Exploring balance between movement and place in designing safe and successful places

An iMOVE CRC project for Transport for New South Wales

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Executive Summary

Project objectives

The purpose of this pilot project is to use the *Movement & Place Framework* to guide the development and testing of a prototype streetscape design assessment system using immersive virtual environments (IVE), to gain insights into citizen perceptions of design elements and safe system treatments. The insights gained from this study will contribute to balancing vehicle movement with place-making and pedestrian perceptions of safety in future street design, thus facilitating the development of *safe and successful places*. The project sets out to address the following questions:

- Can immersive virtual environments be used to assess the impact of pedestrian-oriented urban design elements and safe system treatments on pedestrians' perceptions of safety and place?
- How do safety treatments enhance or dimmish pedestrians' perception of safety and place?
- Is it possible to rank or prioritise pedestrian-oriented urban design elements and safe system treatments based on pedestrians' perceptions?
- Do street trees and other forms of street landscaping improve pedestrians' perception of safety and place?

The outcomes of this research can be used to inform Transport for NSW and local councils toward development and planning of high-quality successful places in both existing and greenfield areas.

Method (at a glance)

To address the objectives listed above, we first established key *streetscape variables* including place-making, safe system treatments and urban design elements which could be expressed in 3D immersive virtual environment (IVE) scenarios. The choice of these variables was informed by two stakeholder workshops with input from Transport for NSW and the Government Architect of NSW. We then used these variables to develop 3D immersive virtual environments streetscape scenario models from the point of view of a pedestrian that included dynamic 'stressor' elements such as vehicle quantity, speed, sound and proximity. We then embedded these IVE scenario models into an interactive online survey (e-participation) to elicit responses from citizens. We collected user experience data through interactive survey techniques including an adaptation of the 'emotion slider' (Laurans et al., 2009) with 'Visual Analogue Scale' (Klimek et al., 2017), and an adaptation of the 'Affect Grid' response method as described by (Russell et al., 1989).

Results (highlights)

'Main streets' are clearly difficult public spaces to 'get right' as they are home to intense multisensory interactions and conflicts between traffic movement and place. The results of this study show that pedestrians chiefly experience '*actively displeased* emotions such as 'Upset' and 'Tense' whilst visiting and navigating main streets that provide limited consideration of pedestrian amenity. However, vast improvements to the experiential qualities and pedestrian perceptions of main streets can be achieved through relatively small, inexpensive design changes such as reducing traffic noise and speed, increasing pedestrian separation from traffic, providing safe cycling, pedestrian prioritised crossing conditions and increasing tree canopy cover.

With respect to the key research questions, we found:

Immersive virtual environments *can* be used to assess the impact of pedestrian-oriented urban design elements and safe system treatments on pedestrians'. The study has provided a wealth of data that allows for the detailed interrogation of citizen perceptions for a variety of streetscape treatments with statistically significant results.

Understanding how safety treatments enhance or diminish pedestrian's perceptions of safety and place is complex, and in some scenarios quite nuanced. While some safety treatments received overwhelmingly positive responses for all questions about quality of place and perceived safety, for example reducing the speed limit from 50km/hr down to 30km/hr, others safety treatments such as the 'Barrier fence', received more divided responses.

It *is* possible to rank or prioritise pedestrian-oriented urban design elements and safe system treatments based on pedestrians' perceptions of safety and place. It is possible to use our IVE e-participation approach to rank and help prioritise different streetscape place and safety approaches based on citizen's perceptions (see table below). The rankings should be considered alongside other practical factors that impact decision making processes such as safety, cost, and potential impacts on traffic flows.

Table 1: Summary table showing statistically significant responses (Sig. $\leqslant$ 0.05) with respect to the 'Baseline' street configuration for all four emotion-slider questions with findings from ranked from most positive to less positive with Exp(B) results included in brackets.

	'would this be a good place to stop for coffee?'		**'how inviting does it feel to cross the street to visit shops on the other side?'**		**'how pleasant is it to stand in this space?'**		**'how safe do you feel in this space?'**
1	'Cycle lane' (3.97)	1	'Wombat cross' (10.40)	1	'Cycle lane' (3.64),	1	'Barrier fence' (3.66)
2	'Wombat crossing' (3.48)	2	'Refuge island' (4.57)	2	'Wombat cross' (3.52)	2	'Wombat crossing' (3.58)
3	'Reduced speed' (3.43)	3	'Sig. cross short-wait' (3.75)	3	'Reduced Speed' (3.23)	3	'Cycle lane' (3.41)
4	'Refuge island' (3.12)	4	'Reduced speed' (3.25)	4	'Refuge island' (2.94)	4	'Parked car buffer' (3.34)
5	'Widened footpath' (2.43)	5	'Sig. cross long-wait' (2.7)	5	'Widened footpath' (2.32)	5	'Reduced speed' (2.86)
6	'Parked car buffer' (2.36)	6	'Cycle lane' (2.63)	6	'Increased tree canopy' (0.99)	6	'Refuge island' (2.66)
7	'Increased tree canopy' (0.73)	7	'Widened footpath' (0.11)	7	'Parked car buffer' (0.74)	7	'Widened footpath' (2.27)
8	'Barrier fence' (0.59)	8	'Increased tree canopy' (0.53)	8	'Ground vegetation buffer' (0.72)	8	'Increased tree canopy' (0.40)
			–	9	'Barrier fence' (0.30)	9	'Ground vegetation buffer' (0.10)
			'Barrier fence' (-0.38.2)			10	'Sig. cross short-wait' (0.62)

***Yes,* street trees and other forms of street landscaping *do* improve pedestrians' perception of safety and place.** The response to street trees was positive in every aspect of the study. In the stated preference ranking questions, Trees were the most popular choice to be ranked no.1 for elements that make a street feel *MORE* pleasant, consistent across *all* scenarios. Trees increased desirability for stopping for coffee, how pleasant it was to stand in the place, how safe they felt, and even how inviting it was to cross the street to visit retail.

Key insights and recommendations for practitioners

The study has revealed a wide range of insights that may be of benefit to practitioners and contributes to the knowledge base and understanding of streetscape design treatments and their impact on perceptions of safety and place. Based on our findings, the following section summarises five key recommendations to practitioners:

1. ***Immersive virtual environments embedded within an online-survey is an effective method for community engagement for streetscapes.*** We recommend adopting the approach for community participation relating to streetscape treatments as it allows focused responses from a large number of citizens that can be analysed using empirical methods.
2. ***Implementing pedestrian safety infrastructure, increasing separation from traffic and calming vehicle speeds makes main streets significantly less stressful.*** As higher speed and noise levels had the strongest negative impact on emotional responses and perceptions of place, we recommend speed reduction as the best safety treatment as it is a low-cost and highly effective adjustment that has the co-benefit of simultaneously reducing noise. Provision of treatments that increase pedestrian separation from traffic, such as cycle lanes adjacent to footpaths, are also an effective way to positively impact perceptions of place.
3. ***Cycle lanes vastly outperform barrier fences in making a positive contribution to safety and place.*** Consistent with prior research findings, barrier fence separations that obstructed pedestrian movement in lieu of traffic speed reduction were perceived as having a low to negative impact on perceptions of place. Presence of cyclists (even for non-cyclists) were strongly indicated as a positive safety and place element, ranking the most popular choice for making a street feel more pleasant and in the top three most popular choices for making a street feel more safe. We recommend separated

bike paths located adjacent the footpath as a highly effective main street intervention for improving perceptions of both safety and place. Barrier separations that impede pedestrian movement and can ‘feel claustrophobic’, such as fencing, should only be used sparingly, for example, where distance separation cannot be achieved, or areas adjacent school exit points.

4. ***Increasing tree canopy should be in conjunction with other treatments.*** Increasing tree canopy coverage makes a significant positive place contribution but should be undertaken in conjunction with other safety and place treatments, such as reducing speed.
5. ***Combining multiple treatments can have a synergistic, positive impact on place.*** Multiple treatments can have a synergistic impact on place. Combinations of treatments that blend the reduction of vehicle speed, increase physical separation from vehicles, prioritise pedestrian crossing access and increase tree canopy are likely to greatly improve perceptions of safety and place. Further research is required to explore possible synergistic combination of treatments (discussed further in the next section).

Suggested further research - what next?

While the *Exploring balance between movement and place in designing safe and successful places* pilot project has demonstrated the successful application of a new e-participation approach that combines online survey methods with animated immersive virtual environments, ‘affect grid’ and ‘emotion sliders’ to quantify and assess citizen’s perceptions of safety and place, results and insights gained from the project suggest great potential in expanding this research. Further work is recommended to build on the outcomes of this project:

- The study could be extended to include in-person assisted e-participation that would be more inclusive for older adults and increase accessibility for people with visual impairment.
- Further study on immersion for IVE experiences through controlled environment experiments.
- Expansion of the range of streetscape variables.
- The results from the study suggest further testing of designs that combine multiple street treatments, such as ‘Cycle lanes’ combined with ‘Wombat crossings’; ‘Reduced speed’ combined with ‘Increased tree canopy’; and ‘Wombat crossing’ combined with ‘Reduced speed’, ‘Cycle lanes’, and ‘Increased tree canopy’.

Part 1: Review of research relevant to project

Understanding perceptions of safety and place for different street design treatments is a complex cross-disciplinary area of study. In this part of the document, we provide an introduction and background to the project, discuss the importance of safety, and the importance of place. We go on to touch on key research related to using immersive virtual environments to analyse perceptions of safety and place, approaches for eliciting and measuring citizen participant perceptions, followed by a discussion of safe and successful places and a variety of design treatments for ‘main streets’.

Introduction

As Australian urban populations expand and cities adjust to accommodate higher densities, increased pressure is placed on already contested space within streets. As our cities grow, it is important to develop policies and streetscape designs that provide pedestrians with safe comfortable walking conditions to major destinations such as public transport, shops, healthy food, parks and recreation facilities (Thomson et al., 2017).

Streets and roads can make up to 80% of the public open space of cities. Consequently, designing successful streets and roads is critical to the vibrancy and liveability of these cities, and the safety, activity, and health of their communities. As outlined in the *Future Transport Strategy 2056*, successful streets and roads meet the demands of both transport movement and place-making (Transport for NSW, 2018a). The *Road Safety Plan 2021* is a supporting plan of the *Future Transport Strategy 2056,* that identifies liveable and safe urban communities as priority areas to progress towards NSW road safety goals (Transport for NSW, 2018b). This plan acknowledges the challenges involved in keeping urban places liveable and safe and emphasises the important role of streets around busy destinations such as shopping centres, entertainment precincts, education facilities, in supporting and encouraging the movement of people, goods, and services.

The *Movement & Place Framework* (GANSW, 2019) underpins the *Future Transport 2056* Strategy. This framework is used as an integrated place-making[1] and transport movement planning tool, focused on delivery of health and wellbeing benefits for the community. At the core of this framework is an aim to; *allocate road space in a way that improves the liveability of places*. From a place-making perspective, the framework illustrates how amenity for pedestrians is diminished in spaces that prioritise efficient motor vehicle thoroughfares over the human experience of streets. Busy, noisy streets with fast moving traffic can be unpleasant for pedestrians and cyclists as well as detrimental to retail, restaurants, and cafés. Conversely, successful streets, that moderate between vehicle movement and pedestrian amenity and allow local communities to come together, support social and economic growth and thus become successful places.

The importance of safety

The safety of streets and roads is an important aspect of successful places. *The Road Safety Plan 2021*, in the short term, aims to deliver the *State Government's Priority Target* of reducing fatalities and serious injuries by 30% by 2021 (Transport for NSW, 2018b) and in the long term, it aims to deliver on the *Towards Zero Vision*, committing to zero fatal and serious injuries across the NSW road network by 2056 (Transport for NSW, 2018c, 2019). This plan is supported by the internationally recognized *Safe System* approach (Turner & Jurewicz, 2016) that acknowledges:

- The human body has physical limits to withstanding the impact of a crash.
- People sometimes make mistakes, but this shouldn't cost anyone their life.
- Roads, roadsides, travel speeds and vehicles should be designed to avoid a crash or reduce the impact of a crash.
- Road safety is a shared responsibility, from road and vehicle design, investments, laws, education, to each road user acting safely every day, and
- Improving road safety encourages sustainable transport modes which helps to reduce emissions and contribute to improved public health through walking and cycling.

There is a wide range of safety measures and possible solutions for improving street and road safety such as: reducing the number of lanes, slowing traffic, adding buffers and safety barriers, and removing trucks from particular streets (note: a series of streetscape design safety measures will be discussed in greater detail later in this document). Instigating any one of these

[1] Placemaking is a multi-faceted approach to the design, planning, and management of public spaces to create 'places' where people *want* to live, work and visit. Places are complex, multi-layered and diverse environments within the broader context of society and the public realm (Government Architect NSW, 2017).

measures needs to be carefully considered in relation to its impact on other interrelated street network systems and urban change processes both long and short term (Wegener Spiekermann, 2004).

Each safety measure can be likened to an adjustable variable in the overall street network system. Adjustment of any variable aimed at improving safety can also come with associated ‘costs’; financial, physical or perceptual. For example, reducing car speed from 60km/h to 40km/h can reduce the risk of pedestrian fatalities by 60% but at the same time, can negatively impact vehicle movement and network efficiency (Transport for NSW, 2016). The signalising and shortening of signal wait times for pedestrian crossings, installation of refuge islands or the narrowing of traffic lanes, can dramatically reduce conflicts between pedestrians and vehicles at intersections but can come at the cost of congestion on others, caused by redirected traffic (Gårder, 1989; Kang, 2019). Kerbside barriers can reduce fatalities but also result in a cost to streetscape perceptions of attractiveness, comfort and convenience for pedestrians (Pitt et al., 1990; Zheng & Hall, 2003).

The importance of place

Places, according to the Government Architect of NSW, are ‘inclusive, connected, diverse, safe, comfortable, liveable, functional, efficient, fit for purpose, engaging, inviting, attractive and create or add value’ (Government Architect NSW, 2017). Place-making and perceptions of place have been a growing concern for urban designers, particularly in relation to busy streets with high volumes of both pedestrian and vehicular traffic, as these shared and vibrant places are increasingly understood as a pivotal component of public open space and the life blood of cities and towns (Dover & Massengale, 2013).

Main streets are often characterised as shared multipurpose spaces which can be transformed to host cultural and community events, thus providing critical social infrastructure (Montgomery, 1998; Project for Public Spaces & UN Habitat, 2012). For these shared spaces to be successful, vibrant places, they must allow movement and be safe, but also provide a high-quality human experience through pedestrian oriented amenities such as seats and trees. Ensuring busy streets are successful vibrant places is important for multiple commercial, human and environmental health reasons. The success of retail and commercial outlets relies on the quality of the street for pedestrians (Desyllas & Ward, 2009; Gehl & Gemzøe, 2003; Litman, 2010). Streets that are associated with positive pedestrian perceptions are linked to communities with better physical and mental health and higher rates of walking (Giles-Corti et al., 2011, 2016; Taylor et al., 2015). Higher rates of walking also mean reduced rates of car use, which in turn lead to improved environmental outcomes through reductions in energy consumption and carbon emissions (Kenworthy et al., 1999; P. G. Newman & Kenworthy, 1989; P. Newman & Kenworthy, 2015).

The co-presence of vehicles and pedestrians in main streets presents challenges from both safety and place-making perspectives. Pedestrians in these environments are exposed to several variable stressors associated with speed, proximity and volume of adjacent vehicle traffic that detract from walking experiences. Stressors such as noise and air pollution can create negative perceptions of the character and safety of these streets (Kaparias et al., 2012). Installation of safety measures on busy streets can contribute to streetscape success in both positive and negative ways. Some safety measures promote pedestrian activity and encourage vibrancy while others can incur negative perceptions of place. For example, streets that have kerb edge guard railing were found by Zheng and Hall to have fewer positive perceptions of convenience and attractiveness than streets without them (2003). In addition, not all safety measures are physically achievable as street space is often very limited. Given the variety of options for improving street safety and the constrained nature of streetscapes, it is essential to understand the impact different safety measures have on safety and movement, *in conjunction* with the impact these measures have on pedestrian experiences and perceptions of safety, to improve and optimise methods for their selection. Understanding perceptions is important for achieving safety without diminishing the qualities that contribute to successful places.

Using virtual environments to analyse safety perception and place

Visual representation

Studying pedestrian preferences and perceptions of place and safety in urban environments is challenging because these perceptions are affected by both static and dynamic variables. For example, static spatial variables such as street widths and number of lanes can affect the perceived ease of making street crossings while dynamic visual and auditory variables associated with the speed, proximity, and volume of adjacent vehicular traffic can powerfully impact or significantly alter the perceived safety or convenience of making that crossing.

While the use of images, either 2D photographs, photomontage or graphic illustration stimuli have been found to have a high level of efficacy in preference studies for static aspects of street configuration (Ng et al., 2015; Stamps, 2010), preference studies, aimed at understanding the multisensory impact of dynamic traffic conditions on pedestrian perceptions of safety and place in streetscapes, require more complex stimuli and methods of data collection (Zacharias, 2001).

Even for static variables, there are limitations to using photographic stimuli for preference studies. Not only is photography of spatially comparable conditions from comparable locations within the street required, the quality of the imagery, impacted by light conditions, the time of day, season, weather variation and the quality of the camera can confound results. Control for individual variables using this method is not possible as it would require streets with only a single difference between them (Moudon & Lee, 2003). These issues can be somewhat negated through use of the photomontage technique where still images are modified to reflect a single variable change, or through the use of more abstracted forms of representation such as those used on the recent Sydney Road improvement project (VicRoads, 2019).

Geographic Information Systems (GIS) data analysis-based methods for assessing the impact of measures of urban street green space and streetscape spatial proportions on rates of walking and perceptions of safety have also been developed (Harvey et al., 2015; Sarkar et al., 2015). However, as identified by Sakar, these methods have not accounted for the impact of changes in traffic parameters and thus cannot be used to understand causality. In addition, as outlined in the study by Harvey, measures were limited to the vertical spatial configuration of streetscapes rather than horizontal aspects such as lane widths, bike lanes and traffic proximity.

Overcoming some of the issues associated with still image visual assessment stimuli and GIS based methods, studies have also been undertaken through selection and pairing of video samples of existing streetscapes (Ewing & Clemente, 2013). This method while it is more suitable for understanding the impact of traffic movement on perceptions, it also suffers from similar difficulties to those that arise in selection of still photographic studies, with an added complication of sound variations.

In recognition of the difficulties in application that the above methods pose for analysing the impact of single variables on walking behaviour, Borst developed a coupled environmental audit and survey-based respondent mapping technique (Adkins et al., 2012; 2008). While this method allows for more detailed breakdown of physical variables impacting results, it is difficult to control for individual experiences, local knowledge and memories of the specifics of places included in the surveys which may impact perceptions of place and safety.

Ultimately pedestrians do not experience streets from a static point of view, the adjacent transport is in motion which has more than simple visual perceptive affects. Nor is it easy for people to separate lived experiences of specific locations from their physical characteristics. Virtual 3D environment models can overcome many of these problems more effectively than the previous described methods as confounding factors can be minimised, individual variables can be controlled for, lived experiences and memory can be avoided and movement and sound can be simulated in addition to visual and spatial aspects.

While virtual environments must address the concept of embodiment (or how real it feels to exist in the simulated space) and of levels of realism, virtual environments have been found to offer excellent insight into how people express movement choices

(Grechkin et al., 2014) and allow controlled adjustment of dynamic visual and auditory variables through movement, light and sound simulation (Berger & Bill, 2019; Yu et al., 2018).

Immersive virtual environments (IVEs)

Over the past three decades, there has been growing promise in the use of Virtual reality (VR) and immersive virtual environments (IVE) in design, to enable increased spatial understanding. These include IVEs viewed using enclosures with multi-directional projections such as Cave Automatic Virtual Environments (better known by the acronym CAVE) (Joseph et al., 2020), interactive desktop applications, and through head mounted displays (HMDs) (Schnabel & Kvan, 2003). Over the last decade there has been a significant increase in the availability of affordable, high-quality HMDs for consumers such as Oculus Rift and HTC Vive. These options are significantly cheaper than the CAVEs and HMDs from the 1990s which cost in the tens of thousands of dollars. An even cheaper approach is to use smart phones to achieve IVEs. By using smart phone's inbuilt gyroscope sensors, it is possible to display a virtual environment in such a way as to allow the viewer to look around. The smart device can be held in the user's hands or can be placed in a cheap VR headset such as Google Cardboard, Daydream and Samsung Gear VR. The user can download IVE three-dimensional models to the phone and interact with the environment in a similar way to the higher end HMDs. They are however limited by the computational power of their specific smart device, meaning that an older or lower performance phone may be limited to very basic or abstracted geometry, material and light rendering quality.

A solution to this limitation is using animated computer graphics, that allow IVEs to be pre-rendered as equirectangular projection videos (White, 2015). These 360-degree videos (also known as immersive videos or spherical videos) are rendered with metadata that informs the smart-phone to project the video spherically and allow for interaction through the movement of the device using its gyroscope sensor to track movement. Though not necessarily commonly known, this capability has been available on all Android and iPhone devices for several years and even built into Google's YouTube app (Bonnington, 2015). Though this approach is not necessarily the highest fidelity method for IVEs, the ubiquitous nature of this technology makes it ideal for high reach or crowd sourced research into user perceptions of spaces such as streets, as almost everyone already has the technology to interact with the IVE's in their pocket.

360-degree auditory cues in immersive virtual environments

Sound is an important aspect in supporting the feeling of presence and "being there" in virtual environments (Nordhal & Nilsson, 2014). Until recently, the study of presence in interactive virtual reality has been dominated by a focus on visual stimuli. While vision is regarded as dominant for spatial localisation and human experience (Radeau, 1994; Schifferstein, 2006), according to Larsson et al. (2010), the auditory modality possesses unique features that may make it a deciding factor in achieving a full sense of presence. In the real world, our ears are "always open", hence auditory perception cannot be turned off. Additionally, while the visual perception which supports our sense of the surrounding environment is inherently directional, as determined by our field of view, auditory perception is omni-directional.

If we look further at presence as it relates to the concept of immersion, in particular perceptual immersion, this is achieved by substituting stimuli from the real world with artificial stimuli through 360-degree virtual environments and spatialized sound systems. Spatial sound rendering can 'create an impression of a sound environment surrounding a listener in 3D space, thus simulating auditory reality' (Larsson et al. 2010). In addition to providing information about the environment beyond our field of view, sound can also influence perception of visible and tangible events and objects in the virtual environment (Nordhal & Nilsson, 2014). Auditory cues can help establish direction and visual cues for navigation in virtual environments (Lokki, 2005) while visual feedback helps the user interpret the sensory cues (Berhhard et al., 2011). Larsson et al. (2010), identify four categories of auditory factors that can influence presence: the spatial properties of the sound, the auditory background, consistency within and across modalities, and the quality and content of the sound. These are factors that need to be considered in the design and evaluation of 360-degree sound in immersive virtual environments.

Eliciting responses about perceptions of safety and place

Perceptions of feelings and mood

Immersive virtual environments (IVEs) have recently gained popularity in health sectors for their potential to improve recovery outcomes. A review of the use of IVEs in health sectors by Roche et al. (2019) shows that IVEs including virtual reality (VR) holds great promise in supporting mental wellness in clinical settings, during daily activities, at the workplace and in other stressful situations. Immersiveness and interactivity are important aspects that affect people's feelings and moods when they are using virtual reality. Menzies et al. (2016) suggest that the degree of fidelity of the IVE technology is closely related the degree of presence experienced by the users. Fidelity in virtual reality refers to the degree of authenticity in which the virtual simulation mirrors the real world. Menzies et al. (2016) define visual fidelity in virtual reality as 'a measure of how convincing the virtual environment is and its resultant ability to induce feelings of presence'. Fidelity can be either physical fidelity, that is, the degree to which the physical simulation looks, sounds and feels like the real world it represents (Baum et al., 1982) – or psychological fidelity, how accurately the mind reproduces psychological factors like feelings and moods (Kaiser & Schroeder, 2003). Flow is another aspect which can positively impact a user experience of virtual reality and the effectiveness of intended design outcomes (Janssen et al., 2016). Csikszentmihalyi (1975), who introduced the concept of flow, defines it as a 'holistic sensation that people feel when they act with total involvement' and indicates it as an important aspect of an experience that leads to happiness and enjoyment, while also feeling in control of the situation. Flow is a component that can be measured in assessing the amount of presence that a user is experiencing.

Interactivity within a virtual environment can also affect the user experience. User experience and usability of a virtual environment are strongly linked, and it is difficult for any interactive system to have a good user experience when the usability of that environment and the tools to operate it are not easy to use.

All of these factors, immersion, presence, flow and interactivity, can influence the quality of the user experience of virtual reality, which in turn impacts the kinds of conclusions that can be draw from people's reactions to simulated environments with respect to the real world. There are several validated metrics and tools available for measuring user experience which can be adapted for use within IVE's. Table 2 and Table 3 give an overview of some of the tools available which inspired our evaluation process for eliciting responses about perceptions of safety and place while using our 3D streetscape virtual environment scenario models.

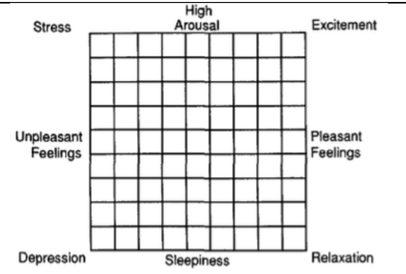
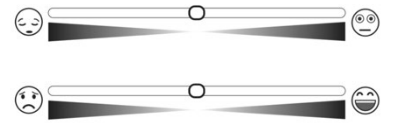
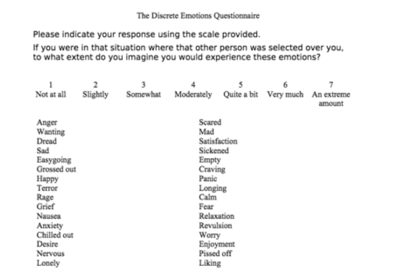
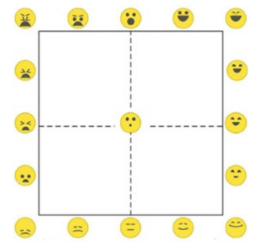
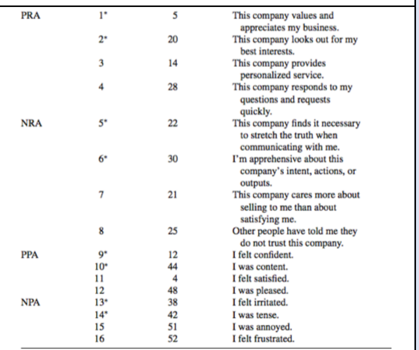
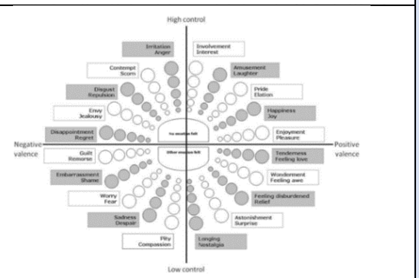
These tools have been designed to understand people's responses to virtual environments and measure different aspects of human experience. Table 2 includes tools that are specifically for measuring user experience and usability of technology, and hence can be directly applied to a user experience of virtual environments. Table 3 includes tools that measure user experience with respect to human perceptions of emotion and mood in responses to different situations. Measuring these reactions within a virtual environment gives access to human emotional responses to changes within that environment. The tools in Table 3 offer different methods for quantifying human experience and emotional responses to different situations, products and services. Both tables catalogue what the tool measures, a description of the type of tool and how it is used in practice, and gives a pictorial illustration of the tool where relevant. A selection of these tools can give access to measures of user experience to be able to conduct comparisons of perceptions of safety within a virtual world, as well as perceptions of place, across different virtual conditions.

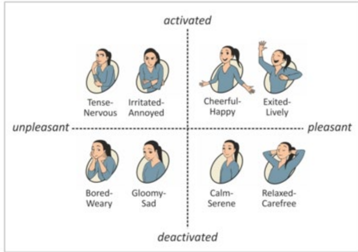
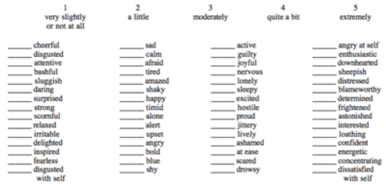
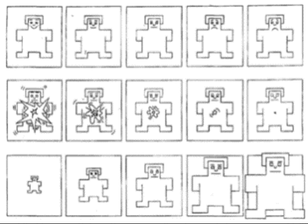
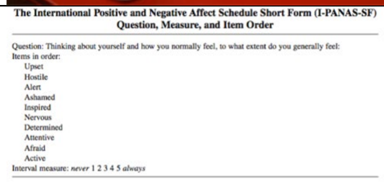
The tools and techniques measure human affective responses through different mechanisms, and often focus on particular aspects of human emotions and feelings that they are eliciting. These mechanisms include responses on a continuum using slider mechanisms, discrete measures using 7-point or bipolar scales, or 2D grids where users can self-assess their current emotional state with respect to the defined axes of the grid, place their response within the 2D space. The tools can be delivered at different times during the experience, to fit the phase and physical activities of the research, where measurements can be collected before the task, during the task, between tasks, or after the entire session. In VR or IVEs evaluations are often conducted before and after the virtual environment experience rather than during the experience, so as to not disrupt the user's sense of immersion and presence in the IVE. Each of the tools have their benefits and shortfalls, and the choice of tools is made with regard to support both the testing environment, and the granularity (or discrete entities) of the response required.

Table 2: Tools Measuring User Experience, and Usability

Name	Author	Measuring	Type of Measure/Tool & Use	Example
Attrakdiff	(Hassenzahl et al., 2003)	Attractiveness of a product	Usability and design of an interactive product, digital, 7-point subjective ratings scale, distinguishing pragmatic and hedonic qualities of interactive systems ie, ugly-attractive, human-technical, etc. (IT focus)	
Eye tracking	(Elbabour et al., 2017)	Usability testing	Comparting video cued retrospective think-aloud with gaze-cued RTA (systems usability)	
Emotion Slider	(Laurans et al., 2009)	Emotion, user experiences with interactive systems	Slider, Self-reporting, continuous measurement, this is a mechanism not a measure in itself, pushing device vs pulling device (IT focus)	
Holistic UX (HUX)	(Toussaint et al., 2012)	Overall User experience	21 characteristics to form description of user experience - 21 product attributes are pre-filtered or adapted depending on the product category, rated on 7point likert scale (agree) (product focus)	
RTA	(Willis & McDonald, 2016)	Usability	RTA after each task vs after each session (system usability)	
TA-eye tracking	(Freeman, 2011)	Usability	TA with eye tracking cued in task responses (system usability)	
UEQ	(Schrepp, 2008)	User experience	26 items, 6 UEQ scales (attractiveness, familiarity, efficiency, dependability, stimulation, novelty), semantic differentials (2 items with opposite meanings), 7-point scale, pragmatic and hedonic qualities (product focus)	attractive o o o o o o o unattractive

Table 3:Tools Measuring User Experience, Mood and Emotions

Name	Author	Measuring	Type of Measure/Tool & Use	Example
Affect Grid	(Russell et al., 1989) (Killgore, 1998)	Assessment of Mood - Pleasure and arousal	Single-item scale, self-reporting, a quick means of assessing affect along the dimensions of pleasure-displeasure and arousal-sleepiness	
Affective Slider	(Betella & Verschure, 2016)	Human emotions	Self-assessment scale, digital version of SAM (see this table), two slider controls for the quick assessment of pleasure and arousal, continuous scale	
Discrete Emotions Questionnaire (DEQ)	(Harmon-Jones et al., 2016)	Emotions	Self-reported state of emotions, sensitive to eight distinct state emotions: anger, disgust, fear, anxiety, sadness, happiness, relaxation, and desire, 7 point scale (product focus)	
EmojiGrid	(Toet et al., 2018)	Affect – pleasure and arousal	Self-reported 2D pictorial scale, reflecting valence and arousal dimensions of the affect grid	
Emotional Metric Outcomes (EMO) questionnaire	(Lewis & Mayes, 2014)	assess the emotional outcomes of interaction	Multifactor standardized questionnaire that provides an assessment of transaction-driven personal and relationship emotional outcomes, both positive and negative, 16 items, rated as positive or negative, relationship and personal (PRA, NRA, PPA, NPA), interaction of customers with service-provider personnel or software (product focus)	
Geneva Emotion Wheel (GEW)	(Scherer, 2005)	Discrete emotions	40 emotion terms in 20 emotion families on two dimensions, unpleasant to pleasant, low to high control, no emotion in the centre of the wheel (product focus)	
Photographic Affect Meter (PAM)	(Pollak et al., 2011)	Current emotion, affect, mood	Choose from a wide variety of photos what fits current mood, runs on mobile phones, quick, for frequent sampling in context	

Pick-a-Mood (PAM)	(Desmet et al., 2016)	Mood (lasting) – as specific from emotion (immediate)	Self-reporting, visual select from 8 discrete states as represented by male, female or robot character, on 2D axes, pleasant, activated.	
Positive and Negative Affect Schedule (PANAS-X)	(Watson & Clark, 1994)	Feelings and emotions – mood measures	60-item standardized questionnaire, self-rated positive and negative affect, rating emotional words and phrases (general focus)	
Self Assessment Manikan (SAM)	(Bradley & Lang, 1994)	Pleasure, arousal and dominance	Self-reporting tool, non-verbal pictorial assessment, affective response to wide variety of stimuli, 18 bi-polar adjective pairs, 3 simple judgements on pleasure, arousal, dominance in pictures	
Sensual Evaluation Instrument (SEI)	(Isbister et al., 2006)	affect	Self-assessment of affect while interacting with computer systems, objects representing emotions (confusion, frustration, fear, happiness, surprise, satisfaction, contentment, stress, and flow) (IT focus)	
PANAS-SF (short form)	(Thompson, 2007)	Discrete emotions	10 items, international positive and negative affect (general focus)	

1 very slightly or not at all	2 a little	3 moderately	4 quite a bit	5 extremely

___ cheerful	___ sad	___ active	___ angry at self
___ disgusted	___ calm	___ guilty	___ enthusiastic
___ attentive	___ afraid	___ joyful	___ downhearted
___ bashful	___ tired	___ nervous	___ sheepish
___ sluggish	___ amazed	___ lonely	___ distressed
___ daring	___ shaky	___ sleepy	___ blameworthy
___ surprised	___ happy	___ excited	___ determined
___ strong	___ timid	___ hostile	___ frightened
___ scornful	___ alone	___ proud	___ astonished
___ relaxed	___ alert	___ jittery	___ interested
___ irritable	___ upset	___ lively	___ loathing
___ delighted	___ angry	___ ashamed	___ confident
___ inspired	___ bold	___ at ease	___ energetic
___ fearless	___ blue	___ scared	___ concentrating
___ disgusted with self	___ shy	___ drowsy	___ dissatisfied with self

The International Positive and Negative Affect Schedule Short Form (I-PANAS-SF)
Question, Measure, and Item Order

Question: Thinking about yourself and how you normally feel, to what extent do you generally feel:
Items in order:
Upset
Hostile
Alert
Ashamed
Inspired
Nervous
Determined
Attentive
Afraid
Active
Interval measure: *never* 1 2 3 4 5 *always*

Immersion, presence & UX

Immersive virtual environments (IVEs) are different from 2D images in that they are designed to increase the user's deep mental involvement when engaging with the system. A key factor in the creation of virtual environments is that they are perceptually realistic for the users, providing an experience that is similar to normal reality (Loomis et al., 1999). This relies on the ease of the user interaction and a sense of immersion for the participant. A widespread definition of immersion by Witmer and Singer (1998) states that 'Immersion is a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences. A more technical perspective has been adopted by Slater and Wilbur (1997) who argue that immersion is 'a description of a technology, and describes the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding, and vivid illusion of reality to the senses of a human participant'.

Immersion in a virtual environment is linked to a person's sense of presence and a feeling they are actually in that environment. Presence is often described as 'the feeling of being there' in a virtual environment (Slater & Wilbur, 1997). An early paper by Heeter (1992) discusses three different aspects of presence: personal presence, social presence (Short et al., 1976), and environmental presence. Personal presence refers to the individual's perceived sense of "being there". Social presence refers to the degree of interaction with other animated or real characters in the virtual world. Environmental presence refers to the degree in which the environment responds to the user's presence. Heeter (1992) suggests 'a virtual world which is more responsive than the real world could evoke a greater sense of presence than a virtual world where the environment responds exactly like the real world'. It should be noted that the degree of social and environmental presence is thought to positively impact on the degree of personal presence. While immersion is regarded as an objective measure defined by the quality of the sensory fidelity provided by the technology, presence appears to be more subjective and is determined by the user's awareness of being in the VE (Slater & Wilbur, 1997). As Sheridan (1992) points out 'presence is a mental manifestation, not so amenable to objective physiological definition and measurement'. Similarly, Witmer and Singer (1998) refer to it as 'the subjective experience of being in one place or environment, even when one is physically situated in another'. The view adopted by Slater and Wilbur (1997) and Witmer and Singer (1998) suggests a linear causality with high quality three-dimensional images provided by virtual reality systems can result in high levels of immersion, leading to higher levels of mental presence (Cummings & Bailenson, 2016).

Both immersion and presence support a quality user experience in a virtual environment. Whether it is delivered using head-mounted displays or three-dimensional renderings of space via a traditional 2D interface (monitor or smartphone interface), immersion and presence are essential for simulations where we are trying to elicit human responses to equivalent physical environments. In investigating assessment of virtual and real spaces, Chamilothori et al. (2019) move beyond investigation of the experience of interactive virtual environments to a comparison of virtual spaces with corresponding real spaces. They found that important attributes included field of view and user interaction with the presented scene. They report on investigations that identified an interactive panoramic view as the most perceptually accurate, and highlight the importance of immersion and interactivity in a virtual scene. Along with the simulation accuracy of the virtual scene, presence is an important factor in a virtual environment that helps replicate our experience of a real space (Diemer et al., 2015; Kort et al., 2003). The main goal of an immersive virtual environment is to create a high sense of presence (Witmer & Singer, 1998). Presence is one of the most accepted measures of virtual environment effectiveness of a virtual reality experience (Skarbez et al., 2017).

Table 4:Tools Measuring Immersion and Presence

Name	Author	Measuring	Type of Measure/Tool & Use	Example
Immersive Tendencies Questionnaire (ITQ)	(Witmer & Singer, 1998)	Presence, tendencies of individuals to experience presence	Pre-task, set of 29 questions to determine tendencies of individual (around involvement, focus, games) 7 point Likert scale (general focus)	12. What kind of books do you read most frequently? (CIRCLE ONE ITEM ONLY!) Spy novels Fantasies Science fiction Adventure Romance novels Historical novels Westerns Mysteries Other fiction Biographies Autobiographies Other non-fiction 13. How physically fit do you feel today?
iGroup Presence Questionnaire (IPQ)	http://www.igroup.org/	Sense of presence, as a variable of user experience	Specific to VR, Subjective rating scales, 14 questions, rating anchors such as fully disagree-fully agree, discrete, Likert scale	sense of being there | PRES | In the computer generated world I had a sense of "being there" | not at all--very much
Presence Questionnaire (PQ)	(Witmer & Singer, 1998)	Presence in virtual environments	Post-task, set of 32 questions to determine presence in VR (around control, sensory, distraction, realism, natural, auditory, haptic, resolution, interface), 7-point Likert scale, sematic differential scale (VR focus)	18. How compelling was your sense of moving around inside the virtual environment? NOT COMPELLING — MODERATELY COMPELLING — VERY COMPELLING **Figure 1.** *An examplar item from the Presence Questionnaire.*
Slater-Usoh-Steed questionnaire (SUS)	(Usoh et al., 2000)	Presence	6 questions, Measuring the sense of being in the VE, the extent to which the VE becomes the dominant reality, and the extent to which the VE is remembered as a 'place', 7-point scale, compare real and virtual (VR and real env)	1. Please rate *your sense of being in the* office space, on the following scale from 1 to 7, where 7 represents your *normal experience of being in a place.* *I had a sense of "being there" in the office space:* (1) Not at all. (7) Very much.

The sense of embodiment is strengthened when the motion of the participant is mapped to the virtual body in real-time (Kilteni et al., 2012). Head mounted displays contribute to the sense of immersion of the experience, but although to a reduced extent, immersion and presence are still possible using the 360-degree desktop VR format (Marques et al., 2019; Robertson et al., 1997). However, the virtual environments must be adequately realistic to support a good user experience as well as facilitating users in interacting with the environment naturally (Kronqvist et al., 2016), so that it can elicit realistic emotional responses from users (Estupiñán et al., 2014) through presence and immersion. To understand how well a virtual environment simulates a real situation, it is important to understand the levels of immersion and presence that are being experienced by the user in that virtual environment. There are several validated metrics and tools available for measuring immersion and presence, which can be used to establish user experience of these qualities in a virtual environment, irrespective of the delivery mode (ie., CAVE, HMDs or desktop VR). Table 4 gives an overview of tools that can be used to measure presence and immersion in virtual environments which inspired our evaluation process for eliciting responses about perceptions of safety and place while using our 3D streetscape virtual environment scenario models.

Spatial understanding in virtual environments

In the virtual world, perception of spatial relationships needs to match the physical world for users to act (Thompson, 2007). This depth perception is improved by pictorial depth cues, avatars, high quality graphics, texture, sense of presence, and photorealistic rendering and texturing of surfaces (Geuss et al., 2012; Loomis et al., 1999; Renner et al., 2013). Distance can be hard to judge in virtual reality environments and this is attributed to problems of limited field of vision, spatial resolution, poor quality rendering, the physical weight of head-mounted display, or use of large-screen immersive displays (Williams et al., 2007). When we move to a desktop virtual environment, size perceptions are even more difficult to do accurately with users perceiving objects as smaller than they would be in the real world (Stefanucci et al., 2012). At the same time, distance perception has been found to be better in virtual environments involving large-screen immersive displays than in those involving head-mounted displays (Plumert et al., 2005). Using this type of IVE, often referred to as desktop VR, users can perform better for spatial learning that non-ambulatory head mounted display VR (Srivastava et al., 2019). A comparative study showed that participants were better at recalling spatial components related to junction and cyclic order of the navigated virtual spaces in desktop VR than they were using head mounted display VR, and performed equally well on components related to street segments and object associations.

Spatial learning and understanding are similar for both real world spaces and virtual spaces. It is movement and looking around in a world that helps us to gain information about the scale of that world, whether the spatial representations are gained using a virtual display, or by looking at the world around us, it helps us understand where our body is oriented in that environment with respect to our surroundings (Williams et al., 2007). This can be extrapolated to other perceived affordances of the virtual world, which indicates that visual and auditory prompts that match real world affordances, such as traffic noise of passing vehicles in the virtual world should comply with the same distance and spatial qualities that would be experienced in the real world, to confirm spatial understanding. Perceived affordances of an environment are important for users to be able to decide what actions are possible in that virtual world. Interaction devices available in virtual environments give users precise control of the different kinds of perceptual cues that we usually rely on in the physical world, and can therefore deepen our understanding of how people use vision to make decisions about their actions (Lin et al., 2015). Perceived affordances can also be used to measure the perceptual fidelity of virtual environments with respect to the spatial understanding that they give to the users about the space they are in (Geuss et al., 2010).

Safe and successful places - design for ‘main streets’

This research focuses on the design of streetscapes that fit into the category of ‘main streets’ as defined in the *Movement and Place Framework Future Transport Strategy 2056* (Transport for NSW, 2018a). *The* ‘main streets’ category sits between ‘movement corridors’ where the street is primarily dedicated to vehicular movement, and local streets which have slower movement and are more place focused. Main streets have a high demand for vehicle ‘movement’ while still seeking to have ‘place’ elements as shown in [Figure 1]. The ability to balance these competing demands is both difficult and important.

> *[Main] streets are some of the most active areas in our cities with activity and movement at all hours of the day. The need to balance high pedestrian activity and densities, attracted by significant commercial, tourism, leisure and entertainment venues, along with the need to move high numbers of people and goods (Transport for NSW, 2018a)*.

Figure 1: Streetscape type categorisation from Movement and Place Framework Future Transport Strategy 2056, (updated 2020).

Though 'main streets' as defined in the *Practitioner's Guide to Movement and Place* (NSW Government, 2020) vary in size and configuration, they commonly have approximately 20 metres road casement (from building façade to building façade), a traffic speed of 50kms per hour, between two and four lanes of traffic, dispersed street trees, three metre wide footpaths, and no buffer between the footpath and vehicular traffic. The exact configuration and dimensions used to represent a 'typical' main street for this study is described in greater detail in the *Methods* section.

Actual and perceived safety on main streets is influenced by both safety measures and design variables, with perception of safety, also critically influencing perception of 'place'. As defined by Ewing and Clemente in their *Metric for Liveable Places* (2013), there are over 100 potential design variables alone, that impact perceptions of street safety and place. For this study, we held workshops with experts from Transport for NSW and the office of the Government Architect of NSW for selection and prioritisation of the safety measures and design variables to be tested. Over fifty streetscape variables were identified in the workshops. These were prioritised and filtered based upon application to a 'main street' as defined in the *Future Transport Strategy 2056* (Transport for NSW, 2018a). The prioritization and filtering process are discussed in greater detail in the method section. The final variables chosen for investigation in this study focused on those relating to the impact of safety and place of traffic speed, parked car buffers, barrier fencing, vegetation barriers, tree canopies, pedestrian crossings, footpath widening, cycle lane integration, and street clutter reduction.

The impact of speed on safety and place

Reduction of traffic speed is considered the single greatest safety measure for reducing fatal and serious pedestrian injury (Peden et al., 2004; WHO, 2015). Rosén and Sander (2009) demonstrated that small reductions in speed can exponentially reduce incidence of pedestrian fatalities, while Aarts & van Schagen, in their review of studies into the influence of speed on crash rate and crash severity found that reduced risk is consistently related to reduced speed (2006; TfNSW, 2015e). The reduction in rate and severity of crashes with reduced mean speed is illustrated in the speed-fatality probability relationship model by Wramborg (2005) [Figure 2].

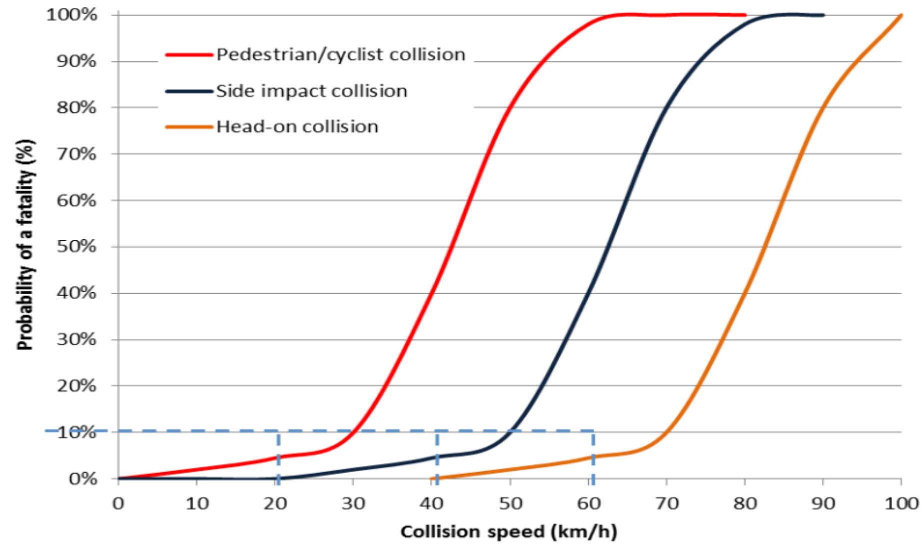


Figure 2: Wramborg's model for fatality probability versus vehicle collision speeds adopted and used in Australia and New Zealand Source: (Jurewicz et al., 2015).

Speed reduction has several important co-benefits that potentially improve the quality of life for residents and people using public spaces. These potential benefits include a reduction in traffic noise, pollution, greenhouse gases, and average fuel consumption. These benefits also encourage cycling and walking that have wider health benefits for society. Speed reduction measures generally fall into four categories: infrastructure interventions, vehicle technology solutions, enforcement and education campaigns and publicity. Infrastructure speed reduction mitigation measures, including speed humps, raised platforms, and pavement narrowing are relatively inexpensive to build and have a high benefit-to-cost ratio compared to other measures (TfNSW, 2015d).

Noise annoyance from traffic is a well-recognised psychological phenomenon which can cause stress (Mitchell, 2009; Ouis, 2001). Many factors impact traffic noise, such as speed, traffic volume, vehicle mix, acceleration, and braking. With a change in traffic speed from 30kms to 50 kms per hour, it can be considered approximate to a linear increase in noise impact (Quartieri et al., 2010), with a reduction in speed of just 10kmh providing up to a 40% reduction in noise (Mitchell, 2009, p. 3).

The impact of a parked car buffers on safety and place

Car parking is commonly considered a buffer for pedestrians from vehicle traffic, but findings on efficacy of this form of buffer for improving safety are mixed. Several UK and US studies find that parked cars increased the incidence of casualties of young people who are more likely to attempt crossing between cars, and that parked cars, close to crossing points, can mask driver views of pedestrians, particularly child pedestrians (Elliott & Baughan, 2003; Martin & TRL Limited, 2006), while other studies have shown that parked cars reduce speed and thereby increase pedestrian safety (Martin & TRL Limited, 2006).

While several studies report that similar streets with no parking are safer than those with parking, the reasons cited for these findings are nuanced by the type of parking. Common conclusions of these studies include: (1) the type of parking affects safety even when parking use, land use, and type of roadway are considered, (2) the safest type of parking on urban streets is parallel parking (as opposed to diagonal parking), and (3) low-angle parking may be safer than high-angle parking (but not as safe as parallel parking). Thus, when parking must be allowed, consideration should be given to using parallel parking instead of angle parking (McCoy et al., 1990).

There is no readily available data pertaining to pedestrian perceptions of safety or place in relation to the presence or absence of parked cars on main streets (or any other type of street). Anecdotally, parked cars can reduce conflicts between pedestrians and moving vehicles that are addressed by increasing the distance between them, such as water splash in wet conditions and other aspects discussed under *vegetation buffer section* below. The proximity and quantity of parked cars in relation to the proportion of pedestrians in a street is likely to impact on the impression of a place that is more or less amenable to pedestrians.

The impact of barrier fencing on safety and place

Kerb edge barrier fencing has a significant impact on reducing rates of pedestrian and vehicle collisions (TfNSW, 2015c). As found by Zheng and Hall in their review of criteria for installing pedestrian fencing in London, the 'pedestrian accident rate at sites without railing was 2.5 times that at sites with railing, and the difference is statistically significant' (2003). However, they also concluded that pedestrian fencing should only be considered when alternative safety measures are not feasible as it had an adverse effect on the perceived convenience and attractiveness of the street scene (Zheng & Hall, 2003). Another caution is that the use of barriers and fencing separation is associated with reduced visibility of child pedestrians, increases in risky behaviour (such as fence jumping) and may lead to poor integration with surrounding places if not led with a strong place vision (Zheng & Hall, 2003).

Barrier fencing research has primarily been conducted to understand its effectiveness as a safety measure. What little research there is on the impact of barrier fencing on place generally supports the idea that fencing negatively impacts attractiveness and perceptions of walkability. The advice from the Zheng and Hall study is that fencing 'should only be considered when the expected effectiveness is significant, and unnecessary guard rails should be removed' (2003).

The impact of a vegetation buffer on safety and place

Many streets have a buffer zone on the traffic edge of the footpath (sidewalk) for street furniture and utilities, that can also include vegetation (turf or planting). In Australia this is often referred to as a 'nature strip'. Streets with a vegetation buffer come under a variety of other names such as 'planted median' or 'green street'. While studies analysing the effectiveness of green/vegetation buffers on street safety are uncommon, their use has some assumed benefits. They provide pedestrians with a separation from reckless driving, help to direct pedestrians to desired crossing points, provide 'recovery zones' for wheelchair users or pedestrians who have fallen and reduce the dangers of toddler escape (Villaveces et al., 2012).

Roadside vegetation can also moderate glare effect leading to a safer road environment. In a study that analysed crash rates as related to environmental conditions (e.g. rainfall, snowfall, blinding sun and strong wind gusts), roadside vegetation was found to have many positive characteristics which improved the safety of road users (Kocur-Bera & Dudzinska, 2015).

The 'human scale' is an important aspect of pedestrian perceptions of 'place'. As demonstrated by Ewing (2013), a large number of variables contribute to the sense of human scale such as sight lines, building heights, proportion of visible sky and 'small planters' (which included both nature strips and planters in the private realm that contribute to the streetscape). In a study undertaken in Portland US, using an adaptation of methods developed by Borst (2008) for measuring the impact of micro-scale elements such as nature strips, on perceptions of attractiveness, found that, high quality 'green streets' had a positive impact on perceptions of attractiveness (Adkins et al., 2012). Other assumed positive impacts of vegetated buffers on perceptions of place are likely due to perceived protection from exhaust fume pollution, noise attenuation and increased exposure to natural and environmental benefits (Ng et al., 2015).

The impact of a continuous tree canopy on safety and place

Roadside tree planting has long been believed to be a safety hazard for drivers. Transportation safety guidelines relating to trees for roadsides are generally derived from studies of high-speed rural roads, where trees have been found to cause a significant number of single vehicle–fixed object fatal collisions, however, recommendations for local urban streets have been less rigorously derived (Wolf & Bratton, 2006). In addition, as outlined by Wolf, there is also limited data to quantify the converse, of how many times trees in nature strips have prevented pedestrian fatalities through protection from reckless driving behaviour (Mok et al., 2006), or through the significant reductions in speed that drivers have been found to make in tree-lined streets (Naderi et al., 2008).

The impact of differing amounts of tree canopy cover on perceptions of the quality of streets, has long been positively correlated with 'sense of place' as they increase a sense of imageability and enclosure. As first described by Henry Arnold (1980) and quantitatively tested by Ewing and Clemente (2013), continuous tree canopy cover has a profound impact on the sense of streetscape enclosure and, as was recently found in a in a study by Harvey et al, was also the most important factor effecting perceptions of streetscape safety (2015).

The impact of pedestrian crossings on safety and place

The impact of crossings on actual pedestrian safety is complex. A study by Gitelman et al (2017) investigated the impacts of pedestrian-crossing configurations on crash frequency at intersections. The authors used statistical analysis to identify factors affecting crashes and compared the crash frequencies to other sites. Four-legged intersections were found to have higher crash frequencies compared to three-legged ones mainly because pedestrians would have higher exposure with greater numbers of lanes in the intersection.

Though mid-block crossings such as signalised crossings, zebra crossings, and wombat crossings reduce the number of pedestrians walking across the road at non-designated crossing points (referred to as Jaywalking in the US), in some cases, crossings were found to increase pedestrian collision frequency due to confounding factors such as higher numbers of pedestrians present within the roadway, and potentially less vigilant behaviours (TfNSW, 2015a, 2015b).

The need for marked pedestrian crossings relates to multiple factors, especially the speed, mix and volume of traffic relative to the type of street. A walkable environment is one that has land uses that are not only safely accessible on foot, but where pedestrian access is attractive, convenient and wayfinding is easy. The location and number of pedestrian crossings to maximise the continuity and convenience of a network of legal and safe crossings has an impact on perceptions of walkability (Villaveces et al., 2012).

The impact of widening the footpath on safety and place

Wider footpaths help to increase footpath capacity and improve access. Poor footpath surfaces or inadequate footpath space (capacity) can force pedestrians onto the road which would expose pedestrians to road traffic and potential injuries (Autumn, 2013). In recent times, e-scooter regulations have also started to examine the issues of footpath width and many regulations around the world have now banned e-scooters from footpaths (Choron & Sakran, 2019).

Footpath width impacts the ability of a 'main street' to accommodate socio-cultural diversity as well as the types of footpath-based activities that contribute to its vibrancy. A wider footpath will accommodate larger numbers of people, whether moving or stationary, standing or seated, and will enable greater access for people who use wheelchairs and mobility aids (assuming the surface is smooth and relatively flat). Wider footpaths enable greater use for alfresco dining, footpath trading and more space for the provision of public seating, street trees and other vegetation. Greater spatial distancing from moving traffic is also an effect of increased footpath width.

The impact of cycle lanes on safety and place

In 2019, researchers from the University of Colorado in Denver undertook a comprehensive study of bicycle and road safety and found that building safe facilities for cyclists is one of the biggest factors in road safety for all road users. Bicycling infrastructure, specifically separated and protected bike lanes, was found to lead to fewer fatalities and better road-safety outcomes for all road users (Marshall & Ferenchak, 2019).

Bike lanes occupy space, generally between the footpath and the roadway. Their form varies from lane markings and coloured surfaces at the same level as the road, to lanes separated from the road by physical features (bollards, planter boxes, trees and/or median strips of varying widths and materials) to pathways formed at the same level as the footpath, or at a level between the footpath and the roadway. The effect of all these possible configurations is to create greater spatial distancing between pedestrians and traffic, which has a positive impact on noise attenuation from motor vehicles. A key element of bike lane design is the method for separating bicycles from motorised vehicles. Most recent studies into pedestrian and cyclist preferences show a preference for trees at this important interface (Lusk et al., 2018). Trees of the right variety, at the right spacing can have value as shade for pedestrians and cyclists during the warmer months, adding to perceptions of amenity for active transport.

The impact of street clutter on safety and place

Decluttering streets can make them safer and enhance their sense of place. Studies have shown that people appreciate streetscape free from clutter particularly so that people with disability can move about more easily (Mackett et al., 2012). Street-based infrastructure and furniture (light and power poles, traffic and pedestrian signage, bins, phone boxes, electrical and other infrastructure boxes, commercial signage, public and commercial seating) can accumulate unless carefully designed and managed, literally creating visual and physical clutter. The quality and quantity of this clutter impacts on the legibility and sense of place of 'main streets' (Gill, 2013).

Part 2: Method

As highlighted in the previous sections, there is a strong need to form a better understanding of streetscape place-making elements, safe system treatments, urban design elements and their impact on citizen's perceptions of safety and place.

This study takes a mixed-method approach with three key parts:

- Identification of specific variables
- Construction of an animated digital 3D parametric street scenario model (IVE)
- Development and deployment of an online survey – testing perceptions of street types with varied parameters

Identification of Specific Variables - choosing pedestrian-oriented place-making and safe system treatments

To proceed with the scenario modelling for the pilot study, an agreed set of safety and place variables for investigation were scoped through two workshops by the Swinburne research team with TfNSW (Including Centre for Road Safety, former Roads & Maritime Services, GANSW, and Transport SMEs in street regulations, planning, design and delivery from the Precincts and Urban Design team). Input was invited from stakeholders within Transport for NSW including: the Head of Sydney Planning, Greater Sydney Division; Director Sydney Network Planning; Senior Manager Safer Transport; Principal Manager Research Unit; Manager Research Unit; Senior Researcher (Research Unit); Director Network & Asset Intelligence; Senior Road Safety Analyst; ED Customer Experience & Design; Senior Manager Network Strategy; Director Safer Systems; Leader Road Network Planning; A/Director Strategic Urban Design; A/Dir Evaluation & Economic Advisory; A/Director Strategy & Policy; Project Manager Transport Planning; A/Director Digital Accelerator; Manager Movement & Place; Deputy Exec Sydney Network Planning; and Snr Manager Network & Safety Service. Input was also sought from the Director Place, Design & Public Spaces, GANSW; Senior Manager Strategy Development, GSC; A/Director Strategic Services, GANSW; and Executive Director, Infrastructure NSW [Figure 4].

At the conclusion of the first workshop, stakeholders contributed to the production of a variables 'long-list' [see Figure 3] with input captured in an interactive collaborative mind-map tool (Coggle™). Stakeholders explored, reviewed and sorted in detail the long-list of variables in the second day of the workshop, developing and agreeing on a prioritised final short-list of high-priority streetscape variables to focus on for the initial pilot study.

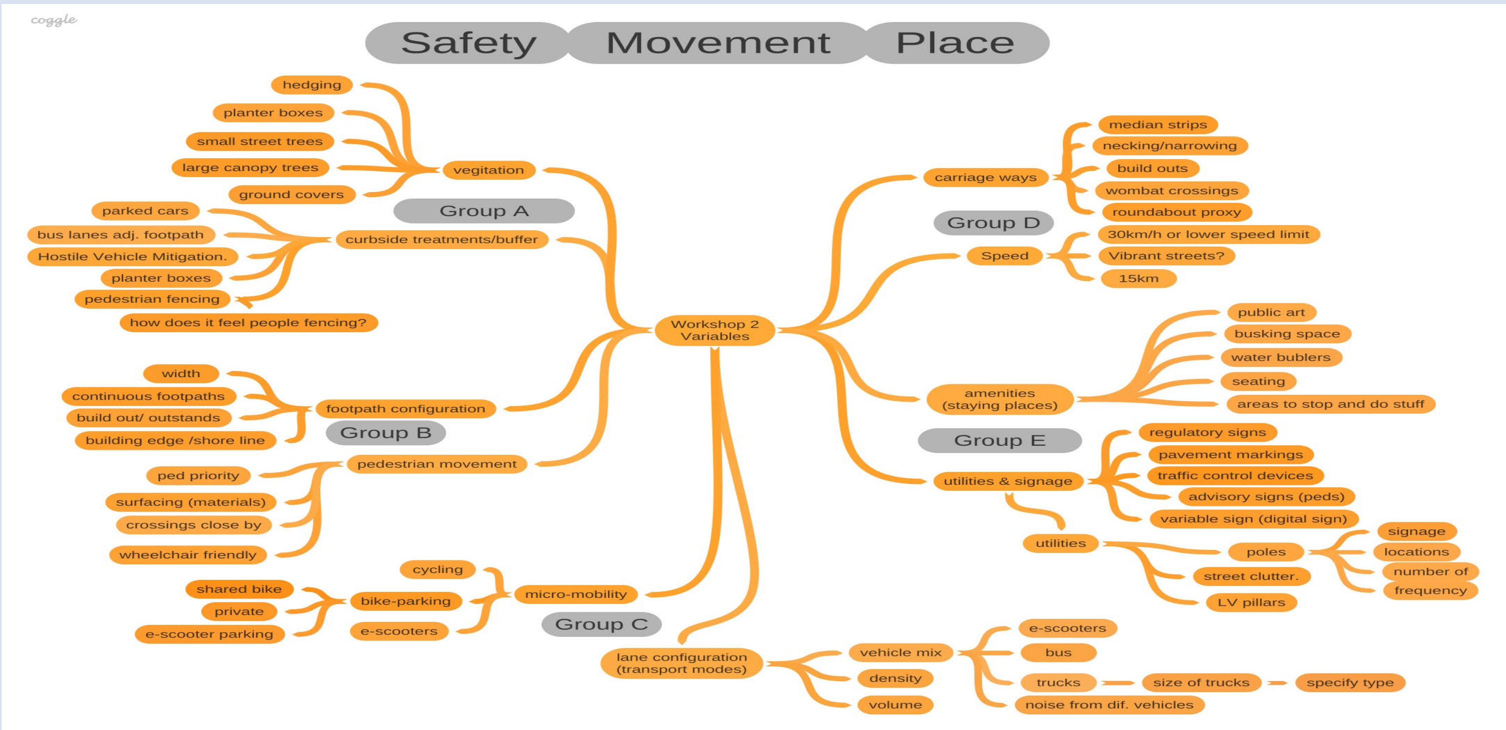


Figure 3: Live 'mind map' of long-list of variables produced during the first workshop.

Figure 4: Photographs taken during the two-day workshop held at the Future Transport Digital Accelerator.

Streetscape scenarios included in the study

Upon completion of the two workshops conducted at the F*uture Transport Digital Accelerator*, street safety and place element variables had been prioritised. The research team put forward streetscape design scenarios that were then rationalised based on the priority, comparability, and modelling feasibility. Some scenarios, while ranking high in terms of priority, were excluded due to the complexity of comparison. For example, those street safety and place element variables requiring night-time scenes such as different street-light treatments were excluded due to the difficulty comparing lighting treatments with daytime scenarios. The following thirteen scenarios were included in the survey and are detailed on the following pages:

- Baseline control configuration: **'Baseline'** scenario (4 lanes of traffic @50km/ph) [Figure 5, Figure 6]
- Speed configuration: '**Reduced speed'** 30km/ph scenario [Figure 7, Figure 8]
- Distance separation configuration: **'Parked car buffer'** scenario (2 lanes of traffic) [Figure 9, Figure 10]
- Barrier separation configuration: **'Barrier fence'** scenario [Figure 11, Figure 12]
- Barrier separation configuration: **'Increased tree canopy'** scenario [Figure 13, Figure 14]
- Barrier separation configuration: **'Ground vegetation buffer'** scenario [Figure 15, Figure 16]
- Distance separation configuration: **'Cycle lane'** scenario (3 lanes of traffic) [Figure 17, Figure 18]
- Barrier separation configuration: **'Less clutter'** scenario [Figure 19, Figure 20]
- Distance separation configuration: **'Widened footpath'** scenario (3 lanes of traffic) [Figure 21, Figure 22]
- Crossing configuration: **'Signalised crossing long-wait'** (non-pedestrian prioritised) [Figure 23, Figure 24]
- Crossing configuration: **'Signalised crossing short-wait'** (pedestrian prioritised) scenario [Figure 25, Figure 26]
- Crossing configuration: '**Refuge island'** (non-pedestrian prioritised) scenario (2 lanes of traffic) [Figure 27, Figure 28]
- Crossing configuration: '**Wombat crossing'** (pedestrian prioritised) scenario (2 lanes of traffic) [Figure 29, Figure 30]

Baseline control configuration: 'Baseline' scenario

The 'Baseline' streetscape represents a typical 'main street' with a mix of uses, common volumes and mix of traffic (based on sample high street data provided by TfNSW), typical dimensions, standard detailing, and typical distribution and types of street furniture and vegetation. The scenario elements include:

- Street width: 20 metres (boundary to boundary)
- Traffic speed limit: 50kms per hour
- 2 lanes of traffic each way
- Cars, busses and small/med trucks, motorbikes, bikes (in traffic)
- No Fencing, No buffer, No parked cars
- Some trees (sparse vegetation/trees)
- Typical lights / power lines / power boxes
- Typical bins / power boxes
- 1-3 level mixed-use buildings (non-specific retail)
- 3.5m lane widths, 3m footpath width
- Some outdoor seating/tables near viewer position, Some pedestrian congestion
- Inclusive peds (different levels of mobility eg. wheelchairs) & prams
- 400x600 honed concrete paving (with banding every 10m), Typical conc. kerb
- Awnings

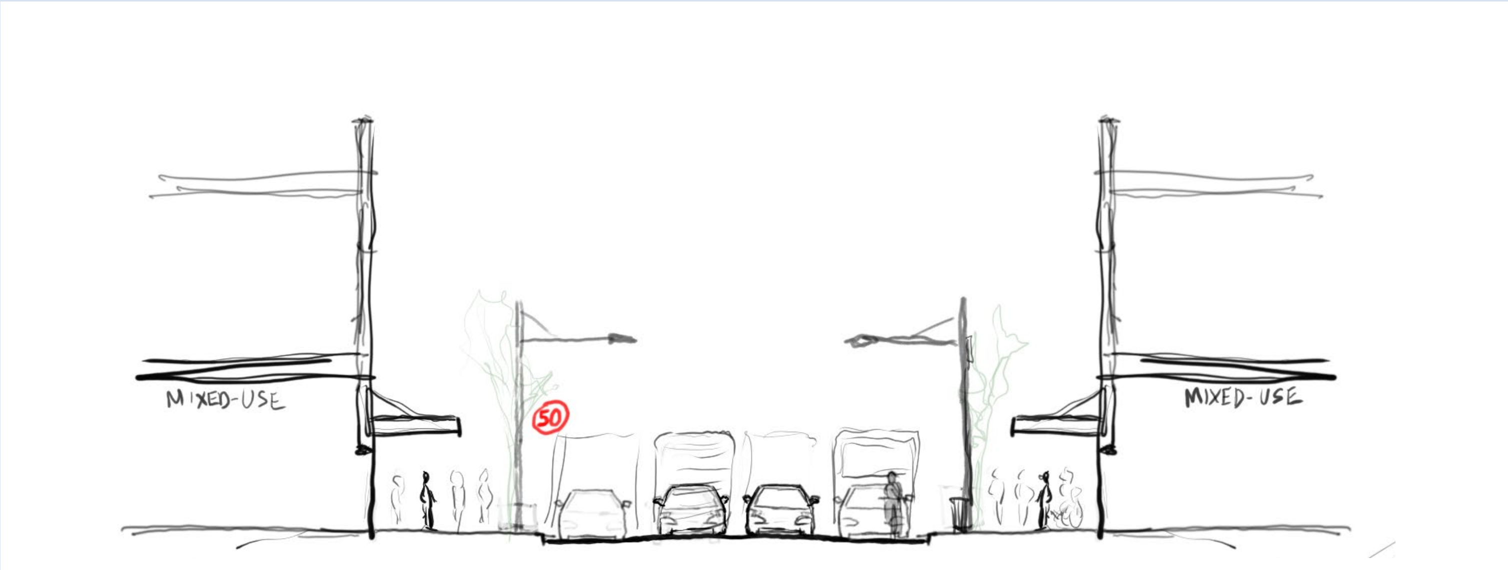


Figure 5: Street section sketch showing the 'Baseline' scenario.

Figure 6: Screengrab of perspective view in game engine immersive virtual environment showing the 'Baseline' scenario.

Speed reduction configuration: 'Reduced speed' (30 km/hr) scenario

The 'Reduced speed' configuration represents a typical 'main street' with the speed limit reduced to 30km/hr. The scenario elements include:

- Same as 'Baseline' model with speed of vehicles altered to (30 km/hr)
- Similar traffic volume
- Vehicle noise reduced (matching reduced speed)

Figure 7: Street section sketch showing the 'Reduced speed' (30 km/hr) scenario.

Figure 8: Screengrab of perspective view in game engine immersive virtual environment showing the 'Reduced speed' (30 km/hr) scenario.

Distance separation configuration: 'Parked car buffer' scenario

The 'Parked car buffer' scenario represents a typical 'main street' with car parking on each side of the street acting as a spatial buffer between moving traffic and pedestrians on the footpath. The scenario elements include:

- Reduction of traffic lanes from 'Baseline' scenario to single lanes each way
- Parked cars on each side of the street as buffer
- No fencing

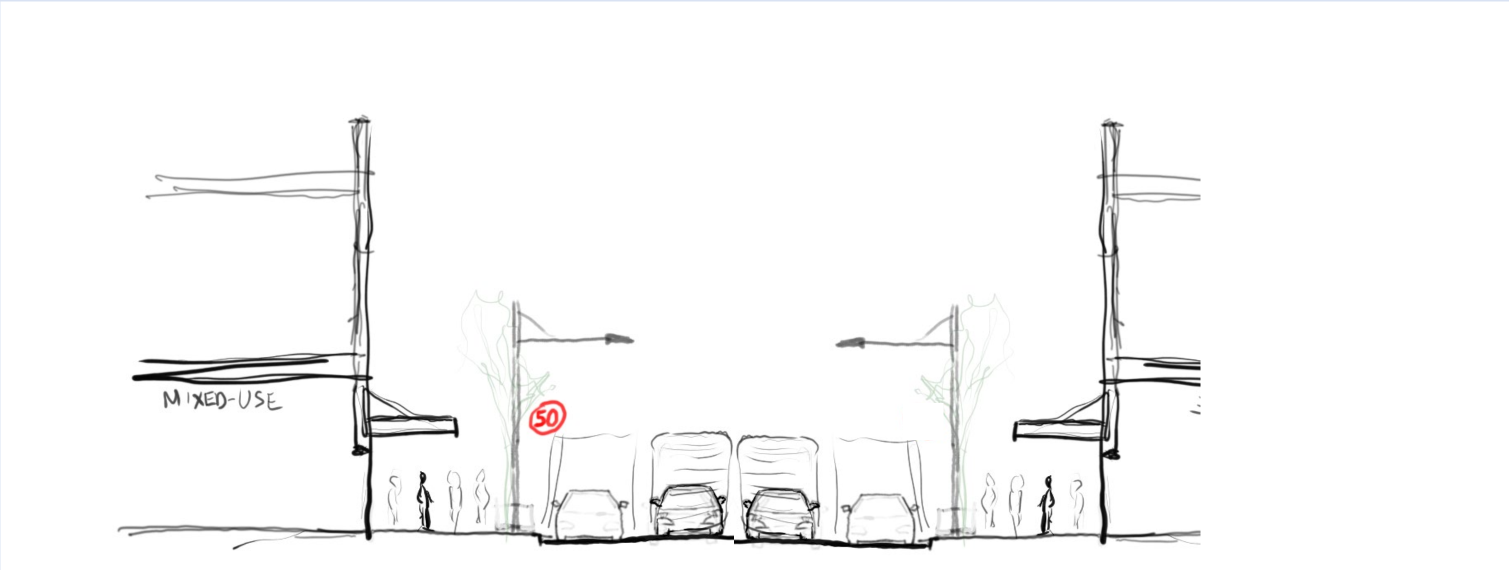


Figure 9: Street section sketch showing the 'Parked car buffer' scenario.

Figure 10: Screengrab of perspective view in game engine immersive virtual environment showing the 'Parked car buffer' scenario.

Barrier separation configuration: ‘Barrier fence’ scenario

The ‘Barrier fence’ scenario represents a typical ‘main street’ with safety fencing installed along the kerb edge, acting as s barrier separation between moving traffic and pedestrians on the footpath. The scenario elements include:

- Traffic conditions same as the ‘Baseline’ scenario (4 lanes of traffic @ 50 km/hr)
- Addition of kerb edge fencing

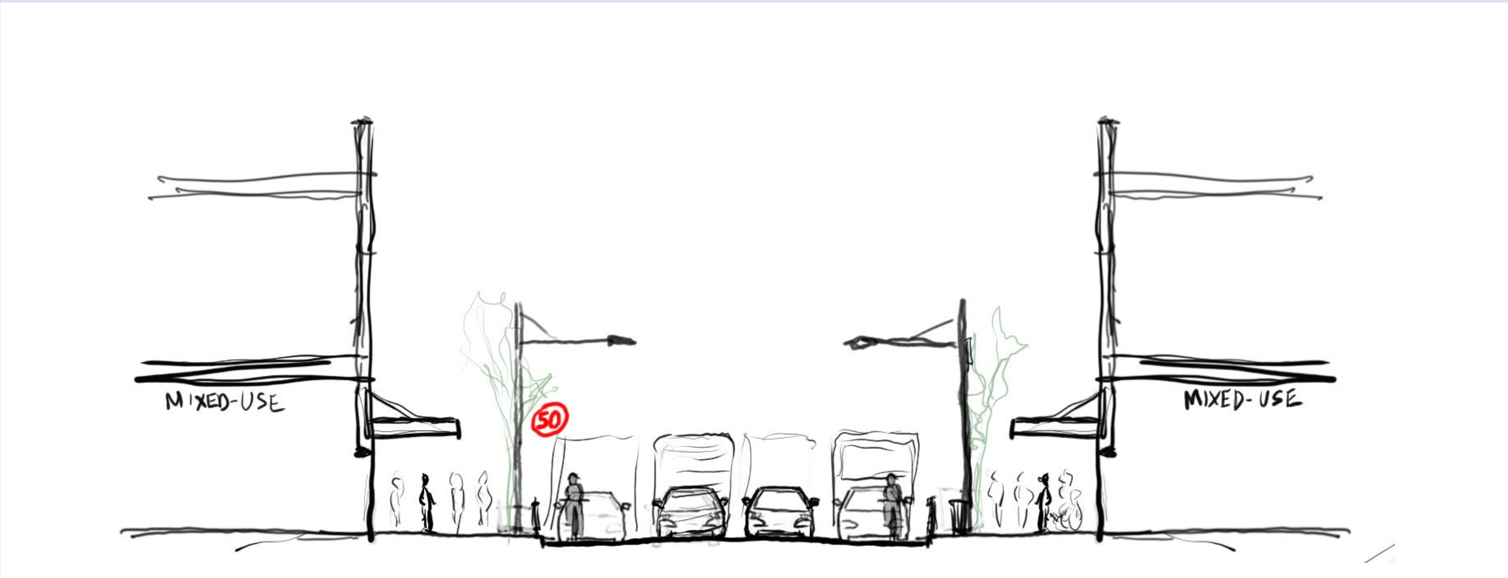


Figure 11: Street section sketch showing the ‘Barrier fence’ scenario.

Figure 12: Screengrab of perspective view in game engine immersive virtual environment showing the ‘Barrier fence’ scenario.

Barrier separation configuration: 'Increased tree canopy' scenario

The 'Increased tree canopy' scenario represents a typical 'main street' with healthy, mature street trees planted at regular intervals, visually suggesting a highly permeable barrier between moving traffic and pedestrians on the footpath. The scenario elements include:

- Traffic conditions same as the 'Baseline' scenario (4 lanes of traffic @ 50 km/hr)
- Trees with more continuous canopy on footpath than the 'Baseline' scenario
- Distance between trunks 10m (approx.)
- Trees planted close to the kerb edge

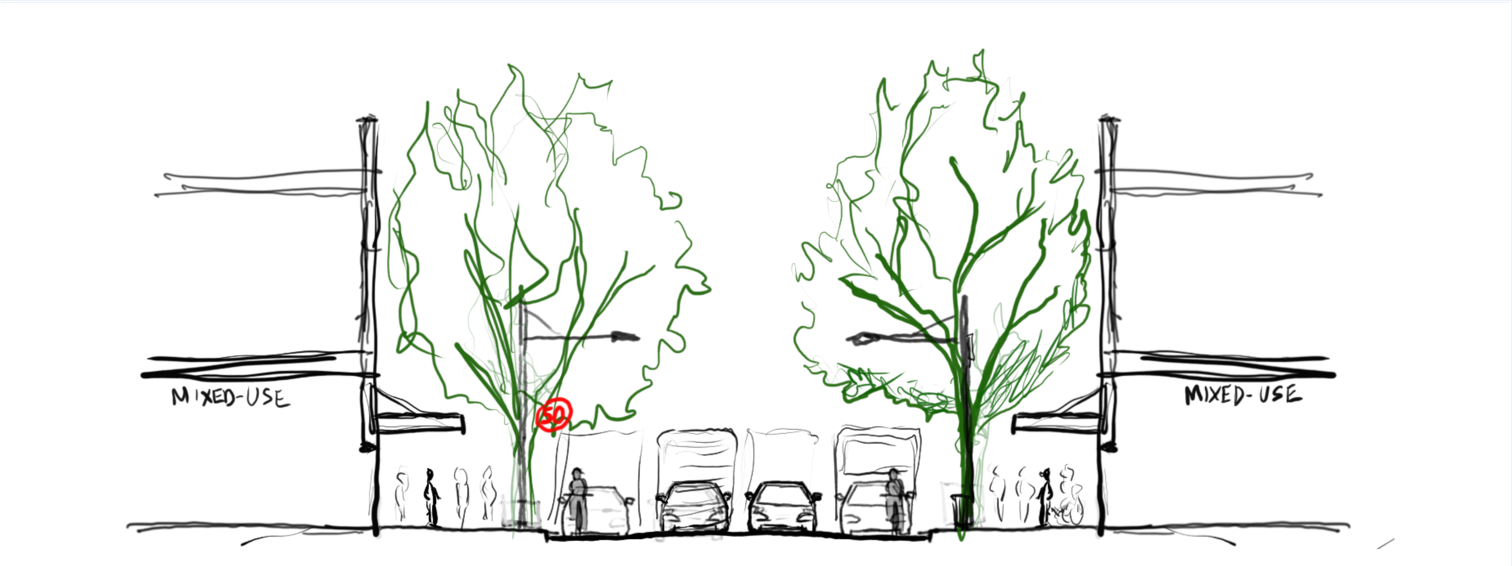


Figure 13: Street section sketch showing the 'Increased tree canopy' scenario.

Figure 14: Screengrab of perspective view in game engine immersive virtual environment showing the 'Increased tree canopy' scenario.

Barrier separation configuration: 'Ground vegetation buffer' scenario

The 'Ground vegetation barrier' scenario configuration represents a typical 'main street' with low-level vegetation acting as a ground-level barrier or buffer between the traffic and the footpath. The scenario elements include:

- Traffic conditions same as the 'Baseline' scenario (4 lanes of traffic @ 50 km/hr)
- Low-level vegetation barrier on the kerb edge of the footpath, no obstruction to visibility between pedestrians and drivers
- Vegetation of thickness and height that it would act as an uncontrolled crossing deterrent for children
- Typical water sensitive urban design (WSUD) plant types i.e. *Dianella sp., Lomandra sp., Clivea sp., Juniperus sp., Trachelospermum (Star Jasmine) sp.*
- Vegetation planted in-ground (not pots)

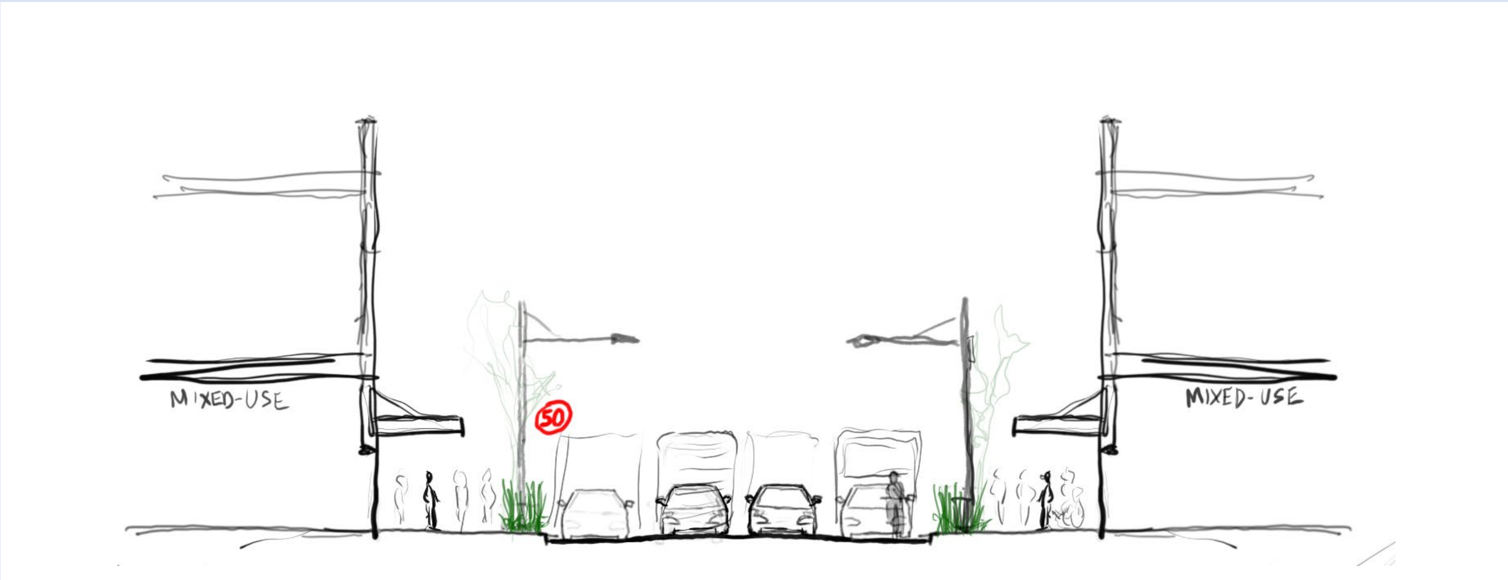


Figure 15: Street section sketch showing the 'Ground vegetation buffer' scenario

Figure 16: Screengrab of perspective view in game engine immersive virtual environment showing the 'Ground vegetation buffer' scenario.

Distance separation configuration: 'Cycle lane' scenario

The 'Cycle lane' scenario street configuration represents a typical 'main street' with a two-way separated/dedicated cycle lane in the place of one lane of traffic on the side of the street adjacent the participant location on the footpath, acting as a distance separation between them and the moving vehicular traffic. The scenario elements include:

- Traffic conditions reduced from four lanes to three from the 'Baseline' scenario (traffic @ 50 km/hr)
- Cyclists in a dedicated two-way cycle lane
- Dedicated cycle lane on road level adjacent footpath (separated from pedestrians by kerb)

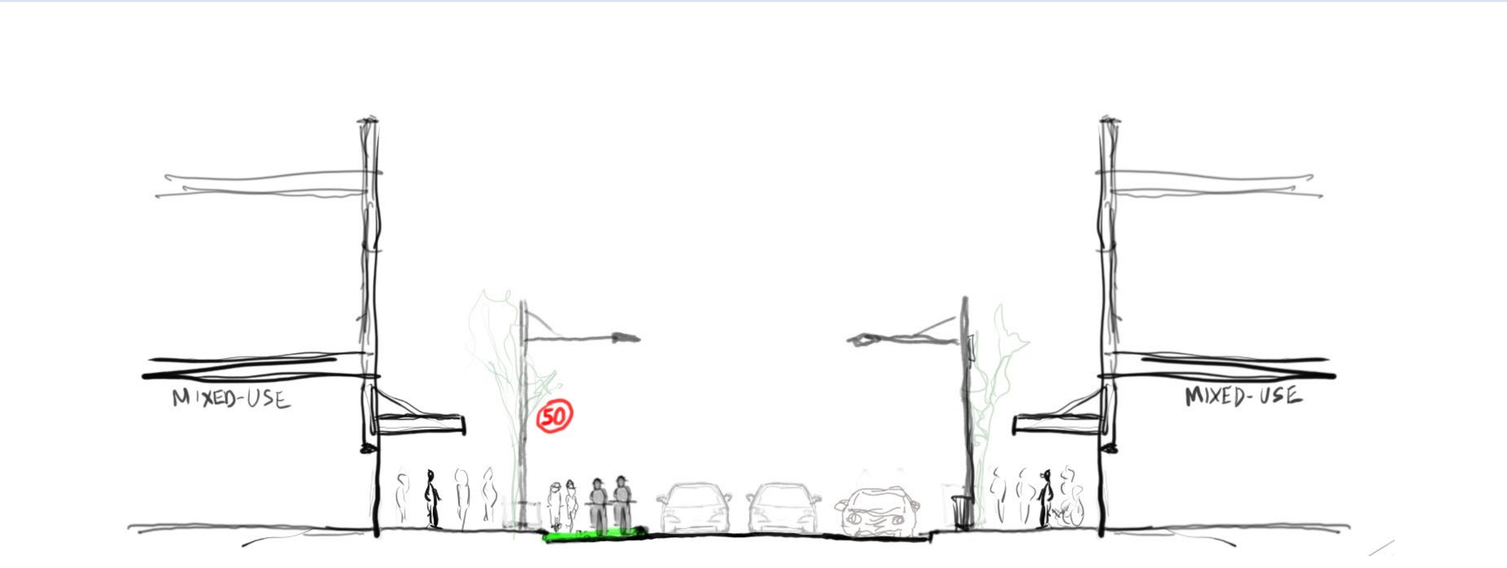


Figure 17: Street section sketch showing the 'Cycle lane' scenario.

Figure 18: Screengrab of perspective view in game engine immersive virtual environment showing the 'Cycle lane' scenario.

Barrier separation configuration: 'Less clutter' scenario

The 'Less clutter' scenario represents a typical 'main street' with a subtle reduction of on-footpath elements and minimalist aesthetic street furniture. The scenario elements include:

- Traffic conditions same as the 'Baseline' scenario (4 lanes of traffic @ 50 km/hr)
- Reduced street clutter (removal of power poles, NBN boxes, light poles, and swapping street furniture for minimalist designs)

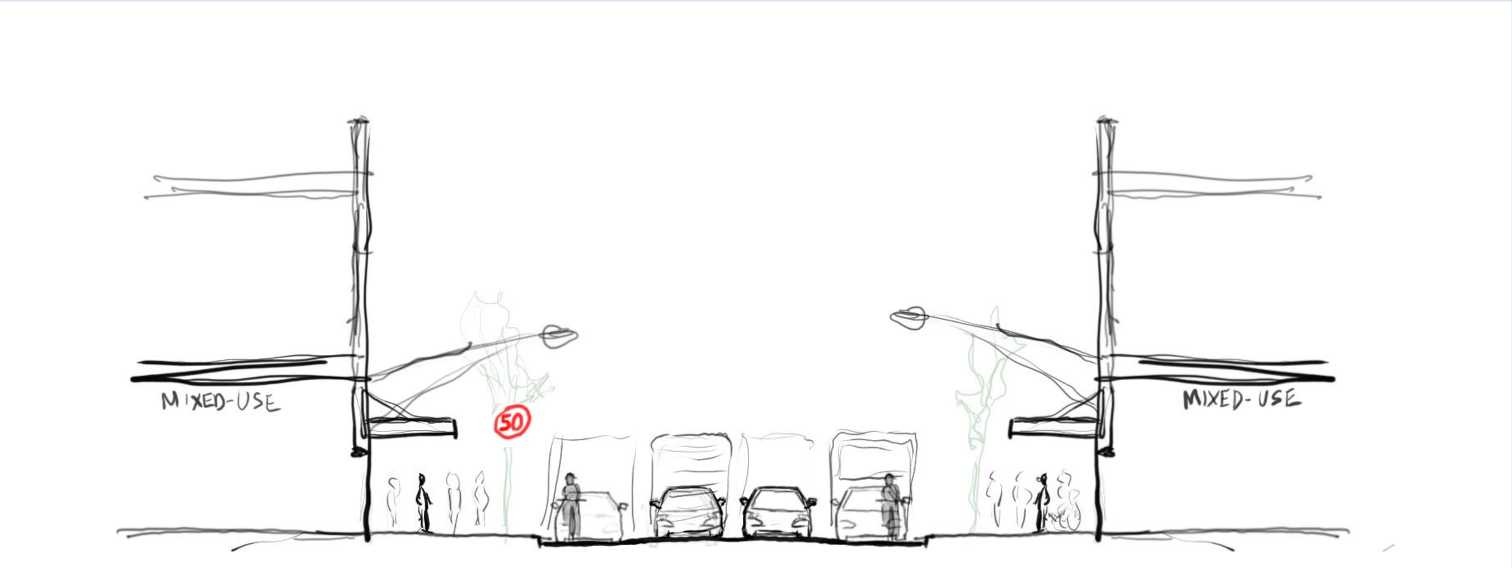


Figure 19: Street section sketch showing the 'Less clutter' scenario.

Figure 20: Screengrab of perspective view in game engine immersive virtual environment showing the 'Less clutter' scenario.

Distance separation configuration: 'Widened footpath' scenario

The 'Widened footpath' scenario represents a typical 'main street' with a widened footpath on one side of the street (adjacent the participant), acting as a distance separation between moving traffic and pedestrians. The scenario elements include:

- 'Baseline' scenario 3m wide footpath increased to 5.5m (+2.5m)
- Traffic conditions reduced from four lanes to three from the 'Baseline' scenario (traffic @ 50 km/hr) to accommodate footpath widening on the side of the street adjacent the participant location

Figure 21: Street section sketch showing the 'Widened footpath' scenario.

Figure 22: Screengrab of perspective view in game engine immersive virtual environment showing the 'Widened footpath' scenario.

Crossing configuration: ‘Signalised crossing long-wait’ (non-pedestrian prioritised) scenario

The ‘Signalised crossing long-wait’ (non-pedestrian prioritised) scenario represents a typical ‘main street’ with traffic lights with typical wait times for crossing signal change. The scenario elements include:

- Traffic conditions same as the ‘Baseline’ scenario (4 lanes of traffic @ 50 km/hr) *though traffic slowing and stopping is associated with red signal
- Signalised crossing within 10-15m from participant
- Animated pedestrian presses button > weight time of 20-30 seconds > pedestrian accessibility / walk signals (chirp and light change) > pedestrians cross
- Pedestrians bunch up on the footpath while waiting to cross

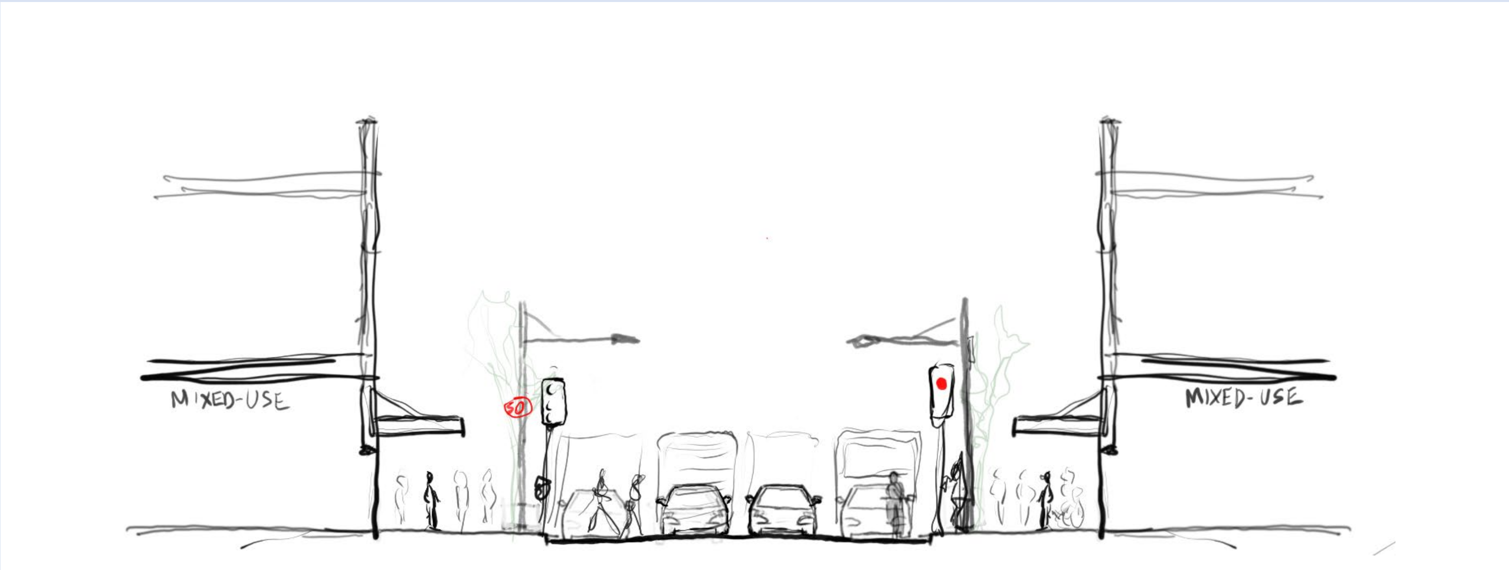


Figure 23: Street section sketch showing the four lanes with ‘Signalised crossing long-wait’ (non-pedestrian prioritised) scenario.

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Figure 24: Screengrab of perspective view in game engine immersive virtual environment showing the four lanes with ‘Signalised crossing long-wait’ (non-pedestrian prioritised) scenario.

Crossing configuration: 'Signalised crossing short-wait' (pedestrian prioritised) scenario

The 'Signalised crossing short-wait' (pedestrian prioritised) scenario represents a typical 'main street' with traffic lights with short (pedestrian prioritised) wait times for crossing signal change. The scenario elements include:

- Traffic conditions same as the 'Baseline' scenario (4 lanes of traffic @ 50 km/hr) *though traffic slowing and stopping is associated with red signal
- Signalised crossing within 10-15m from participant
- Animated person presses button > **weight 5-10 seconds** > pedestrian accessibility / walk signal (chirp sound and light change) > pedestrians cross
- Pedestrians do not wait of bunch up on the footpath
- Two or three cycles of lights during the 2 minute video

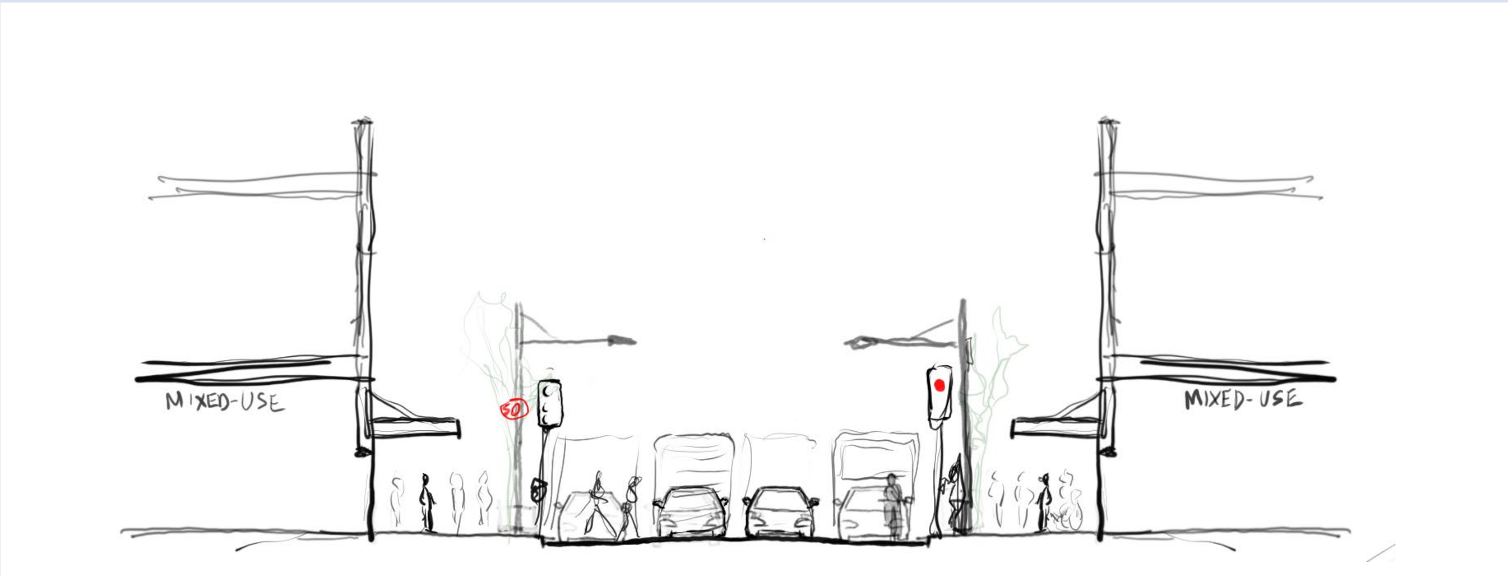

Figure 25: Street section sketch showing the four lanes with 'Signalised crossing short-wait' (pedestrian prioritised) scenario.

Figure 26: Screengrab of perspective view in game engine immersive virtual environment showing the four lanes with 'Signalised crossing short-wait' (pedestrian prioritised) scenario.

Crossing configuration: ‘Refuge island’ scenario

The ‘Refuge island’ scenario represents a typical ‘main street’ with a reduction in the number of lanes, with a non-signalised area for informal pedestrian crossing with mid-road refuge island (gaps in the traffic flow). The scenario elements include:

- Reduction of traffic lanes from ‘Baseline’ scenario to single lanes of traffic each way @ 50 km/hr
- Medium strip/refuge in the middle of the street
- Kerb cut and road level crossing (No zebra marked crossing marked on road)
- Parked car buffer beyond outstand/blister
- Not signalised (no yellow walk signs)
- Pedestrians animated to wait, then cross when gap in traffic is present

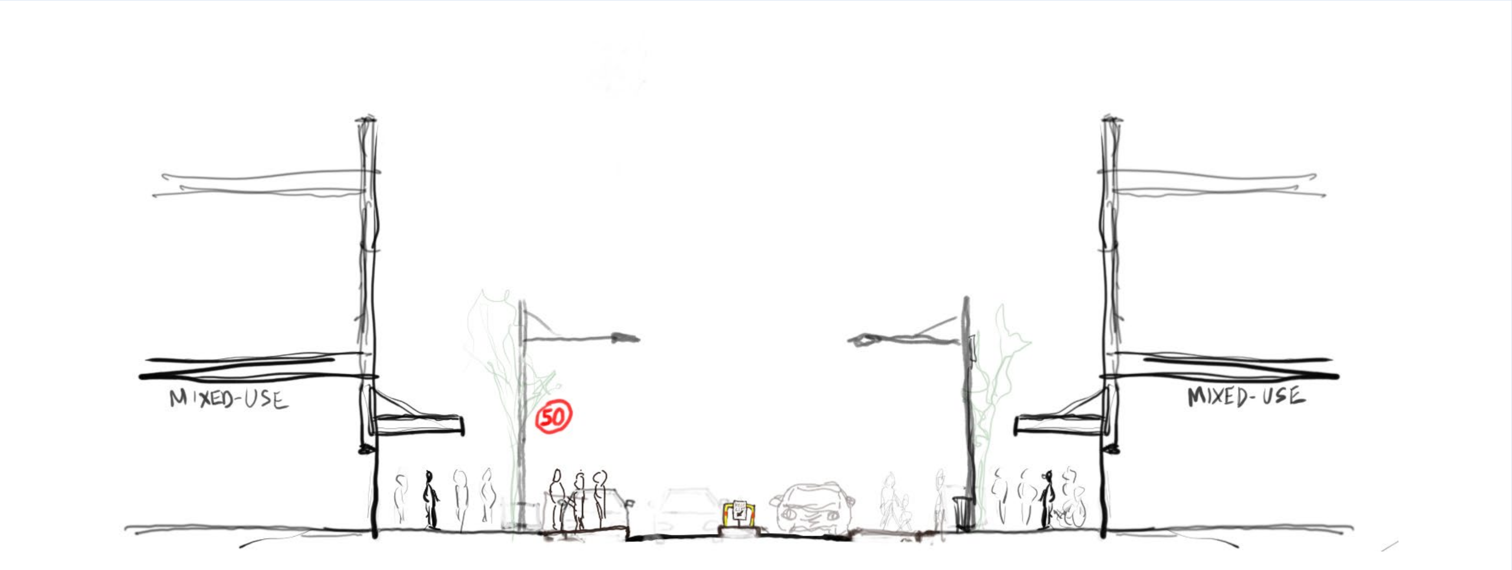

Figure 27: Street section sketch showing the two lanes with pedestrian ‘Refuge island’ scenario.

Figure 28: Screengrab of perspective view in game engine immersive virtual environment showing the two lanes with pedestrian ‘Refuge island’ scenario.

Crossing configuration: ‘Wombat crossing’ scenario (kerb blisters / outstands (reducing to two lanes) with pedestrian priority crossing)

The ‘Wombat crossing’ scenario represents a typical ‘main street’ with a reduction in the number of lanes and a pedestrian priority crossing with mid-road refuge island where vehicles must give way to pedestrians. The scenario elements include:

- Reduction of traffic lanes from ‘Baseline’ scenario to single lanes of traffic each way @ 50 km/hr, though traffic slowing and stopping is associated with pedestrians making crossings
- Non-signalised crossing
- Zebra marking on ground with yellow walk signs
- Footpath level crossing (wombat crossing)
- Cars animated to give way to pedestrians crossing the street

Figure 29: Street section sketch showing the ‘Wombat crossing’ scenario.

Figure 30: Screengrab of perspective view in game engine immersive virtual environment showing the ‘Wombat crossing’ scenario.

Construction of animated digital 3D parametric street model

In the next phase of the research, the team developed a 3D street scenario model which was rendered as IVE's with immersive spatial 360-degree audio as a stimulus for eliciting psychological responses to multiple streetscape variables including different levels of noise intensity, distances from traffic, speed of traffic, the influence of different kinds of traffic buffers, safety treatments and place-making elements. The digital model allowed the production of IVE scenarios with controlled, isolated variable adjustments, which can then be used to prompt feedback from the community that is highly specific. The IVE models allowed for testing many different scenarios with consecutive comparisons (not possible with real-world environments that are often some distance apart), and not relying on the memory of real-world spaces. The flexible digitally modelled scenarios were constructed to allow for scenario alteration by changing parameters, with layers that can be turned on and off (e.g. bike lane, vegetation buffer), and animated vehicles including cars, buses, and trucks with controllable speed and sound variables.

3D digital model development

The virtual environment geometry and material texturing were completed within 3D modelling and animation software, where buildings, road casement, footpaths and street furniture assets were built and assembled. Geometries were parametrically modelled to maximise efficiency with constrained polygon counts and were textured with compressed textures to allow for rapid rendering. The base street geometry was set up and modelled using dimensions and arrangements of a 'typical' twenty metres wide 'main street' with detailed input from TfNSW. We also used street element design details from relevant *Technical Direction: For traffic and transport practitioners* documents by Transport for NSW (Roads and Maritime Services, 2020), including for the detailing of the bike lanes, crossings, footpaths, parking, signages, crossings and line-markings.

The street assets, road and footpath, shopfront geometries were parametrically modelled with procedural objects, which allowed for accurate dimension and distance control, and flexible modification for further research and development. The geometries were parametrically driven by the street centre lines, which created a highly adaptive system that could rapidly be applied to a larger area or more complicated street configuration.

Geometry was textured with a mix of photographs and procedural textures and patterns to provide a sense of materiality and emphasise and enhance the reading of spatial depth (Geuss et al., 2012; Loomis et al., 1999; Renner et al., 2013). We added generic signage that was generated to add realism without specific cultural associations (not using real shop/restaurant names). Trees were procedurally generated to represent typical street trees with a balance of detail to appear reasonably realistic without adding too many polygons to the digital model.

We used different 'layers sets' (data sets) within the model that could be turned on and off to enable the representation of different scenarios. For example, for the safety fence scenario, a fence layer was turned on or turned off for other scenarios. In this way, we can allow for isolation of individual or limited elemental changes and maintain the consistency of IVE environments, not only street environment geometries but also sunlight and skylight.

We added animated vehicles to the model to simulate the traffic. Traffic volume and vehicle mix was simulated based on averages taken from the *Daily Count Summary - Burwood Road and Deane Street, Burwood* (data provided by TfNSW). The traffic volume was maintained in each of the different scenarios as much as possible (note: minor variations in volumes occurred in some scenarios due to different lane configurations).

The animated vehicles in all scenarios were mixed with four types of vehicles, including light vehicles, trucks, buses and motorcycles. To enhance the level of realism of the IVE experience, we used a variety of geometries for each type of vehicle in the simulation, including eight models of light vehicles, two models of trucks, two models of buses and two models of motorbikes. An artificial intelligence calculation system within 3D modelling and animation software was used to simulate all types of vehicle's movement, and we set up different lane configurations, obstacles, parking and crossing rules for different scenarios to test variables. Except for Reduced speed scenario, in the rest of the scenarios, the speed limit for all vehicles was set to 50km/hr, the speed limit of Reduced speed scenario was set to 30km/hr. The traffic lights in two intersections were programmed and shared in all scenarios to keep the environment consistent. The dynamic calculation made the movements of the vehicles more realistic, and the artificial intelligence system helped vehicles to operate independently.

The crowd of pedestrians were simulated in 3D modelling software based on averages taken from the *Daily Count Summary - Burwood Road and Deane Street, Burwood* (data provided by TfNSW). To reduce the 'uncanny valley' effect of non-photo realistic people, and reduce distraction of non-relevant variables that interfere with the study, we textured the crowd and pedestrian appearance in a range of greyscale with different body types, which gave an indication of a diverse population without providing specifics of skin colour, race or age. In addition, in order to enhance the sense of reality and experience of immersion we used a variety of behaviours, including walking, chatting, gesturing, talking on the phone, people with mobility impairment (using wheelchairs), and parents with baby strollers. This agent-based simulation model of pedestrian movements and cyclist movements was programmed and filtered with behaviours driven by interaction 'events' between distinct entities. In other words, these simulated pedestrians and cyclists could avoid each other and street assets, and followed the traffic rule settings in different scenarios, for example, waiting for the traffic lights to cross the street.

Game engine preparation

After we built, texture-mapped and assembled geometries, simulated pedestrians and vehicles in 3D modelling and simulation software, we transferred onto the game development engine. In the game development engine, we were able to optimise the lighting and shadows, image processing, rendering, dynamic simulation of trees and plants, program the traffic lights and audio implementation.

In the game development engine, we set the working project to 'virtual reality project' developing mode to view and control the IVE model in real-time. In order to make the visual effect better and to maximise efficiency, we combined 'baked lighting' with real-time ray tracing rendering technology. In addition to using engine built-in sunlight, we also used a High Dynamic Range Image (HDRI) background skydome. The HDRI skydome simulated daylight and enriched the depth of layers of the scenes, to enhance the participants' immersive experience. Lighting settings were kept consistent in all scenarios.

To keep the consistency of scenario alteration and isolated variables adjustment between 3D modelling software and the game engine, we set up levels in the game development engine (which equivalent to the layers in 3D modelling software). In the engine, we employed the gameplay scripting system to visually script the levels which allowed for combining levels most efficiently and controlling the different combination of variables.

The level animation sequence was adapted in level management to handle complicated pedestrian simulation, cyclist simulation and vehicles simulation from 3D modelling software. This approach guaranteed frame and camera setting synchronisation in the 360-degree video outputs.

We modelled custom vegetation for inclusion in the scenarios using sensitive urban design (WSUD) plant types *dianella, lomandra, dwarf bottlebrush, clivea, juniper, star jasmine*. We scripted the vertices of the tree leaves and ground-level vegetation meshes so they could be randomly moved by a small offset amount to simulate a gentle breeze effect.

In the IVE models, all sounds were set to spatial audio, which involved the manipulation of audio signals, so they mimic acoustic behaviour in the real world. The traffic lights and crossing lights were programmed and synchronised with sound effects in the engine.

We set up vehicle engine noise based on typical RPM (engine revolution per minutes) and related gear changing sound and logarithmic sound decay and intensity levels (DBa) from *Vehicle noise levels for VR project with TfNSW Research Hub* provided by TfNSW. We simulated vehicles noise for four key types of vehicles, which included light vehicles, medium trucks, buses and motorcycles, in two sets of limited speed, 50km/hr and 30km/hr.

We regarded all simulated vehicles as agents in the game engine. We monitored the speed and acceleration of the agents, programmed and analysed the data by the scripts we built in the gameplay scripting system, constructed the relationship between speed, acceleration of the agents and RPM related engine sounds with correspondent pitch and volume. In this way, in the game engine simulation, the corresponding soundtracks of each category of vehicles would be attached to the geometry of the vehicle and played at appropriate *Sound Power Levels* at vehicle location while vehicles in free-flowing traffic. We added horn sound effects at the traffic congestion point to improve the realism of the scenarios. We also added four channels of ambient background city sound, which we recorded on Glenferrie Rd, a 'main street' in Hawthorn, Victoria (before the COVID-19) and included the audio as background noise in each of the scenarios.

While we carefully modelled to control the quality and balance of sounds to provide as realistic an environment as possible, we did not have control the over specific models of devices models, headphone models, volume levels of devices and video players, and the physical environment of the participants. To manage this limitation, we included instructions encouraging participants to use headphones and to adjust their computer or smart device's audio settings to a comfortable volume that 'feels realistic'.

360-degree video and binaural audio output

While we initially envisaged conducting this study with citizens in person using virtual reality in head mounted displays, due to the impact of COVID19, it was not safe or feasible to conduct the experiential aspect of the streetscape scenarios this way. Instead, we adjusted the study to be fully online, and utilised an immersive 360-degree video approach.

In the game engine, we programmed and set up a panorama camera which constructed the scene with two lenses, to represent the virtual left and right eyes in the game engine scenario. We then projected the view captured by the lenses onto a 2:1 canvas in equirectangular form. The rendered scenes were exported as a series of equirectangular projections (flattened globe) image sequences which are 8K UHD 7680 x 3840 pixels per frame and 25 frames per second.

In order to export multi-directional sound (spatial audio), we recorded two channels of the audio at the point of the camera location while facing towards the street. We then recorded another two channels of the audio after horizontally rotating 90 degrees. The spatial audio was combined and rendered with the 8K UHD equirectangular image sequences in the video editing software and injected with specific 360 metadata. The specific metadata was embedded with the videos to help the video player platform (YouTube) to recognise and process 360 videos and spatial audio.

YouTube with gyroscopic feedback and mouse movement to simulate view direction.

We then uploaded 360-degree videos with spatial audio of thirteen scenarios to the YouTube video-sharing platform. Videos were set as unlisted videos (anyone can use video URLs to view the view, but the URLs were not listed on YouTube website) and were embedded in the online survey.

Participants in the study who took the survey could view the 360 videos on their PC or mobile devices. On a PC, they could pan around the video by clicking and dragging or using the pan button in the upper left corner with the mouse. WASD keys on the keyboard could also be used for turning the camera to the left and right, up and down. On smart devices (including smartphones and tablets with a gyroscope sensor), participants could move the device to pan the video view, using the internal gyroscope sensor to determine the orientation of the device.

Online survey – testing perceptions of street types with varied parameters

The 360-degree IVE scenario models were used to elicit responses from respondents through an online survey. The interactive survey was developed for an online format suitable for participants using either desktop/laptop (with a suitable web browser) or smart device (mobile smartphone or tablet). Qualtrics™ software was used for the development of the survey.

Recruiting for the study involved the use of a 'snowball' approach and was initially shared to the community via media posts, website/blogs, emails, social media (Twitter, FB, Instagram, LinkedIn) and an advertisement on Facebook. To enable a confidence level of 95% (the probability that the sample accurately reflects the attitudes of the population), with a margin of error under 10% (the range the population's responses may diverge from the sample), we sought a minimum of 100 participants.

The survey had seven sections:

1. Introduction and informed consent
2. Demographics questions
3. Scenario introduction and instructions
4. Randomised scenarios with associated safety and place questions
5. Post scenario questions
6. Level of immersion and presence questions
7. Contact details.

1. Introduction, explanatory statement and informed consent

The survey was conducted with the approval of the Swinburne University of Technology's Research Ethics Committee, [2752] (Application 20202752-3900, Application Approved 06/03/2020, Human Ethics Full - Low risk, 20202752-4805 Modification Approved 24/07/2020). Survey participants were first greeted with a project introduction and invited to read the full project details in the official Explanatory Statement. They were then asked to agree to the *Informed Consent* on the first question of the survey.

2. Demographic questions

The next set of questions invited participants to share demographic details, including age group, gender, occupation, location, places in the world they had experienced living, and typical transport modes.

3. Scenario instructions

Participants were then provided with a simple explanation of how the streetscape scenario questions were to be answered with instructions asking them to "imagine you are standing on the footpath in nine (9) different streetscapes while viewing and listening to the 360-degree videos". Then they were told that after viewing the scenario, they would be asked questions about how they felt in these streetscapes, how they would feel about crossing the street, and which elements of the street they thought made the space feel more, or less, pleasant and safe. We provided and illustration of the viewing process using an animated .gif image showing a participant moving their smart device (phone with inbuilt gyroscope) while viewing an example scenario, with an animated .gif image of what was being seen on the phone [Figure 31].

Figure 31: Animated .gif images: (RHS) showing participant moving their smart device around to see different angles of the immersive virtual environment, and (LHS) showing a screen capture of what the participant sees on their smart device screen.

4. Randomised scenarios with associated safety and place questions

In the next section, we presented participants with nine of different streetscape design scenarios, each with slightly different road configuration, crossing type, footpath or landscape elements. Though different streetscape designs involved many complex and interlinked variables, were possible, we minimised the number of variable changes in each scenario. We started with the 'Baseline' 'typical main street' scenarios, (described in previous sections), and then modified this street to represent the different streetscape treatments keeping all other variables the same, or as similar as possible given the requirements of the scenario. The intention of restricting variable changes was to allow for a variation on a discrete choice experimentation, a processed used to explore consumer decision-making in marketing and psychology (Louviere et al., 2008).

In order to avoid potential order effect bias (where a participant may react differently to questions based on the order in which questions appear), the streetscape scenarios were run in a randomised order via computer-generated sequence.

To keep the length of time to complete the survey reasonable, of the thirteen different streetscape scenarios were modelled for inclusion in the survey, a five prioritised 'core' scenarios were included in every survey, with a selection from the remaining scenarios made to make up a total of nine scenarios per survey. The non-core scenarios included a random selection of either the pair of signalised crossing scenarios (short wait, or long wait signalised crossing), or the pair of non-signalised crossings (refuge island crossing or wombat crossing scenarios), with remaining survey scenarios randomly selected from the remaining scenes [Figure 32].

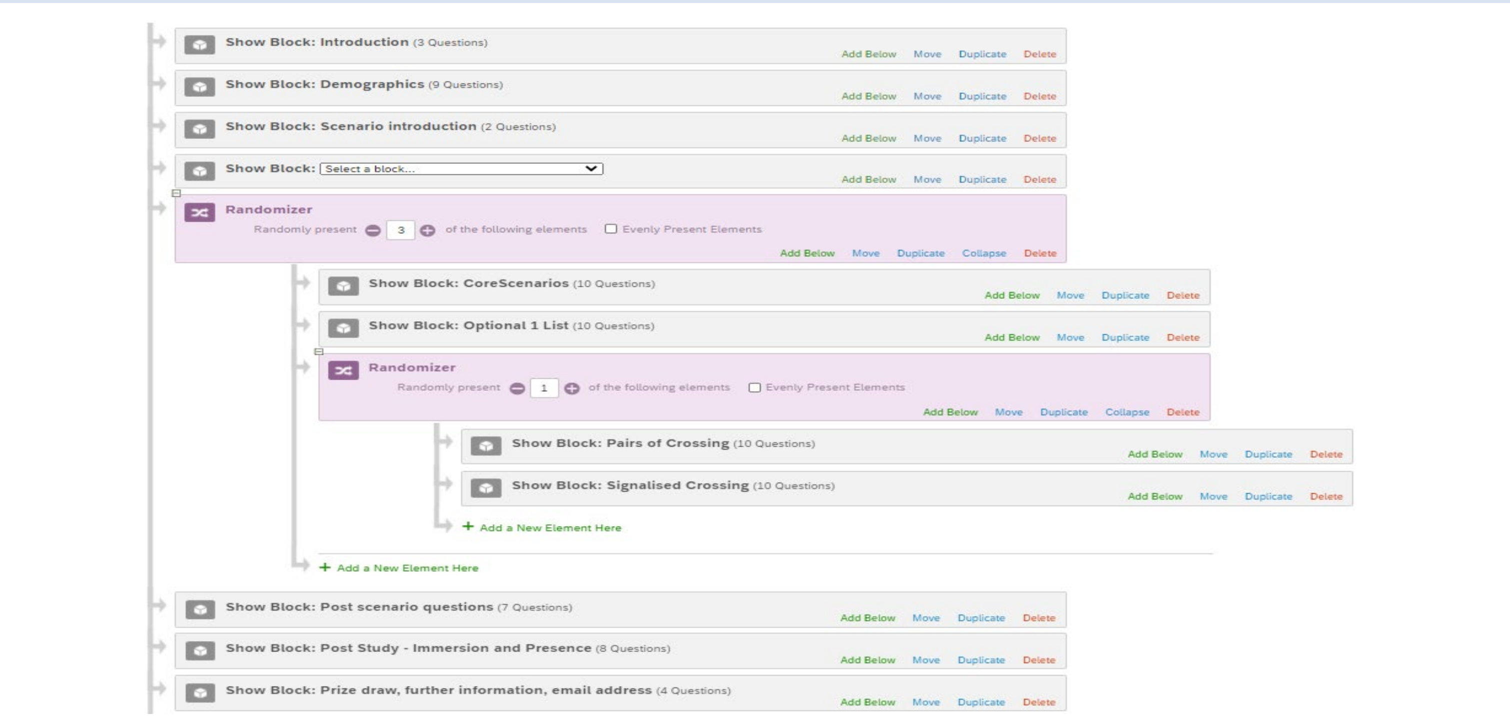

Figure 32: Screen grab showing the structure of survey flow illustrating the randomisation of scenarios included in each survey.

Immersive virtual environment streetscape scenarios as embedded 360-degree videos

Each of the immersive virtual environment streetscape scenarios was presented as an embedded 360-degree video within the survey, with simple instructions included as 'pop-ups' above the video if needed by the participant [Figure 33]. The instructions given describe the process of 'maximising' the view of the video to take up the whole screen, and how to 'move your head' (direction of view) around to experience the virtual environment.

Figure 33: Immersive virtual environment streetscape scenario embedded into survey with 360-degree video able to be enlarged to 'full screen' to for full immersive effect on either mobile smart device or on desktop/laptop computer.

After experiencing the immersive virtual environment (2 minutes), participants were then moved onto answer a series of questions. The questions about user experiences used an adaptation of **'emotion/affect slider'** (Betella & Verschure, 2016; Laurans et al., 2009) with **'Visual Analogue Scale'** (Klimek et al., 2017), with participants asked to respond to questions about the quality of the place to stop and sit down for a refreshment, about crossing over to visit shops on the other side of the street, and how pleasant the space felt on a digital analogue scale (slider). Participants were then asked to 'drag-and-drop' text items into two different boxes in order to prioritise relevant streetscape design elements into two different boxes, one box representing elements that made space feel *MORE* pleasant, and one box representing elements that made the space fell *LESS* pleasant.

Participants were then asked to respond to another emotion affect slider question about how safe they felt in the space, followed by another 'drag-and-drop' prioritising question focused on elements that made the space feel *MORE* safe, or *LESS* safe.

The final question for each scenario asked participants to mark their psychological response to the space on a **2D 'affect grid'** [Figure 34]. The affect grid, based on an adaptation of the method as described by (Russell et al., 1989) was combined with the EmojiGrid, an emotional representation with the use of emojis for affect pleasure and emotion (Toet et al., 2018).

Our affect grid was design to allow participants to register their emotional response, by using their mouse, or finger to register a point within the orange circle, to indicated their current emotion/mood. Depending on the location of the point registered, it falls into either the top half – ***activation*** (what Russell called 'arousal'), the bottom half – ***deactivation*** (what Russell called 'sleepiness'), the left hand side – ***displeasure*** (unpleasant feelings), and the right hand side – ***pleasure*** (pleasant feelings). These overlapping halves provide four quadrants (***activation-displeasure, activation-pleasure, deactivation-displeasure*** and ***deactivation-pleasure***). These quadrants are then broken down to more nuanced feelings, and levels of intensity with distance outward from the neutral centre (darker orange colour), representing a higher level of the emotion.

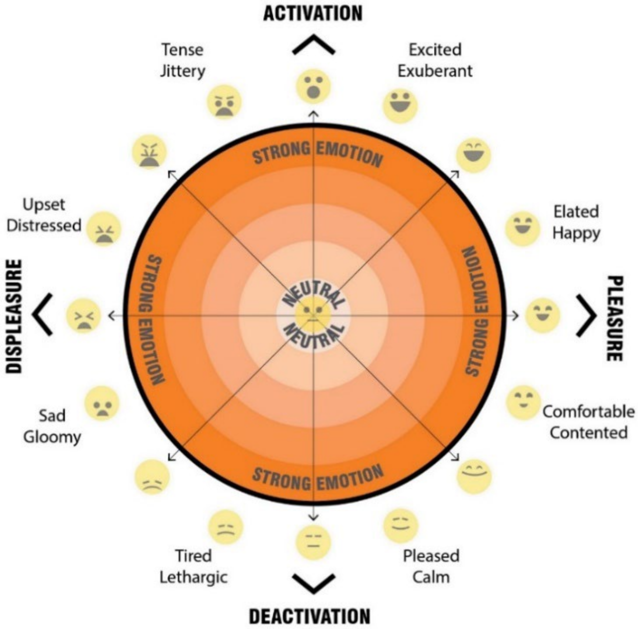

Figure 34: Affect grid for participants to register their emotional response when asked "how do you fell in this space? Please click on the orange segment that represents how you feel about the streetscape".

5. Post scenario questions

After experiencing the nine streetscape scenarios, participants were asked a set of final questions to collect their overall experience of the streetscapes. Firstly, they were asked to rank the elements that positively influenced their feeling of the place as MORE pleasant [Figure 35]. They were then given a text area to type additional thoughts on aspects of the streetscapes that made it feel more or less pleasant. They were then asked to rank elements that made them feel MORE safe and were again given the opportunity to provide any additional thoughts around their response.

The next questions related to the potential impact of COVID-19, and if they believed that their perception of spaces was influenced by the current pandemic situation.

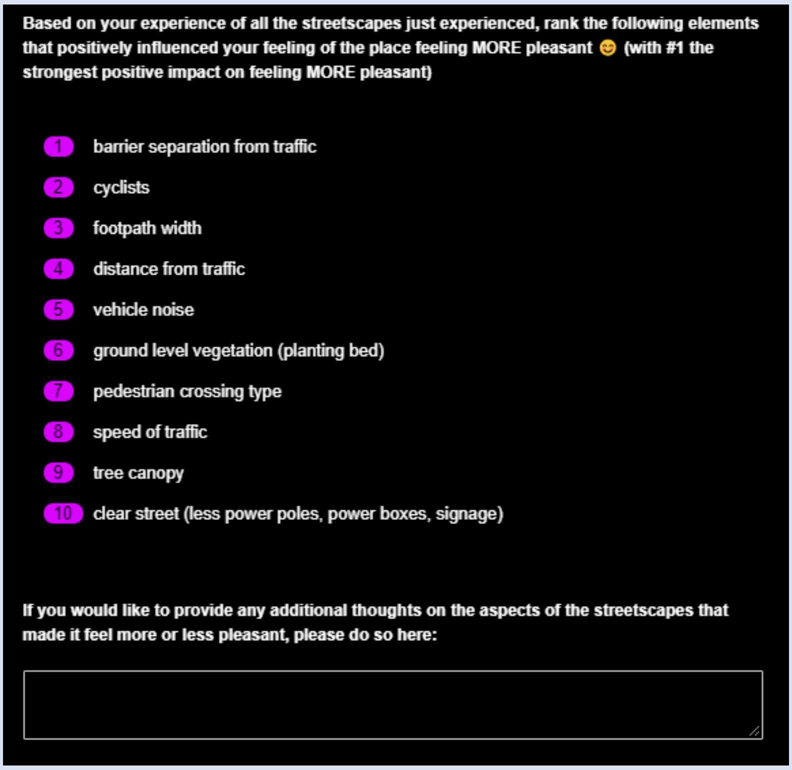

Figure 35: Ranked response question asking participants to sort streetscape design elements that made the streets feel more pleasant.

6. Level of immersion and presence questions

The next section asked participants about the setup they used to do the survey, (for example on phone with headphones, on phone without headphones, on laptop/desktop with headphones and so on), and then a series of questions to evaluate the extent to which they felt immersed in the environment and how real it felt. These questions were based upon the presence in virtual environments questionnaire by Witmer & Singer (Witmer & Singer, 1998). We asked if participants had a sense of "being there" in the streetscapes, if there were times during the experience when the streetscapes were the reality for them, and if the streetscapes seem to me to be more like somewhere they had visited or images that they had seen. We also asked if during the experience, they had a stronger sense of being on the street or being elsewhere, if they thought the streetscapes as places were similar to other places that they had been today, if during the experience they thought that they were really standing in the street, and if the auditory (sound) aspects of the experience made the streets seem more real.

7. Contact details

The final section allowed participants to provide contact details in order to be contacted to receive information about the study results, if they were willing to be contacted for a follow-up interview (in future research outside the scope of this study), and to be contacted if successful in the draw for the participant prize.

Part 3: Results

In this part of the report we will summarise the results of the study.

Firstly, we summarise the response rate, and key demographic questions of respondents.

We go on to explore the scenario analysis of emotion slider feedback using a general estimating equation (GEE) ordinal logistic regression for the questions: ‘would this be a good place to stop for coffee?’, ‘how inviting does it feel to cross the street to visit shops on the other side?’, ‘how pleasant is it to stand in this space?’ and ‘how safe do you feel in this space?’ We then explore the ranking of streetscape elements that made the street feel MORE or LESS pleasant, and MORE or LESS safe.

We then examine response to the ‘Affect grid’ for the question ‘how do you feel in this space?’. We finish with an exploration of the level of immersion and ‘presence’ of the participants.

Survey response analysis

Before detailing the responses to each of the survey questions, it is essential for the validity of the study to understand the volume of responses and the answers to some important demographic questions including, breakdown of genders, ages, occupation, and location, as well as to know the common modes of travel of participants.

Response rate

The response rate to the survey was greater than anticipated with over 800 participants, of which there were over 276 valid responses (more than 50% completion), 238 of these completing the entire survey. This rate of completion and valid responses were considerably higher than expected, given the length of the survey and the level of detailed responses required.

Gender breakdown

Responses to the survey had a gender distribution of 59% of participants identified as male, 38% of participants identified as female, and the remainder were identified as other or preferred not to say [Figure 36]. Responses were analysed for any impact gender may have had on results. We found no significant differences in responses between males and females to the questions: ‘This would be a good place to stop and sit down for a coffee?’, ‘How inviting does it feel to cross the street to visit shops on other side?’, ‘How pleasant is it to stand in this space?’ ‘How safe do you feel in this space?’ when controlling for background, device used, mode of transport and age group.

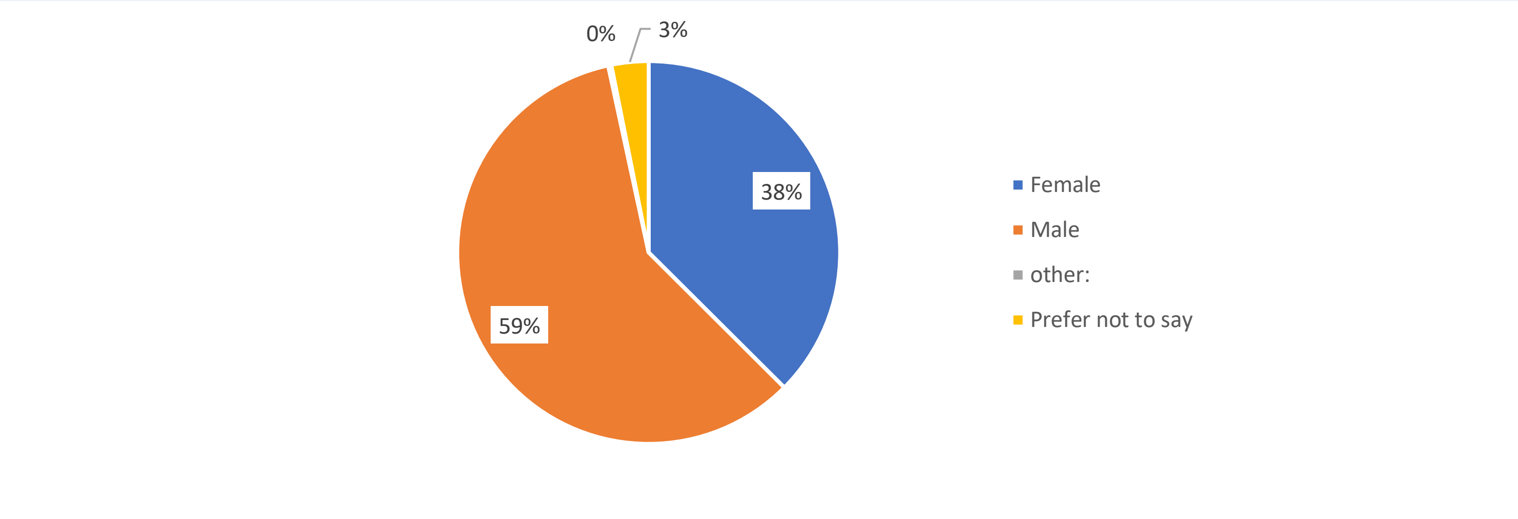

Figure 36: Pie chart showing gender distribution.

Location of participants

We found that the location of the survey participants, according to postcode, were predominantly from NSW with just under two thirds (63.9%) of the responses. The remaining participants included just under one fifth from Victoria (19.7%), and small numbers from WA, ACT, QLD, SA and TAS, [see Appendix A, Figure 63].

Participants within NSW were generally located along the East Coast with a concentration within Sydney [see Appendix A, Figure 64]. There was a reasonable spread of participants across the wider metropolitan, and a concentration found in the areas closer to, and within central Syney [see Appendix A, Figure 64].

Age of participants

When asked to choose from the series of age categories, we found participant response to have a reasonable spread across each of age groups with the exception of the 75–84-year-old (1%) and the over 85 category (less than 1%) [see Figure 37], which was expected to be a consequence of a survey limited to an online-only format. A small percentage of responses was found in the 16-18 senior-school age group (3%), but as this is a smaller age range (just two years), the percentage was considered relatively even with other age categories. When response to key questions were analysed against age category, we found that opinions tended to be more positive, the younger the participant, with participants under the age of 34 were on average more likely to responded positively in all scenarios.

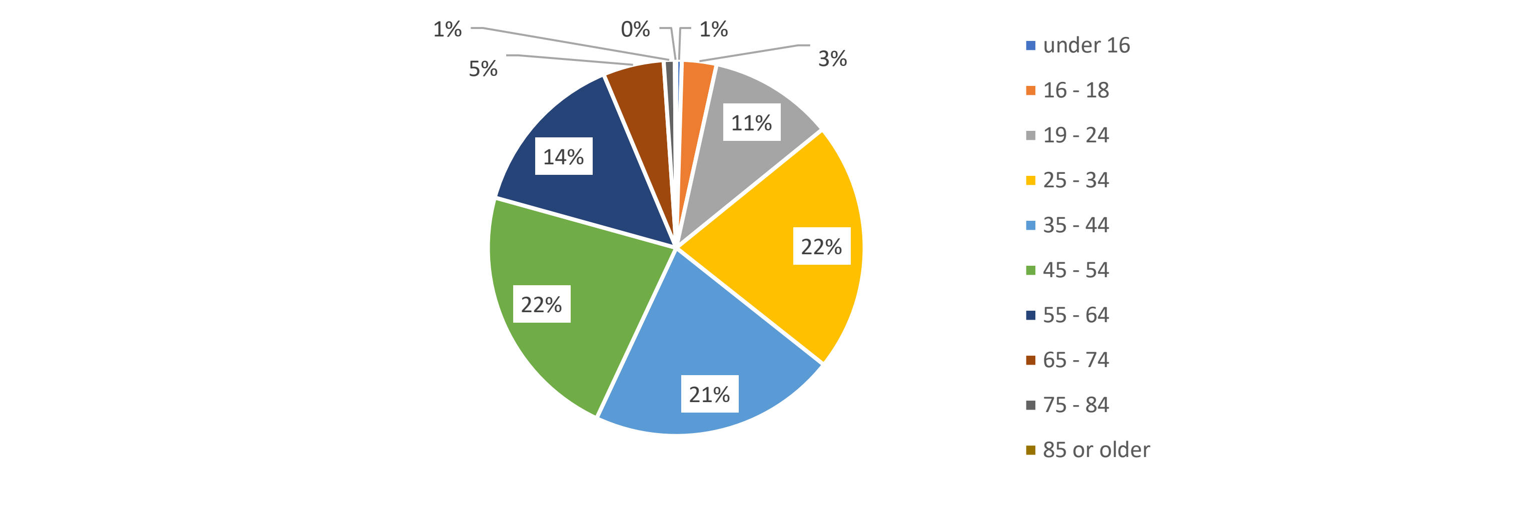

Figure 37: Pie chart showing distribution of stated age categories of participants.

Occupation of participants

The question of occupation was included in the survey to enable checking for any potential bias relating to occupation. We found a high level of participation from those stating they worked in industries related to transport, education, as well as students [Figure 38]. We also found that participants in the study represented a wildly diverse range of occupations including health sector, engineering, finance, hospitality, defence, through to a tailor and a zookeeper [see Appendix B, Table 10].

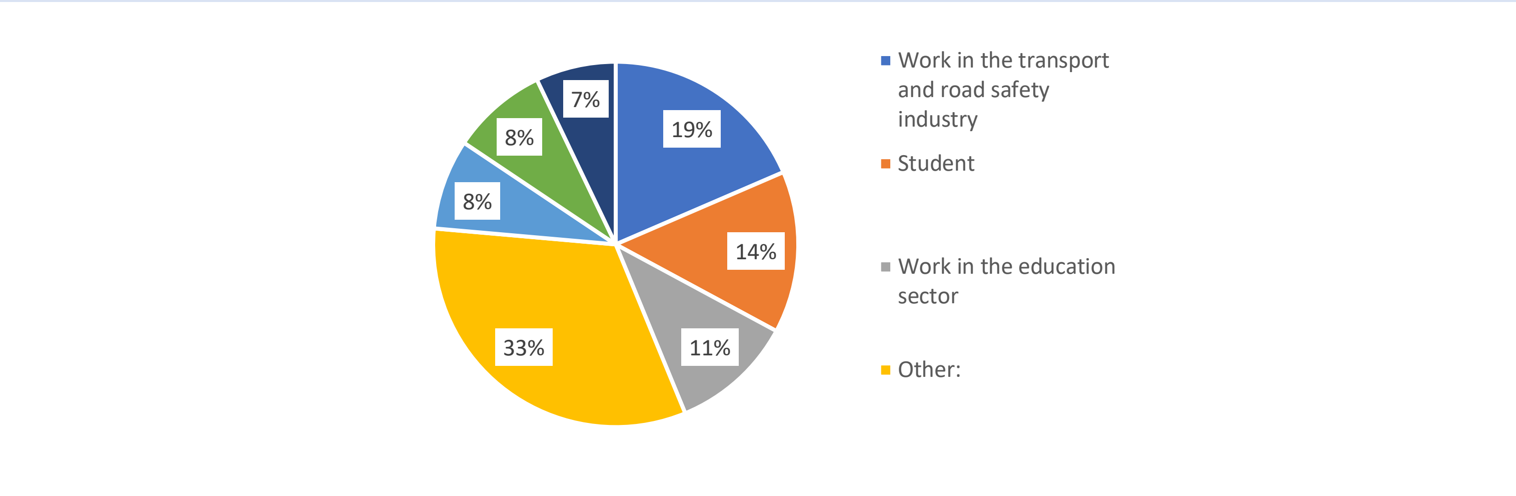

Figure 38:Pie graph showing the percentage breakdown of respondent's response to the question of occupation.

We did not find significant differences between answers to the four key affect slider questions, across all scenarios by occupation field, other than the question: *'Would this be a good place to stop for coffee?",* to which **designers responded 54% more positively** than all other occupations [Exp(B) 1.544]. When we compared the transport field to all other occupation fields as a combined group, we found there were no significant differences between these two groups for any of the questions. Some of the significant levels were close to 1 indicating almost no difference between those who work in transport and those who work in other fields.

Designers were one and a half times more likely to respond positively to the question of 'would this be a good place to stop for coffee?' for all scenarios.

For the specific scenarios where the research team believed there may potentially be an occupation-based bias in respondents who worked in transport due to their professional training: the **'Parked car buffer'** scenario, and the **'Barrier fence'** scenario, we compared the responses of those in the transport field with all other occupations combined as a single group. Between these two groups, there were no statistically significant differences for any of the questions for those two selected scenarios.

Transport modes

Respondents were asked to nominate transport modes they commonly used from a list of seven (including other). Respondents were allowed to choose multiple transport modes [Figure 39]. Across all scenarios, for all questions, the impact of transport mode was minimal, though there were small statistically significant differences in the responses of those who selected trams and those who selected cycling, both of whom were more likely to be negative than those who did not select trams or cycling. This was true in all four questions apart from: 'How safe do you feel in this space?", for which there was no statistically significant difference between those who did and those who did not select trams as a common transport mode. As none of the scenarios included trams in the street, the slightly lower number of positive responses of those who selected trams is not unexpected.

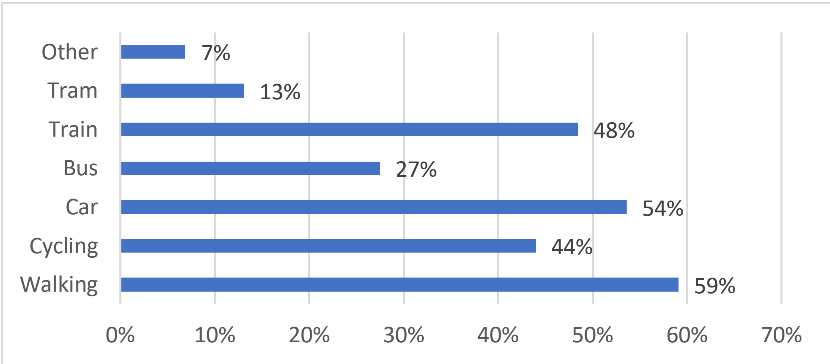

Figure 39: Nominated modes of transport commonly used by participants. Participants were permitted to choose multiple transport modes.

Non-cyclists were on average 45.6% more likely to have positive responses compared to cyclists to the question: *Would this be a good place to stop for coffee?* ($p<.001$). Non-cyclists were on average 39.1% more likely to have positive responses to the question: *How inviting does it feel to cross the other side?* ($p=.002$). They were on average 45.9% more likely to have positive responses to the question: *How pleasant is it to stand in this space?* ($p<.001$), and 30.3% more likely to have positive responses to the question: *How safe do you feel in this space?* ($p = .009$).

The likely reasoning for the consistently less positive response of cyclists compared to non-cyclists to all four questions was found in several of the written responses which included statements such as:

'Seeing cyclists mixed in with fast moving traffic upset me'.

'Seeing cyclists riding alongside cars driving at 50km/h made me feel anxious for their safety'.

'All are awful. Speeding cars, cyclists nearly being hit by cars, loud noise, crossing noise. None of those scenarios were pleasant. Divert the cars elsewhere'.

'Having a different colour lane for cyclists looks fantastic and adds more safety to the cyclists'

'More cyclists made me feel safe if the cyclists appeared safe. If the cyclists looked in mortal danger (too close to fast traffic) I felt even more unsafe because I was scared for them'.

Though the overwhelming majority of comments appeared to be positive towards concern for cyclists and providing dedicated space, regardless of whether they stated that they cycled or not, there was one respondent that opposed cyclist's inclusion on the street saying:

'Cyclists should be removed from these places. They should park their bikes and walk like other pedestrians'.

To further investigate the differences between the responses of cyclists and non-cyclists, we analysed the responses to the individual scenario that included the dedicated cycling lane. In contrast to the results across all scenarios, responses from cyclists to this individual scenario were statistically more positive than non-cyclists across all questions.

In the 'Cycling lane' configuration street scenario responses from non-cyclists were consistently less positive than cyclists. Non-cyclists were on average 51.5% less likely to have positive responses to "How pleasant is it to stand in this space?". They were also on average 60.6% less likely to have positive responses to the "How safe do you feel in this space?". They were 53.8% less likely to have positive responses to the "How inviting does it feel to cross the street to visit the shops on the other side?" and 48.4% less likely to have positive responses for the "This would be a good place to stop for coffee?".

Scenario analysis of emotion slider feedback

As outlined in the method section of this document, twelve streetscape scenarios along with the 'typical main street' 'Baseline' scenario, were randomly presented to the participants without any indication of the scenario names, along with four slider questions prompting participants to respond to their perceptions of place and safety.

- Baseline control configuration: **'Baseline'** scenario (4 lanes of traffic @50km/ph)
- Speed configuration: '**Reduced speed'** 30km/ph scenario
- Barrier separation configuration: **'Barrier fence'** scenario
- Barrier separation configuration: **'Increased tree canopy'** scenario
- Barrier separation configuration: **'Ground vegetation buffer'** scenario
- Barrier separation configuration: **'Less clutter'** scenario
- Distance separation configuration: **'Parked car buffer'** scenario (2 lanes of traffic)
- Distance separation configuration: **'Cycle lane'** scenario (3 lanes of traffic)
- Distance separation configuration: **'Widened footpath'** scenario (3 lanes of traffic)
- Crossing configuration: **'Signalised crossing long-wait'** (non-pedestrian prioritised) scenario
- Crossing configuration: **'Signalised crossing short-wait'** (pedestrian prioritised) scenario
- Crossing configuration: '**Refuge island'** (non-pedestrian prioritised) scenario (2 lanes of traffic)
- Crossing configuration: '**Wombat crossing'** (pedestrian prioritised) scenario (2 lanes of traffic)

General estimating equation (GEE) ordinal logistic regression

Four analysis models were conducted to determine whether the 12 streetscape scenarios had statistically significantly different responses to the 'Baseline scenario for each question. We chose a general estimating equation (GEE) method with an ordinal logistic regression as the chosen model. We chose this model because GEE is useful in handling repeated measures studies and ordinal logistic regression handles Likert scale data well. The responses were transformed into Likert scale data format for data analysis and data visualisation [Figure 40]. For the purpose of this report, when we say responses are 'more positive' it means that the odds of the responses being either 'agree' or 'strongly agree' as opposed to 'disagree' or 'strongly disagree when compared with the 'Baseline model. The detailed results of the model can be seen in [Appendix C: Table 11, Table 12, Table 13, Table 14] and simplified summaries in [Figure 41, Figure 43, Figure 45, and Figure 47].

Responses to the question: 'would this be a good place to stop for coffee?'

The emotion slider responses when expressed as a diverging stacked bar chart (Likert plot) [Figure 40], suggest that overall responses tended to fall on the negative side of the neutral centre point for all scenarios. This was also the case for the other emotion-slider questions illustrated in [Appendix C, Figure 42, Figure 44, and Figure 46]. This generally negative response was be expected given the high volume of traffic movement that make up streets classified as 'main streets', and provides confirmation the of the need to study the conflict of traffic movement and place. It is worth noting that the responses from participants were for individual streetscape treatment changes in most scenarios, and there is a strong likelihood that combinations of treatments (for example increased canopy with reduced speed, and cycle lane addition) would result in more positive perceptions.

In assessing the responses to the question: 'would this be a good place to stop for coffee?' when visualised as a diverging stacked bar chart (Likert plot) of responses [Figure 40], we found that 'Ground vegetation buffer', 'Increased tree canopy', and 'Wombat crossing' received very strong positive *Agree* and *Strongly Agree* responses. There was also a considerably high number of *Agree* and *Strongly agree* for the 'Cycle lane' scenario. We found high numbers of participants registering their response in the *Disagree* and *Strongly disagree* range on the emotion/affect slider for the 'Baseline', 'Less clutter', and both signalised crossing scenarios. Though the reasoning for the strong negative response to the signalised crossings, some of the respondent's written comments suggest this may be due to the 'irritating noise' of chirp/percussive sound of the accessible pedestrian signals (APS) (different sounds at the light button used to indicate when to cross for people with visual impairment).

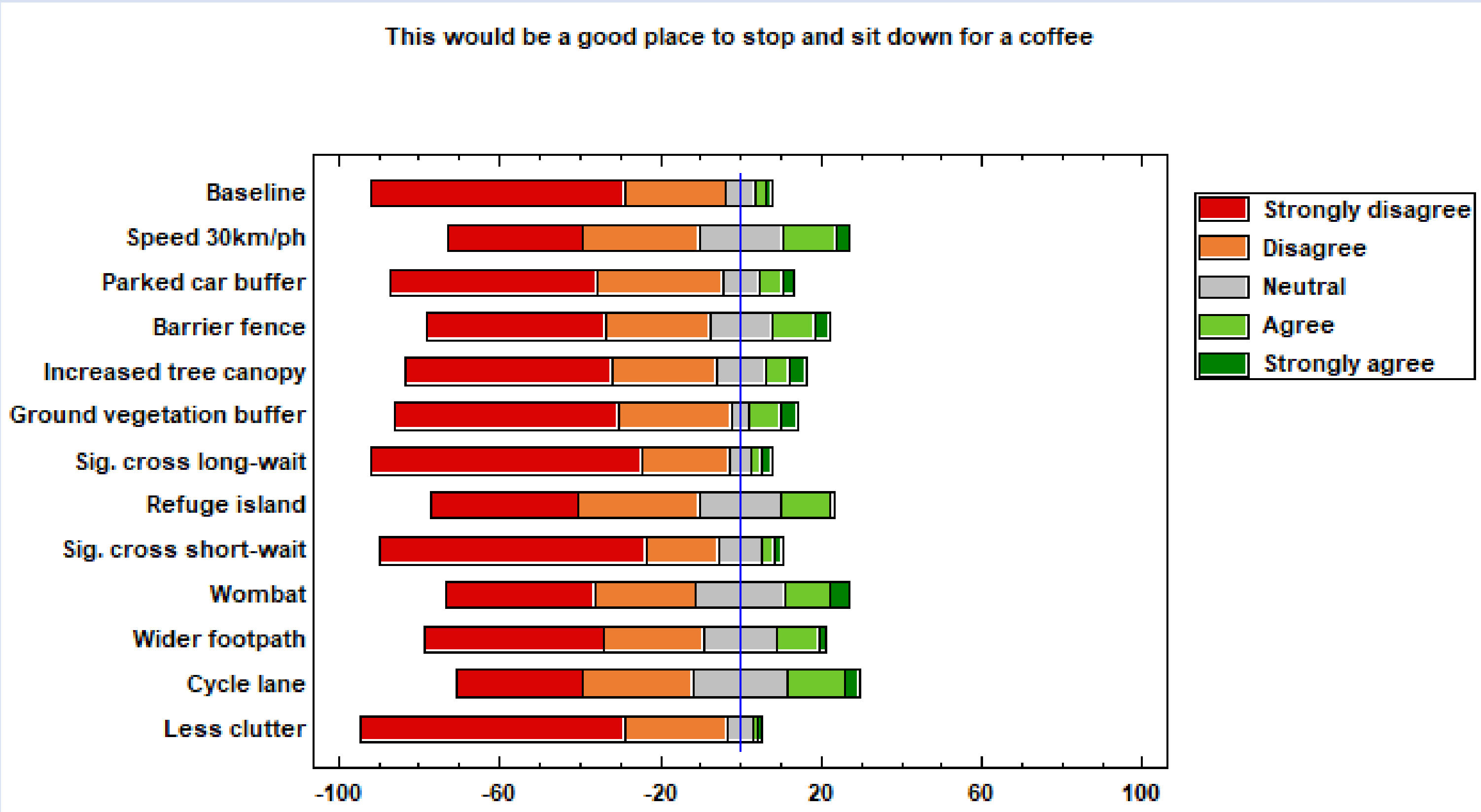

Figure 40: Diverging stacked bar chart (Likert plot) of responses to the question 'would this be a good place to stop for coffee?'.

***Reducing the speed** to 30km/hr was nearly **three and a half times** more likely to receive a positive response than the 50km/hr baseline street.*

An ordinal logistic regression using GEE was conducted for the results of the survey question 'Would this be a good place to stop for coffee (or other refreshments)?'. Compared to the 'Baseline' scenario, statistically significant responses to 8 of the 12 scenarios were more positive [see Appendix C, Table 11]. The **'Cycle lane'** (p<.001) responses were on average **3.97** times more likely (3.01, 5.14) to be positive**,** the **'Wombat crossing'** (p<.001) responses were on average **3.48** times more likely (2.44, 4.99) to be positive, **the 'Reduced speed 30km/ph'** responses were on average **3.43** times more likely (2.69, 4.37) to be positive, the **'Refuge island'** (p<.001) responses were on average **3.12** (2.19, 4.44) times more likely to be positive, the **'Widened footpath'** (p<.001) responses were on average **2.43** times more likely (1.91, 3.08) to be positive, the **'Parked car buffer'** (p<.001) responses were on average **2.36** times more likely (1.49, 3.72) to be positive, the '**Increased tree canopy'** (p<.001) responses were on average **72.9%** more likely (1.397, 2.140) to be positive and the **'Barrier fence'** (p<.001) responses were on average **59.3%** more likely (1.245, 2.039) to be positive. A summary of these statistically significant findings is shown in [Figure 41]. The results for the scenarios 'Ground vegetation buffer', 'Sig. cross long-wait', 'Sig cross short-wait' and 'Less clutter' did not significantly differ from the 'Baseline' scenario.

Findings ranked for 'would this be a good place to stop for coffee?':

1. **'Cycle lane' (3.97 times more likely to be positive)**
2. **'Wombat crossing' (3.48 times more likely to be positive)**
3. **'Reduced speed' 30km/ph (3.43 times more likely to be positive)**
4. **'Refuge island' (3.12 times more likely to be positive)**
5. **'Wider footpath' (2.43 times more likely to be positive)**
6. **'Parked car buffer' (2.36 times more likely to be positive)**
7. **'Increased tree canopy' (72.9% more likely to be positive)**
8. **'Barrier fence' (59.3% more likely to be positive)**

Figure 41: Statistically significant (p<.001) findings ranked for 'would this be a good place to stop for coffee?' [see Appendix C for detailed table].

Responses to the question: 'how inviting does it feel to cross the street to visit shops on the other side?'

The same model was then conducted for the responses to the question 'How inviting does it feel to cross the street to visit shops on the other side?' for the thirteen scenarios.

When we visualised the results as a diverging stacked bar chart (Likert plot) [Figure 42], the responses to the question: 'How inviting does it feel to cross the street to visit shops on the other side?' show 'wombat crossing', 'refuge island' and both 'signalised crossings' scenarios received very strong *Inviting*, or *Very inviting* responses. 'Reduced speed 30km/hr', 'Cycle lane' and 'increased tree canopy' also received comparatively high *Inviting*, or *Very inviting* responses.

We found high numbers of participants registering their response in the *Uninviting* and *Very uninviting* range on the emotion/affect slider for the 'Barrier fence', 'Ground vegetation barrier', 'Baseline', 'Less clutter', scenarios. The barrier fence received the strongest response in the *Very uninviting* range of all scenarios. This negative response was also reiterated with strong negative comments by participants through their written comments, such as:

'Barrier separation just feels claustrophobic. I'd much rather be close to slow traffic than behind a fence'.

'Barriers are third tier treatment, and basically are an admission of failure'.

'Easy and safe access to the other side of the road should feel intuitive and not a chore, nor degrading'.

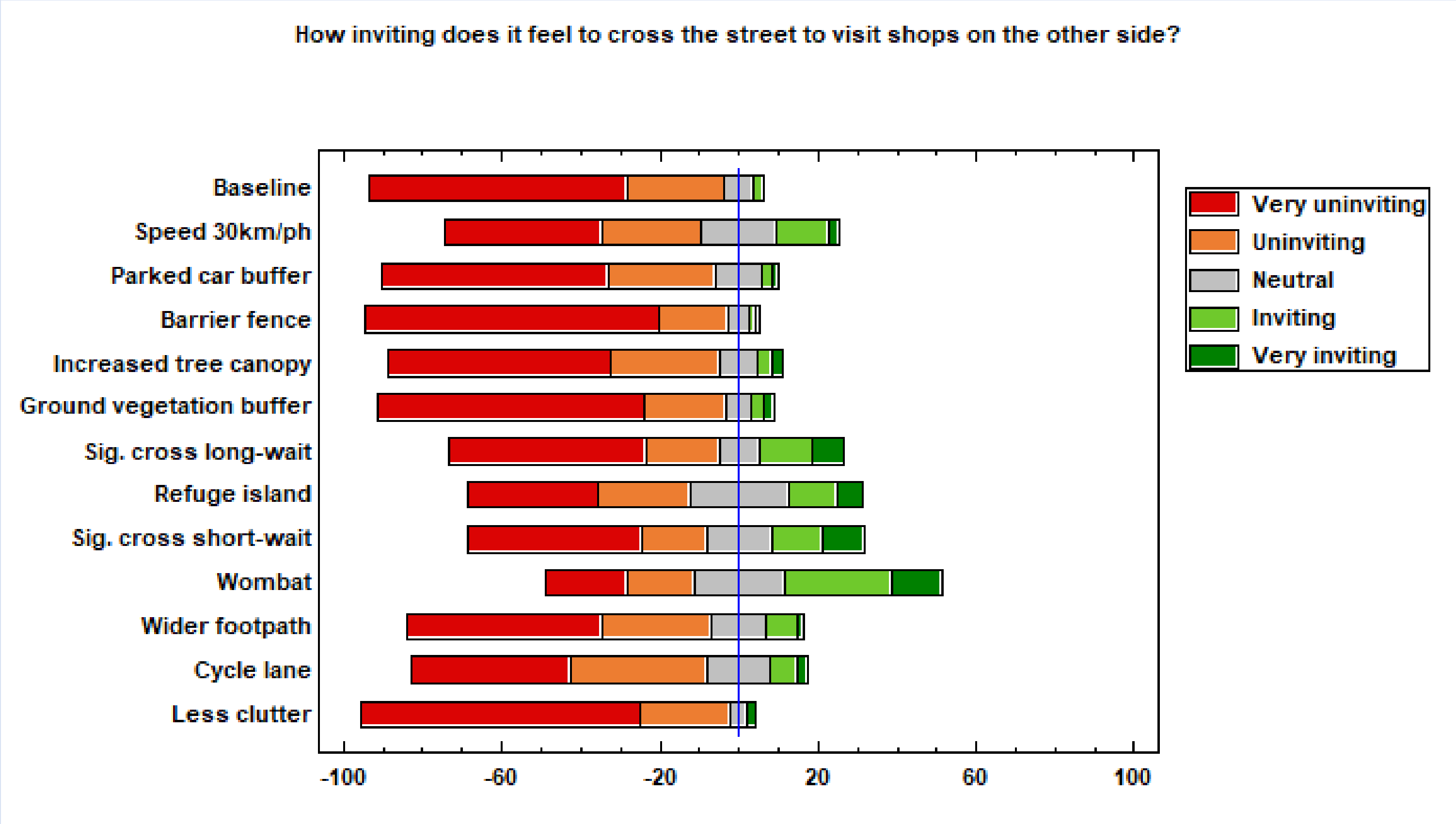

Figure 42: Diverging stacked bar chart (Likert plot) of response to the question 'how inviting does it feel to cross the street to visit shops on the other side?'.

The scenarios '**Speed 30km/ph'**, '**Sig cross long-wait'**, '**Refuge island**', '**Sig cross short-wait**', '**Wombat crossing**', '**Wider footpath**' and '**Cycle lane**' all had strong and significant differences in their responses compared to the 'Baseline' (p<.001 for all of the scenarios) while the '**barrier fence**' (p = .017) and '**Increased tree canopy**' (p = .001) had significantly different responses compared to the 'Baseline'. The responses to the scenarios 'Parked car buffer' (p = .111), 'Ground vegetation buffer' (p = .961) and 'Less clutter' (p = .448) did not differ to the responses of the 'Baseline' scenario to a statistically significant degree. The results of the model can be seen below in [Appendix C, Table 12].

*Responses to the **wombat crossing** scenario were on average **over ten times** more likely to be positive.*

Key findings:

Compared to the 'Baseline', responses to 8 of the 12 scenarios were substantially more positive. The '**Wombat cross'** responses were on average **10.40 times** more likely (7.11, 15.23) to be positive, The '**Refuge island'** responses were on average **4.57 times** more likely (3.20, 6.44) to be positive, the **'Sig. cross short-wait'** responses were on average **3.75 times** more likely (2.58, 5.44) to be positive, the '**Speed 30km/ph'** responses were on average **3.25** times more likely (2.51, 4.20) to be positive, the '**Sig. cross long-wait'** responses were on average **2.7 times** more likely (1.86, 3.93) to be positive, and the **'Cycle lane'** responses were on average **2.63** (2.03, 3.42) times more likely to be positive.

Compared to the 'Baseline', responses to 2 of the 12 scenarios were moderately more positive. The '**Wider footpath'** responses were on average **106%** (1.60, 2.66) more likely to be positive and the '**Increased tree canopy'** responses were on average **52.4%** more likely (1.18, 1.96) to be positive. Responses to the '**Barrier fence'** scenario were on average **38.2%** (-

1.50, -1.06) less likely to be positive compared to the 'Baseline' scenario. A summary of these statistically significant findings is shown in [Figure 43].

When we visualised the results as a diverging stacked bar chart (Likert plot) [Figure 42], the responses to the question: 'How inviting does it feel to cross the street to visit shops on the other side?' show 'Wombat crossing', 'Refuge island' and both signalised crossings scenarios received very strong *Inviting*, or *Very inviting* responses. 'Reduced speed 30km/hr', 'Cycle lane' and 'Increased tree canopy' also received comparatively high *Inviting*, or *Very inviting* responses.

We found high numbers of participants registering their response in the *Uninviting* and *Very uninviting* range on the emotion/affect slider for the 'Barrier fence', 'Ground vegetation barrier', 'Baseline', 'Less clutter', scenarios. The 'Barrier fence' received the strongest response in the *Very uninviting* range of all scenarios. This negative response was also reiterated with strong negative written comments by participants, such as:

The ***'Barrier fence' scenario had a more negative response*** *on-average [Exp(B) .682] to a statistically significantly degree to the question 'How inviting does it feel to cross the street to visit shops on the other side?' when compared to the 'Baseline' scenario.*

Findings ranked for 'how inviting does it feel to cross the street to visit shops on the other side?':

1. **'Wombat cross' (10.40 times more likely to be positive)**
2. **'Refuge island' (4.57 times more likely to be positive)**
3. **'Sig. cross short-wait' (3.75 times more likely to be positive)**
4. **'Reduced speed' 30km/ph' (3.25 times more likely to be positive)**
5. **'Sig. cross long-wait' (2.7 times more likely to be positive)**
6. **'Cycle lane' (2.63) times more likely to be positive)**
7. **'Wider footpath' (106% more likely to be positive)**
8. **'Increased tree canopy' (52.4% more likely to be positive)**
9. **'Barrier fence' (38.2% LESS likely to be positive).**

Figure 43: Statistically significant (p<.001) findings ranked for 'how inviting does it feel to cross the street to visit shops on the other side?' [see Appendix C for detailed table].

Responses to the question 'how pleasant is it to stand in this space?'

The responses to the question 'how pleasant is it to stand in this space?, visualised as a diverging stacked bar chart (Likert plot) of responses [Figure 44], show that, of the four crossing scenarios the two non-signalised, 'Wombat' and 'Refuge island' scenarios were more often deemed as *Pleasant* or *Very pleasant* than the signalised crossings. There are two factors that are likely to have influenced this outcome. Firstly, as suggested by the comments provided by the respondents, the sounds associated with the signalised crossings may have been found to be *Unpleasant*, and secondly, as the non-signalised crossing scenarios dictate the addition of a parked car buffer and, particularly in the case of the 'Wombat crossing', reductions in vehicle speed, these non-signalised crossing scenarios represent multiple place improvement elements working in conjunction.

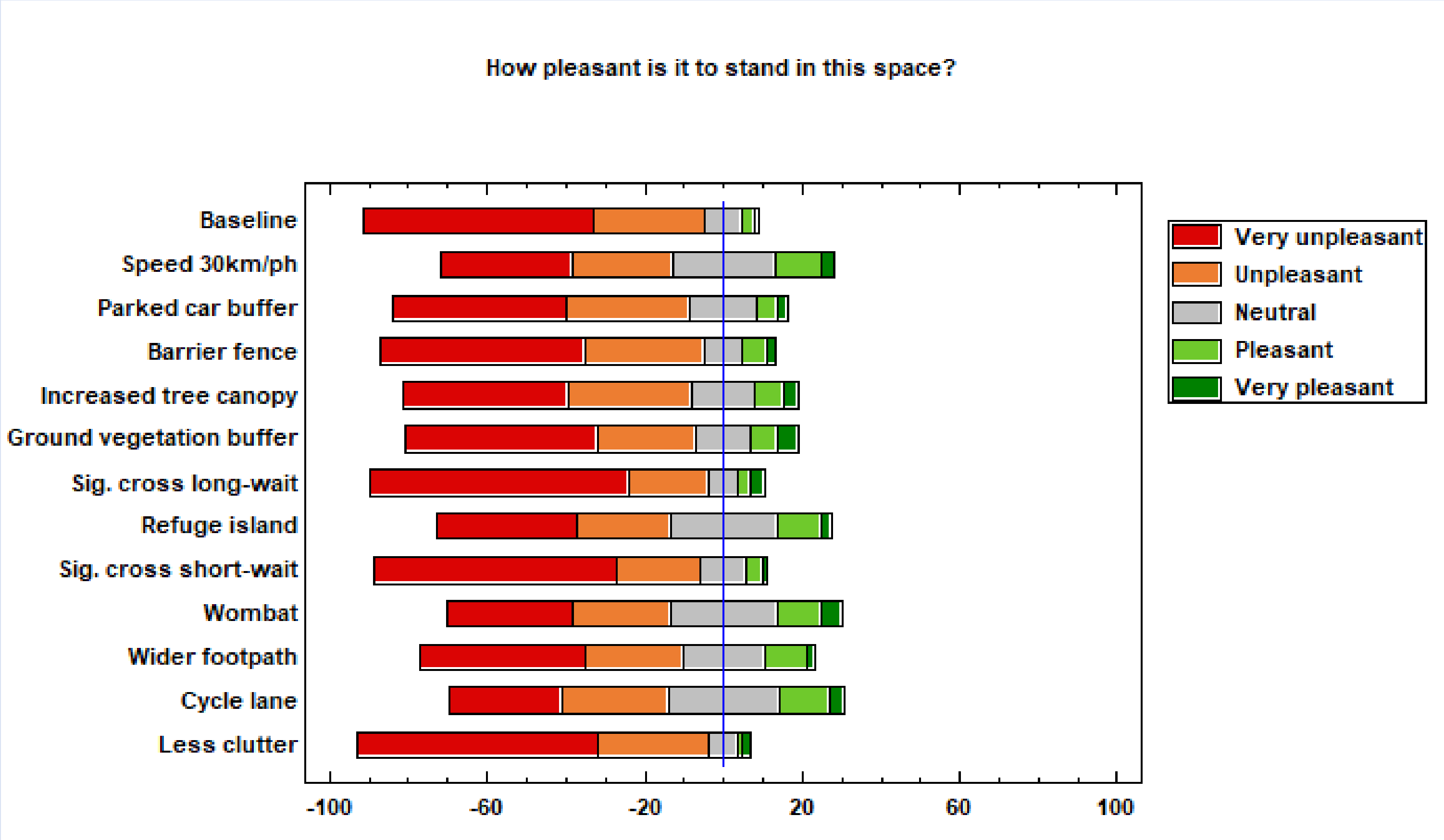

Figure 44: Diverging stacked bar chart (Likert plot) of response to the question 'how pleasant is it to stand in this space?'.

Of the scenarios without crossings, the 'Cycle lane' and 'Reduced speed' scenarios were the least likely to be deemed *as Unpleasant'* or V*ery unpleasant*. The result for the 'Cycle lane' is interesting in comparison to the 'Parked car buffer' and 'Widened footpath' scenarios that also add a **distance separation** from the traffic but received more negative responses. There are multiple potential reasons for this outcome. Firstly, the relatively high number of self-identified cyclists who undertook the survey showed a strong preference for this scenario, and secondly, on a visual level, the 'Cycle lane' provides a clear delineation of the footpath edge, while at the same time minimising the type of visual obstruction that would be associated with other buffer types such as parked cars. This positive result for the 'Cycle lane', is also interesting in comparison to the other scenarios that provide a physical barrier from the traffic but do not reduce traffic speed, volume or sound (such as the barrier fence and the ground vegetation buffer). Compared to the responses to the 'Cycle lane', these two scenarios received proportionally larger rates of *Unpleasant* and *Very unpleasant* in answer to the question, 'How pleasant is it to stand in this place?'. Responses to the scenarios 'Reduced speed 30 km/ph', 'Increased tree canopy', 'Refuge island', 'Wombat cross', 'Wider footpath', 'Cycle lane' were highly significantly different to the 'Baseline' scenario responses ($p<.001$) and responses to the scenarios 'Parked car buffer' ($p = .011$), 'Barrier fence' ($p = .040$), and 'Ground vegetation buffer' ($p = .011$) were moderately significantly different. The scenarios 'Sig. cross long-wait', 'Sig. cross short-wait' and 'Less clutter' were not significantly different from the 'Baseline' scenario.

Key findings:

Compared to the 'Baseline', responses to 6 of the 12 scenarios were substantially more positive. The '**Cycle lane'** responses were on average **3.64** times more likely (2.80, 4.72) to be positive, the '**Wombat cross'** responses were on average **3.52** times more likely (2.49, 4.99) to be positive, the '**Speed 30km/ph'** responses were on average **3.23** times more likely (2.51, 5.16) to be positive, the '**Refuge island**' responses were on average **2.94** times more likely (2.09, 4.11) to be positive, the '**Widened**

footpath' responses were on average **2.32** times more likely (1.81, 2.98) to be positive, the '**Increased tree canopy'** responses were on average **98.6%** more likely (1.57, 2.51) to be positive.

Compared to the 'Baseline', responses to 3 of the 12 scenarios were moderately more positive. '**Parked car buffer'** responses were on average **73.8%** more likely (1.14, 2.66) to be positive, the '**Ground vegetation buffer'** responses were on average **72.3%** more likely (1.13, 2.62) to be positive and the '**Barrier fence'** responses were on average **30%** more likely (1.01, 1.67) to be positive. A summary of these statistically significant findings is shown in [Figure 45].

*Responses to the 'Cycle lane', 'Wombat crossing', and 'Reduced speed 30km/hr' scenarios were all **over three times** more likely to be positive.*

Findings ranked for 'how pleasant is it to stand in this space?':

1. **'Cycle lane' (3.64 times more likely to be positive),**
2. **'Wombat cross' (3.52 times more likely to be positive)**
3. **'Reduced speed' 30km/ph (3.23 times more likely to be positive)**
4. **'Refuge island' (2.94 times more likely to be positive)**
5. **'Wider footpath' (2.32 times more likely to be positive)**
6. **'Increased tree canopy' (98.6% more likely to be positive)**
7. **'Parked car buffer' (73.8% more likely to be positive)**
8. **'Ground vegetation buffer' (72.3% more likely to be positive)**
9. **'Barrier fence' (30% more likely to be positive)**

Figure 45: Statistically significant (p<.001) findings ranked for "how pleasant is it to stand in this space?' [see Appendix C for detailed table].

Responses to the question 'how safe do you feel in this space?'

In answering the question: 'how safe do you feel in this space?', when visualised as a diverging stacked bar chart (Likert plot) of responses [Figure 46], the strong impact of speed reductions, traffic barriers and buffers the provide separation from traffic on respondent's sense of safety can be seen. Interestingly, the 'Reduced speed' scenario, received similar levels of negative and positive responses to the 'Parked car buffer', suggesting that speed and buffer elements maybe of relatively equal importance in perceptions of safety. There is little similarity between the two scenarios that attracted the most positive responses (the 'Barrier fence' and 'Wombat crossing') in relation to the variables of speed, traffic volume, sound or provision of a distance separation from traffic, however, it should be noted that any form of fencing is strongly associated with the perception of 'defensible space' and thus also gives rise to perceptions of safety (Brower et al., 1983; O. Newman, 1972).

Responses to feeling of safety for the 'Barrier fence', 'Wombat crossing', and 'Cycle lane' scenarios were around three and a half times more likely to be positive.

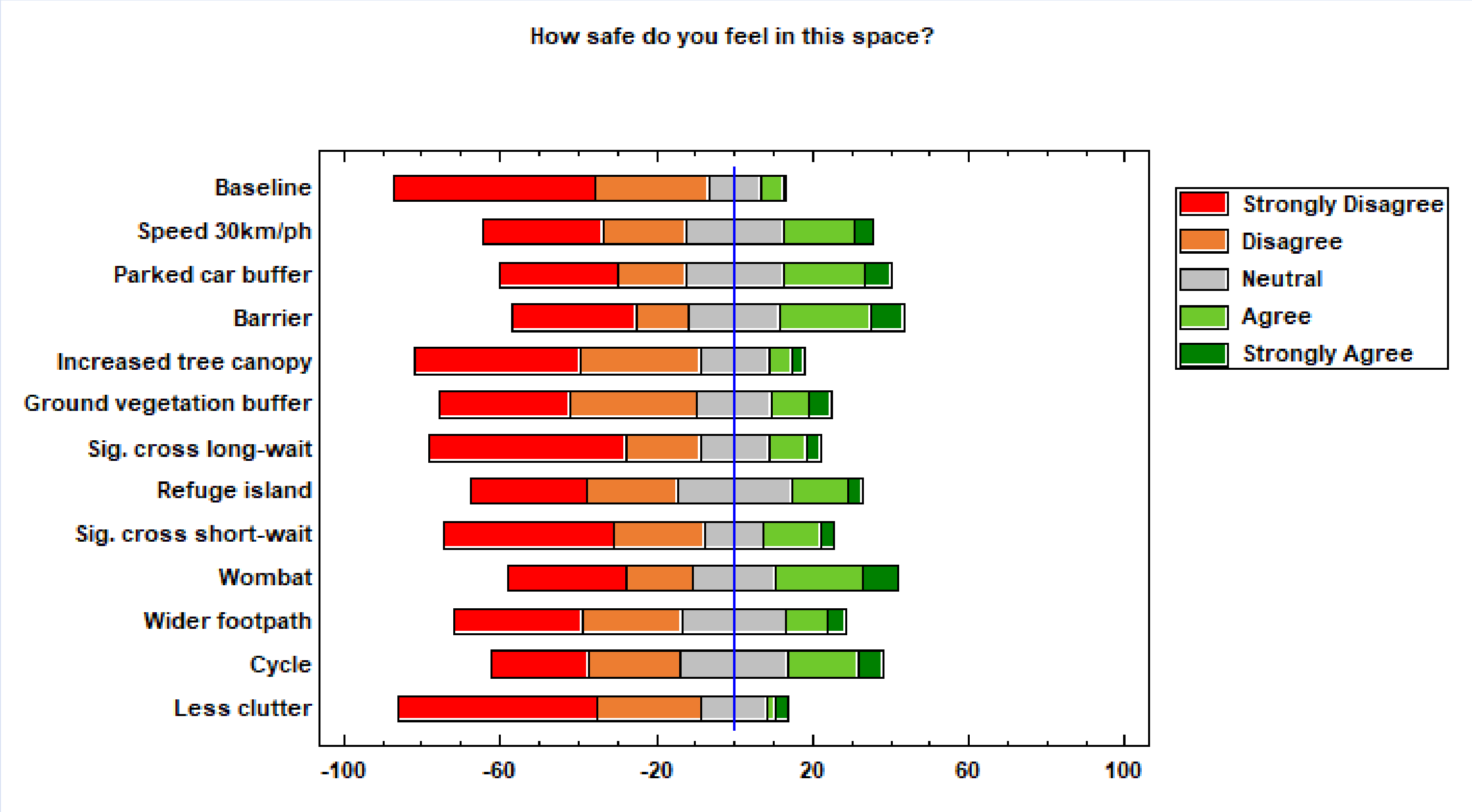

Figure 46: Diverging stacked bar chart (Likert plot) of response to the question 'how safe do you feel in this space?'.

The same model was conducted for the question 'How safe do you feel in this space' for each of the scenarios. The scenarios 'Speed 30km/ph', 'Parked car buffer', 'Barrier fence', 'Refuge island', 'Wombat crossing', 'Wider footpath' and 'Cycle lane' (p<.001 for all of these scenarios) had highly statistically significant different responses to the 'Baseline' scenario, and the scenarios 'Increased tree canopy' (p = .003) and 'Sig. cross short-wait' (p = .003) had moderately significant differences from the 'Baseline' scenario. Responses to the scenarios 'Sig cross long wait' (p = .137) and 'Less clutter' (p = .834) did not significantly differ from those of the 'Baseline' scenario [Table 14].

Key findings:

Compared to the 'Baseline', responses to 6 of the 12 scenarios were substantially more positive. The '**Barrier fence**' responses were on average **3.66** times more likely (2.85, 4.69) to be positive, the '**Wombat crossing**' responses were on average **3.58** times more likely (2.46, 5.20) to be positive, the '**Cycle lane**' responses were on average **3.41** times more likely (2.63, 4.40) to be positive, the '**Parked car buffer**' responses were on average **3.34** times more likely (2.16, 5.17) to be positive, the '**Speed 30km/ph**' responses were on average **2.86** times more likely (2.23, 3.66) to be positive, the '**Refuge island**' responses were on average **2.66** times more likely (1.88, 3.76) to be positive and the '**Wider footpath**' responses were on average **2.27** times more likely (1.77, 2.89) to be positive.

Compared to the 'Baseline', statistically significant responses to 3 of the 12 scenarios were moderately more positive. The '**Increased tree canopy**' responses were on average **39.7%** more likely (1.12, 1.74) to be positive, the '**Ground vegetation buffer**' responses were on average **103%** more likely (1.42, 2.89) to be positive and the '**Sig. cross short-wait**' responses were on average **62.1**% more likely (1.17, 2.24) to be positive. A summary of these statistically significant findings is shown in [Figure 47].

Unexpectedly, responses to feeling of safety for the 'Barrier fence' scenario [Exp.(B) 3.66], was not vastly better than 'Wombat crossing' [Exp.(B) 3.58] or 'Cycle lane' [Exp.(B) 3.41] scenarios more likely to be positive.

Findings ranked for 'how safe do you feel in this space?':

1. **'Barrier fence' (3.66 times more likely to be positive)**
2. **'Wombat crossing' (3.58 times more likely to be positive)**
3. **'Cycle lane' (3.41 times more likely to be positive)**
4. **'Parked car buffer' (3.34 times more likely to be positive)**
5. **'Reduced speed' 30km/ph (2.86 times more likely to be positive)**
6. **'Refuge island' (2.66 times more likely to be positive)**
7. **'Wider footpath' (2.27 times more likely to be positive)**
8. **'Increased tree canopy' (39.7% more likely to be positive)**
9. **'Ground vegetation buffer' (103% more likely to be positive)**
10. **'Sig. cross short-wait' (62.1% more likely to be positive)**

Figure 47: Statistically significant (p<.001) findings ranked for 'how safe do you feel in this space?' [see Appendix C for detailed table].

Summary of the four emotion slider questions

To compare results of each of the four slider questions, we have combined a simplification of the General estimating equation (GEE) ordinal logistic regression analysis including statistically significant results (Sig. ≤ 0.05) and Exp(B) response indicating the likelihood of a positive response in comparison with the 'Baseline' scenario [Table 5].

This table shows the clearly positive response to all questions for 'Wombat crossing', 'Cycle lane', and 'Reduced speed' 30km/hr scenarios. It also shows the lower ranking of the Barrier fence scenario in each question with the exception of 'how safe do you feel in this space', which as a slightly more positive response than 'Wombat crossing' and 'Cycle lane' scenarios. The 'Signalised crossing short-wait' (pedestrian priority) had more positive responses than the 'Signalised crossing long-wait scenario'.

Table 5: Summary table showing statistically significant responses (Sig. ⩽ 0.05) with respect to the 'Baseline' configuration for all four emotion-slider questions with findings from ranked from most positive to less positive with Exp(B) results included in brackets. Negative response coloured red.

	'would this be a good place to stop for coffee?'		***'how inviting does it feel to cross the street to visit shops on the other side?'***		***'how pleasant is it to stand in this space?'***		***'how safe do you feel in this space?'***
1	'Cycle lane' (3.97)	1	'Wombat cross' (10.40)	1	'Cycle lane' (3.64),	1	'Barrier fence' (3.66)
2	'Wombat crossing' (3.48)	2	'Refuge island' (4.57)	2	'Wombat cross' (3.52)	2	'Wombat crossing' (3.58)
3	'Reduced speed' (3.43)	3	'Sig. cross short-wait' (3.75)	3	'Reduced speed' (3.23)	3	'Cycle lane' (3.41)
4	'Refuge island' (3.12)	4	'Reduced speed' (3.25)	4	'Refuge island' (2.94)	4	'Parked car buffer' (3.34)
5	'Wider footpath' (2.43)	5	'Sig. cross long-wait' (2.7)	5	'Wider footpath' (2.32)	5	'Reduced speed' (2.86)
6	'Parked car buffer' (2.36)	6	'Cycle lane' (2.63)	6	'Increased tree canopy' (0.99)	6	'Refuge island' (2.66)
7	'Increased tree canopy' (0.73)	7	'Wider footpath' (0.11)	7	'Parked car buffer' (0.74)	7	'Wider footpath' (2.27)
8	'Barrier fence' (0.59)	8	'Increased tree canopy' (0.53)	8	'Ground vegetation buffer' (0.72)	8	'Increased tree canopy' (0.40)
			'Barrier fence' (-0.38.2)	9	'Barrier fence' (0.30)	9	'Ground vegetation buffer' (0.10)
						10	'Sig. cross short-wait' (0.62)

Ranking of streetscape elements (stated preference)

In this stated preference section of the survey respondents were asked to rank elements from a list, that positively or negatively influenced their sense of safety or pleasure. Respondents were not required to rank all elements in the list, only those that had the greatest impact on their perception. While there are many aligned relationships between stated and revealed preferences, there are also marked misalignments. For instance, across all scenarios in this stated preferences section, ‘trees’ were consistently the most popular choice to rank no. 01 for elements that make a street *MORE* pleasant, despite only moderately more positive results associated with the increased tree canopy scenario (compared to the ‘Baseline’) in the revealed preferences section.

The list of elements to select from, were the same for each scenario regardless of whether those elements appeared in the stimulus or not, specifically; not all scenarios contained pedestrian crossings and not all scenarios had barrier separations (B. separation) such as fencing / and or distance separation (D. separation) such as wider footpaths from adjacent traffic. It is therefore important to qualify the results of the ranking section in relation to these specific critical differences between the scenarios, as specified by the ticks in the tables below [Table 6, Table 7, Table 8 and Table 9].

Of the 13 scenarios, four included crossings and nine included separation from traffic. Of these nine scenarios that included separation from traffic, only three increased the distance separation (D. separation) between pedestrians and moving vehicles. It should also be noted that there is both crossover and a potential misunderstanding of the distinction between the two types of separation, as the ‘barrier separation’ ranking element included both distance and barrier separation aspects in a bracketed qualification: (parked cars, fences, low vegetation and increased distance).

Ranking of elements that made the street feel *MORE* pleasant

Across all scenarios, the three most popular elements to rank no. 01, for making a street *MORE* pleasant were first **trees**, then **separation from traffic** and **third presence of cyclists**

Trees were the most popular choice to be ranked no.1 for elements that make a street feel *MORE* pleasant, consistent across all scenarios.

‘I was quite surprised at how much the increased tree canopy contributed to feelings of pleasantness’.

‘Tree lined streets are very inviting, more trees should be planted. Deciduous trees will provide cooling in summer while letting the sun in during winter’.

Separation from traffic (through parked car buffers, fences, ground vegetation, wider footpaths and cycle lanes), was the second most popular choice to be ranked no.1 for elements that make a street feel *MORE* pleasant. Responses to two of the three scenarios that increased the **distance separation** between pedestrians and moving traffic (‘Wider footpath’ and ‘Cycle lane’), distance separation was in the top three most popular elements to rank no.01 for making those scenarios *MORE* pleasant.

Presence of cyclists was the third most popular choice to be ranked no.1 for elements that make a street feel *MORE* pleasant.

In the four crossings scenarios, crossings were either the second or third most popular choice of element that make a street feel *MORE* pleasant.

*Note: ‘Barrier separation’, was the only element that was found in the three most popular choices to rank no. 01 to make the street feel *MORE* pleasant as well as the top three most popular choices to make the street feel *LESS* pleasant [see ‘Barrier fence’ scenario Table 6 and Table 8].

Table 6: The three most popular elements to rank no.01 that made the street feel MORE pleasant with percentage of respondents who make that selection, shown in relation to specific critical differences between the scenarios in relation to inclusion of crossings, separation from traffic and distance separation from traffic.

Scenario	Crossing	Separation from traffic	Distance separation from traffic	Most popular element to rank no 01	2nd most popular element to rank no 01	3rd most popular element to rank no 01
Baseline				Trees (60%)	Cyclists (16%)	B. separation (9.4%)
Reduced speed 30kms/ph				Trees (41%)	Speed (21%)	Cyclists (13%)
Parked car buffer		✓	✓	Trees (48%)	B. separation (26%)	mixed
Barrier fence		✓		Trees (50%)	**B. separation (21%)***	Cyclists (12%)
Increased tree canopy				Trees (72%)	Cyclists (13%)	Less clutter (5%)
Ground vegetation		✓		Trees (42%)	B. separation (27%)	Cyclists (16%)
Signal crossing long-wait	✓			Trees (40%)	Crossing (22%)	Cyclists (18%)
Refuge island	✓	✓		Trees (38%)	B. separation (18%)	Crossing (13%)
Signal crossing short-wait	✓			Trees (40%)	Crossing (26%)	Cyclists (18%)
Wombat crossing	✓	✓		Trees (32%)	Crossing (24%)	B. separation (17%)
Wider footpath		✓	✓	Trees (47%)	D. separation (19%)	Cyclists (15%)
Cycle lane		✓	✓	Trees (33%)	Cyclists (30%)	D. separation (18%)
Less clutter				Trees (57%)	Cyclists (16%)	B. separation (10%)

Ranking of elements that made the street feel *MORE* safe

Likewise, across all scenarios, the same three elements were the most popular choices to rank no 01 for making a street feel *MORE* safe however the distribution element selection was different.

Trees and **barrier separation** (B. separation) were equally the most popular choice to be ranked no.1 for elements that make a street feel *MORE* safe. However, in three of the four crossing scenarios, the presence of crossings was the most popular choice and in the fourth crossing scenario (‘Refuge island’), the presence of crossings was the second most popular choice.

Presence of cyclists was the third most popular choice to be ranked no.01 for elements that make a street feel *MORE* safe.

**Note: Distance separation, was the only element that was found in the three most popular choices to rank no. 01 to make the street feel both *MORE* safe as well as the top three most popular choices to make the street feel *LESS* safe (in scenario ‘Wider footpath’). For some respondents, the additional footpath width clearly increased their perceived safety, but the lack of vertical or edge delineation between the footpath and adjacent traffic in this scenario also resulted in a lack of perceived safety for others (compared to the ‘Baseline’).

Table 7: The three most popular elements to rank no.01 that made the street feel MORE safe with percentage of respondents who make that selection, shown in relation to specific critical differences between the scenarios in relation to inclusion of crossings, separation from traffic and distance separation from traffic.

Scenario	Crossing	Separation from traffic	Distance separation from traffic	Most popular element to rank no 01	2nd most popular element to rank no 01	3rd most popular element to rank no 01
Baseline				Trees (50%)	Cyclists (12%)	B. separation (11%)
Reduced speed 30kms/ph				Speed (33%)	Trees (26%)	B. separation (9%)
Parked car buffer		✓	✓	B. separation (45%)	Trees (28%)	D. separation (13%)
Barrier fence		✓		B. separation (60%)	Trees (16%)	Cyclists (11%)
Increased tree canopy				Trees (56%)	Cyclists (16%)	Separation (8.4%)
Ground vegetation		✓		B. separation (32%)	Trees (29.4%)	Cyclists (14%)
Signalised cross. long-wait	✓			Crossing (43%)	Trees (27%)	Cyclists (12.5%)
Refuge island	✓	✓		B. separation (34%)	Crossing (19%)	Trees (13%)
Signalised cross. short-wait	✓			Crossing (49%)	Trees (19%)	Cyclists (10%)
Wombat crossing	✓	✓		Crossing (34%)	B. separation (21%)	Trees (12%)
Widened footpath		✓	✓	Trees (31%)	**D. separation (29%)****	Cyclists (13%)
Cycle lane		✓	✓	Cyclists (31%)	Trees (21%)	D. separation (21%)
Less clutter				Trees (39%)	Cyclists (17%)	B. separation (14%)

Ranking of elements that made the street feel *LESS* pleasant

Across all scenarios, the three most popular elements to rank no. 01, for making a street *LESS* pleasant were first **noise, followed by speed**, and thirdly (lack of) **distance separation from traffic**, (D. separation). Street clutter was also a popular choice to rank no.01, however, as this element has uncertain meaning, and the word itself may simply have had 'unpleasant' connotations for respondents, not necessarily connected to the scenario stimuli, we feel this result is confounded [marked in blue in Table 8].

Noise was the most popular choice of element to rank no.1 that makes a street feel *LESS* pleasant (10 out of 13 scenarios).

Speed was the second most popular choice of element to rank no.1 that makes a street feel *LESS* pleasant.

Lack of distance separation (D. separation) was the third most popular choice of element to rank no.1 that make a street feel *LESS* pleasant (notwithstanding the confounding result of 'street clutter')**.**

There was no obvious difference in the responses to the crossing scenarios for most popular elements to rank no. 01 across all scenarios, to make the street *LESS* pleasant.

*Barrier separation (fence) was chosen as one of the top elements that make the street **MORE pleasant** AND **LESS pleasant***

Table 8: The three most popular elements to rank no.01 that made the street feel LESS pleasant with percentage of respondents who make that selection, shown in relation to specific critical differences between the scenarios in relation to inclusion of crossings, separation from traffic and distance separation from traffic.

Scenario	Crossing	Separation from traffic	Distance separation from traffic	Most popular element to rank no 01	2nd most popular element to rank no 01	3rd most popular element to rank no 01
Baseline				Speed (29%)	Noise (28%)	D. separation (23%) (lack of)
Reduced speed 30kms/ph				D. separation (39%) (lack of)	Noise (19%)	Clutter (12%)
Parked car buffer		✓	✓	Noise (42%)	Speed (27%)	Clutter (11%)
Barrier fence		✓		Noise (28%)	Speed (24%)	**B. separation (15%) (type of)***
Increased tree canopy				Speed (33%)	Noise (23%)	D. separation (19%) (lack of)
Ground vegetation		✓		Speed (31%)	Noise (25%)	Clutter (16%)
Signalised cross. Long-wait	✓			Noise (35%)	Speed (27%)	D. separation (14%) (lack of)
Refuge island	✓	✓		Noise (42%)	Speed (21%)	Clutter (12%)
Signalised cross. Short-wait	✓			Noise (30%)	Speed (26%)	D. separation (17%) (lack of)
Wombat crossing	✓	✓		Noise (46%)	Speed (17%)	Clutter (12%)
Widened footpath		✓	✓	Noise (39%)	Speed (28%)	Clutter (10%)
Cycle lane		✓	✓	Noise (40%)	Speed (31%)	Clutter (12%)
Less clutter				Speed (37%)	Noise (29%)	D. separation (27%) (lack of)

Ranking of elements that made the street feel *LESS* safe

Across all scenarios, the three most popular elements to rank no. 01, for making a street *LESS* safe were **speed, noise** and (lack of) **distance separation from traffic (D. separation).** The popularity of speed as the most popular choice to rank no.01 to make the street *LESS* safe took over from noise as the most popular choice to make a street feel *LESS* pleasant**.** In scenarios that did not contain crossings, this lack of crossings was also a popular selection, for elements that made the street feel *LESS* safe.

Speed was the most popular choice of element to rank no.1 that makes a street feel *LESS* safe.

Noise was the second most popular choice of element to rank no.1 that make a street feel *LESS* safe.

*'The proximity to the traffic, the **speed of the traffic** and the noise of the traffic made me feel most unsafe'.*

'All the traffic elements combined (distance from/footpath width, noise and speed) were the main things that made the space unpleasant for me'.

Lack of distance separation (D. separation) was the third most popular choice of element to rank no.1 that make a street feel *LESS* safe. This was a popular choice even in scenarios that provided separation through physical barriers (such as the **barrier fence)** and distance buffers (such as the **wider footpath** scenario).

Lack of crossings was the fourth most popular choice of element, in the top three choices to rank no. 01 in three of the nine scenarios that lack a crossing.

Table 9: The three most popular elements to rank no.01 that made the street feel LESS safe with percentage of respondents who make that selection, shown in relation to specific critical differences between the scenarios in relation to inclusion of crossings, separation from traffic and distance separation from traffic.

Scenario	Crossing	Separation from traffic	Distance separation from traffic	Most popular element to rank no 01	2nd most popular element to rank no 01	3rd most popular element to rank no 01
Baseline				Speed (32%)	D. separation (25%) (lack of)	Noise (18%)
Reduced speed 30kms_ph				D. separation (41%) (lack of)	Noise (14%)	Crossing (13%) (lack of)
Parked car buffer		✓	✓	Speed (44%)	Noise (18%)	mixed
Barrier fence		✓		Speed (36%)	Noise (18%)	D. separation* (15%) (lack of)
Increased tree canopy				Speed (35%)	Noise (27%)	D. separation (10%) (lack of)
Ground vegetation		✓		Speed (39%)	Noise (19%)	Crossing (15%) (lack of)
Signal crossing long wait	✓			Speed (32%)	D. separation (24%) (lack of)	Noise (23%)
Refuge island	✓	✓		Speed (39%)	Noise (26%)	Crossing (11%) (lack of)
Signal crossing short wait	✓			Speed (31%)	D. separation (24%) (lack of)	Noise (21%)
Wombat crossing	✓	✓		Noise (42%)	Speed (16%)	Clutter (16%)
Wider footpath		✓	✓	Speed (35%)	Noise (27%)	**D. separation (10%) (lack of)****
Cycle lane		✓	✓	Speed (39%)	Noise (28%)	Crossing (10%) (lack of)
Less clutter				Speed (36%)	Noise (25%)	D. separation (18%) (lack of)

'Affect grid' responses to the question 'how do you feel in this space?'

The following section summarises the participant's responses registered on the *affect grid*, when participants were asked to register their emotional response when asked '*how do you feel in this space? Please click on the orange segment that represents how you feel about the streetscape*'.

Participants used their mouse, or finger to register a point upon the *affect grid*, which indicated their emotional response to each streetscape scenario. Depending on the location of the point registered, we captured the response and categorised the point as falling into either the top half – ***activation***, the bottom half – ***deactivation***, the left-hand side – ***displeasure***, and the right-hand side – ***pleasure***. We also categorised the response data based on the overlapping halves as quadrants (***activation-displeasure, activation-pleasure, deactivation-displeasure*** and ***deactivation-pleasure***). In addition, we analysed the more nuanced feelings, and levels of intensity based on the registered response point location where responses marked further away from the neutral centre (darker orange colour), the higher the level of emotion [see Figure 48 to Figure 57].

Across all scenarios we found 70% of emotional responses were in the ***displeasure*** zone. 50% of these were in ***activation-displeasure***, 20% were in ***deactivated-displeasure***. Of the 30% of responses in the ***pleasure*** zone, 21% were ***deactivated-pleasure*** and 9% were in the ***activation-pleasure*** zone. No statistically significant responses to scenarios reduced or increased specific pleasure emotions. It is likely that scenarios that reduced displeasure emotions account for increases in pleasure emotions.

*Cycle lanes reduced the level of ‘Tense’ feeling responses by **81%***

Tense (activation–displeasure)

‘Tense’ was the most common emotional response, selected 29.63%. In comparison to the ‘Baseline’, respondents felt significantly less ‘Tense in the ‘Cycle lane’, ‘Reduced speed’ and ‘Ground vegetation buffer’ scenarios, with responses to ‘Cycle lane’ [Exp(B) .186] (reduced the selection of ‘Tense’ by 81%), ‘Reduced speed’ [Exp(B) .288] (reduced selection of ‘Tense’ by 71%), and ‘Ground vegetation buffer’ [Exp(B) .302] (reduced selection of ‘Tense’ by 69%).

*‘Vehicle noise and the **speed** at which motor vehicles were travelling past made the streetscape most unpleasant and irritating. The loudest and fastest "streetscapes" are similar to standing on the side of Parramatta Rd, which is enough to raise your blood pressure’.*

*‘**Slower** traffic made me feel much safer and calmer’.*

*‘The **slower the traffic** was moving, the less noise there generally was (except some trucks/buses and hoons). This provides a generally more relaxed vibe’.*

Upset (displeasure–activation)

‘Upset’ was the second most common emotional response, selected 19.83%. In comparison to the ‘Baseline’ respondents felt significantly less ‘Upset’ in the ‘Barrier fence’ and ‘Reduced speed’ scenarios, with responses to ‘Barrier fence’ [Exp(B) .179] (reduced selection of ‘Upset’ by 82%), and ‘Reduced speed’ [Exp(B) .383] (reduced selection of ‘Upset’ by 61%).

Sad (displeasure–deactivation)

‘Sad’ was selected in 11% of the responses. In comparison to the ‘Baseline’, respondents felt significantly less ‘Sad in the ‘Cycle lane’ and ‘Reduced speed’ scenarios, with responses to ‘Reduced speed’ [Exp(B) .158] (reduced selection of ‘Sad’ by 84%), and ‘Cycle lane’ [Exp(B) .233] (reduced selection of ‘Sad’ by 76.7%).

Tired (deactivation–displeasure)

‘Tired’ was selected in 8.3% of the responses. In comparison to the ‘Baseline’, respondents felt significantly less tired in the ‘Wombat crossing’, ‘Signalised crossing long-wait’, the ‘Barrier fence’, ‘Parked car buffer’ and ‘Reduced speed’ scenarios with responses to ‘long wait signalised crossing’ [Exp(B) .100] (reduced selection of ‘Tired’ by 90%), ‘Barrier fence’ [Exp(B) .108] (reduced selection of ‘Tired’ by 89.2%), ‘Parked car buffer’ [Exp(B) .135] (reduced selection of ‘Tired’ by 86.5%), ‘Wombat crossing’ [Exp(B) .182] (reduced selection of ‘Tired’ by 81%), and ‘Reduced speed’ [Exp(B) .190] (reduced selection of ‘Tired’ by 81%).

The nuanced emotional responses point registration can be seen in the response heatmaps [Figure 48 to Figure 57], though it should be noted that due to the different number of responses to each scenario not being consistent, not all scenarios are directly comparable, as unlike other results discussed above, we have not factored/adjusted based the number of responses for each scenario (ie. heatmaps generated based on over scenarios with 300 responses should not be compared with heatmaps generated based on scenarios with just over 100 responses).

Affect grid response heat maps (with 300-320 responses)

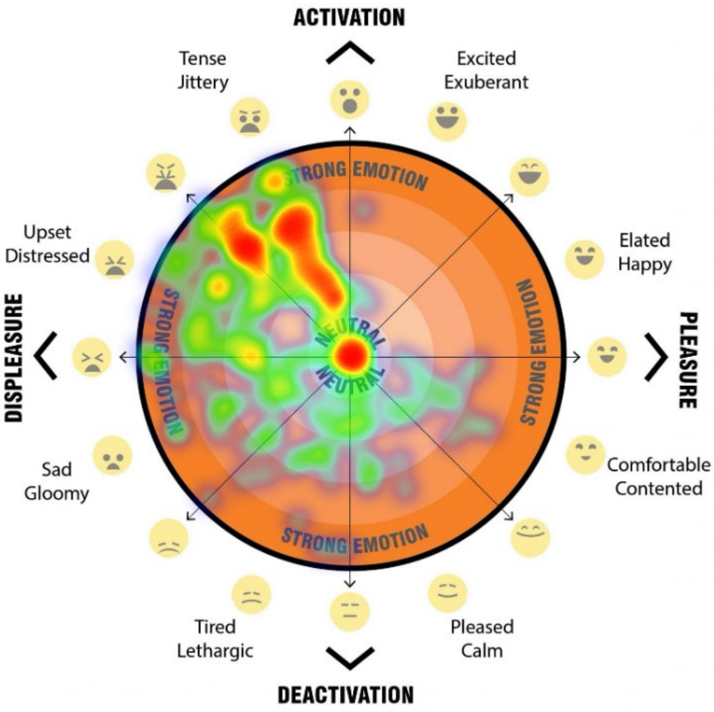

*Figure 48: Heatmap visualises the '**Baseline'** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [300 responses]*

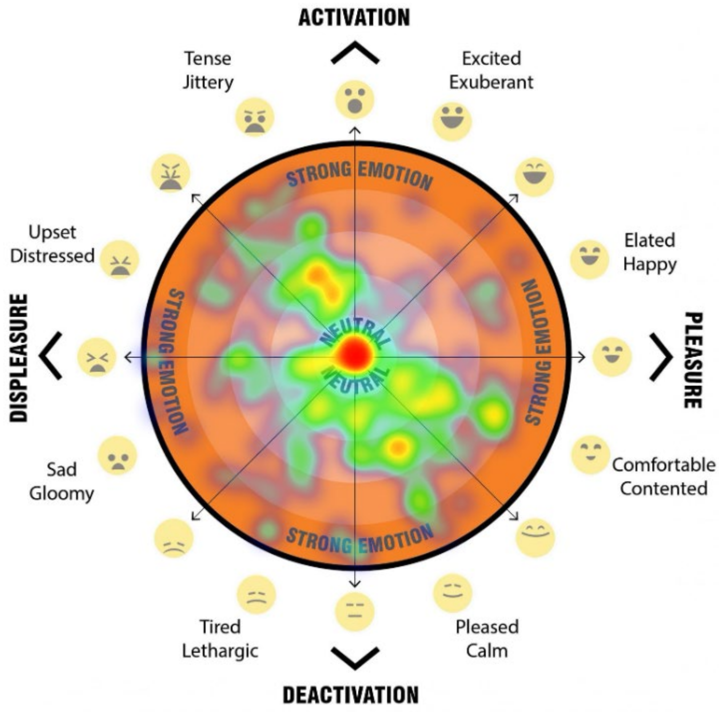

*Figure 49: Heatmap visualises the **Reduced speed (30km/ph)** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [309 responses]*

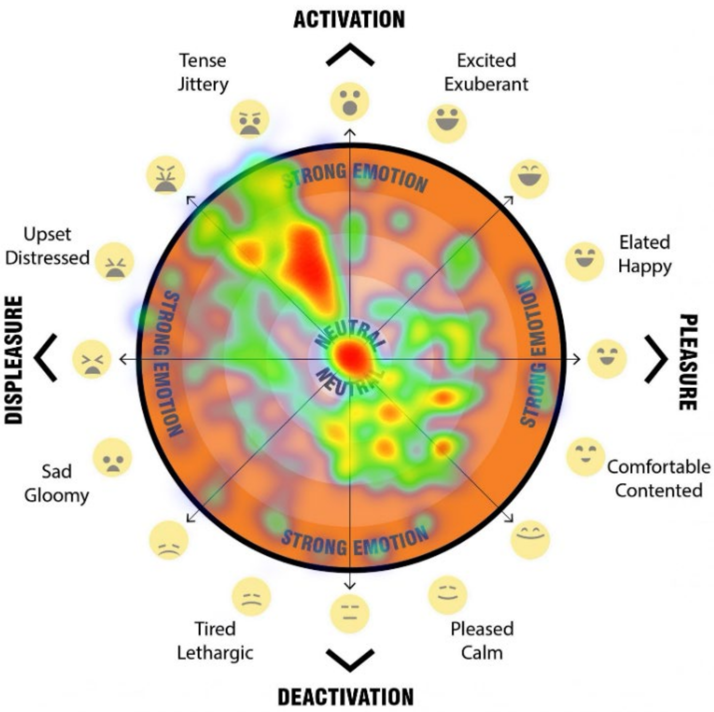

*Figure 50: Heatmap visualises the **Increased tree canopy** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [318 responses]*

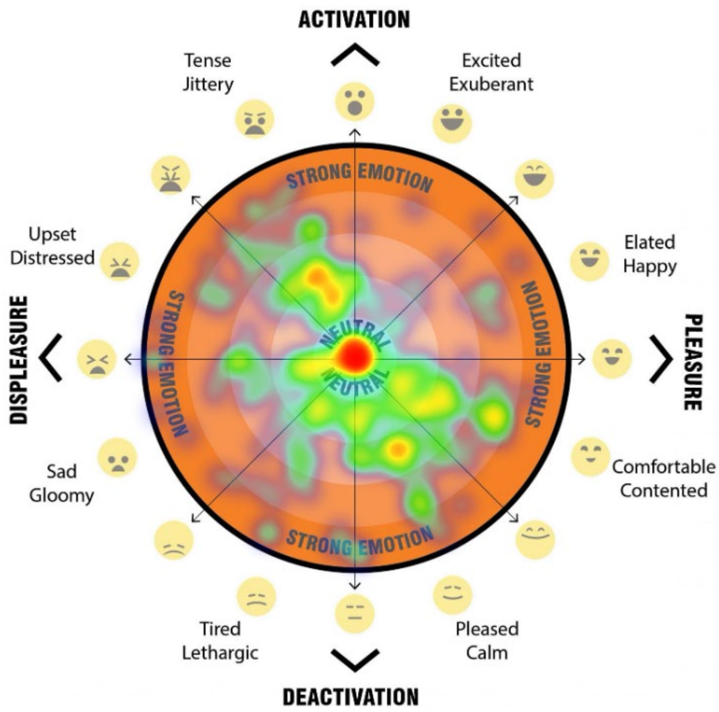

*Figure 51: Heatmap visualises the **Barrier fence** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [312 responses]*

Affect grid response heat maps (with 149-160 responses)

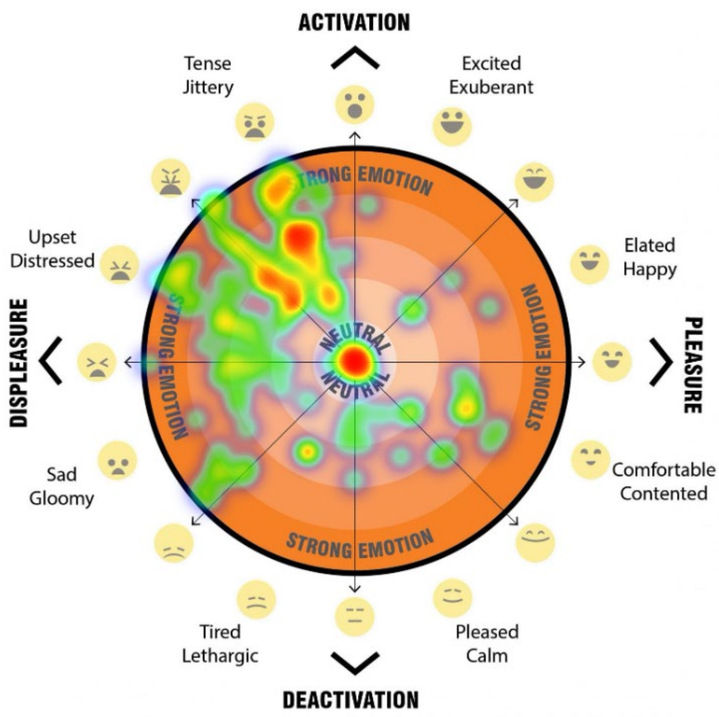

*Figure 52: Heatmap visualises the **Signalised crossing long-wait** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [155 responses]*

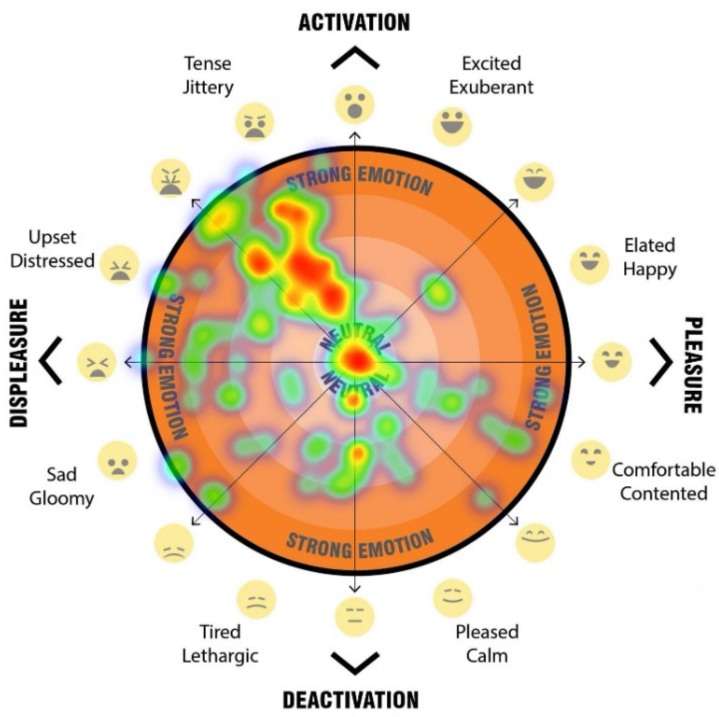

*Figure 53: Heatmap visualises the **Signalised crossing short-wait** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [160 responses]*

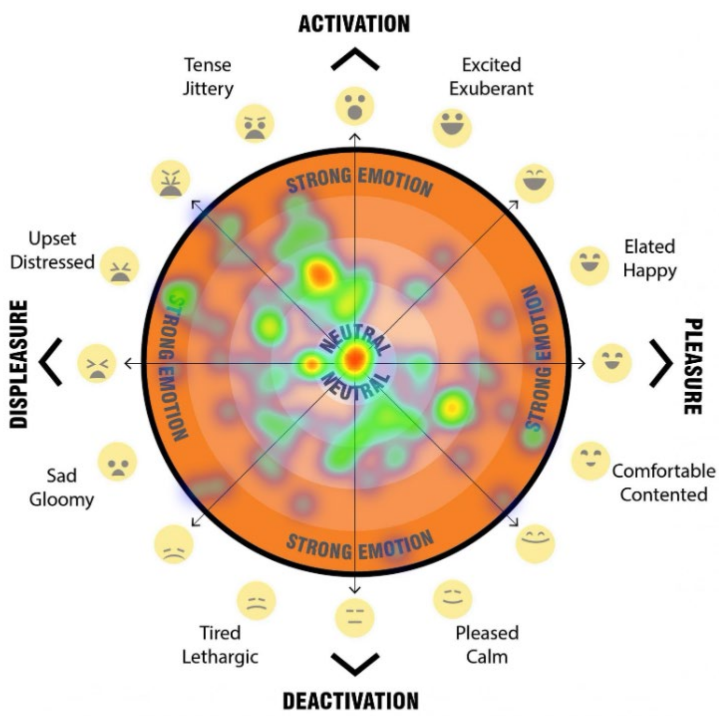

*Figure 54: Heatmap visualises the **Refuge island** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [149 responses]*

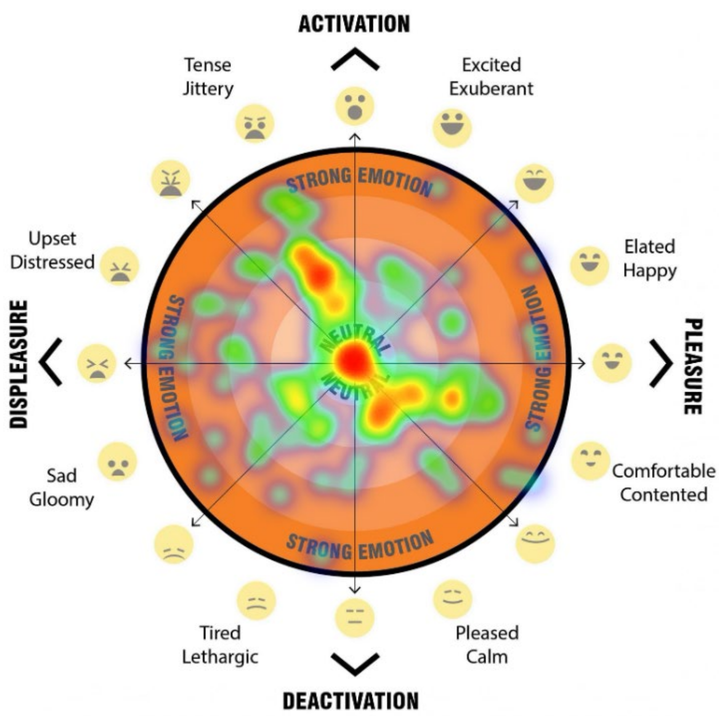

*Figure 55: Heatmap visualises the **Wombat cross** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [155 responses]*

Affect grid response heat maps (with 95-120 responses)

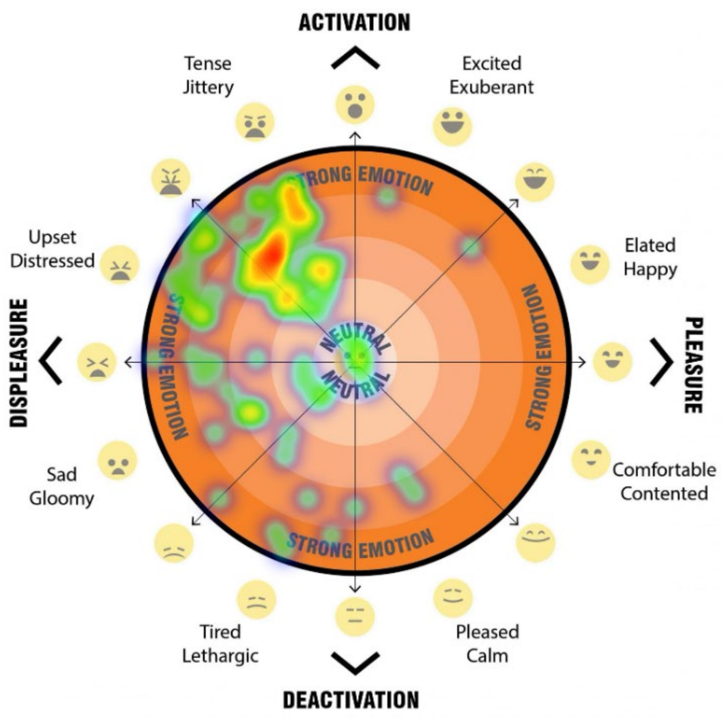

*Figure 56: Heatmap visualises the **Less clutter** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [111 responses].*

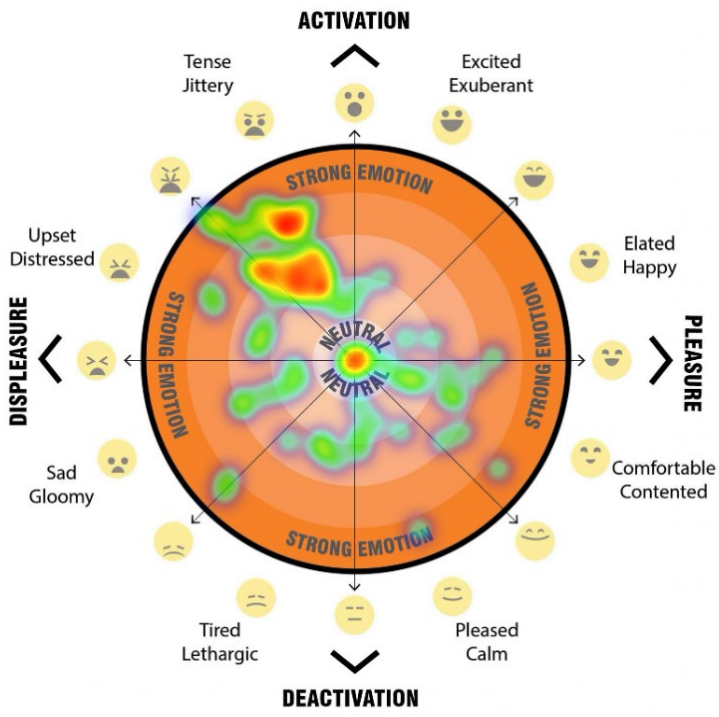

*Figure 57: Heatmap visualises the **Ground vegetation buffer** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [105 responses]*

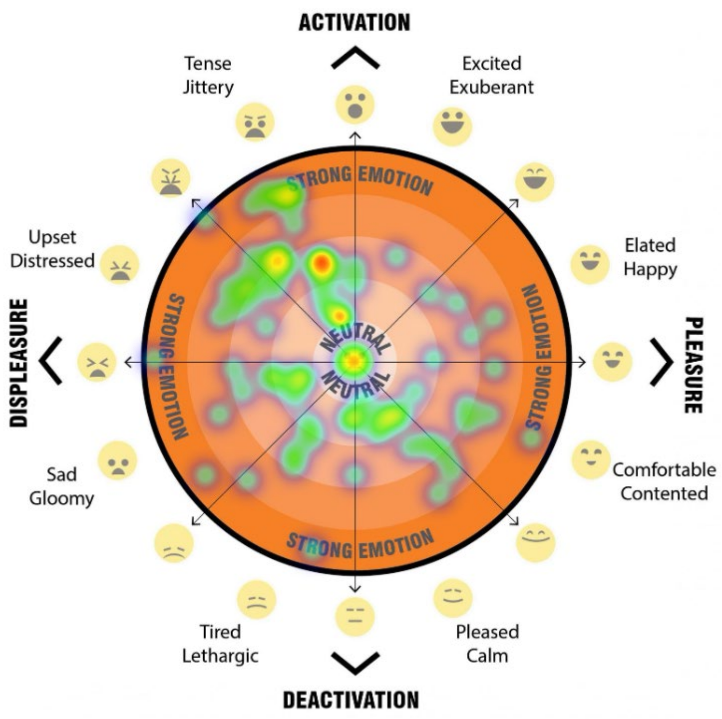

*Figure 58: Heatmap visualises the '**Parked car buffer'** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [95 responses]*

Affect grid response heat maps (with 220-230 responses)

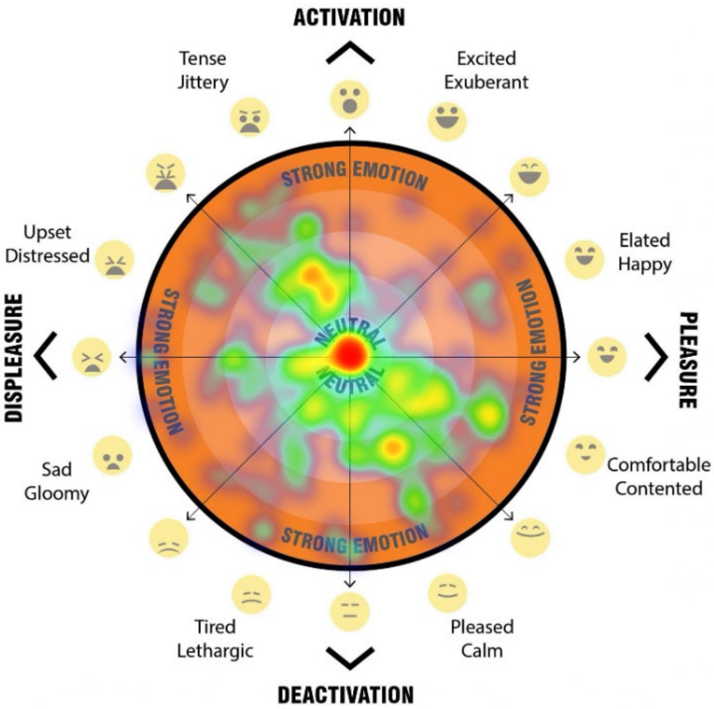

*Figure 59: Heatmap visualises the **Wider footpath** scenario responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [229 responses]*

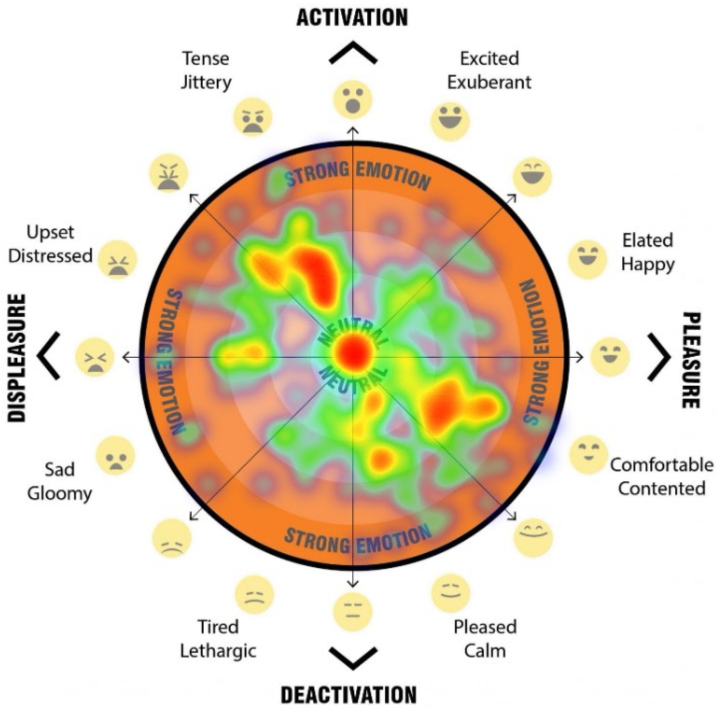

*Figure 60: Heatmap visualises the **Cycle lane scenario** responses of the affect grid for participants to register their emotional response when asked "how do you feel in this space? [229 responses]*

The impact of COVID-19 on participant responses

Only 12% of participants responded said 'yes' to the question 'Do you believe COVID-19 and social distancing impacted upon your responses to the virtual environment scenarios?'. Of those responding in the affirmative, most commented that the footpath did not feel wide enough or have 'enough space' to socially distance adequately, and that the proximity to people passing by made them feel less comfortable [Figure 61].

Figure 61:Word cloud representation of written responses to the question: 'How did COVID-19 and social distancing impact upon your responses to the virtual environment scenarios?'.

Level of presence

As discussed in earlier sections, this study was altered to accommodate challenges presented due to the COVID-19 pandemic. The *level of immersion* questions were originally written for the study when it was intended to be conducted using full virtual reality (VR) in a controlled environment using head mounted display (HMD). Due to impacts COVID-19 including the need for social distancing and lockdowns, as well as heightened risk of sharing devices that touch multiple people's faces, we pivoted to an online survey conducted remotely using participant's devices. Though we did not expect high levels of presence, we did keep questions including 'I had a sense of "being there" in the streetscapes': [Very much so/Not at all]; 'There were times during the experience when the streetscapes were the reality for me': [Almost all the time/At no time]; 'During the experience I often thought that I was really standing in the street': [Very much so / Not very often]; and 'The auditory (sound) aspects of the experience made the streets seem more real': [Very much so/Not at all]. The results of these questions were considerably more positive than anticipated [Figure 62].

While further research would be required to quantifiably compare our *360-video laptop/desktop and smart device* approach when with *still image* based, or *full VR with HMD* methods, the results suggest our approach is an effective in method in eliciting emotional responses about environments.

We also found no statistically significant differences between the responses from those who completed the survey on their laptop, desktop, or smart phone. We people using headphones were found to be slightly more negative, though not to a statistically significant level.

Responses to the question on the auditory (sound) aspects of the experience making the streets seem more real, the results suggested a strong negative response [Figure 62]. This result was unexpected, given anecdotal feedback during preliminary testing of the 360-degree video scenarios with stakeholders and colleagues, which suggested the audio enhanced the level of presence greatly, particularly when headphones were worn. We speculate that this may be because of the wording of the question being unclear, or that the participant's emotions about the sound of vehicles may have negatively impacted their response to the 'auditory' question. In some of the written comments, it appears that *realism* may have been confused with *pleasantness* of the sound.

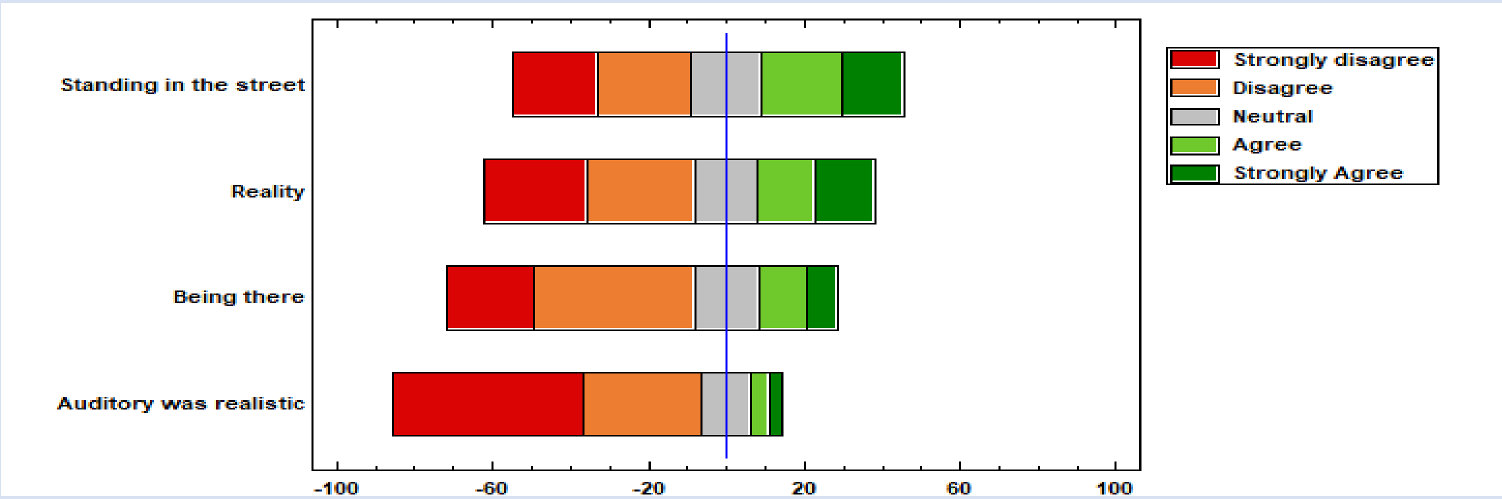

Figure 62: Likert plot of response to 'how safe do you feel in this space?' question.

Part 4: Discussion

In this part of the report we will summarise the findings with respect to the key research questions, limitations of the study, Key research insights including discuss methodological insights and for retail traders, make key recommendations for practitioners, and suggest further research.

Summary of findings with respect to the key research questions

This study set out to address four key research questions:

Can immersive virtual environments be used to assess the impact of pedestrian-oriented urban design elements and safe system treatments on pedestrians' perceptions of safety and place?

The answer to this first question is that, yes, it is clearly possible to illicit citizen response to streetscapes using immersive virtual environments. The study has provided a wealth of data that allows for the detailed interrogation of citizen perceptions of a variety of streetscape treatments with statistically significant results.

How do safety treatments enhance or dimmish pedestrians' perception of safety and place?

The answer to this second question is not as straight forward. Some safety treatments were very clear-cut such as the reduction of speed from 50km/hr down to 30km/hr. There was an overwhelmingly positive response to this scenario in every aspect, from improving the likelihood of stopping for coffee, how inviting it was to cross the street to visit retail, how pleasant it was to stand in the place, to how safe participants felt. The 'reduced speed also had a very positive impact on people's levels of emotional state. Respondents were *less 'Tense'*, *less 'Sad'* and *less 'Upset'* to a statistically significant degree.

The responses to 'Barrier fences' as a safety treatment were less clear cut. While they were associated with strong positive perceptions of streetscape safety and place they were also associated with strong negative perceptions of place particularly in relation to the ease of making road crossings. This is an interesting outcome in light of the strong positive perceptions of both safety and place that were associated with all four crossing scenarios. Clearly, being able to make crossings safely and easily is important to people but equally so is a sense of separation from the flow of adjacent traffic.

The methods of separation from traffic had a particularly divisive impact on the range of emotional responses and perceptions of safety, from the very positive to the very negative. This was particularly evident in responses to the barrier separations ('Ground vegetation buffer', 'Barrier fence' and 'Increased tree canopy cover', regardless of the level of continuity of these treatments but also true for the distance separation method 'Widened footpath'. Thus, perceptions of individual safety afforded by different distance separation methods maybe unique to individuals and potentially based on prior experience or intrinsic long held attitudes.

Is it possible to rank or prioritise pedestrian-oriented urban design elements and safe system treatments based on pedestrians' perceptions of safety and place?

The answer to this third question is – yes. It is clearly possible to use our approach to rank and help prioritise different streetscape place and safety approaches based on citizen's perceptions of safety and place. The rankings or prioritisations based on perceptions such as perceived safety would need to be considered alongside estimated actual safety. The rankings would also need to be considered alongside other practical factors that impact decision making processes such as cost, and potential impacts on traffic flows.

Do street trees and other forms of street landscaping improve pedestrians' perception of safety and place?

The answer to this final question, with an overwhelming positive response is – yes. Like the reduction of speed, the response to street trees was positive in every aspect of the study. In the stated preference ranking questions, Trees were the most popular choice to be ranked no.1 for elements that make a street feel *MORE* pleasant, consistent across *all* scenarios.

Trees increased desirability for stopping for coffee, how pleasant it was to stand in the place, how safe they felt, and even how inviting it was to cross the street to visit retail. While the street trees performed outstandingly, ground level 'Vegetation buffer' received positive responses, but did not stand out to quite the same extent as street trees. The 'Vegetation buffer' scenario responses were less conclusive as the scenario was limited in the number of responses (considerably less than the 'Increased canopy', 'Baseline', 'Barrier fence', and 'Reduced speed' scenarios), which may explain the lack of statistically significant results. The 'Vegetation buffer' was a narrow strip that was at the expense of footpath width (the overall kerb location remained the same). It would be interesting to revisit the 'Ground vegetation buffer' if it was combined with other treatments such as footpath widening.

Limitations

Online-only study

As discussed earlier, due to the impact of COVID-19, this study was modified from an in-person virtual reality study with head mounted display, to an online-only study using participant's own devices and headphones. While this delayed the project and required a significant reworking of the study, the number of participants was substantially more than anticipated, allowing for a greater number of statistically significant findings. It did however introduce limitations in terms of environmental and audio consistency across the study. As each participant was doing the survey online, we could not control the environment where the survey was conducted. They may have been in agitating environments for example, which may skew their responses. In addition, we were unable to control or measure the settings of the volume or quality of the audio they experienced. Though we found no statistically significant difference in response from those using headphones to those without headphones, the difference between doing the survey with the volume turned down very low on a laptop and turned up full on high-quality headphones could be considerable.

Another limitation was that the researchers were not able to see participants as they were using the immersive virtual environment, trouble shoot if the participant was having any problems, or clarify any questions. We were also not able to ask questions directly or follow up with more open-ended questions based on what we saw as responses, for example, 'you have marked down the extremely unpleasant, can you tell us what particular aspect of the street made it that unpleasant?'.

Though the level of presence questions suggested that the immersion in the environments was quite good, we expect that full virtual reality would be much more immersive. Due to the limitation of using 360-video which is limited to 3 degrees of freedom (DoF), allowing a participant to pivot their point of view around a fixed point, a full VR setup with head mounted display would have allowed 6 DoF allowing participants to move around (tilt their head, move up and down etc). The impact of this potentially quite different of immersion is worthy of further study (in a post-COVID environment).

Community representation

This study was aimed at engagement with the population as a whole, and not specifically aimed at gauging different attitudes between age groups. For more detailed analysis on different perceptions of safety and place for different age-groups, ideally, we would have more people do it from each different age groups, particularly participants younger than 16 years old who were omitted from the study (due to complexities in obtaining parental consent), and more responses from the population of older adults, people aged 75 and above). In a post-COVID environment, we hope to continue this study with an in-person option to allow for these under-represented age groups to participate fully.

Due to the rapid 'pivot' to an entirely online survey, there survey format may have not been suitable or fully accessible, for example, did not cater specifically for people with a visual impairment who may have found the survey visual content and response methods difficult to complete. In future expansion of this study, this is an issue we would like to address through further investigations of multi-sensory stimuli such as sound.

The survey recruitment was not entirely random. Like most studies of this kind, people have self-selected to agree to fill in the survey, and though it appears that we have managed to elicit good representation across genders, cultural backgrounds, occupations and ages, participants were all within sectors that were either interested in streetscape design, interested in immersive virtual environments, interested in winning the VR HMD prize or were willing to commit 20-30 minutes to the study.

There is also a good representation of people who use different transport modes – with 44% of people identifying as people who use cycling as a 'form of transport'. Data from both the City of Sydney and City of Melbourne suggest that cycling as a mode of commuting (daily travel to and from work) is relatively low two cities (under 10%). Cycling as a 'form of transport' and 'for commuting' are clearly not the same, and we would expect to see this higher number of people using cycling as one component of their more general 'forms of transport' options, but these results were interesting and warrant further research.

Complexity of discrete variable changes for different scenarios

Streetscapes are highly complex, adaptive systems with hundreds of interwoven variables. While we have attempted to simplify and limit our scenario variations to changing 'single variables' where possible, it was not possible to isolate a single variable for each scenario. While some scenarios were relatively simple, for example the 'Barrier fence' scenario, which was identical in every way to the 'Baseline' except for the inclusion of the barrier fence, changing variables for other streetscapes scenarios were considerably more complex. For example, widening the footpath in one scenario, required reduction in the number of lanes of traffic. Though we were primarily interested in the difference that increasing the distance to traffic and feeling of footpath 'generosity' made to perceptions of safety and place in this scenario, the reduction in traffic lanes, would also impact traffic volume and thus noise levels, in addition to the increase in distance to the traffic. To include the 'Refuge island' and 'Wombat crossing' scenarios, due to regulations related to this particular detail, it was necessary to reduce the number of lanes to two, meaning that these scenarios also included elements of 'Car park buffer' scenario and thus increased distance to traffic (with associated slight reduction in traffic volume coming from greater distance from vehicle noise source), and for the 'Wombat crossing', due to the pedestrian prioritisation, while still designated as a maximum speed of 50km/hr, the speed of the vehicles was on a whole, was considerably slower than the 'Baseline'. This complexity means that for some scenarios, it is not possible to completely isolate the element that is impacting on the participant's safety and place.

The limited number of scenarios

Due project constraints, as well as the issue of survey fatigue, the number of scenarios we could test was limited. There were many important and worthy variables that were not included in this initial pilot study due to this limitation.

Key methodological insights

This pilot study combined multiple novel methods for representing streetscape elements and measuring participant responses. Key methodological insights include the following:

1. ***The approach garnered a strong level of engagement,***

The digital survey format and content appear to have been suitably engaging with the number of valid response-rates being considerably greater than expected, with a high number of mid-way to full completions of survey. The high numbers of responses allowed for eliciting large numbers of statistically significant results.

2. ***The digital survey (e-participation) approach resulted in input from a wide range of citizens.***

By using the e-participation approach to the method for engagement, it allowed us to reach a broad sector of society. Citizens were not required to be available to physically attend workshops, negating some of the issues usually associated with streetscape change consultation forums which can be restricted to highly localised groups and individuals. While the e-participation approach did appear to limit engagement from older adults, in a post-pandemic environment, it would be possible to augment the study with assisted in-person e-participation.

3. ***Using immersive virtual environments (IVE) allowed for multiple controlled scenario analysis,***

Using immersive virtual environments (IVE) allowed for controlled variable adjustments, enabling us to test many different scenarios consecutively, while overcoming limitations of 'recall' methods that rely on a participant's memories of real-world spaces.

4. ***The IVEs allowed for the testing of complex dynamic street interactions,***

Modelling the complex interaction of streetscape systems and space to produce clear, realistic, dynamic and multi-sensory stimuli with minimal confounding variables, overcomes limitations of still photographic image comparison methods.

The IVE method using a de-identified streetscape (based on a real street), also negated biases associated with personal experiences of specific local spaces.

5. The approach allowed for the quantification of human emotional and perceptual responses,

The use of this e-participation method, with its inclusion of interactive emotion sliders and the affect grid allowed us to quantify human emotional and perceptual responses to the streetscape scenarios. The approach also allowed us to understand which interventions on streets have the most positive or negative impacts on perceptions of safety and place.

Key insights for traders and local government

For traders in local neighbourhood centres, these outcomes are important as retail spending, as a factor of time spent in a location, has been shown to relate to perceptions of safety and place. It is also important for retail traders, that customers can easily access their shops from either side of the street in a way that is safe and convenient. There were many findings that may be of particular interest to traders, but the key insights were:

1. 'Cycle lanes', 'Wombat crossings' and 'Reduced speed' are the best treatments for retail traders

Results suggest that 'Cycle lane', 'Wombat crossing' and 'Reduced speed' 30km/ph are highly beneficial treatments for traders due to the strong improvement in perceptions of both safety and place that these scenarios elicited.

2. Carparking appears to be less beneficial to retail traders than dedicated cycle lanes.

On-street carparking is commonly considered to be desirable by traders, but the results of this study suggested that from a perceived safety and place perspective, providing carparking is not particularly beneficial. 'Cycle lane', 'Wombat crossing', 'Reduced speed 30km/ph', 'Refuge island' and 'Wider footpath' were each found to have a more positive response than 'Parked car buffer' for the question of 'would this be a good place to stop for coffee?'. 'Parked cars buffer' provided no significant positive response to the 'how inviting does it feel to cross the street to visit shops on the other side?' question whereas all mid-block crossing scenarios, 'Cycle lane', 'Wider footpath' and 'Increased tree canopy' all did. While 'Parked car buffer' did perform well with respect to the feeling of safety, 'Barrier fence', 'Wombat crossing', 'Cycle lane', each received more positive results.

3. Barrier fencing appeared the least suitable treatment from a successful retail trader perspective.

While the results show that 'Barrier fencing' does improve perceptions of safety, this option would be difficult to support with respect to providing successful places for retail. In addition to the added difficulties fencing can have on loading of goods, the treatment received a significantly negative response to the question of 'how inviting does it feel to cross the street to visit shops on the other side?', and ranked the lowest out of each of the statistically significant positive responses to both 'would this be a good place to stop for coffee?', and 'how pleasant is it to stand in this space?' questions.

4. Pedestrian priority and ease of making street crossings is an important aspect of place.

As shown by the results for the question *'how inviting does it feel to cross the street to visit shops on the other side?',* the length of crossing time is an important factor. While the 'Signal crossing long wait' still had a positive impact on sense of crossing ease, it was far less effective than 'Signal crossing short wait' which affords a greater sense of pedestrian prioritisation.

While signalised crossings were associated with positive perceptions of place, they were less effective than physical crossings potentially due to either associated 'chirp sound' of the accessible pedestrian signals (APS) and their low impact on traffic speed.

Physical crossings such as 'Wombat crossing' and 'Refuge island' had exceptionally strong positive impact on perceptions of place. The response were many times more likely to be positive to each question, for example, the question 'would this be a good place to stop for coffee?' resulted in 'Wombat crossing' at 3.48, and 'Refuge island' 3.12 times more likely to receive a positive response.

Key insights and recommendations for practitioners

The study has revealed a wide range of insights that may be of benefit to practitioners and contributes to the knowledge base and understanding of streetscape design treatments and their impact on perceptions of safety and place. Based on our findings, the following section summarises five key recommendations to practitioners:

1. ***e-participation – immersive virtual environments embedded within an online-survey is an effective method for community engagement for streetscapes***

Perceptions are a complex psychological process involving interactions of memories, past experiences, beliefs and values. Perceptions data gathered through traditional community consultation processes can be challenging to integrate into streetscape decision-making as it is difficult to analyse and can be subjective.

Using embedded Immersive Virtual Environments (IVE) as visual and auditory stimulus within an e-survey tool coupled with three types of questions; revealed preference (gathered through rating scale questions), stated preference (gathered through element ranking) and emotion affect (gathered through affect grid questions) is a robust method for understanding human preferences and perceptions of safety and place of individual variables of streetscapes with input from large numbers of participants. The use of IVE enabled two important innovations. Firstly, it focused responses from a forced point of view (POV), that of the pedestrian, regardless of respondent's personal day to day transport choices, and secondly, through virtue of being simulated, reduced confounding emotional responses based on personal experience of specific streets. The use of an online survey enabled the gathering of data from a larger user group with a broader geographic range than is possible using traditional community consultation methods that focus on smaller, localised stakeholder groups.

We recommend:

- Adopting the approach described above for community participation relating to streetscape treatments to overcome some of the issues with traditional community engagement, enabling focused responses from a large number of citizens that can be analysed using empirical methods.

2. ***Reducing speed and noise, and increasing separation from traffic make main streets significantly less stressful.***

In response to the 'Baseline' scenario, pedestrian respondents experienced predominantly actively negative emotions (active-displeasure), such as 'Upset' and 'Tense'. However, they experienced substantially more positive emotions and more positive perceptions of safety and place in response to scenarios with adjusted variables of; reduced speed, reduced noise and increased separation from traffic through provision of either a barrier or increased distance between pedestrians and moving vehicles. The considerable improvements to emotional responses demonstrated, particularly to reduced speed and noise, show the potential of designing main streets from a pedestrian perspective, to go beyond improving perception of safety and place towards increasing rates of active transport uptake and improving general levels of community wellbeing and health.

We recommend:

- As higher speed and noise levels had the strongest negative impact on emotional responses and perceptions of place, reducing speed is a low-cost and highly effective adjustment that has the co-benefit of simultaneously reducing noise.
- As inadequate distance separations between pedestrians and traffic also have a strong negative impact on emotional responses, provision of elements that increase pedestrian separation from traffic, such as cycle lanes adjacent to footpaths, are an excellent way to positively impact perceptions of place.

3. ***Cycle lanes vastly outperform barrier fences in making a positive contribution to safety and place.***

The methods used to separate pedestrians from vehicles (distance or barrier) influenced perceptions of safety and place.

Scenarios where separation increased the distance between the pedestrian and adjacent traffic ('Parked car buffer', 'Cycle lane' and 'Widened footpath'), were perceived more positively than scenarios where separation was provided through a barrier alone ('Barrier fence' and 'Ground vegetation buffer'). Consistent with prior research findings, barrier separations that obstructed pedestrian movement in lieu of traffic speed reduction were perceived as having a low to negative impact on perceptions of place.

Of the three types of distance separation tested, those that did not obstruct visual connectivity for street crossings ('Cycle lane' and 'Widened footpath' scenarios) were perceived more positively than those that were visually obstructive ('Parked car buffer').

Of the two most positively perceived distance separations ('Cycle lane' and 'Widened footpath'), cycle lanes were perceived the most positively for both safety and place. This may be attributable to three aspects. Firstly, in comparison to wider footpaths, cycle lanes reduce conflict between cyclists and cars; secondly, cycle lanes provide a strong visual cue for pedestrians on location of the footpath edge (green surface paint); and thirdly, presence of cyclists (even for non-cyclists) were strongly indicated as a positive safety and place element, ranking the most popular choice for making a street feel more pleasant and in the top three most popular choices for making a street feel more safe.

We recommend:

- Separated bike paths located adjacent the footpath as a highly effective main street intervention for improving perceptions of both safety and place.
- Visually transparent traffic distance separations such as wider footpaths and cycle lanes are more effective than separations that impede pedestrian visibility such as parked car buffers,
- Barrier separations that impede pedestrian movement and can 'feel claustrophobic', such as fencing, should only be used sparingly, for example, where distance separation cannot be achieved, or areas adjacent school exit points.

4. Increasing tree canopy should be in conjunction with other treatments

Some surprising differences arose between the responses in the stated and revealed preference sections. One marked difference was the impact of trees on perceptions of place. When asked outright (stated preference) about what elements contributed to pleasantness, trees were consistently the highest ranked element to increase positive perceptions of place, and yet in response to their role in the IVE simulations, increasing tree canopy made less of a difference than reduced speed, reduced noise and increased traffic separation to perceptions.

This suggests three possibilities: Firstly, trees are clearly important to people with respect to perceptions of place but on busy main streets, pedestrian attention and experience is dominated by interaction of traffic variables specifically noise and speed. Secondly, in the Increased tree canopy scenario, traffic speed was unchanged, suggesting that increasing tree planting alone is not a sufficient treatment for improving perceptions of place without also considering speed and noise reductions and provision of safe crossings. Thirdly, while trees on streets are important to people, in the virtual environments (IVE), the climatic benefits (thermal comfort) that trees provide such as shade, are less pertinent to the experience.

We recommend:

- Increasing tree canopy coverage makes a positive place contribution but should be undertaken in conjunction with other safety and place treatments, such as reducing speed.

5. Combining multiple treatments can have a synergistic, positive impact on place.

While this survey was focused on understanding the impact of individual variables, the overwhelmingly positive responses demonstrated by reactions to the 'Wombat crossing' scenario, shows the potential of the many possible synergies between variables. In this scenario, where the application of a crossing, necessitated a traffic distance separation, and also impacted traffic speeds as cars slowed at crossings, responses were more than ten times likely to be positive from a perceived safety, AND perceived place than in response to the 'Baseline' scenario.

In this survey, 'Wombat crossing' scenario was represented in the IVE with a parked car buffer as the type of distance separation. Cycle paths or footpath widening could be used in place of parked car buffers in the Wombat crossing scenario and may have had an even greater impact on perceptions of place as discussed in key recommendation no.3.

Scenarios that represented more than one variable adjustment, such as the 'Wombat crossing' (which afforded safe pedestrian prioritised crossing, reduced speed, reduced noise and increased separation between pedestrians and moving vehicles) were perceived as both considerably more pleasant and more safe.

We recommend:

- Multiple treatments can have a synergistic impact on place. Combinations of treatments that combine the reduction of vehicle speed, increase physical separation from vehicles, prioritise pedestrian crossing access and increase tree canopy are likely to greatly improve perceptions of safety and place. Further research is required to explore possible synergistic combination of treatments (discussed further in the next section).

Suggested further research - what next?

While the *Exploring balance between movement and place in designing safe and successful places* pilot project has demonstrated the successful application of a new e-participation approach that combines online survey methods with animated immersive virtual environments, an affect grid, and emotion response sliders to quantify and assess citizen's perceptions of safety and place, results and insights gained from the project suggest great potential in expanding on this work. Further work is recommended to build on the outcomes of this project. In particular:

- When limitations on in-person engagement and COVID19 related restrictions are lifted, the study could be extended to include in-person assisted e-participation that would be more inclusive for older adults who were underrepresented in the study.
- Further refinement of the online-survey interface could also improve accessibility for people with visual impairment.
- The impact of different devices, resolutions and audio experiences (headphones) could be further explored through a series of controlled environment experiments.
- The level of immersion in the streetscape environments could also be explored by comparing full virtual reality with Head Mounted Displays against the immersive 360-degree videos in this study.
- The stakeholder workshop raised a wide range of interesting streetscape variables and possible scenarios that were outside of the project scope, many of which would be worth exploring using the same methodology.
- The results from the study suggest further testing of designs that combine multiple street treatments, to analyse if dramatic improvements to perceptions of streets can be obtained when (for example)**:**
    - 'Cycle lanes' are combined with 'Wombat crossings'
    - 'Reduced speed' is combined with 'Increased tree canopy'
    - 'Wombat crossing' is combined with 'Reduced speed', 'Cycle lanes' and 'Increased tree canopy'

There are also several potential areas of interest into which this work could expand such as:

- An exploration of potential impacts of COVID-normal NYC 'open restaurant' expansion of retail onto the roadway
- Treatments for other street types could be explored including Local Streets, Main Roads, and Civic Places
- Investigation of the impact of different tree species and spacing, on perceptions of place
- The potential impact of electric vehicles (given the reduction in engine noise) on perceptions of place
- To explore the impact of various 'micro-mobility' vehicles such as e-bikes, e-scooters and their parking on place
- And to explore the future impact of Autonomous Vehicles and significant potential street reconfigurations.

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Part 6: Appendices

Appendix A

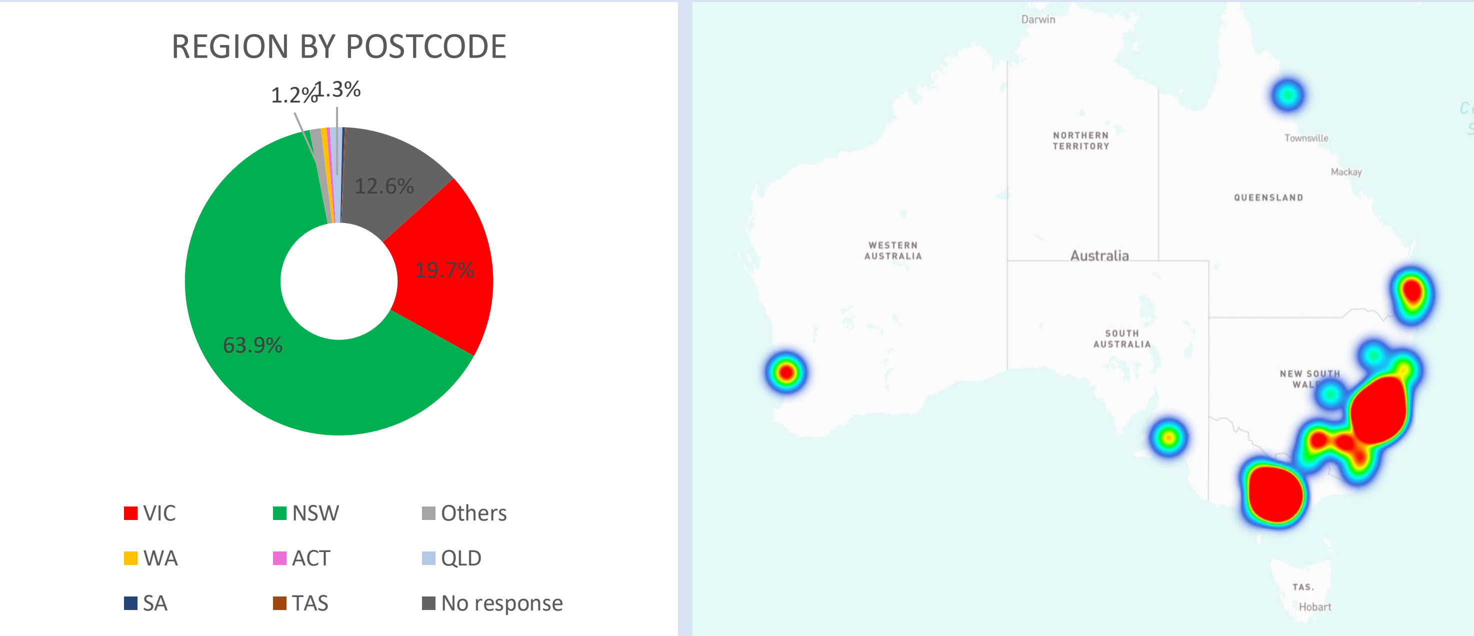

Figure 63: [Left] Doughnut chart shows the location of participants according to postcode; [Right] distribution heat-map of responses across Australia showing concentration of survey participants primarily within NSW, followed by Victoria.

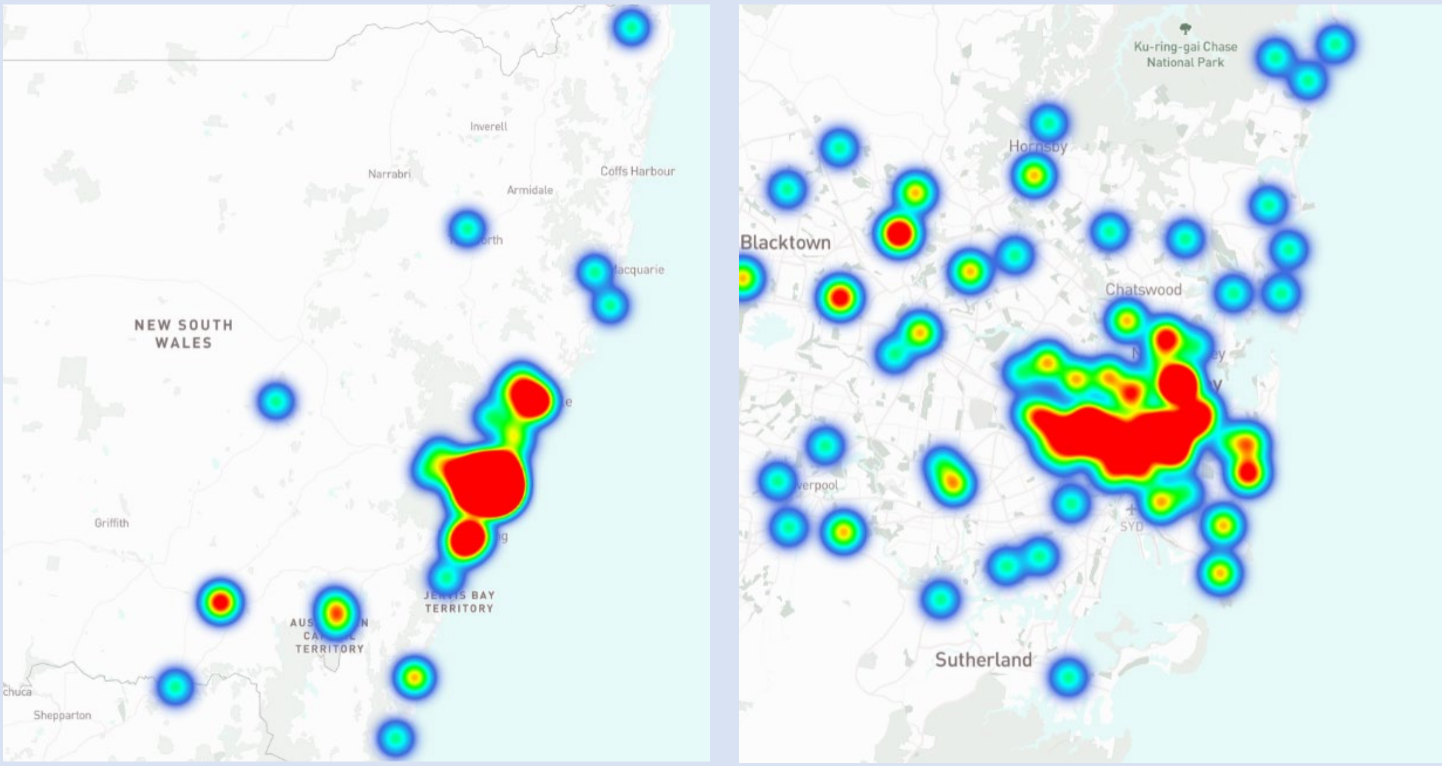

Figure 64: [Left] Distribution heat-map of responses across NSW showing concentration of survey participants along the East Coast, [Right] heat-map showing the distribution within Sydney with concentration of participants in central Sydney.

Appendix B

Table 10: List showing the variety of occupancies stated in the text response for those who chose 'other' in response to the occupation question.

Administration (2)	council	Health sector (13)	Medical research	Retail (6)	Unemployed
Administration finance	Councillor	Homemaker	Multiple casual entertainment and food related jobs	Retail business owner	Urban planning
Advertising	Counterterrorism Analyst	Hospitality (6)	Musician	Retail Manager	Veterinary Pharmaceutical Industry
Aged Care	Currently neither employed nor retired.	mother, a volunteer, a writer, a thinker, a place-maker	NFP	Science	Warehouse operator
Air Services	Defence	Home carer for people with disabilities and elderly	NGO sector	Scientist	Wildlife carer
Anti-Communist Activist	Department of health	Independent researcher	Not for profit	Security	Wok in health
Artist (2)	Director	Insurance	Nurse	Self-employed (3)	Work in another sector
Aviation	Disability	international aid	Nursing agency	Self-employed disability advocate	Work in environmental protection
Bicycle shop	Disability support	Labourer	Pharmaceuticals	Service station	Work in government
Biosecurity	Doctor	Law (3	Planning	Sole trader meet clients via bicycle	Work in government
Built environment	Electrician	Lawyer	Policy	superannuation	Work in government sector
business owner	Energy	Legal (3)	Project development	State Government	Work in healthcare
Carer (2)	Energy	Local gov (3)	Project Manager	State Government	work in logistics
Volunteer	energy sector	Marketing (5)	Property	Stay at home parent	Work in research
CCTV Technical	Engineer (8)	Marketing/Tourism	Public Domain at a local council	Stay at home parent.	work in social/equity planning
Chemical manufacturing	Environment	Meat	Public health/social sciences research	Swim instructor / elite athlete	Work in the arts sector
Church pastor	Environmental engineer	Medical practitioner (3)	Public health/social sciences research	tailor	Work is sales and marketing
Cleaner	Environmental scientist		Public policy (2)	Taxi driver	works in utility industry
Coles	Essential services		Public Servant (2)	Teacher	Writer and Freelance Scientist
Commercial	Executive NGO		Rail safety regulation	Tourism	Youth worker
Communications	Federal Government		Registered Nurse	Town Planner (4)	Zookeeper
Community worker and unionist	Finance/analyst (8)		Removalist	Trade in the road	
Construction (4)	Nurse Manager		Researcher	Traffic Safety	
Construction Management	Warehouse worker			Train Driver	
Consultant (4)	Funeral and cemetery industry			TV	
Content manager SaaS	Government (4)				
Copy writer and web publisher					

Appendix C

Table 11: General estimating equation (GEE) ordinal logistic regression for 'Would this be a good place to stop for coffee'. Statistically significant results (Sig. ≤ 0.05) are signified in bold font and highlighted in light green. Exp(B) >1 response indicating the likelihood of a positive response in comparison with the 'Baseline' scenario.

This would be a good place to stop for coffee?

Parameter		B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
				Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
Threshold	1	.591	.1214	.353	.829	23.694	1	.000	1.806	1.424	2.291
	2	1.826	.1370	1.557	2.094	177.592	1	.000	6.208	4.746	8.120
	3	2.885	.1664	2.559	3.212	300.575	1	.000	17.911	12.926	24.819
	4	4.299	.2480	3.813	4.785	300.469	1	.000	73.597	45.266	119.660
Less clutter		-.079	.2174	-.506	.347	.133	1	.715	.924	.603	1.414
Cycle lane		1.379	.1316	1.121	1.637	109.907	1	**.000**	**3.972**	3.069	5.141
Wider footpath		.887	.1216	.649	1.125	53.219	1	**.000**	**2.428**	1.913	3.081
Wombat Cross		1.248	.1827	.890	1.606	46.671	1	**.000**	**3.483**	2.435	4.983
Sig. cross short-wait		-.041	.1771	-.389	.306	.055	1	.815	.959	.678	1.358
Refuge island		1.138	.1800	.785	1.491	39.990	1	**.000**	**3.121**	2.193	4.440
Sig. cross long-wait		-.165	.1756	-.509	.179	.883	1	.347	.848	.601	1.196
Ground vegetation buffer		.390	.2202	-.042	.821	3.131	1	.077	1.476	.959	2.273
Increased tree canopy		.548	.1088	.334	.761	25.354	1	**.000**	**1.729**	1.397	2.140
Barrier fence		.466	.1259	.219	.713	13.680	1	**.000**	**1.593**	1.245	2.039
Parked car buffer		.857	.2325	.401	1.312	13.576	1	**.000**	**2.355**	1.493	3.715
Speed 30km/ph		1.232	.1235	.990	1.474	99.505	1	**.000**	**3.427**	2.690	4.365
Baseline		0[a]	.	.	.	.	.	.	1	.	.
(Scale)		1									

Dependent Variable: This would be a good place to stop for coffee
Model: (Threshold), Index1, a. Set to zero because this parameter is redundant.

Table 12: GEE Ordinal logistic regression for 'How inviting does it feel to cross the street to visit shops on the other side?'. Statistically significant results (Sig. ≤ 0.05) are signified in bold font. Exp(B) >1 repsonse indicating the likelyhood of a positive reponse in comparison with the 'Baseline' scenario (highlighed in light green, and Exp(B) <1 repsonse indicating the likelyhood of a negative reponse in comparison with the 'Baseline' scenario.

How inviting is it to cross the street to visit the shops on the other side?

Parameter		B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
				Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
Threshold	1	.729	.1258	.483	.976	33.598	1	.000	2.074	1.621	2.654
	2	1.915	.1308	1.658	2.171	214.376	1	.000	6.784	5.250	8.766
	3	2.923	.1415	2.645	3.200	426.548	1	.000	18.592	14.089	24.535
	4	4.232	.1923	3.855	4.609	484.010	1	.000	68.831	47.213	100.349
Less clutter		-.183	.2406	-.654	.289	.576	1	.448	.833	.520	1.335
Cycle lane		.969	.1335	.707	1.230	52.688	1	**.000**	**2.634**	2.028	3.422
Wider footpath		.723	.1292	.470	.977	31.350	1	**.000**	**2.061**	1.600	2.655
Wombat Cross		2.342	.1944	1.961	2.723	145.144	1	**.000**	**10.404**	7.107	15.229
Sig. cross short-wait		1.320	.1906	.947	1.694	48.018	1	**.000**	**3.745**	2.578	5.441
Refuge island		1.520	.1819	1.164	1.877	69.852	1	**.000**	**4.574**	3.202	6.534
Sig. cross long-wait		.993	.1912	.618	1.367	26.972	1	**.000**	**2.699**	1.855	3.925
Ground vegetation buffer		.011	.2262	-.432	.454	.002	1	.961	1.011	.649	1.575
Increased tree canopy		.421	.1286	.169	.673	10.735	1	**.001**	**1.524**	1.184	1.961
Barrier fence		-.382	.1597	-.695	-.069	5.722	1	**.017**	**.682**	.499	.933
Parked car buffer		.357	.2239	-.082	.796	2.542	1	.111	1.429	.921	2.216
Speed 30km/ph		1.178	.1316	.920	1.436	80.146	1	**.000**	**3.247**	2.509	4.202
Baseline		0[a]	.	.	.	.	.	.	1	.	.
(Scale)		1									

Dependent Variable: How inviting is it to cross the street to visit the shops on the other side?
Model: (Threshold), Index1, a. Set to zero because this parameter is redundant.

Table 13: GEE Ordinal logistic regression for 'How pleasant is it to stand in this space?'. Statistically significant results (Sig. ≤ 0.05) are signified in bold font and highlited in light green. Exp(B) >1 repsonse indicating the likelyhood of a positive response in comparison with the 'Baseline' scenario.

How pleasant is it to stand in this space?

				95% Wald Confidence Interval		Hypothesis Test				95% Wald Confidence Interval for Exp(B)	
Parameter		B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.	Exp(B)	Lower	Upper
Threshold	1	.405	.1174	.175	.635	11.909	1	.001	1.500	1.191	1.888
	2	1.612	.1268	1.364	1.861	161.744	1	.000	5.014	3.911	6.429
	3	2.845	.1591	2.533	3.157	319.552	1	.000	17.199	12.590	23.494
	4	4.313	.2573	3.809	4.817	280.999	1	.000	74.674	45.098	123.648
Less clutter		-.156	.2103	-.568	.256	.548	1	.459	.856	.567	1.292
Cycle lane		1.292	.1329	1.031	1.552	94.450	1	**.000**	**3.638**	2.804	4.721
Wider footpath		.843	.1276	.593	1.093	43.592	1	**.000**	**2.323**	1.809	2.983
Wombat Cross		1.260	.1778	.911	1.608	50.222	1	**.000**	**3.524**	2.488	4.993
Sig. cross short-wait		-.052	.1783	-.401	.298	.085	1	.771	.949	.669	1.347
Refuge island		1.077	.1722	.739	1.414	39.087	1	**.000**	**2.935**	2.094	4.113
Sig. cross long-wait		-.214	.1755	-.557	.130	1.480	1	.224	.808	.573	1.139
Ground vegetation buffer		.544	.2133	.126	.962	6.501	1	**.011**	**1.723**	1.134	2.616
Increased tree canopy		.686	.1198	.451	.921	32.760	1	**.000**	**1.986**	1.570	2.511
Barrier fence		.262	.1277	.012	.513	4.221	1	**.040**	**1.300**	1.012	1.670
Parked car buffer		.552	.2171	.127	.978	6.473	1	**.011**	**1.738**	1.135	2.659
Speed 30km/ph		1.172	.1289	.919	1.424	82.575	1	**.000**	**3.227**	2.507	4.155
Baseline		0[a]	.	.	.	.	.	.	1	.	.
(Scale)		1									

Dependent Variable: How pleasant is it to stand in this space?
Model: (Threshold), Index1 a. Set to zero because this parameter is redundant.

Table 14: GEE Ordinal logistic regression for 'How safe do you feel in this space?'. Statistically significant results (Sig. ≤ 0.05) are signified in bold font and highlighted in light green. Exp(B) >1 response indicating the likelihood of a positive response in comparison with the 'Baseline' scenario.

How safe do you feel in this space?

				95% Wald Confidence Interval		Hypothesis Test				95% Wald Confidence Interval for Exp(B)	
Parameter		B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.	Exp(B)	Lower	Upper
Threshold	1	.169	.1118	-.050	.388	2.288	1	.130	1.184	.951	1.474
	2	1.172	.1175	.941	1.402	99.369	1	.000	3.227	2.563	4.064
	3	2.302	.1371	2.033	2.571	282.068	1	.000	9.993	7.639	13.073
	4	3.856	.1983	3.467	4.244	377.983	1	.000	47.254	32.036	69.702
Less clutter		.041	.1968	-.344	.427	.044	1	.834	1.042	.709	1.533
Cycle lane		1.225	.1312	.968	1.483	87.196	1	**.000**	**3.405**	2.633	4.404
Wider footpath		.818	.1238	.575	1.060	43.631	1	**.000**	**2.265**	1.777	2.887
Wombat Cross		1.274	.1911	.900	1.649	44.471	1	**.000**	**3.576**	2.459	5.200
Sig. cross short-wait		.483	.1649	.160	.806	8.567	1	**.003**	**1.621**	1.173	2.239
Refuge island		.977	.1776	.629	1.325	30.245	1	**.000**	**2.656**	1.875	3.762
Sig. cross long-wait		.241	.1622	-.077	.559	2.210	1	.137	1.273	.926	1.749
Ground vegetation buffer		.708	.1809	.353	1.062	15.312	1	**.000**	**2.029**	1.424	2.893
Increased tree canopy		.334	.1126	.114	.555	8.812	1	**.003**	**1.397**	1.120	1.742
Barrier fence		1.297	.1269	1.048	1.546	104.398	1	**.000**	**3.659**	2.853	4.692
Parked car buffer		1.206	.2231	.769	1.643	29.218	1	**.000**	**3.339**	2.157	5.170
Speed 30km/ph		1.050	.1267	.802	1.298	68.675	1	**.000**	**2.858**	2.229	3.663
Baseline		0[a]	.	.	.	.	.	.	1	.	.
(Scale)		1									