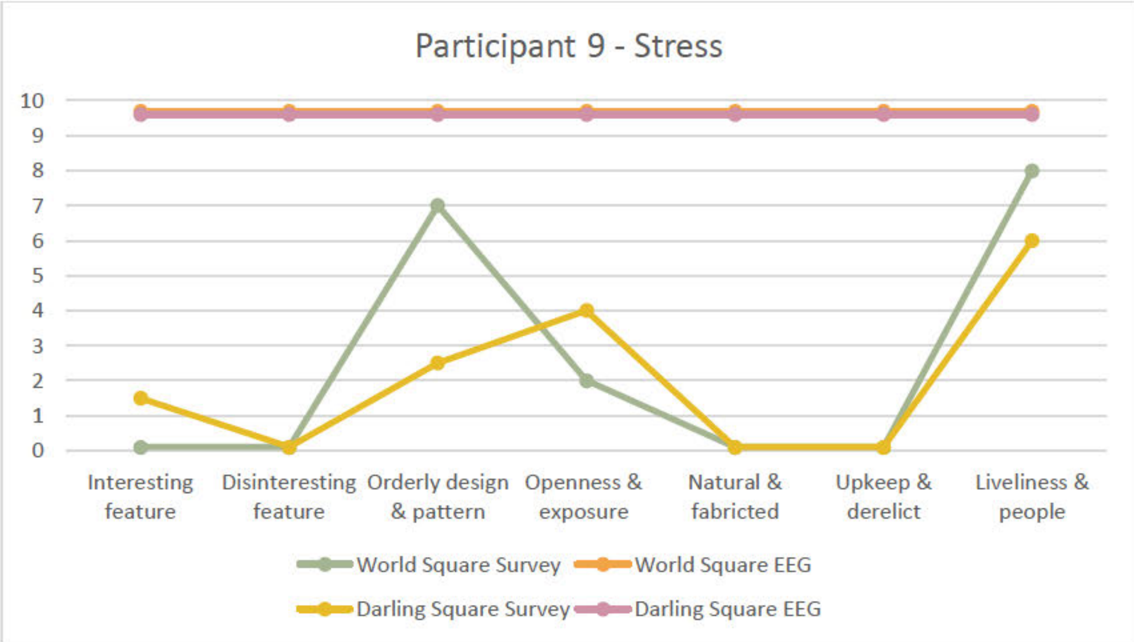


Figure 132. Graph of Participant 9's survey and EEG scores for stress at World Square and Darling Square.

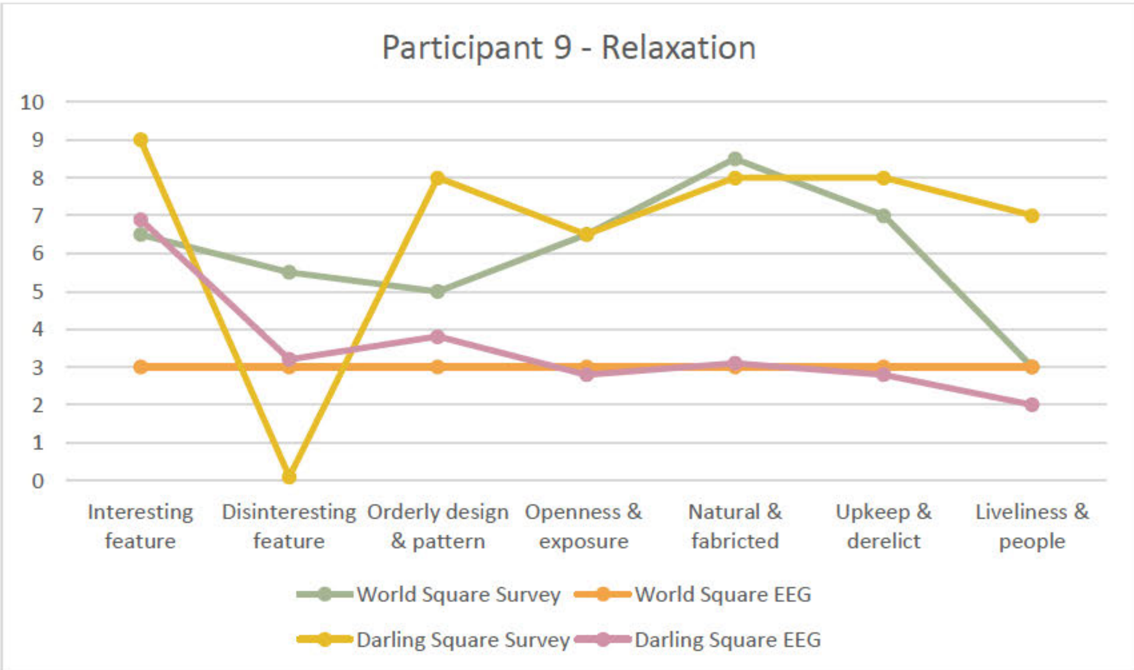


Figure 133. Graph of Participant 9's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 10 "MIKE"

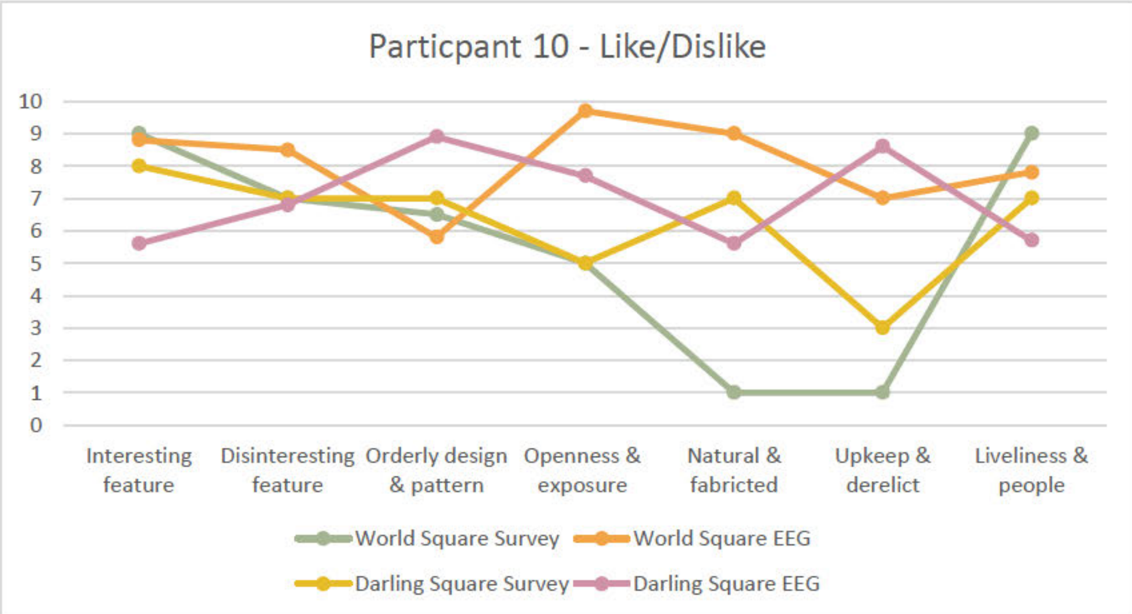


Figure 134. Graph of Participant 10's survey and EEG scores for like/dislike at World Square and Darling Square.

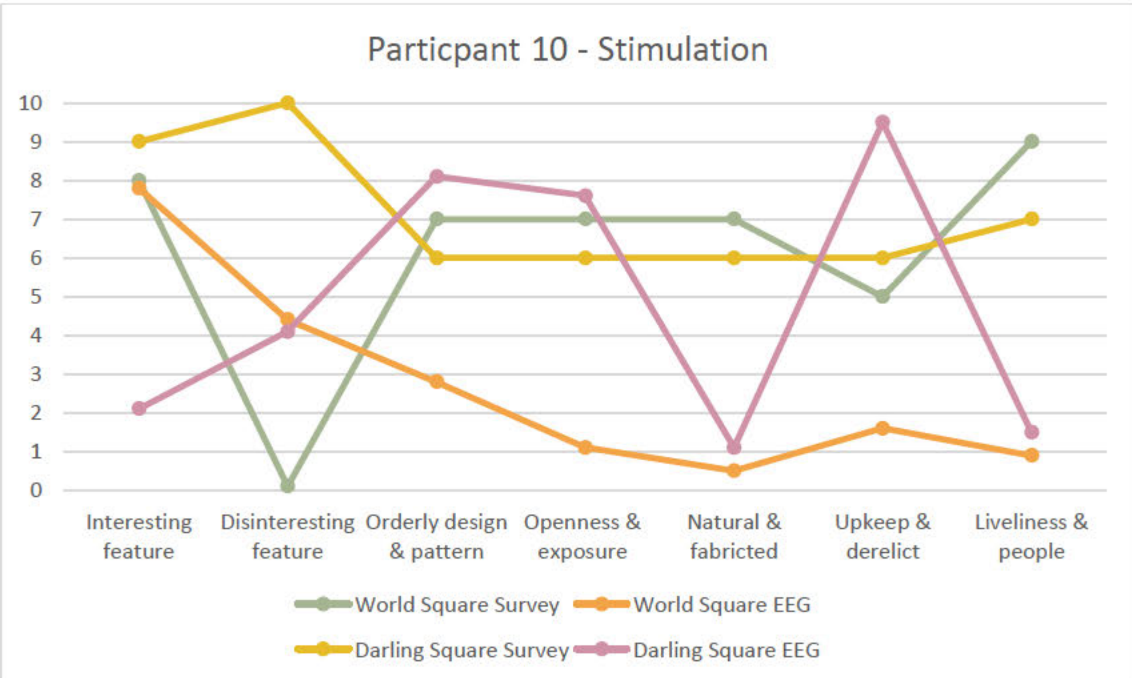


Figure 135. Graph of Participant 10's survey and EEG scores for stimulation at World Square and Darling Square.

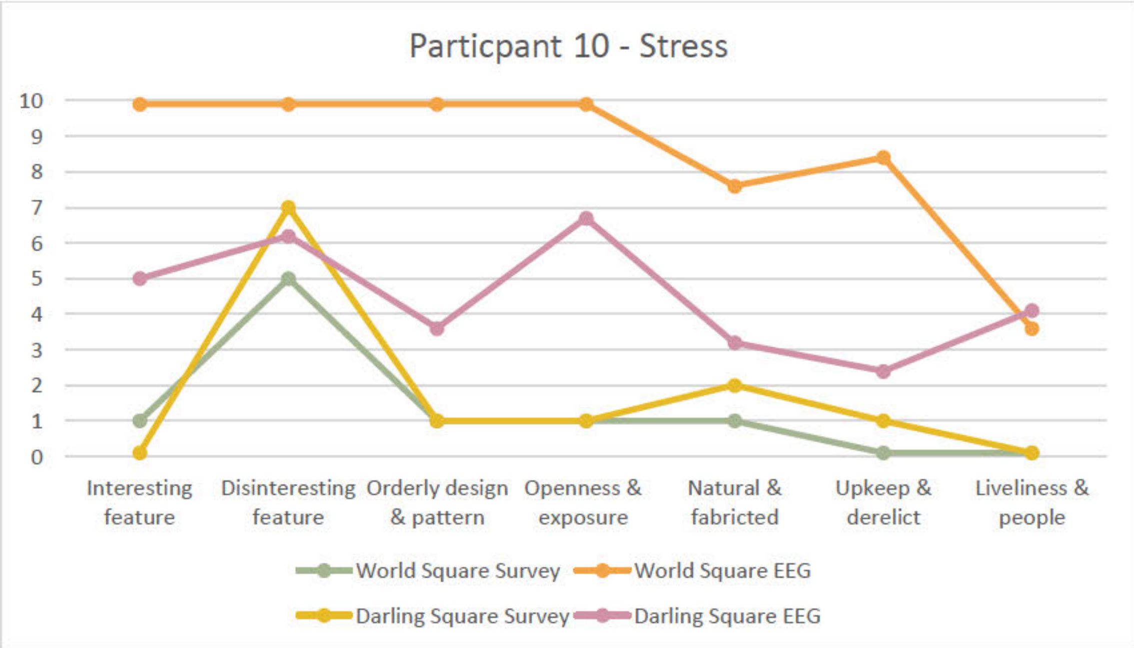


Figure 136. Graph of Participant 10's survey and EEG scores for stress at World Square and Darling Square.

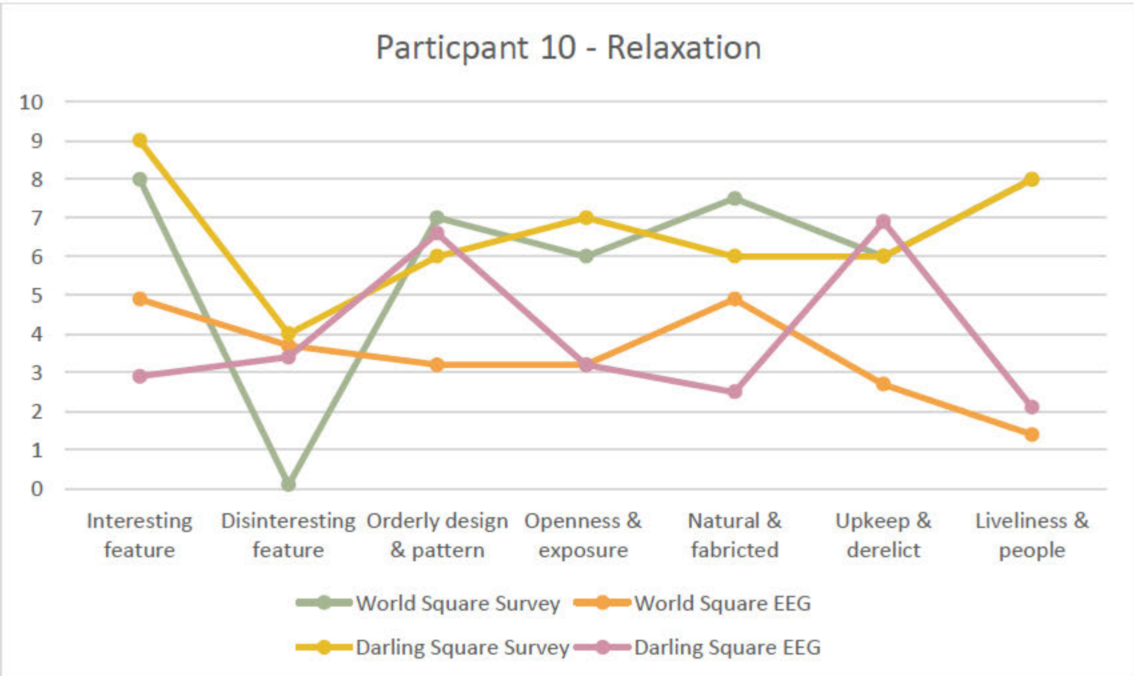


Figure 137.. Graph of Participant 10's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 11 "JOHN"

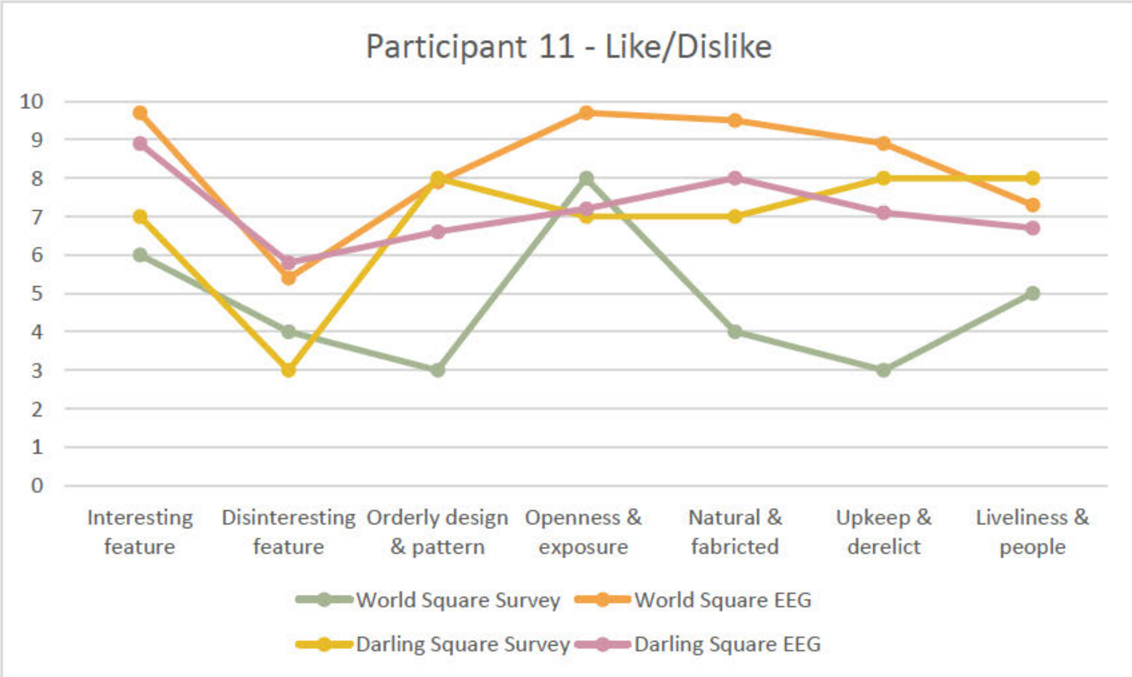


Figure 138. Graph of Participant 11's survey and EEG scores for like/dislike at World Square and Darling Square.

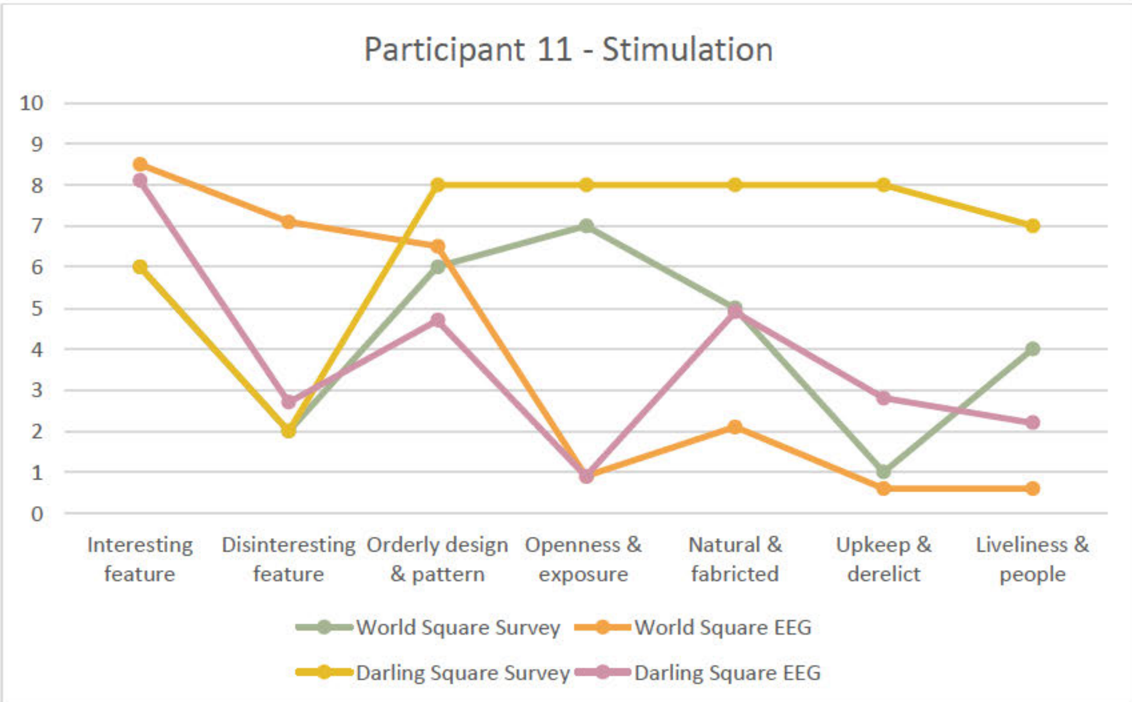


Figure 139. Graph of Participant 11's survey and EEG scores stimulation at World Square and Darling Square.

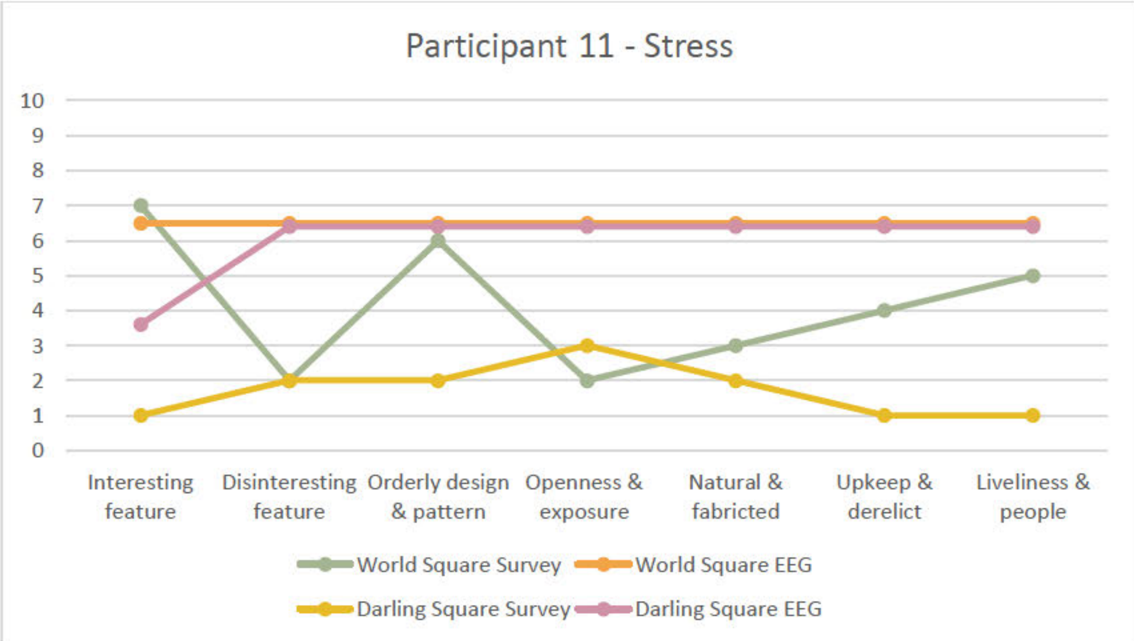


Figure 140. Graph of Participant 11's survey and EEG scores for stress at World Square and Darling Square.

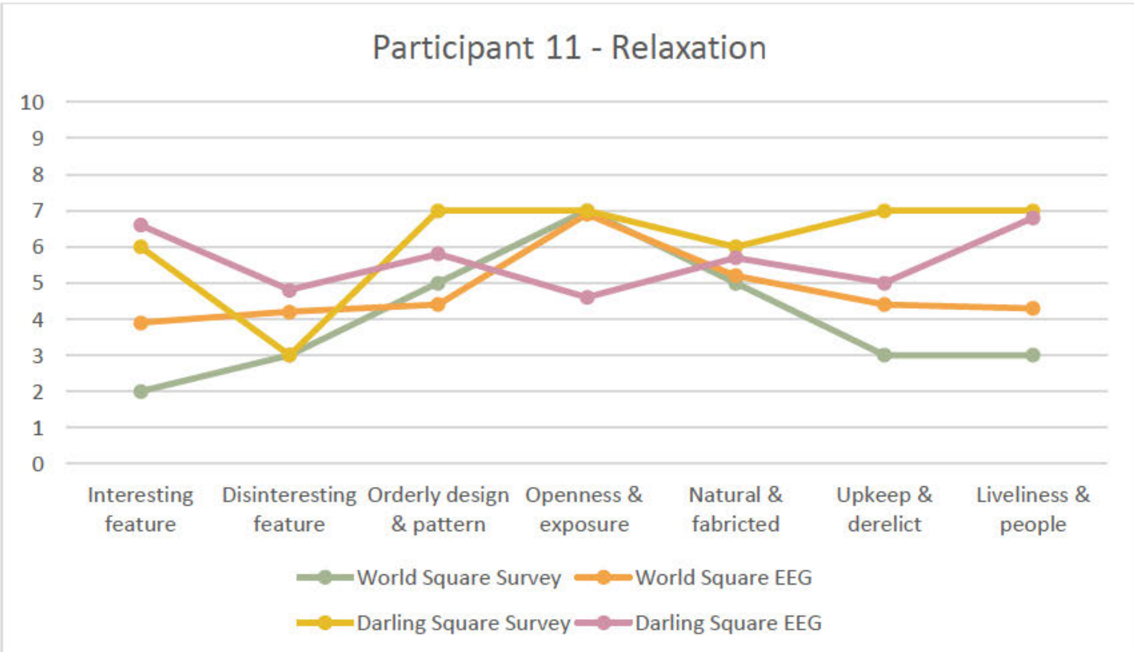


Figure 141. Graph of Participant 11's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 12 "LARRY"

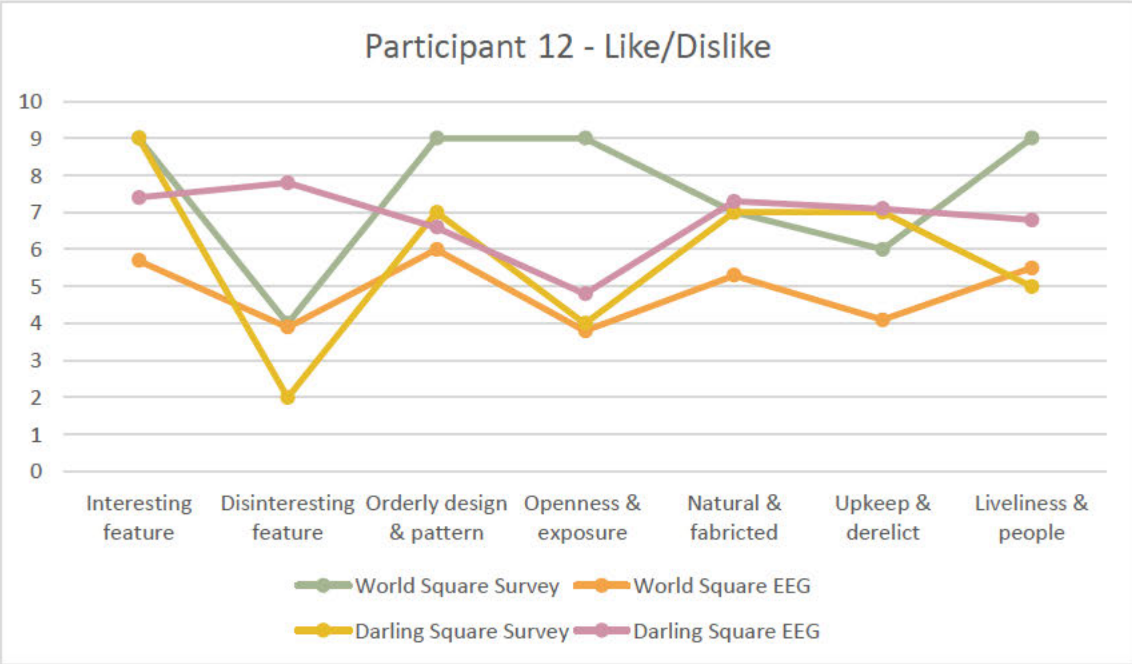


Figure 142. Graph of Participant 12's survey and EEG scores for like/dislike at World Square and Darling Square.

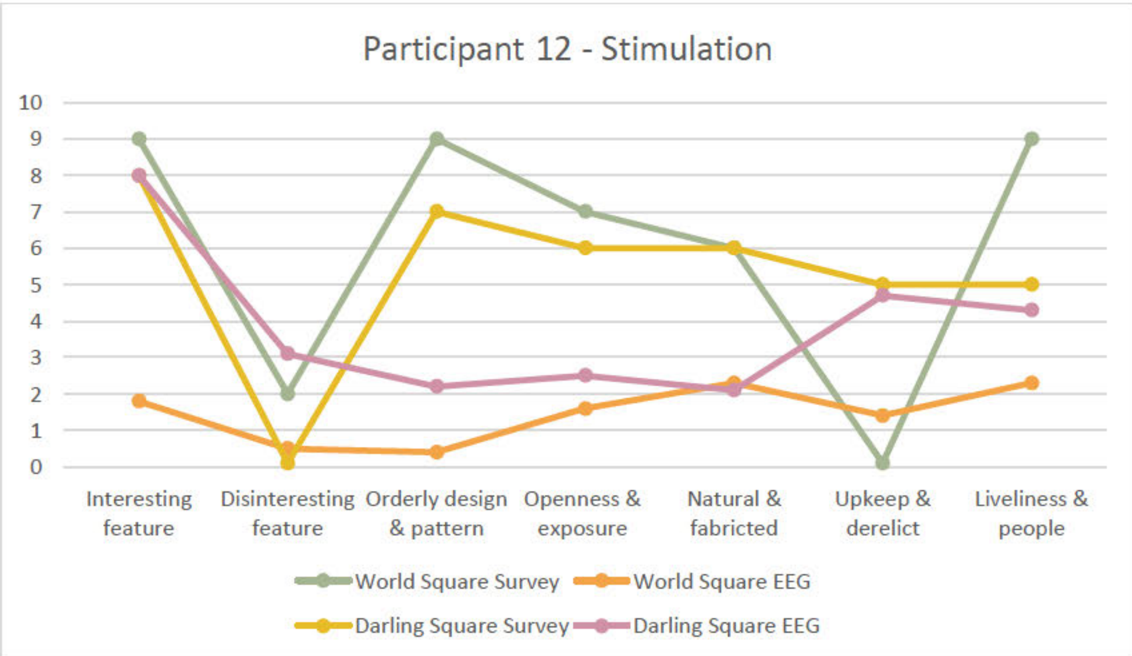


Figure 143.. Graph of Participant 12's survey and EEG scores for stimulation at World Square and Darling Square.

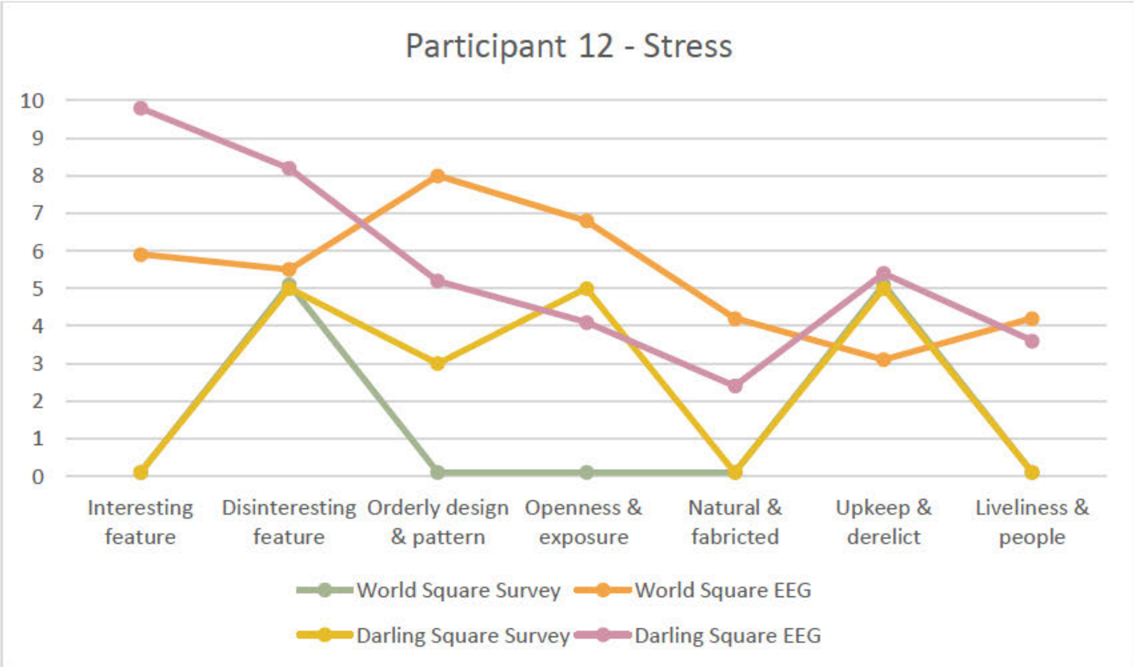


Figure 144. Graph of Participant 12's survey and EEG scores for stress at World Square and Darling Square.

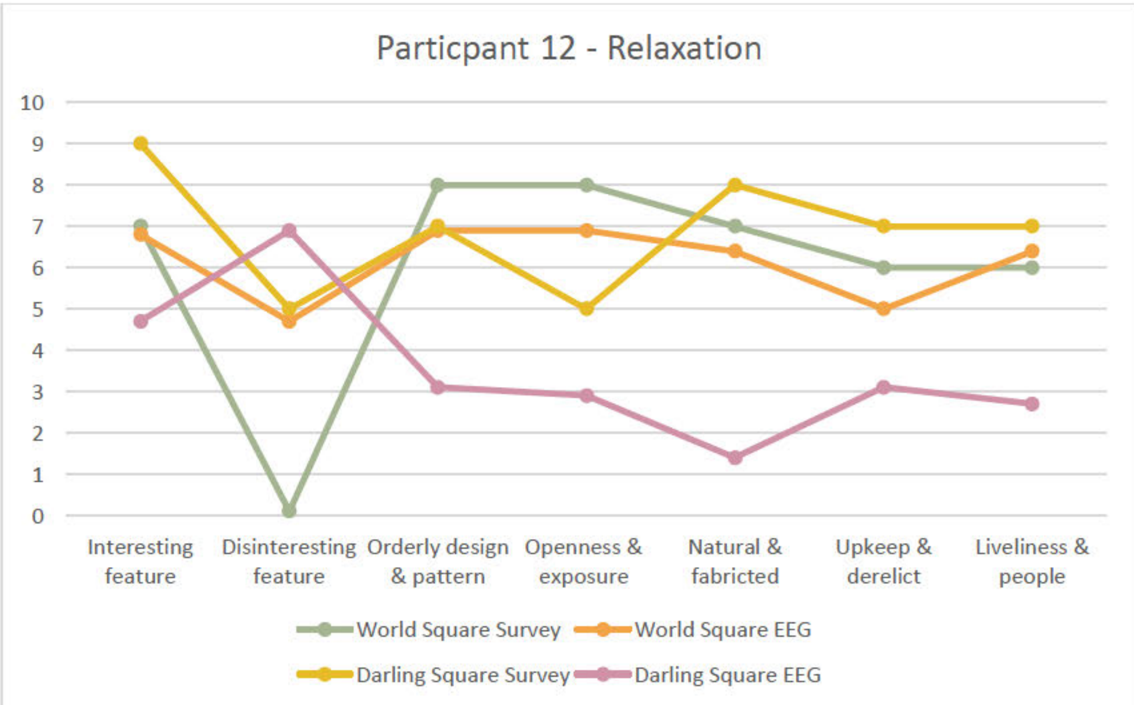


Figure 145. Graph of Participant 12's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 13 "JOSEPHINE"

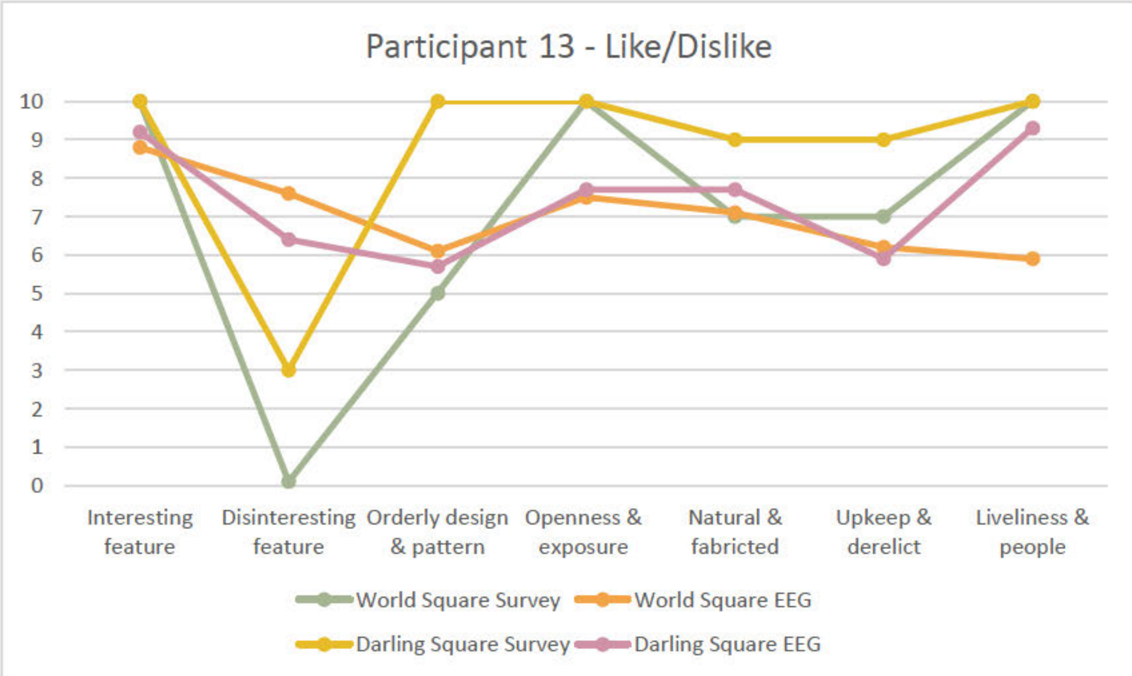


Figure 146. Graph of Participant 13's survey and EEG scores for like/dislike at World Square and Darling Square.

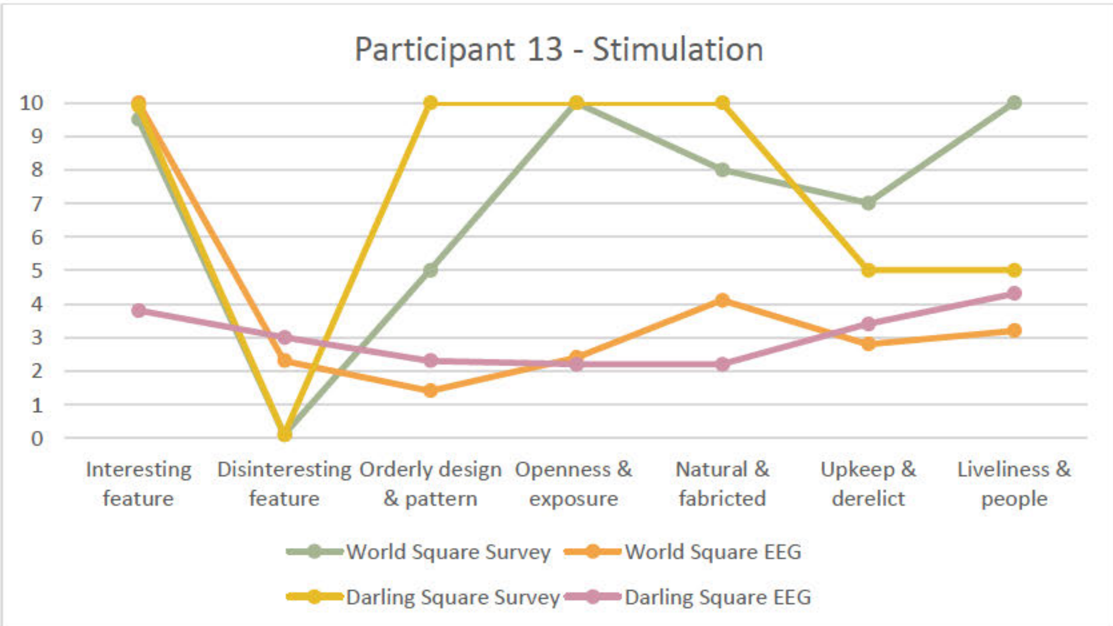


Figure 147. Graph of Participant 13's survey and EEG scores for stimulation at World Square and Darling Square.

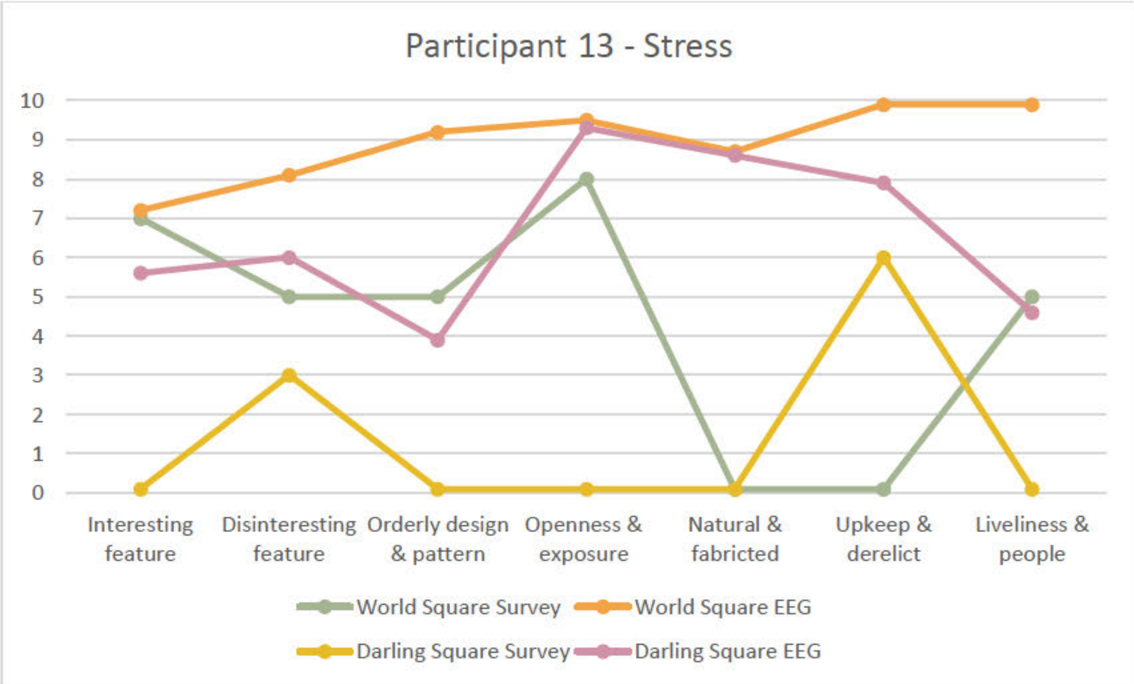


Figure 148. Graph of Participant 13's survey and EEG scores for stress at World Square and Darling Square.

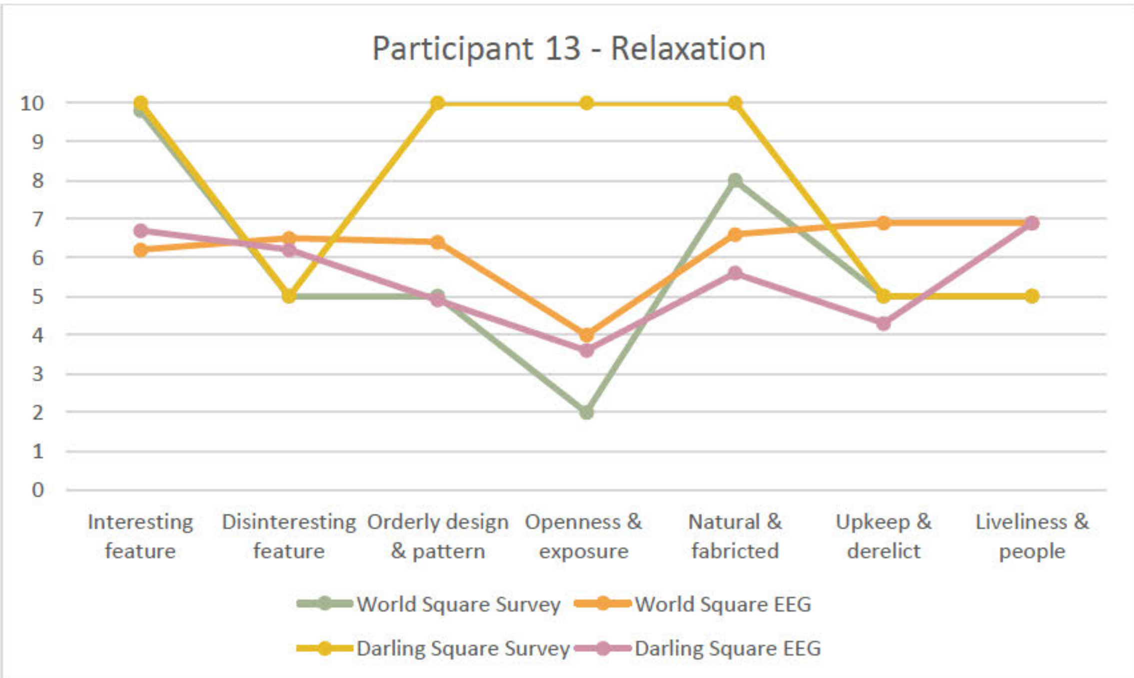


Figure 149. Graph of Participant 13's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 16 "BEN"

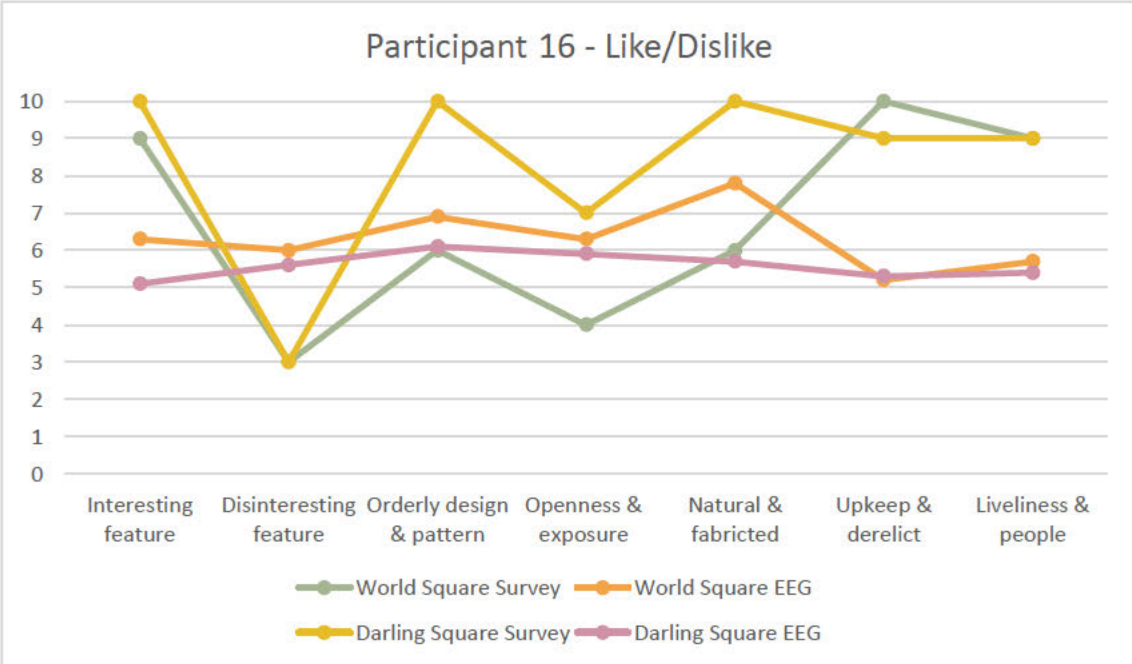


Figure 150. Graph of Participant 16's survey and EEG scores for like/dislike at World Square and Darling Square.

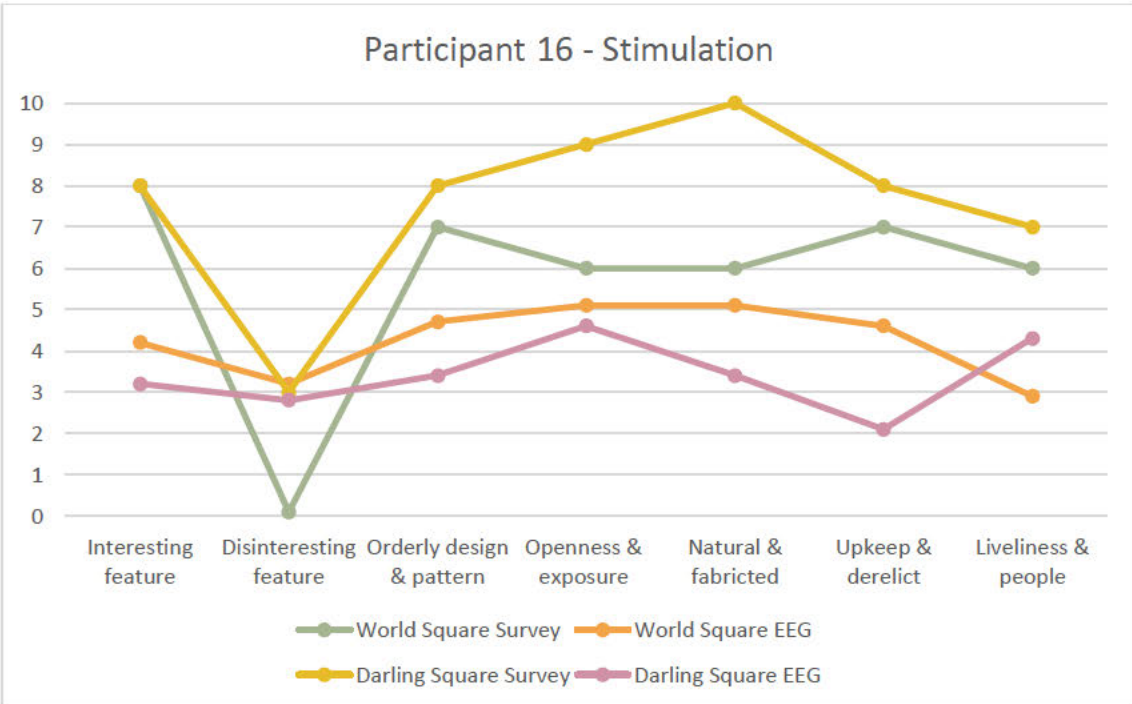


Figure 151. Graph of Participant 16's survey and EEG scores for stimulation at World Square and Darling Square.

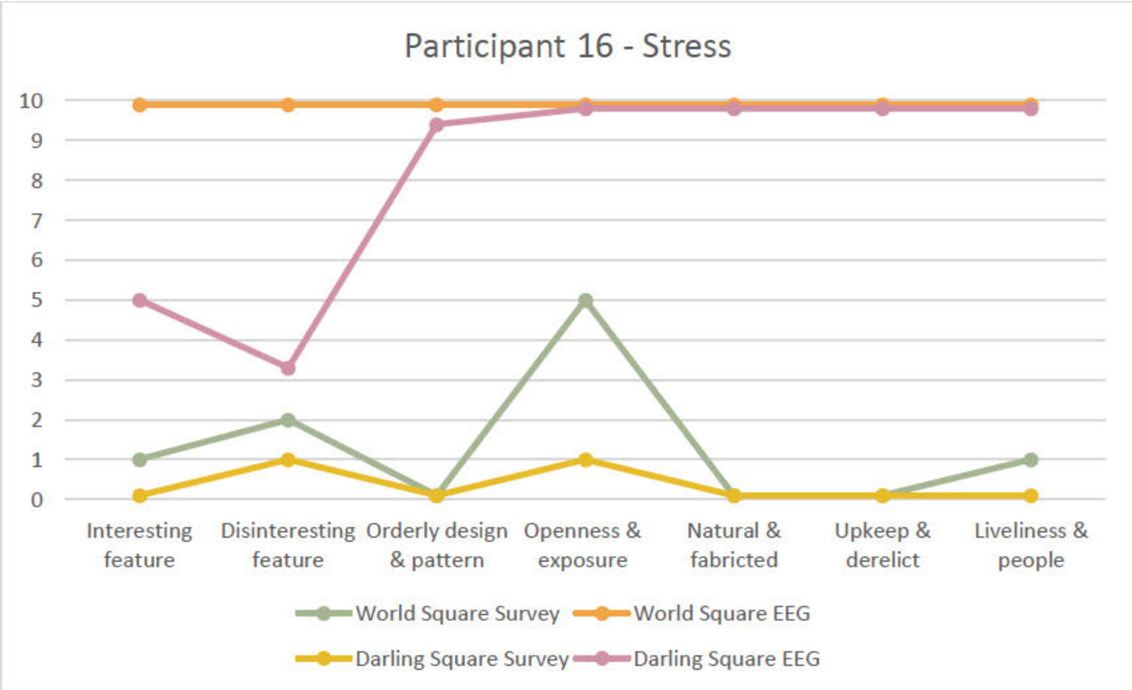


Figure 152. Graph of Participant 16's survey and EEG scores for stress at World Square and Darling Square.

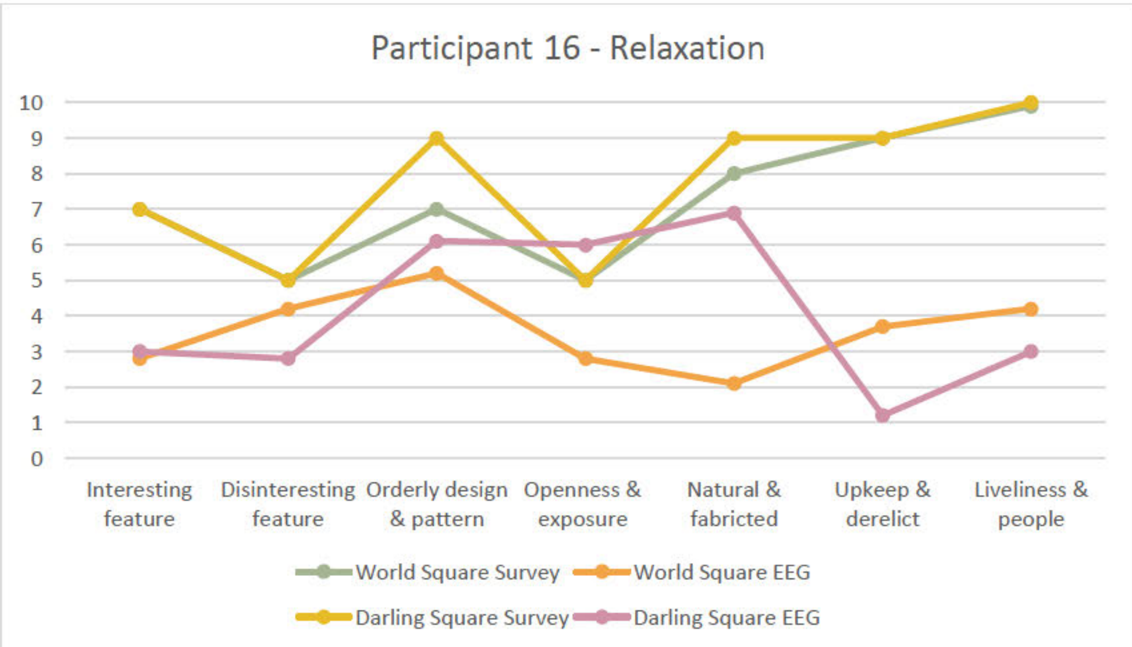


Figure 153. Graph of Participant 16's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 14 "JING"

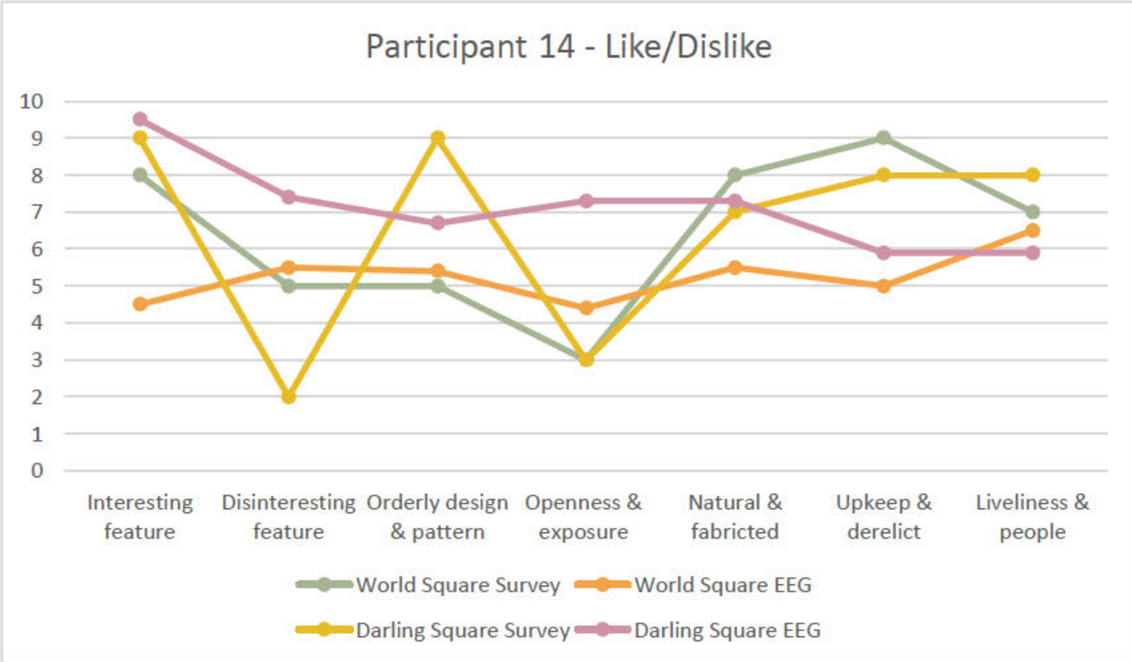


Figure 154. Graph of Participant 14's survey and EEG scores for like/dislike at World Square and Darling Square.

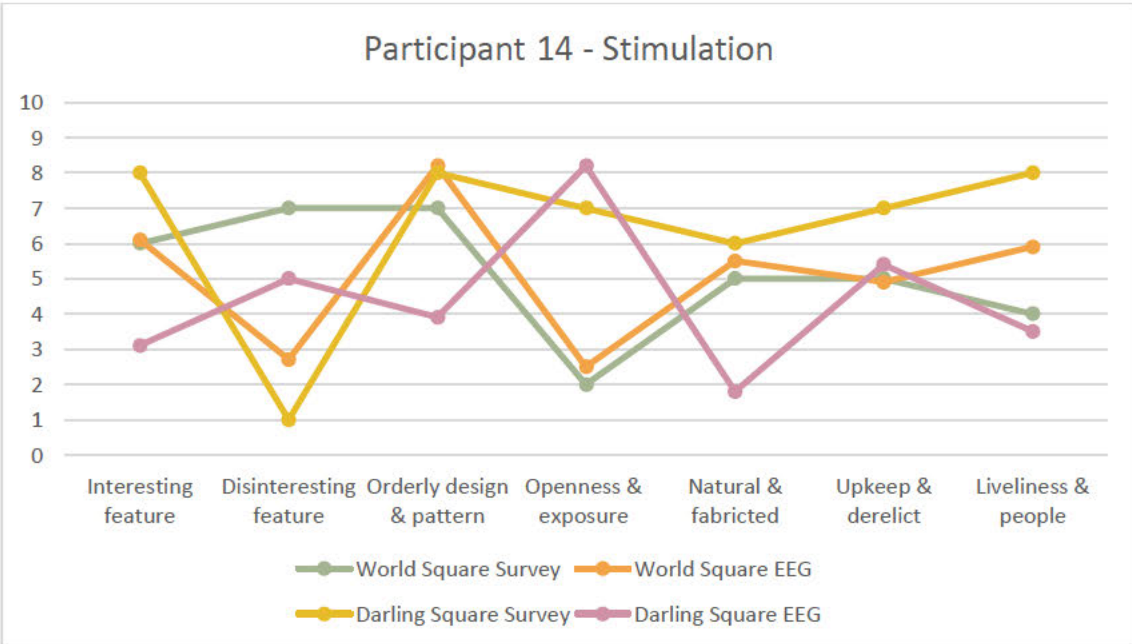


Figure 155. Graph of Participant 14's survey and EEG scores for stimulation at World Square and Darling Square.

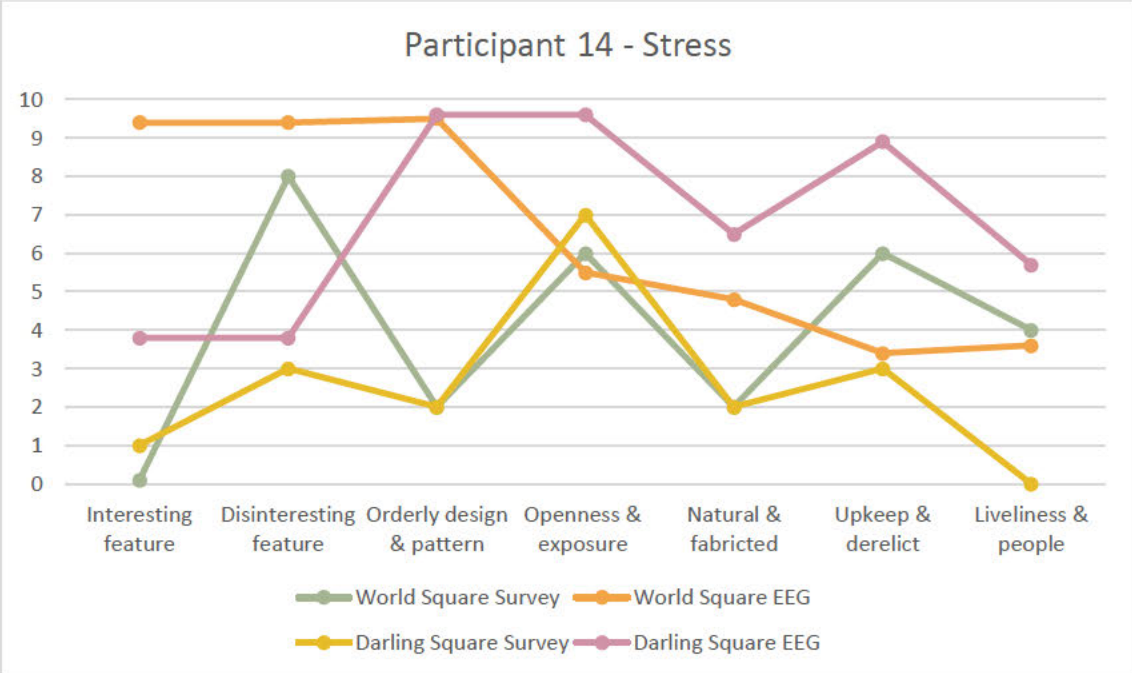


Figure 156. Graph of Participant 14's survey and EEG scores for stress at World Square and Darling Square.

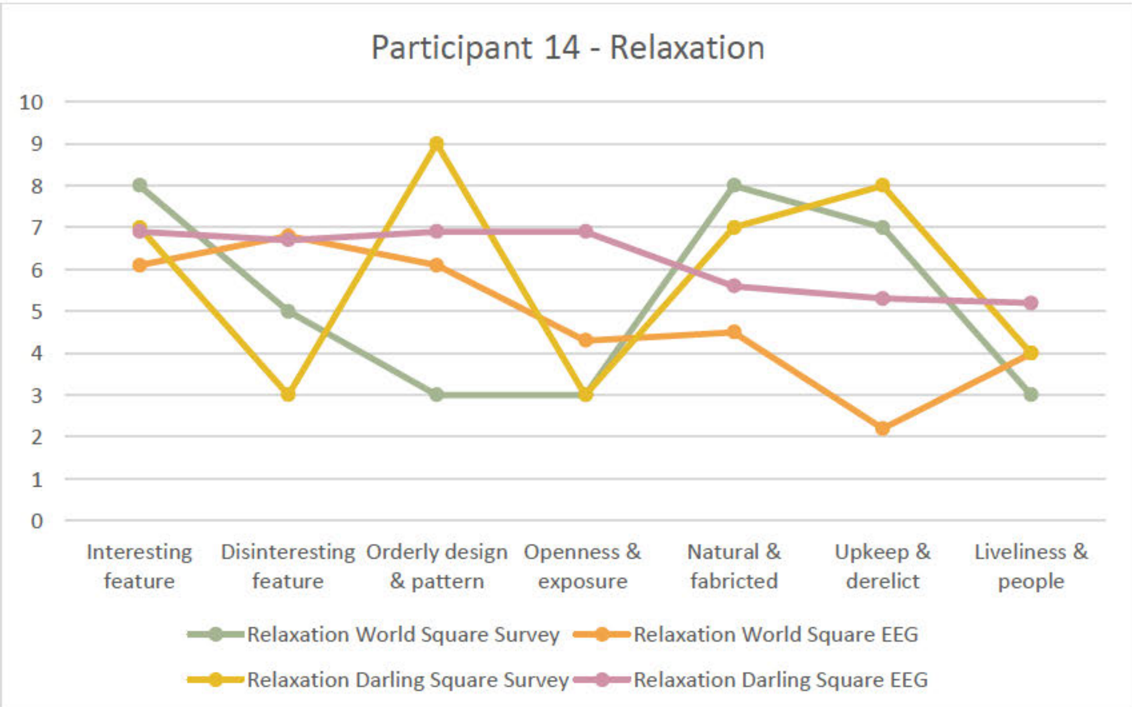


Figure 157. Graph of Participant 14's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 15 "JANE"

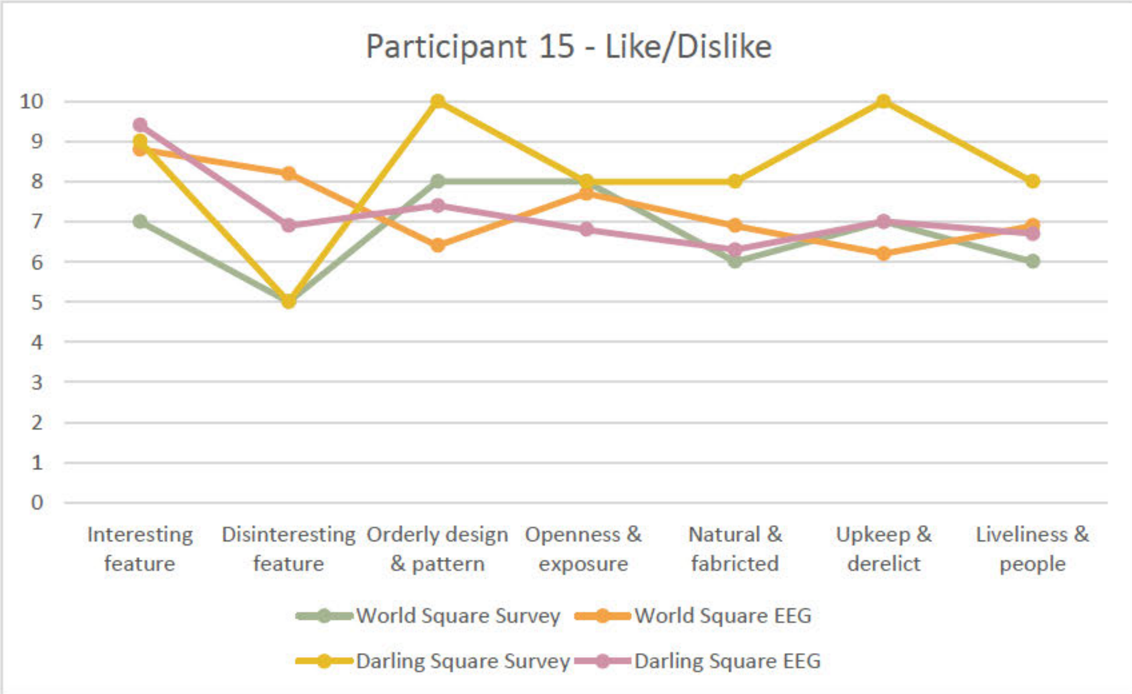


Figure 158. Graph of Participant 15's survey and EEG scores for like/dislike at World Square and Darling Square.

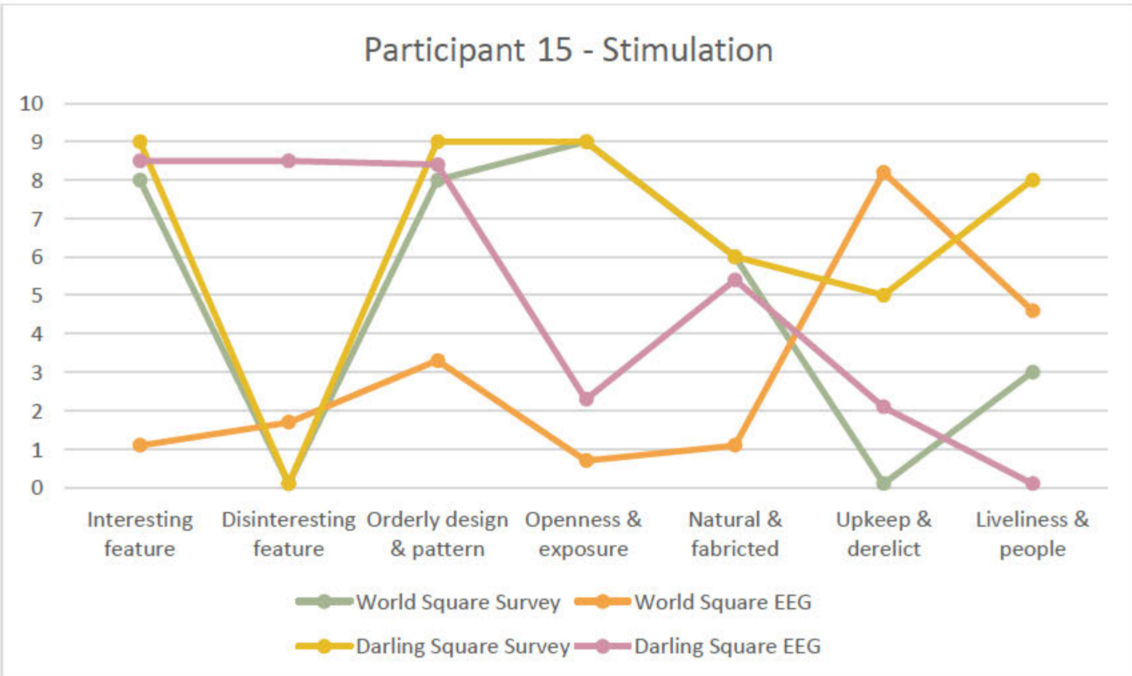


Figure 159. Graph of Participant 15's survey and EEG scores for stimulation at World Square and Darling Square.

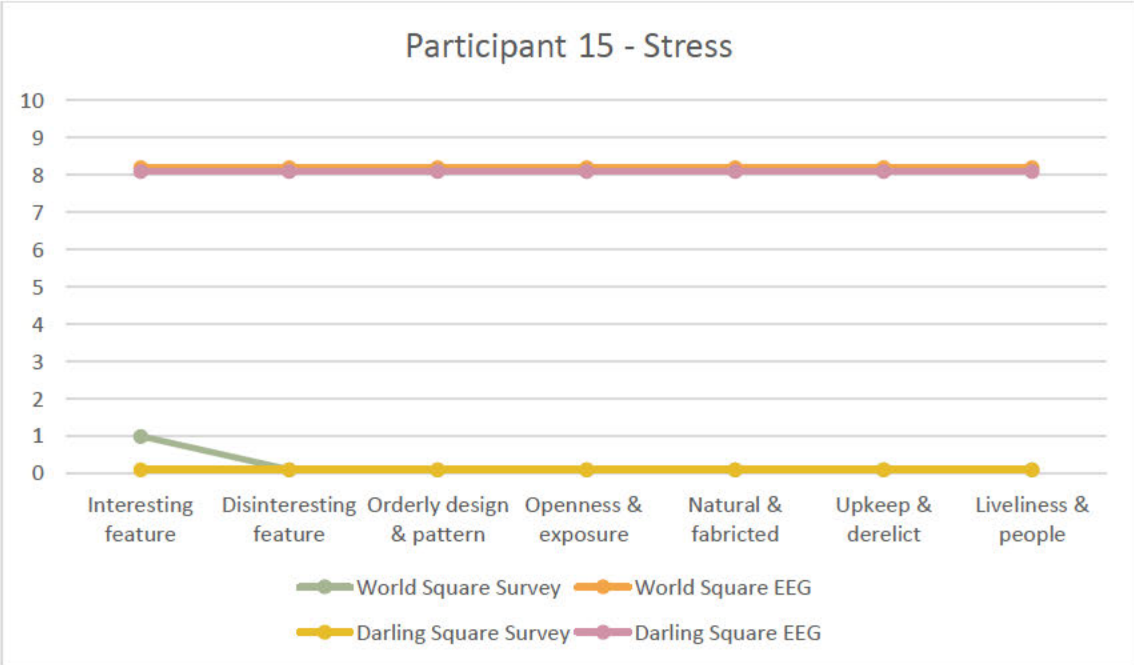


Figure 160. Graph of Participant 15's survey and EEG scores for stress at World Square and Darling Square.

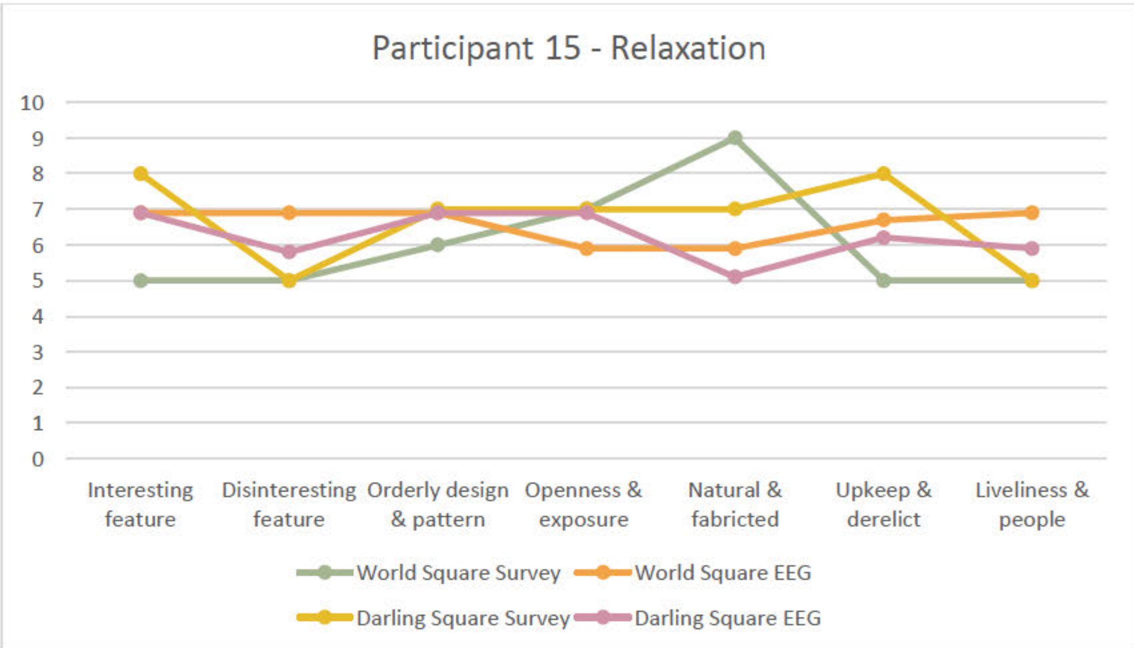


Figure 161. Graph of Participant 15's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 17 "ALEXANDER"

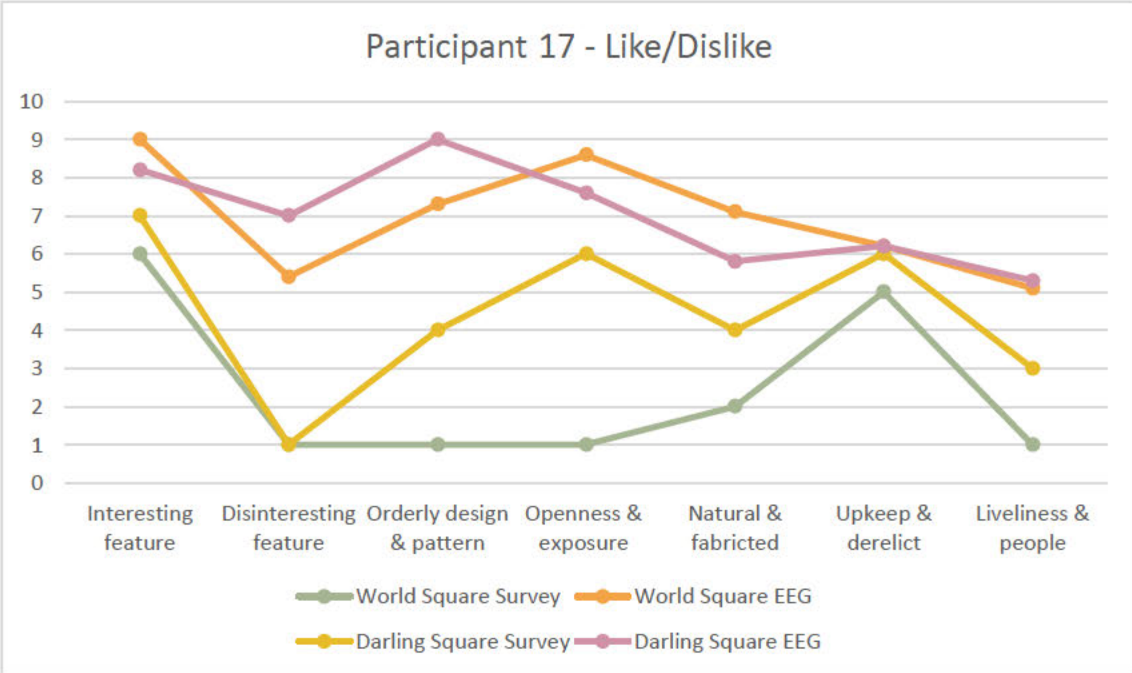


Figure 162. Graph of Participant 17's survey and EEG scores for like/dislike at World Square and Darling Square.

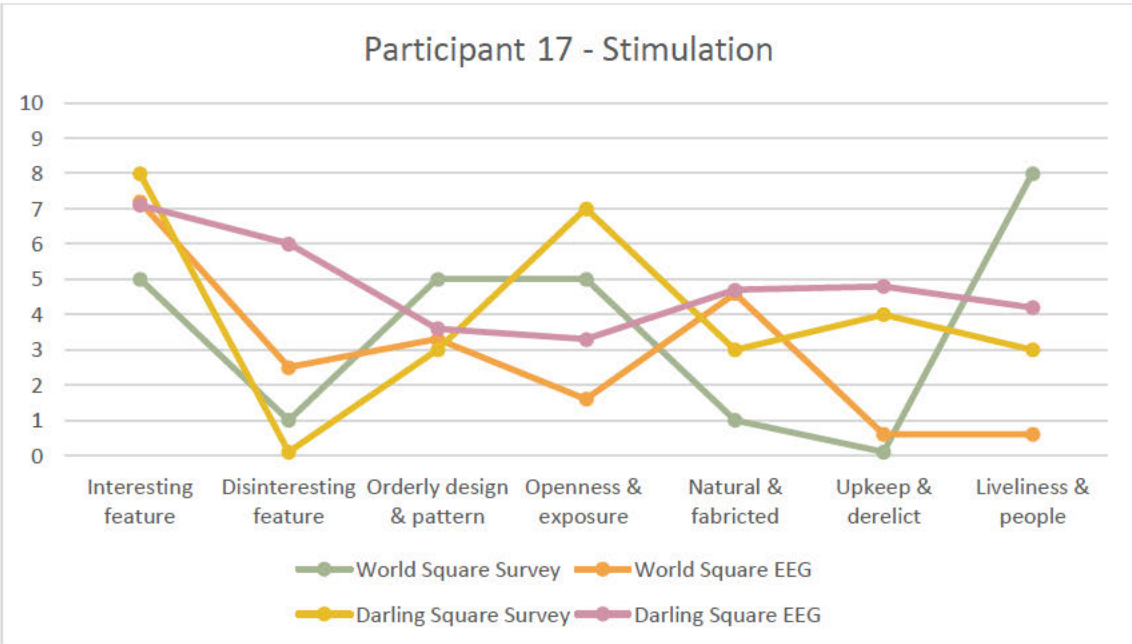


Figure 163. Graph of Participant 17's survey and EEG scores for stimulation at World Square and Darling Square.

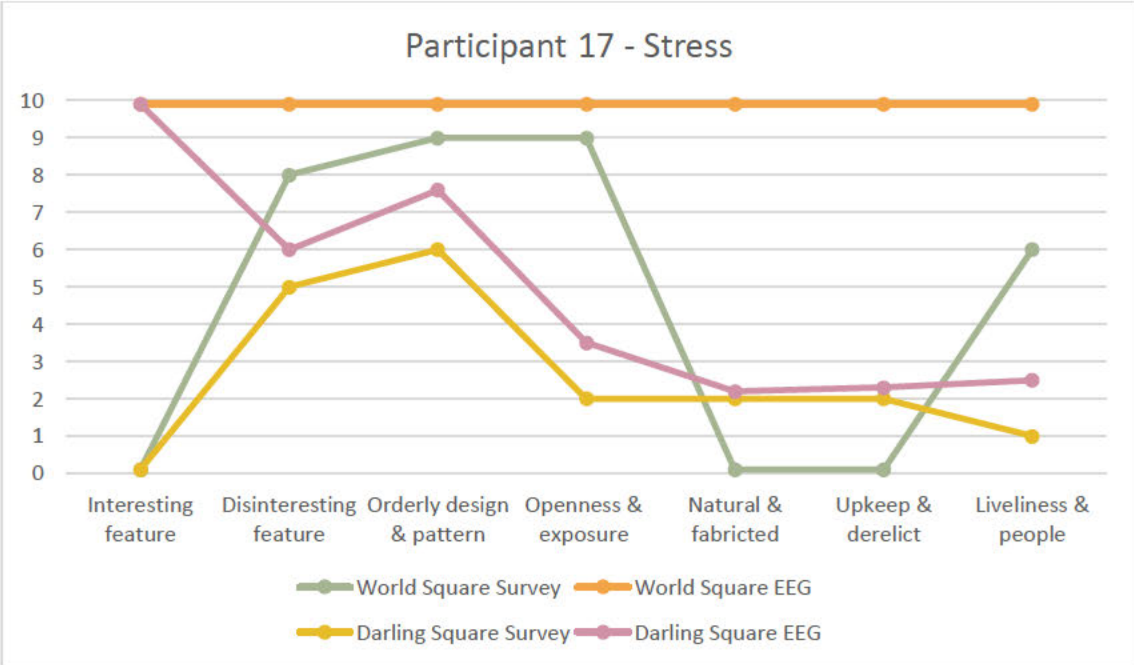


Figure 164. Graph of Participant 17's survey and EEG scores for stress at World Square and Darling Square.

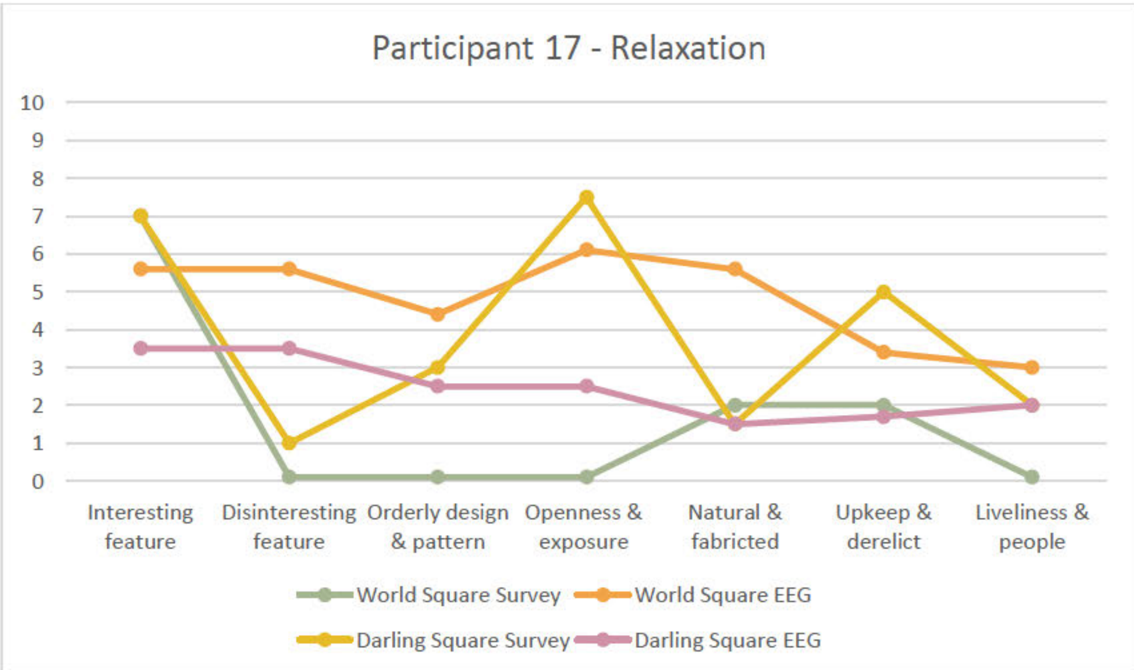


Figure 165. Graph of Participant 17's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 18 "HELEN"

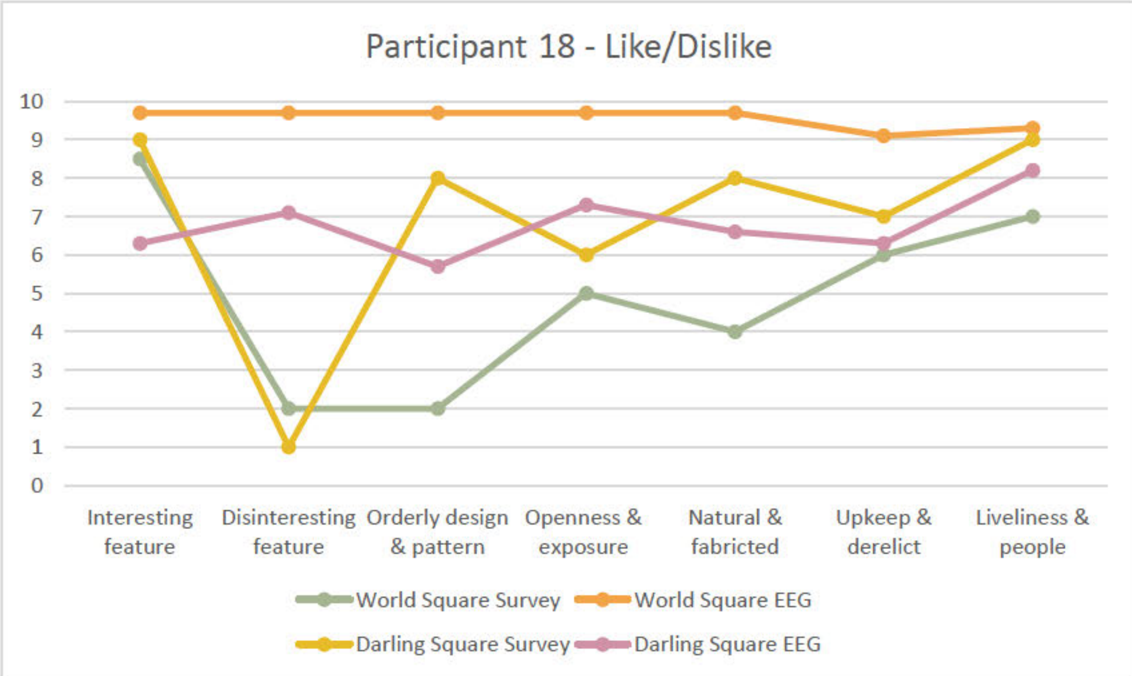


Figure 166. Graph of Participant 18's survey and EEG scores for like/dislike at World Square and Darling Square.

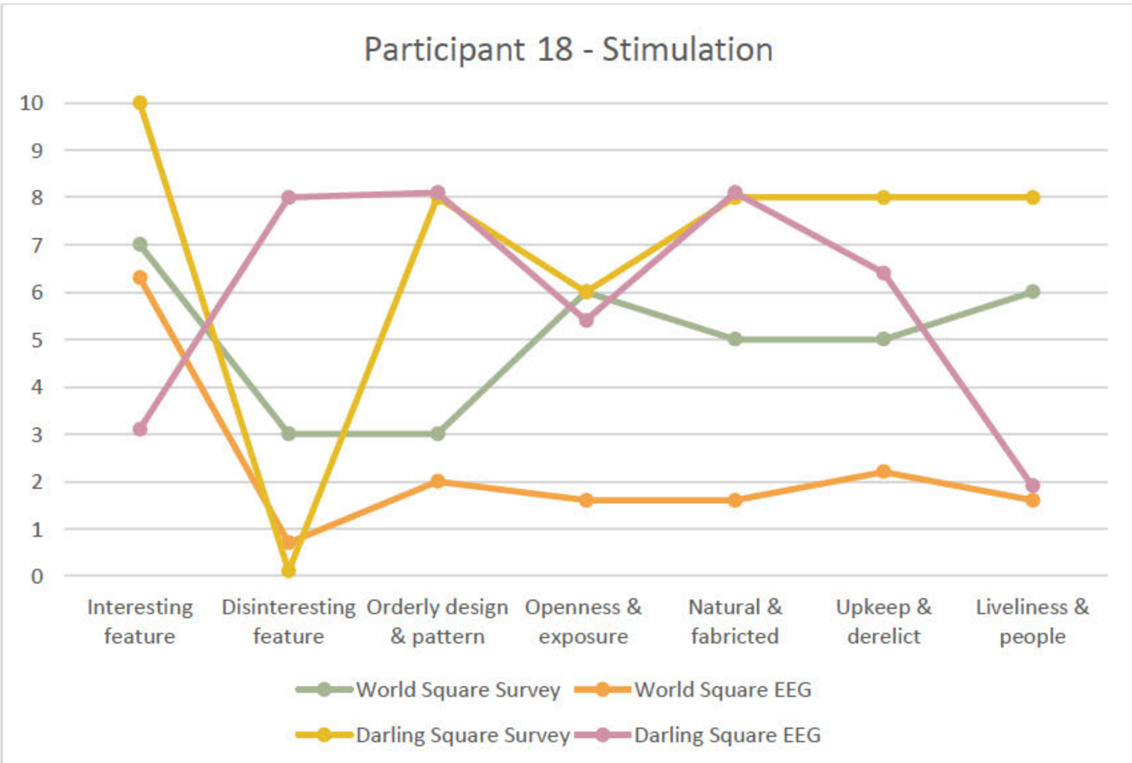


Figure 167. Graph of Participant 18's survey and EEG scores for stimulation at World Square and Darling Square.

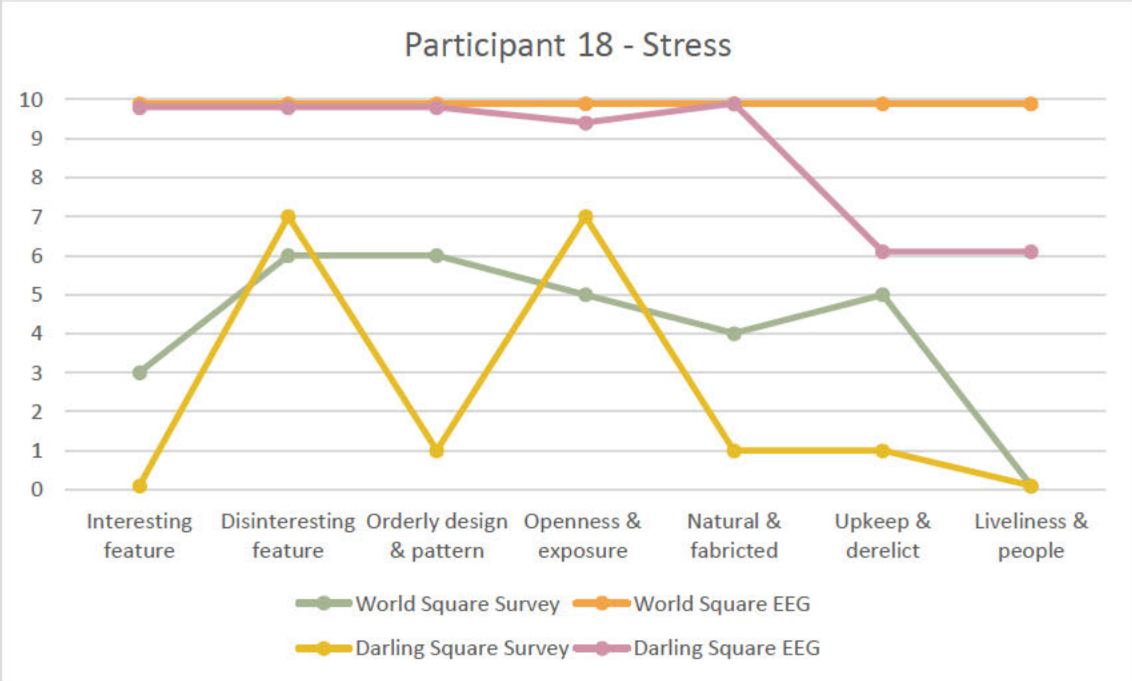


Figure 168. Graph of Participant 18's survey and EEG scores for stress at World Square and Darling Square.

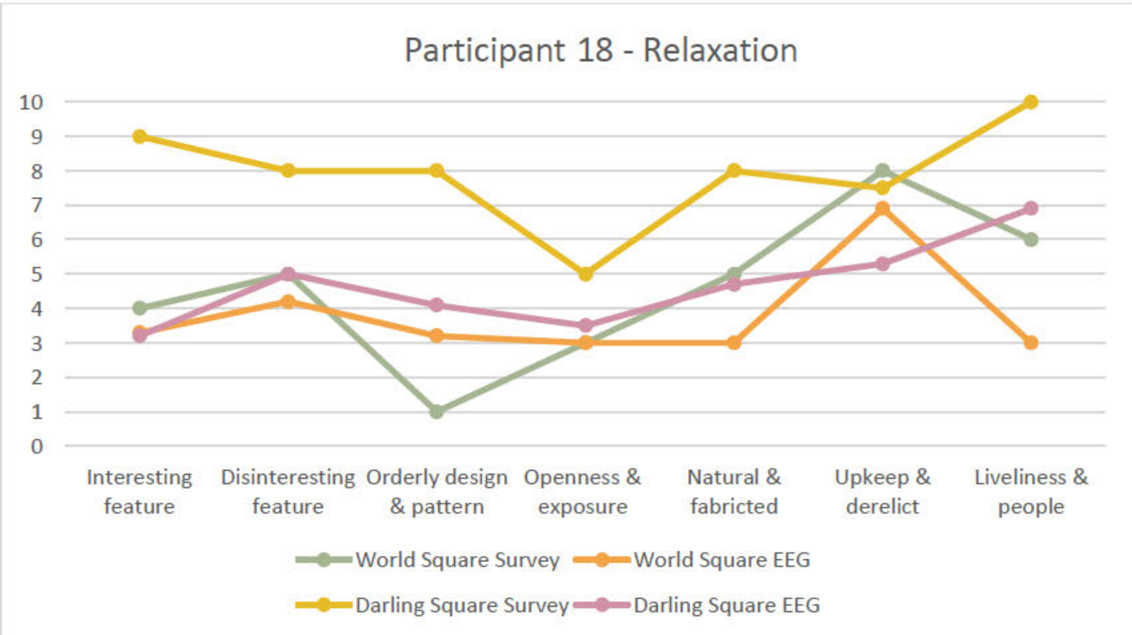


Figure 169. Graph of Participant 18's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 19 "NEHA"

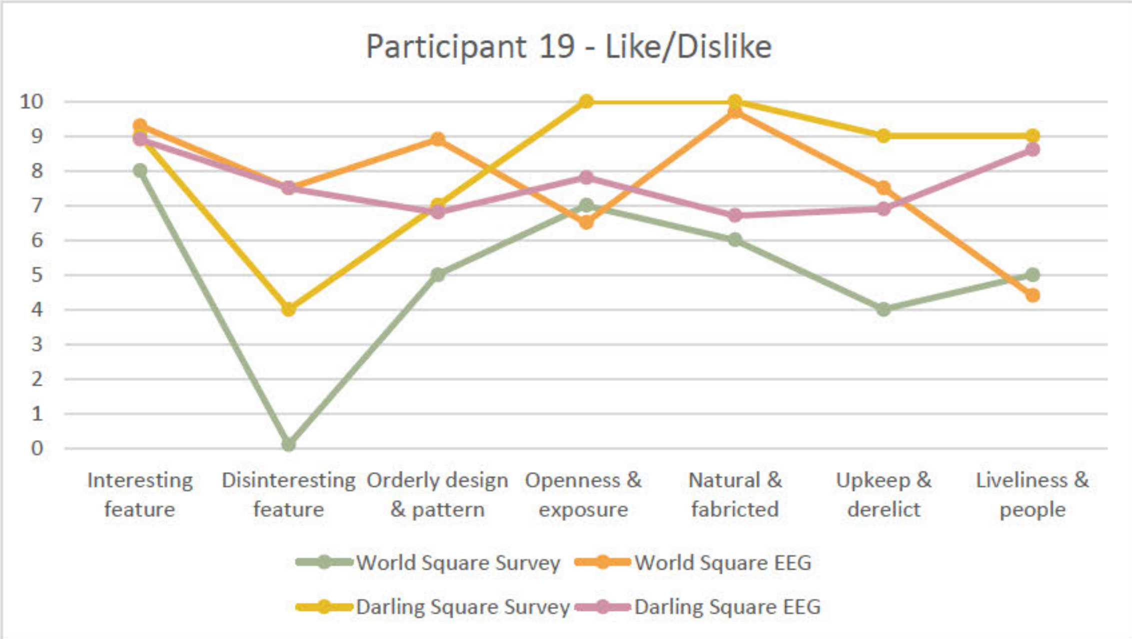


Figure 170. Graph of Participant 19's survey and EEG scores for like/dislike at World Square and Darling Square.

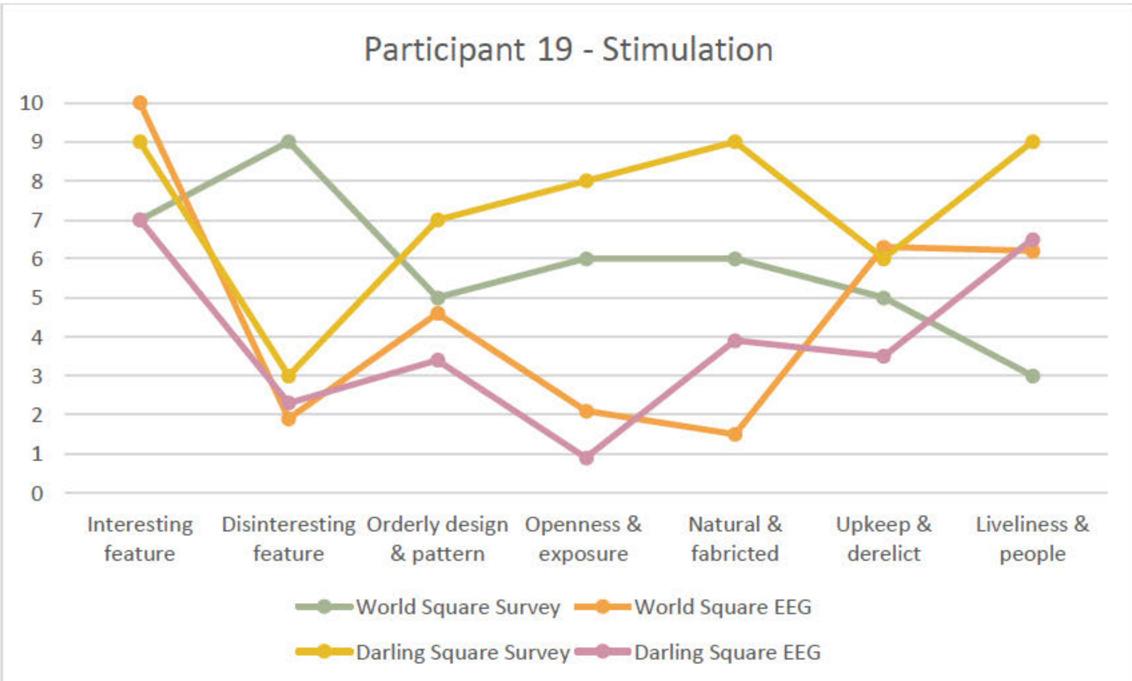


Figure 171. Graph of Participant 19's survey and EEG scores for stimulation at World Square and Darling Square.

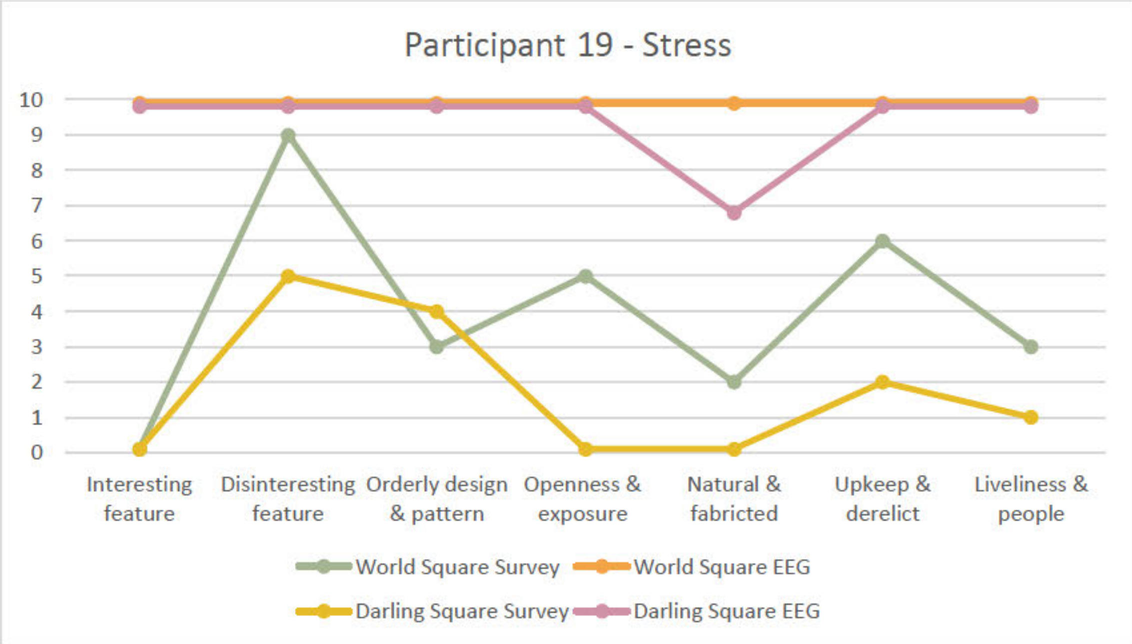


Figure 172. Graph of Participant 19's survey and EEG scores for stress at World Square and Darling Square.

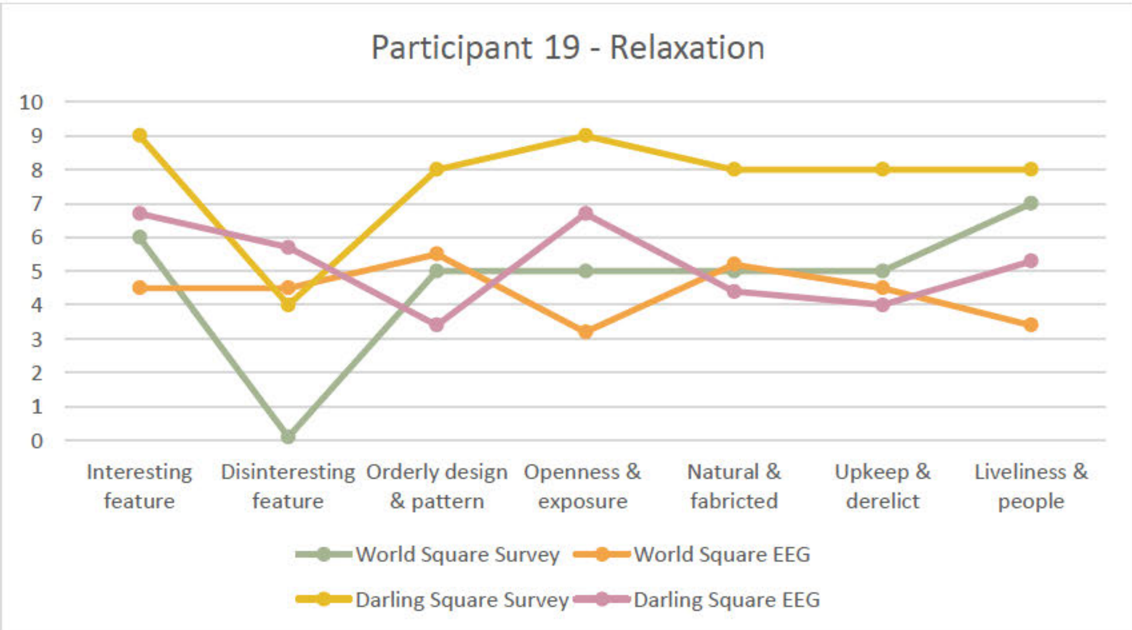


Figure 173. Graph of Participant 19's survey and EEG scores for relaxation at World Square and Darling Square.

PARTICIPANT 20 "NOEL"

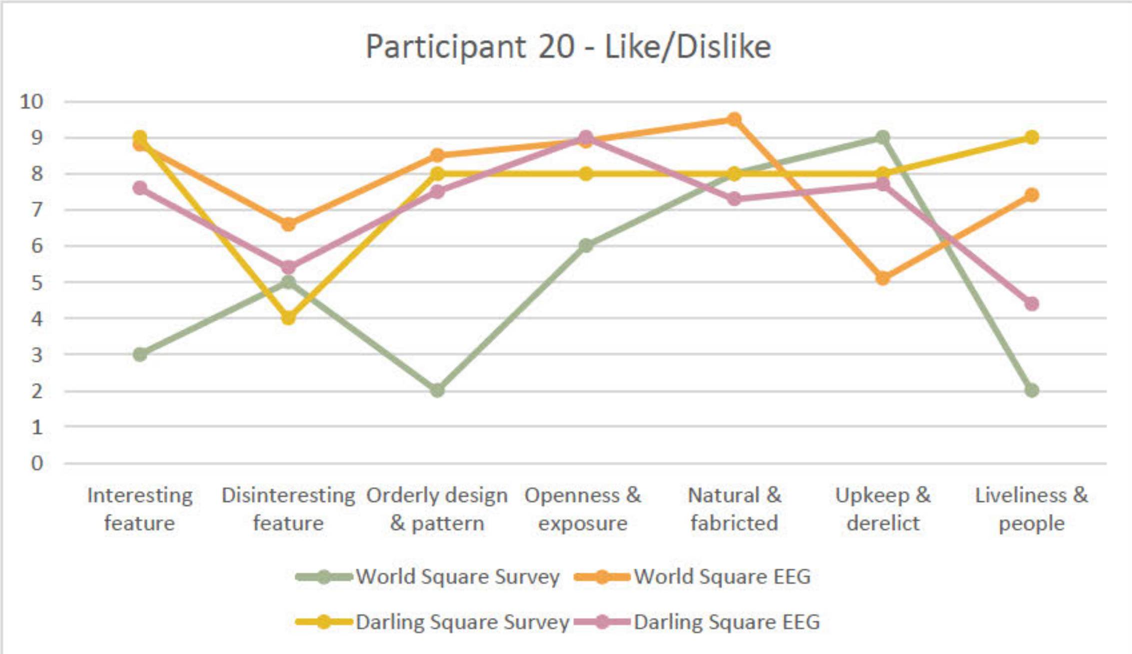


Figure 174. Graph of Participant 20's survey and EEG scores for like/dislike at World Square and Darling Square.

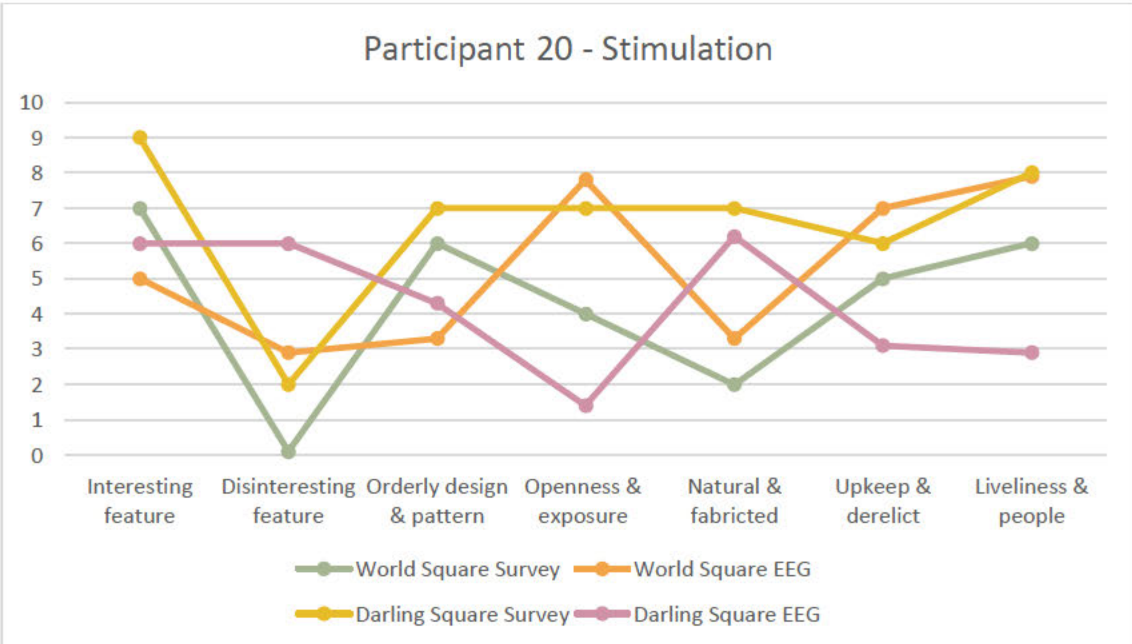


Figure 175. Graph of Participant 20's survey and EEG scores for stimulation at World Square and Darling Square.

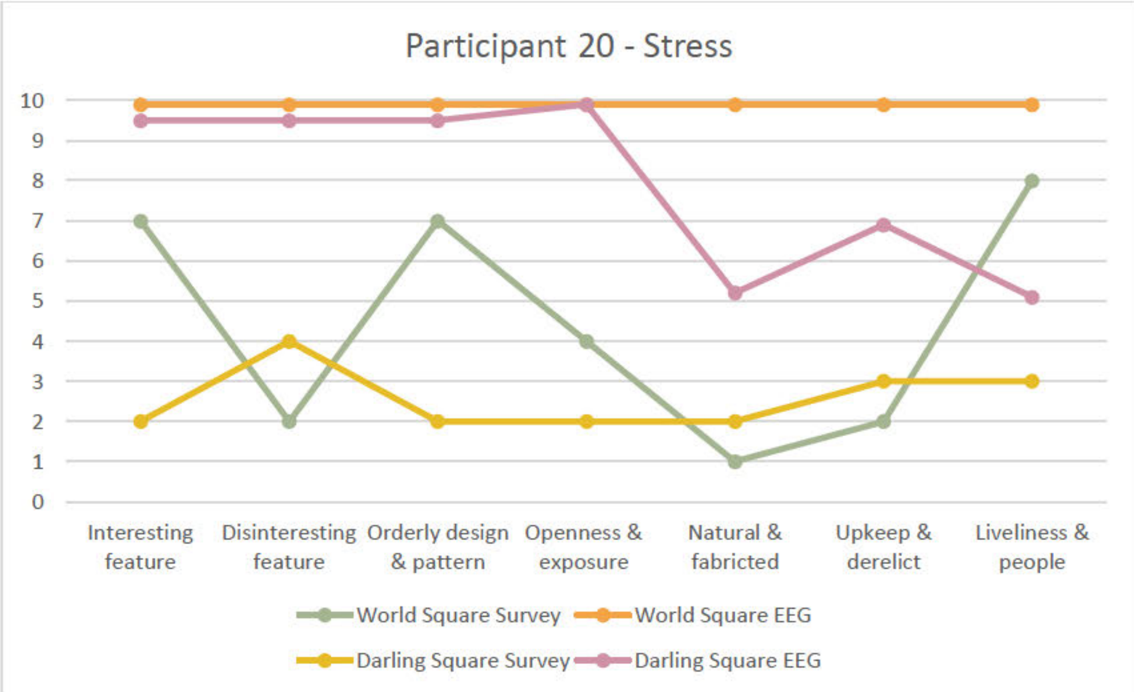


Figure 176. Graph of Participant 20's survey and EEG scores for stress at World Square and Darling Square.

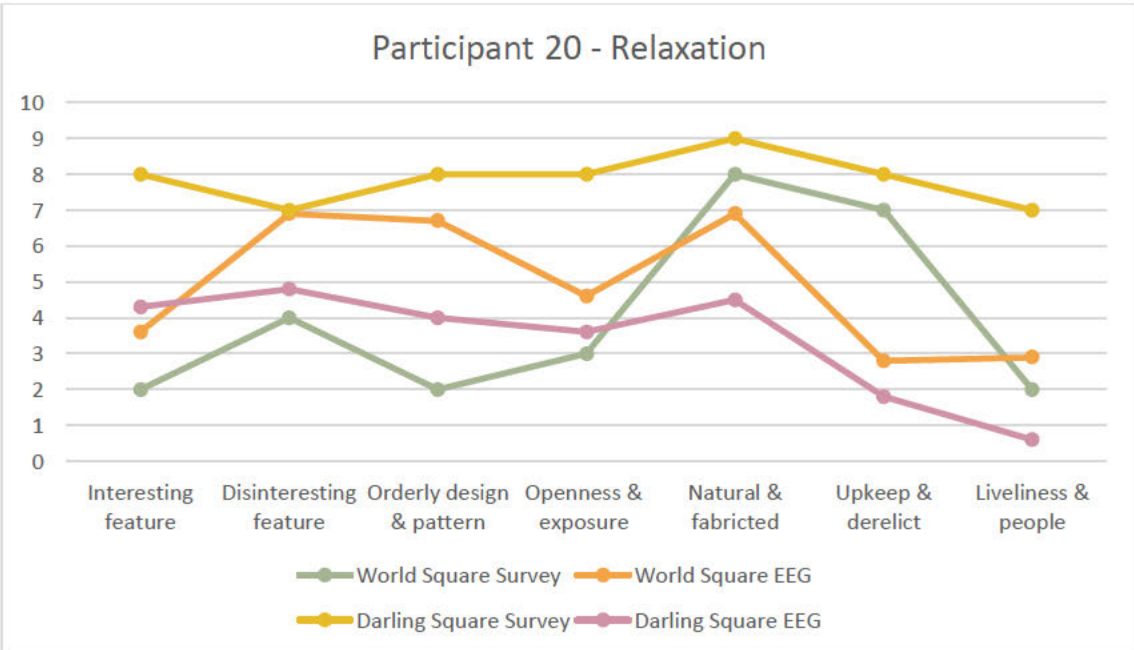


Figure 177. Graph of Participant 20's survey and EEG scores for relaxation at World Square and Darling Square.