

Window Views in the Built Environment:

Preferences and Behaviours

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Synopsis

With 90% of our time spent indoors, and an estimated 75% of the world population living in cities by 2050, the challenge of designing habitats for people is of primary importance. From an evolutionary perspective, humans have only recently started to occupy buildings for the majority of their day. When inside buildings, windows are favoured by building occupants due to the view and connection to the outside that they afford, which positively affect their environmental satisfaction. Accordingly, based on the scientific literature, building guidelines have started to include specific criteria for designing window views – e.g., providing natural and long-distance views, containing various layers of information, etc. – to enhance appreciation and preference. However, there are still research gaps to be filled, particularly for designing window views in an urban context. Multi-layered natural views are improbable in dense urban settings. Also, existing studies are built upon subjective appraisals of different stimuli with results that are difficult to reproduce due to the inherent complexity and variability of the view out of a window. Even when the views hold specific environmental qualities, we still do not know how they would affect the observer's perception and their resultant behaviour; that is how the occupants would engage with the window view. What features of views will encourage them to look out of the window? What will drive their gaze away from a task and towards the outside?

To address some of these questions, the aim of this Ph.D. research was to provide robust evidence on the relationship between window views and the associated preferences and behaviours. Through holistic and objective analysis of what observers engage with when looking out of a window, this study embraced a subject-centred and multi-method approach to triangulate findings extrapolated from different measures. First, within controlled laboratory experiments, physiological measures of involuntary gaze response (eye-tracking) to views, subjective preference ratings, and reasons for preferences were collected and analysed to reach a deeper

understanding of the phenomenon. Then, in real-life built environment, surveys were designed to investigate and identify attributes of window views that were liked and disliked, leading to a more thorough characterisation of responses to the view out.

Among the findings of this work is the association between gaze behaviour and subjective preference. That is, those elements in an urban view that were not preferred, or needed more deciphering, effectively attracted gaze for longer with longer fixation durations. Views with natural content elicited similar oculomotor behaviour. This link demonstrates a personal engagement with the view out of the window, either when the view is not appreciated – e.g., due to an incongruent element – or when the view affords a connection with natural features. Further interest in the view out of a window can also be ensured through dynamic features, including transient, daily, and seasonal changes in the view. This link between window view preference and gaze behaviour offers a better insight into why an interesting or dynamic view might be noticed more often by humans.

These results have relevant design implications. Among these, the suggestion that, to notice the view out of a window and look at it more often, it does not necessarily need to be preferred, but rather it needs to be dynamic. Since building occupants, their subjective preferences, and attention mechanisms might shift over time, a review of design guidelines might be required to enable a more adaptable design of windows and their settings over the multiple lives of a building.

Key words

Window views, View preference, Gaze behaviour, Eye-tracking measures, Built Environment, Window design

خرد دیکھے اگر دل کی نگہ سے

جہاں روشن ہے نور 'لا الہ' سے

فقط اک گردش شام و سحر ہے

اگر دیکھیں فروغ مہر و مہ سے

علامہ محمد اقبال

If only intellect would see through the eye of the heart,

the universe is enlightened with Allah's light.

If, however you see the waxing sun and moon,

it is a mere cycle of dawn and dusk.

Sir Muhammad Iqbal

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Definitions: Window, View and Preference

A window is defined as 'a space usually filled with glass in the wall of a building, to allow light and air in and to allow people inside the building to see out' (Cambridge University Press, 2020a). A view is defined as 'what you can see from a particular place, or the ability to see from a particular place' (Cambridge University Press, 2020b). In this research, view refers to the scene viewed outside from the window of a building, or 'window view'. View is the extent of the outdoor environment that is made available for a building occupant, with the window as providing the frame of reference. Given the fact that 'humans are active observers' in buildings who must acquire view 'representations over time' (Tarr and Kriegman, 2001) the view is experienced, and this perception leads to preference formation.

The definition for preference adopted in this research – that is, '*how much you like the scene for whatever reason you may have*' – derives from previous literature studies on window view perception (Herzog and Shier, 2000, Kaplan, 2001, Butler and Biner, 1989). Window view preference refers specifically to visual preference and is used in its noun form for expressing how much an observer 'likes' the view (real or simulated) out of a window.

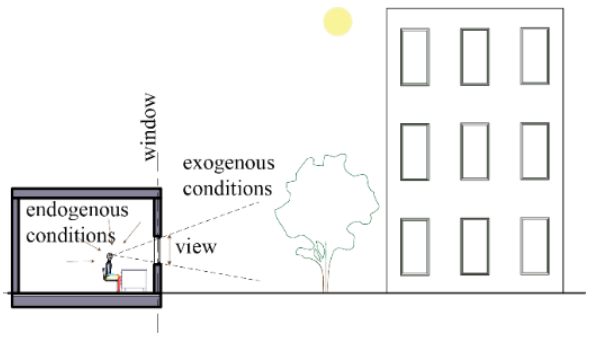


Figure 0.1. Window View (Source: Author)

Symbols and Acronyms

CI	Confidence Interval
d	Cohen's *d*
ft	Feet
H	Kruskal-Wallis test statistics
χ^2	Chi-square statistic
IQR	Interquartile Range
m	Meter
M	Mean
M_{dn}	Median
N, n	Sample size
ns	Not statistically significant
p	The attained level of significance (*p*-value)
r	Pearson's correlation coefficient
r_s	Spearman rank coefficient
R^2	R-Squared or the coefficient of determination
SD	Standard deviation
t	Test statistic for the parametric t-test
U	Test statistic for the non-parametric Mann-Whitney test
z	z-score (A data point expressed in standard deviation units)
ETM	Eye-tracking measures
CRT	Cathode Ray Tube monitor
VAS	Visual Analogue Scale
Cardinal	Any compass direction – i.e., north, east, south, west

1. Introduction

1.1. Interest in the View Out of the Window

People spend up to 90% of their time inside buildings (Klepeis et al., 2001), most often in cities (Lee and Xu, 2020). Research on view preferences within the built environment can help address several environmental and social challenges that cities present, particularly those relating to occupant health and wellbeing (EEA, 2009). As such, while the restorative potential of natural views has been well-documented (Ulrich et al., 1991, Valtchanov and Ellard, 2015, Franěk et al., 2018, Van den Berg et al., 2016), research on view preferences in the built environment has mostly focused on evaluating differences between natural and urban views (Valtchanov and Ellard, 2015, Herzog, 1992, Nasar and Terzano, 2010, Staats et al., 2016, Kaplan et al., 1972). Since, from inside buildings, windows afford our primary means of connection with the outside, there is a substantive need for research

exploring visual preferences in an urban built setting (Herzog, 1992, Nasar and Terzano, 2010, Staats et al., 2016).

Humans receive information from the environment featured in a view through all five senses, although most stimulation occurs through vision. Sight is, therefore, our major engagement mechanism with the view out of a window. Looking through a window allows for a difference of depth of focus (accommodation) compared to interior surfaces, which in turn relaxes the ocular muscles and provides benefits for eye health (Figure 1.1). When the view out allows a diversion in attention from a stressful stimulus indoors, it can increase observers' ability in sustained attention and cognition (Carver, 2003) and reduce their stress levels (Leather et al., 1998, Ulrich et al., 1991). Viewing a setting, and the opportunity of looking beyond a glass pane into the world, might encourage the mind to wander (Kaplan, 2001, Oates, 2004), providing restorative moments (Kaplan, 2001) and a channel for "*creative rest"* (Ward, 2021). A wandering mind is a better predictor of happiness than what one is doing (Killingsworth and Gilbert, 2010). We look out of a window even when we need to stay focused on a task; under a stringent visual activity (e.g., working on a computer), studies have shown a tendency to look away from it 40% of the time, which increases to about 80% of the time when the task does not require continuous attention (Khanie Sarey et al., 2013). Window views offer the potential for visual engagement with the outside world.

Of course, aesthetic appraisal of a scene is also informed by stimuli

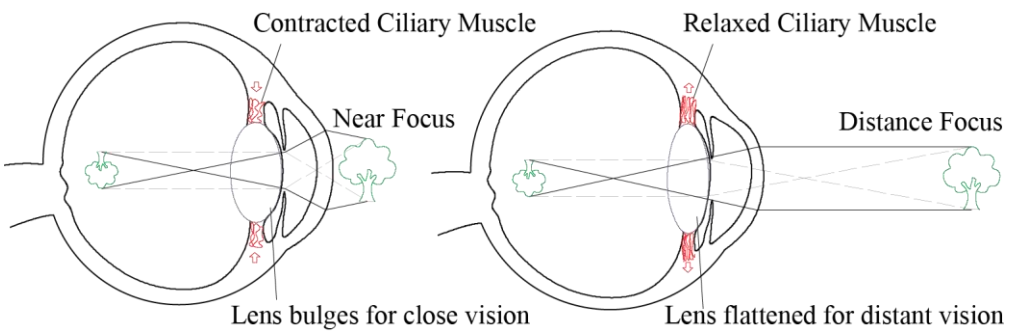


Figure 1.1 Conceptual section of the eye showing that muscles in the eye relax when focused on a distant object. Adapted from University of Waikato (2021)

other than vision, and our eyes want to 'collaborate with the other senses' (Pallasmaa, 2007: p.42). The presence of any anthropogenic noise, for example, air and ground traffic, or human voices, has been shown to negatively impact on visual assessments of pristine natural environments (Benfield et al., 2010).

An interesting view has been associated with lower visual discomfort ratings than a less interesting view with the same mean luminance (Tuaycharoen and Tregenza, 2005, Tuaycharoen and Tregenza, 2007). Other studies have associated better quality views to lower visual discomfort (Hopkinson, 1972, Aries et al., 2010, Shin et al., 2012), although this finding has not been consistently confirmed by field studies (Hellinga, 2013, Hirning et al., 2013). Further research drawing on the differences of view types in healthcare settings has concluded that scenes of nature might have a more positive influence on the psychophysiological states of patients than urban scenes (Ulrich, 1981, Kohn et al., 2013, Ulrich, 1984).

The beneficial effects of window views can be found in multiple settings. In a study of workspaces, daylighting and preferred views have been associated with a 50% reduction in sick leave of office employees (Elzeyadi, 2012). Views of nature have buffered the negative impact of job stress on employees' intention to quit (Leather et al., 1998), while an unobstructed view of natural surroundings has been related to improvements in self-reported physical and mental health in rehabilitation programs (Raanaas et al., 2016, Ruth Kjærsti et al., 2011). A view of a simulated green roof has been associated with a more consistent task response and fewer omission errors, compared to viewing a concrete roof (Lee et al., 2015). In some studies, significant differences in task performance have not been detected in rooms with or without windows (Stone, 1998), although performance in high demand and stressful environments has been found to improve with the presence of a poster of an outdoor view (Stone, 2003). The proximity of an outdoor view, and a feeling of connection to the outside, is generally considered important by occupants of office buildings (Chau et al., 2006, Heschong Mahone Group, 2003a) and has been found to compensate some negative perceptions associated with open plan offices (Charles and Veitch, 2002, Yildirim et al., 2007).

In other contexts, such as residential spaces, occupants might show different concerns that could hinder view appreciation. For example, privacy might play an antagonistic role with the view out. In real built settings, people have complex relationships with the view out based on their previous experiences and may close their blinds and the view out to maintain their

privacy or prevent glare. The effect of window(s) may also differ based on the attention demanded by the task at hand, with creative tasks benefiting more from having a view out than those that require constant attention (Stone and Irvine, 1994). It has also been argued that the presence of windows could, in some cases, even inhibit performance depending on the type of task (Stone, 1998).

Windows and views also contribute towards the economic value of a space (Hui and Liang, 2016, Wolverton, 1997). Using different methods and contexts – also including hotels (Latinopoulos, 2018) and housing (Hui et al., 2012, Benson et al., 1998, Mittal and Byahut, 2019) – Turan et al. (2020) have shown that in the dense built environment of Manhattan, good access to daylight added a 5-6% premium to property value (Turan et al., 2020a). However, the value of having an additional view out did not incrementally contribute to the combined effect of daylight and view (+6.5%) (Turan et al., 2021). These studies suggest that the qualities of daylight and view out are closely intertwined and disentangling this relationship is not simple. This is consistent with other research that found a correlation (r = 0.36) between view quality and light quality in buildings (Hellinga, 2013:p.145).

In summary, the effect of the view out of a window on building occupants is a topic of substantial interest that demands a more holistic characterisation so as to parse the complex relationships between the view out and the observer's behaviour (e.g., gaze focus, interaction with windows and blinds, etc.) resulting from it.

1.2. The Urban Predicament

Today, more than half of the world's population (55%) lives in urban areas, and this proportion is set to reach 66% by the middle of the 21st century (United Nations, 2019). Worldwide, the number of megacities, each with a population of over 10 million, is expected to increase from 33 to 43 by 2030 (United Nations, 2019). Sprawling urban growth may lead to morphological boundaries that differ from the administrative limits of cities. Since existing cities have an upper limit for densification, new cities are being created to accommodate the growing urban population (Taubenböck et al., 2019). Globally, each week a built-up area the size of Manhattan is added to the planet. With 'urban land' expanding at a faster pace in comparison to the 'urban population', rapid urbanization poses a threat to agricultural and natural protected landscapes. In response to this risk, common measures taken are further intensification of land use, compaction of cities (Barr and Cohen, 2014), and protection of natural landscapes from further development (U M History Department, 2021).

With rapid urbanisation, human beings have become an indoor species (Klepeis et al., 2001); spending most of their lives enclosed within buildings. From an evolutionary perspective, this contrasts with all that has been previously known to humans. This shift in occupying buildings for most of the day is relatively new and took place over the past century. In the last decades, this situation has been further exacerbated by various phenomena that have been shifting the use-patterns of our built spaces, including

demographic trends (e.g., an increasingly ageing population) but also *technological* and *socio-cultural* developments. Information technology and the internet of things have enabled new live-work practices, while the shortage of floor space in urban centres has encouraged the redefinition of typical office layouts, moving towards open workspaces (which might increase the distance between desks and windows), requiring more collaborative practices and user-based design (Ma and Cha, 2021). Since there are many parameters that may influence productivity at work (Newsham et al., 2019), the possibility of choosing one's working location might render the presence of windows increasingly important for wellbeing and satisfaction (Aries et al., 2010). The social distancing practices imposed by the pandemic that swept the globe in 2020, have encouraged many people to adopt work from home practice and introduced flexible working patterns. This may further accelerate the redundancy of large office layouts with fixed desk spaces, encouraging the use of hot-desks and adaptable workstations. With this flexibility, the importance of windows and workstations, and the view out of them, will become more important, given the building occupant will have more choice where and how to work.

On the surface, the advent of mechanical heating, ventilation, and air conditioning (HVAC), artificial lighting and the internet of things might have eliminated the apparent dependency on the external environment for thermal comfort, air change, luminous comfort, and for social, learning and working relationships. It has been argued, however, that while the lighting and ventilation functions of a window could be partially compensated via

artificial means, ignoring the role of a view and of the connection to the outside could result in adverse psychological (and physiological) effects on building occupants (Nimnicht, 1966). When inside buildings, windows can act as a means that offer a fundamental opportunity for opening to the outside world (Ne'Eman and Hopkinson, 1970, Ludlow, 1976, Batool et al., 2021).

1.3. Research Challenge

At the time of this research, no robust and objective measures exist to assess window view preference from the perspective of the building occupant.

Many models for landscape preference have been proposed in the literature to evaluate outdoor scenes. However, the metrics incorporated therein are mostly based on subjective interpretation, often giving inconsistent results and low reproducibility due to methodological discrepancies (Stamps III, 2004). Literature studies consistently report that long distance, multi-layered, natural views are preferred by building occupants over close-up urban scenes. From a building designer perspective, this is valuable information only at the larger scale of developments, when they are designing both the window and what is being viewed, or when the access to the view can be guaranteed in the long run (Downtown Commission, 2007, Greater London Authority, 2012). Within the constraints of a site, while designing for different tasks in a building, as a designer it is

more important to understand how building occupants might behave in response to the views available outside.

Our current understanding of window view preferences and behaviours has some substantial shortcomings. Firstly, what we know about the inferences drawn from the differences between urban and natural views has likely limited applicability in future cities, where urban greening efforts will be more common, making the stark distinction between what is urban and what is natural less meaningful. Secondly, what can be defined as an 'urban' view is not totally clear, and therefore may be prone to differences of 'perception of urbanity' between the researcher and a window user, rendering the reproducibility of studies difficult in new contexts. Thirdly, studies solely using experimental or simulated settings to explore user perception of window views may involuntarily introduce a response bias, whereas subjective ratings alone may not fully explain the underlying mechanisms driving preferences. Fourthly, many studies, especially on window view preferences and associated behaviours, draw on self-reported responses, either in experimental or real window settings. Self-reports present only a partial view of a phenomenon (Poulton, 1977), and require some form of objective measures to be supported and verified. Finally, since window view preference is related to an observer's interest in the view (Tuaycharoen, 2006), it is important to know how this interest elicits a response in terms of gaze behaviour. This is particularly relevant because what people report that they prefer to look at in a view – for example, green elements – might have little role to play towards their actual view appraisal

(Matusiak and Klöckner, 2016). Natural views and attractive views may have different routes to predict well-being outcomes (Aries et al., 2010) and research needs to explore the relevance of external environments, beyond the predominant debate on whether it is natural or urban (van Esch et al., 2019). This presents a gap with direct impact on how window views could be framed based on human preferences and associated behaviours. We know that, in humans, attention precedes perception in real world scenes (Cohen et al., 2011). To measure view preference more accurately, there is a need to move beyond subjective appraisals and to implement a robust method to objectively measure the response in human attention through the analysis of gaze behaviour.

1.4. Research Aim and Objectives

As mentioned in par. 1.3 Research Challenge, and through a comprehensive review of the scientific literature (presented in Chapter 2), there are strong reasons to believe that there is a relationship between the preference expressed for the view out of a window and the behaviour in response to that view. Behaviour could be in the form of physical (e.g., moving close to the window, interacting with blinds, etc.), psychological (e.g.,) and physiological (oculomotor response). This research specifically focuses on the latter, that is gaze behaviour related to the eye movements. There is still insufficient evidence of the link between window view preference and gaze behaviour. Therefore, this study is based on the

research hypothesis that the gaze behaviour associated with a window view contributes to explaining the visual preference for the view out. In response to this hypothesis:

The aim of this thesis is to provide significant and relevant evidence that a relationship exists between window view preference and related gaze behaviour.

Given the exploratory nature of this research, the ***specific objectives*** of this study emerged as follows:

- to define a robust measure of preference in window views
- to identify what features of window views influence preference

1.5. Research Methodology

Designing the relationship between constructs that are, within themselves, difficult to define is a challenging undertaking. Firstly, the interaction of view and changing daylight conditions brings drastic variations to the visual appearance of the view outside. When measured across observers, in a real environment or within a controlled laboratory condition, this may be difficult to maintain stably. The view out of a window may also vary slightly, from person to person, based on their viewing position, and may appear more or less engaging depending on their personal interests. To add to this complexity, personal inclinations and the tasks performed in a space may moderate the level of engagement with the view out of the window.

Therefore, several factors play a role in the aesthetic assessment of a view, and many of these factors are not constant features of the environment: daylight, weather, traffic, movement of birds and people, etc.

To robustly measure the phenomenon of view preference, this thesis adopted a systematic two-step multi-method approach, collecting both quantitative and qualitative data on subjective preference.

To respond to the first objective of this research, a series of controlled laboratory experiments were designed to identify a holistic measure of view preference, while controlling for some of the many extraneous variables at play in a real window setting. In accordance with the existing gaps identified in the literature, the first of the two laboratory-based studies employed urban views. The findings from three types of data – subjective preference ratings, qualitative reasoning for these preferences and participants' gaze behaviour – were triangulated to reach a holistic measure of view preference in urban views. Previous literature, however, has mostly focused on the differences in perception and behaviour associated with view type: natural or urban. Therefore, the results from the initial laboratory study needed to be contextualised within the existing literature. Accordingly, a second follow-up study employed half of the participants from the first study but used, instead, natural views as the visual stimuli. This allowed the researcher to contextualise the findings on view preference by drawing a comparison through a within-subject repeated-measures design.

While conducting the laboratory studies, it was acknowledged that the results in terms of preference and behaviour might not necessarily

translate in real window views, where view dynamism, familiarity, viewing frame, and access may play a role in the perception of window view. To address the second objective of the thesis, and to contextualise the findings from the first two studies, therefore, another study was simultaneously designed and executed in parallel to the laboratory experiments.

Previous research using a case study approach noted that results for the perceived view quality were inconsistent between different buildings (Hellinga and Hordijk, 2014) and that the specific physical features of a particular region or location could lead to recurrent elements of interest identified by observers (Mirza, 2015). To address the shortcomings that could be associated with a data collection in a particular city, a global online survey was designed to reach participants in situ with their views. As the data were being collected, in the early months of 2020 the COVID-19 pandemic arrived to threaten the pursuit of this research.

Perceptions measured under unprecedented situations, in fact, are difficult to anchor and evaluate unless a comparable control condition is present. However, since a dataset for pre-pandemic (normal) time already existed, the new condition during the pandemic outbreak created the opportunity to investigate the differences in perception due to the circumstances imposed by the social distancing measures. The online survey was, therefore, repurposed and re-launched in April 2020, with the aim of investigating the differences in the perception of window views in a period of lockdown with respect to a pre-pandemic condition.

At this stage, a final experimental study had been designed to verify the findings of previous studies and further explore some of the detected effects. However, due to the UK government COVID-19 health and safety guidelines, this final study had to be cancelled. Also, it was considered that the pandemic and its associated psychological effects on people might have rendered problematic any investigation with human participants knowing the implicit and explicit physiologic and mental consequences that the pandemic, and the lockdown, have had on their perceptions. The cancellation of the final study did not have a significant impact on the achievement of the aim and objectives of this thesis. In fact, this research could already count on two sets of data from laboratory experiments and one dataset from a global online survey. Based on these data, robust inferences and conclusions could be drawn. Quantitative and qualitative data on view preference collected using different types of studies, and multiple approaches, were linked to reach a holistic understanding of window view preference and associated human (gaze) behaviour. Some of these results have been published in peer-reviewed papers.

Yet, it would have been interesting to launch the exploration of new potential future developments in research on window views. This is a legacy for future researchers to address.

1.6. Thesis Outline

The outline presented in this section provides a flow of the various steps undertaken to design and conduct the studies, to analyse the data, to draw inferences, and to propose conclusions. This thesis is based on the following structure:

Chapter 1 – Introduction: introduces the context of this PhD research, the research challenge, and the research aim in response to this challenge.

Chapter 2 – View Preference and Gaze Behaviour: presents the state-of the art of research on window view preferences, including the current knowledge on the topic and the methodologies used to evaluate window views with human subjects. Since this thesis draws on literature from different fields of knowledge, a detailed review of studies was used to identify current gaps in knowledge and, consequently, define the research design for this thesis.

Chapter 3 – Methods: a background and description of the methods employed in this study, and their integration, are presented.

Chapter 4 – Laboratory Studies: the experimental studies conducted under a laboratory condition, study 1 and study 2 investigating urban and natural scenes, respectively, are presented in this chapter. Subjective preference ratings, qualitative reasoning associated with these preferences, and eye-tracking measures were recorded, analysed and triangulated to reach a holistic and comprehensive measure of view preferences. Measurement of personality attributes afforded the ability to test how the

participant's personal connection with nature could be included in the interpretation of findings. The comparison of urban and natural views, and the gaze behaviour associated with each, as well as those with preferences, allowed for contextualizing these findings within existing literature. Results from Study 1 were published in a journal publication, in Lighting Research and Technology, titled 'View Preference in Urban Environments' (Batool et al., 2020). A publication based on the results from Study 2 and featuring a comparative analysis of data from Study 1 and Study 2, is currently under peer review in Lighting Research and Technology.

Chapter 5 – Preferences in Real Window Views: in the second stage of the thesis, a global online survey was launched to collect quantitative and qualitative perceptions of people in relation to their windows and the view out of them. The aim of the survey was to account for personal experience with their own views, and explore which factors contribute towards their preference, in real world conditions. The survey collected photographs of the view outside, along with subjective responses to the view. Both quantitative and qualitative data were analysed to draw robust inferences from the data. A second aim of the data collection was to make such a dataset publicly available for future researchers to replicate the study, if appropriate.

Chapter 6 – Differences of Perception due to Extraordinary Circumstances: at the beginning of 2020, a global pandemic broke out and, in response, many governments imposed social distancing and isolation measures. This section of the thesis presents the analysis of the differences of perceptions between data from Survey 1, conducted before the pandemic,

and Survey 2, run during a period of enforced confinement. Both quantitative data and qualitative descriptions of differences of perceptions due to the lockdown are presented. The results from this comparative study were published in LEUKOS: 'Window Views: Difference of Perception during the COVID-19 Lockdown' (Batool et al., 2021).

Chapter 7 – Discussion: this section draws on the key findings from the two types of studies, under laboratory conditions and using an online survey, contextualizing the results within an inter-disciplinary literature ranging from the field of architecture, vision, psychology, and environmental psychology.

Chapter 8 – Conclusion: this final chapter presents the key conclusions and recommendations for future practice and research in the design of windows and their views.

2. View Preference and Gaze Behaviour: Literature Studies

The design of a window includes many competing interests, such as access to daylight, sunlight, protection from glare, providing passive solar gains, protecting from excess heat and heat losses through the window, amongst others. A window sits at the interface between the inside and the outside, with two faces, one that looks inwards towards the building and the other facing the outside, thereby providing an active connection between the occupant and the world around (Markus, 1967).

From the perspective of the building occupant, a view is the image of the surrounding environment seen through the bounds of a window. The views, in themselves, are difficult to characterise, because they are what we know as the world outside the building, as non-static evolving settings. The

relationship between the building occupant and the window also plays a part in accessing the view out.

In the following sections, the existing literature on window view preferences and associated behaviour will be reviewed. This will include evidence-based studies involving healthy adult subjects (participants) and, for the purpose of preserving inferences applicable to real-life building settings, excluding research using simulation-based design (Shach-Pinsly et al., 2011) (Mardaljevic, 2019, Li and Samuelson, 2020, Turan et al., 2021, Turan et al., 2020b, Sundborg et al., 2020), desk research (Collins, 1976, Farley and Veitch, 2001, Veitch and Galasiu, 2012), and studies on indoor views (Biner et al., 1991) and skylights (Butler and Biner, 1990).

This chapter begins with a review of knowledge on designing windows for their view out, based on the building guidelines and design criteria (Section 2.1). Subsequently, theories in support of current understanding of window view preference, and the associated behaviours in response to these preferences, are discussed (Section 2.2). Methods used to investigate window view preference and behaviour associated with views are discussed in Section 2.3. Section 2.4 provides key findings and research gaps in the literature to clearly frame the thesis aim and objectives.

2.1. Designing windows for a view: building codes and guidelines

In the past decade, several building codes and sustainable building guidelines have emerged defining new benchmarks for spaces with a

provision of view out of windows. Some building standards establish requirements for the minimum/maximum size and performance of daylight openings, distance between the building envelope and an object in the view, and physical components of the viewed scene. However, the nature of these requirements is rather generic, and the specifications are often not comparable between countries or regions, with only some exceptions, as for example the new European code (CEN/TC/169, 2018) that aims to provide integrated guidelines on daylight and view design for the whole European Union.

One way to explore the state-of-the art on window view design is to investigate their characteristics and differentiate them based on *endogenous* parameters – that is, those that may be in the control of building occupants and the designer of the space and the envelope – and *exogenous* factors – which may not always be in the control of the designer and the occupant but, nonetheless, play a role in characterising the view out. The endogenous parameters are often referred to as *intra-architectural* features, while the endogenous factors are also known as *inter-architectural* features (Aries, 2005). These terms will be used here interchangeably. With an understanding that views with specific *features* would be framed in the specific *spaces* where those features are desirable, the following sections review the current recommendations on window views. This study acknowledges that this is a rapidly evolving field. Therefore, studies that were published simultaneously with the development of this doctoral research are reviewed in Section 2.1.3. As already mentioned, a pandemic broke out in the first half of 2020, and the

lockdown measures associated with it offered the researcher an opportunity to reflect on the unusual circumstances that may affect the preferences for the view out of a window. These circumstances are briefly discussed in Section 2.1.4.

2.1.1. *Inter Architectural Features*

Distance between the window and other objects in the view

Long-distance views are favoured by building occupants, and often recommended in building codes. Overlooking distant scenes support the evolutionary theories purporting that long distance open views give advantage to the observer to identify potential hazards as well as prospects and opportunities (see Section 2.3.1). When a person can look out of a window and see a far object, the ocular (ciliary) muscles are relaxed. Medical health specialists often recommend the '*20-20-20 rule'*, that is to look at an object at least 20 ft (6 m) away for at least 20 seconds, every 20 minutes apart, in order to prevent eye strain from digital devices (Seltman, 2019). Long distance views offer more layers of information and elicit greater interest in the scene (Bell, 1973, Tuaycharoen, 2006, Markus, 1967, Matusiak and Klöckner, 2016) (Figure 2.1). Figure 2.1 illustrates how when the distance between the window and the closest external building increases (from 'x' to 'y' to 'z'), the number of layers visible to the observer also increase. Other studies have also found a relationship between view preference and view stratification (Markus, 1967, Keighley, 1973a, Tregenza and Loe, 2014),

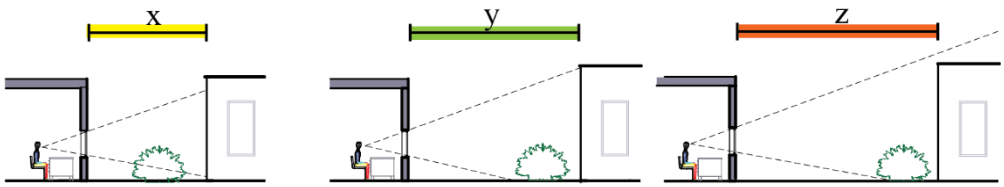


Figure 2.1 Number of layers related to distance from objects. Hypothetical distances between elements in view and window are denoted by 'x', 'y' and 'z' where 'x' < 'y' < 'z'. As the distance increases, more layers are visible in the view. (Source: Author)

thereby recompensing 'monotony' and leading to respite from the 'feeling of being closed in' (CEN/TC/169, 2018). It has also been pointed out that windows obscuring the dividing lines between view layers lose their orientation effect, thereby suggesting a preference to look at the horizon (Markus, 1967).

In dense urban settings, long distance views can be possible from the top of tall buildings overlooking less dense areas. Experimental studies on high-rise buildings often use stimuli of window views with three layers of information (featuring the ground), with the scene presented as if the participant were sitting next to the window and looking down (Elsadek et al., 2020, Olszewska-Guizzo et al., 2018). These studies suggest additional benefits and experience in high-rise apartments when people can see greenery on the ground (Olszewska-Guizzo et al., 2018). In real buildings, however, occupants do not always locate themselves next to the window, so a view to the ground is not necessarily consistently accessible. Studies involving surveys in real buildings reveal the issue of disconnection with the

greenery and activities at the ground level (Haber, 1977, Dornbusch and Gelb, 1977). In fact, the more familiar the participants are with high-rise buildings, the less desire they report to live there (Brenda and Herrenkohl, 1977). Having a distant view, nonetheless, is one of the most positive attributes of living in a high-rise building (Yuen et al., 2006, Haber, 1977), where this is available considering the growing density in most urban environments. Apart from high-rise buildings, the topography of the site may also enable the viewer to look out towards a long-distance view, for example, on the side of a cliff, or overlooking a valley. These views are very valuable because they do not necessarily have issues of disconnection with the ground, greenery and activities, as in high-rise buildings (Nichols, 1977:p.77), and provide a vista over other buildings. In a generally flat topography, the distance from the adjacent building determines the extent and number of layers available in a window view, for example to someone sitting next to the window.

In response to this evidence, building guidelines suggest minimum benchmarks for achieving a quality view in the window frame as a function of the distance from the nearest object in the scene. In the European standard EN17037 and in the SLL – Society of Light and Lighting - Lighting Guide, a threshold of 6 m is recommended (CEN/TC/169, 2018, SLL, 2014) as a minimum for sufficient view, a distance greater than 20 m for medium/good view, and a distance of 50 m for high/excellent view quality. Another minimum recommendation concerns the number of layers present in the view, with a minimum of two layers: landscape layer with either the sky or

the ground layer. The US LEED standard requires that two out of the following three options should be present in the view: 1) sense of movement; 2) flora & fauna or sky; and, 3) a minimum distance of 7.6 m (25 ft) from the nearest object (USGBC, 2018). The International WELL Building Institute recommends two of these three elements to be present in the view: 1) distance between ground floor window and road and parking to be at least 7.5 m (25 ft); 2) view factor of 3 or greater (IWBI, 2021, Heschong Mahone Group, 2003a) and, 3) vertical view angle of 30 degrees to include the ground or the sky. The view factor is defined according to a study by Heschong Mahone Group (2003a) that recommended certain quality of views including, as a minimum, a landscape layer with or without nature. As such the minimum number of layers according to WELL (IWBI, 2021) is one, and according to the SLL (2014) and EN17037 (CEN/TC/169, 2018) is two.

Other recommendations concerning distance are based on privacy issues in views through '*remoteness*', by allowing sufficient distance between buildings or avoiding windows directly facing each other. Littlefair has suggested a distance of 18 m to 35 m between buildings (Littlefair, 2011:p.25) for this purpose.

The bulk of the literature on assessing view quality focuses on how far a building should be placed from others to enable long distance and multi-layered views. Multiple points of interest can provide a stimulating view, but this approach has its limitations as the design of a building, within the context and the size of the site, is not always in control of the designers. Many studies have examined the relationships between low-rise views with ground

and landscape layers as adjacent contents (CEN/TC/169, 2018:p.33). As mentioned, in fact, in high-rise views the observers have to be seated next to the window to fully experience landscape layers (BRE Global Ltd, 2018), especially in relatively dense developments. Figure 2.2 illustrates this concept where the number of layers in view vary as a function of density (height) of adjacent areas. Only when the height of the adjacent building is lower (Figure 2.2 – c), the observer placed on the first floor of the building is able to access the sky layer. In Figures 2.2-a, and 2.2 b, the sky layer is not visible due to height (density) of surrounding buildings and the visual angle of observer.

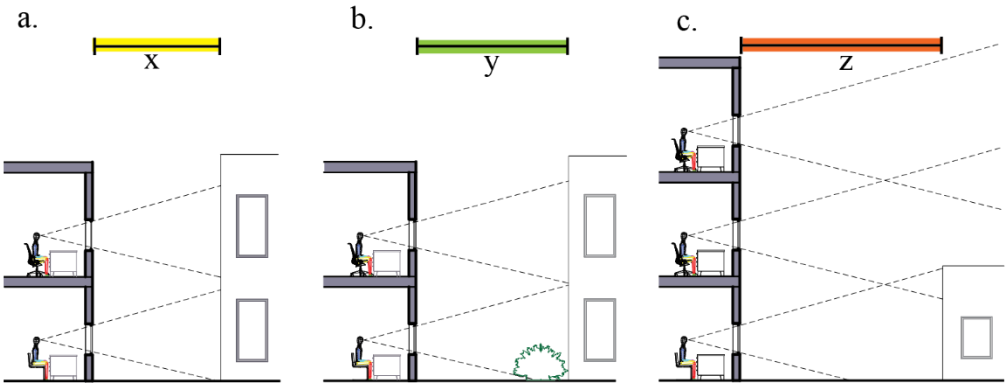


Figure 2.2 Number of layers as a function of building density. Hypothetical distances between elements in view are denoted by 'x', 'y' and 'z' where 'x' < 'y' < 'z'. Number of objects and layers visible in the view are also dependent on building heights and position of the observer in the building. (Source: Author)

Context

The site assigned for a project may come with a pre-existing context in which the architect is required to respond to the brief as well as to environmental challenges. The benefits of views overlooking nature outside

the building are supported by different theories (Section 2.3.1). However, frequently, it is a matter of whether the context in which a site is located has greenery or not. If the site is large enough, and the design brief includes large-scale master planning, then substantial greening efforts could take place within a site and between buildings. Views of nature could, therefore, be designed for their associated benefits.

The presence of natural features in window views results in higher scoring points in many sustainable building design regulations (USGBC, 2018, IWBI, 2021, FITWEL, 2020, CEN/TC/169, 2018). Regulations also encourage physical connections with nature, and the presence of trees and water, apart from just through a view out of the window (International-Living-Future-Institute, 2018). The provision of indoor plants are encouraged where outdoor views of nature are not possible (FITWEL, 2020). The minimum credit scores assigned to view with natural components are always higher in comparison with non-natural features (Heschong Mahone Group, 2003a). Research has shown that although view preference is positively correlated with the natural components of view (Adjusted R^2 - linear = 0.45), a non-linear trend analysis (Adjusted R – power = 0.53) showed that preference for a view increases with tree cover up to around 41%, after which it plateaus with a positive trend (Jiang et al., 2015). Scenes with vegetation that blocks the view, however, get a lower preference rating than views without obstructions (Meerdink et al., 1988, Hellinga, 2013:p.129). The reasons for natural preference and the upper limit of natural cover in the view are yet

not known. Nonetheless, a green-only window view out of a building is often not possible in cities.

In views overlooking urban environments, building maintenance, complexity and building age have been found to affect preference ratings (Herzog and Gale, 1996, Herzog and Shier, 2000, Wang et al., 2016). Frewald (1989) showed that, with a sample of buildings carefully selected and properly maintained, older buildings are generally rated higher in preference. Buildings that have classical or neo-classical features are associated with holding cultural importance. They are often attributed to host important civic institutions, such as museums. Herzog and Gale (1996) suggested that this preference only holds when older buildings are well preserved. The relationship between complex environments also entails subjective assessments. Research has shown non-linear relationships between preference and complexity in the external environment (see Section 2.2.1).

The European daylight standard EN 17037 suggests that, when composing the view out of a window, the perceived quality of the view is correlated with '*complexity, maintenance, age*' (CEN/TC/169, 2018). However, since the correlation between building age and preference appears to be mediated by maintenance, decisions to frame a view out might become ambiguous and requires further clarification.

Solar Orientation

Humans have been designing their shelters in response to the sun for a long time. The orientation of a building may require some additional insight for

designing windows for a view out, even if this could entail conflicting requirements with passive solar design principles (Littlefair, 2011). In design projects, the site is provided by the client with not much leeway in the positioning of the building, for example with reference to the road and existing site boundaries. Based on building and façade orientation, for example in the northern hemisphere, solar exposure in the South, and low angles of the sun in the East and West orientation, may cause risks of visual and thermal comfort. Figure 2.3 illustrates this concept in terms of solar penetration with respect to orientation. In the Northern Hemisphere, direct solar penetration is not possible through the North facing windows. Markus (1967) found that building occupants preferred to sit closer to the window in the coldest orientation (North-East) and farther away from glazed surfaces on the warmest side of a building (South-West), which conflicts with the symmetry of solar exposures, split around noon.

Visual and thermal discomfort from high solar gains and glare from low sun angles results in building users often closing off their blinds and curtains (Inoue et al., 1988, Hellinga, 2013:p.112), thereby making the view inaccessible (Inkarojrit, 2005). There is, therefore, a marked difference

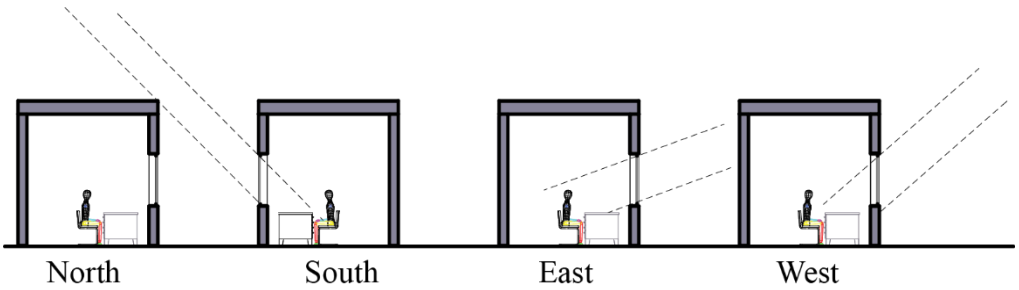


Figure 2.3 Solar orientation affecting the solar penetration in space through the space size of the window, in the northern hemisphere. (Source: Author)

in blind operation between orientations, with North facades requiring less occlusion than South, East and West (Van Den Wymelenberg, 2012). For a detailed review on this topic see Van Den Wymelenberg (2012) and Kuhn (2017).

When the blind is fully closed in response to the risks of discomfort, it also often impedes the view out. On these bases, recent interest in view clarity through blinds has been prompted. In response to blind operation issues, research has tested view clarity through solar shading fabrics (Konstantzos et al., 2015, Ko et al., 2017) with the sun in the field of view (Konstantzos et al., 2016, Yamín Garretón et al., 2021). Recommendations have been made for colours and opacity of fabrics to enable a view out when the shades are closed. A recent study comparing different types of shading devices concluded that the most preferred view is the one without any shade. Conversely, in the presence of a shading device, the difference between the systems adopted is not significant (Abboushi et al., 2020).

Right to view

The right to light is a legal entitlement of any individual property, which can be acquired to guarantee the lighting quality above sufficient levels (Littlefair, 2011:p.60). Legal rights to light, however, do not protect the rights of view. Nevertheless, in the UK, there is a legal precedent, whereas a proposed extension to a property was rejected as it was shown to block a view to the River Thames (PLC Property, 2008). View ordinances have been enacted by some cities around the globe to recognize and conserve the

scenic value of landmarks (Downtown Commission, 2007, San Francisco Planning Department, 2011, City of Vancouver, 2011, Greater London Authority, 2012, The City of Edinburgh Council, 2019). When designing for a view out with specific features, the changing context outside of a site should be acknowledged, which could require future projections of the area, especially in terms of the heights and uses of the surrounding environment.

Dynamic views and movement in the outdoor environment

Building regulations usually cite dynamism, movement, people and activity in a view. According to EN 17037, *"a diverse and dynamic view is more interesting than a monotonous view."*(CEN/TC/169, 2018:p.27). Similarly, in the UK, the Society of Lighting and Lighting indicate that, also at ground level, a window view is important due the movement of people and automobiles, since people's gaze is drawn towards these activities (SLL, 2014). The LEED View credit offers a choice of three parameters, out of which two are "*movement"* and "*flora, fauna or sky"* (USGBC, 2018), all offering dynamism and variation. If dynamism is explained in terms of environmental diversity, the outdoor environment is the best illustration. There is diversity at every scale, from human to the built environment, from the present time to the daily and annual cycles (Steemers and Steane, 2004). Even in experimental settings, human beings are known to have a preference for variability in the stimuli they are exposed to (Munsinger and Kessen, 1964).

Moreover, green landscapes, especially trees, invite birds and wildlife, and sometimes domesticated animals and pets could be the 'moving'

components in a window view. In fact, research shows that the preference for the same tree modulates over the course of the year based on differences in foliage and season (Zhao et al., 2017). The view of a single tree, for this reason, creates opportunities for detecting its changes over the whole year. Movement can be featured as an inherent characteristic of the objects in the view, such as the swaying of the tree with wind, a Ferris wheel, a wind turbine (Hübner et al., 2019), or night lights (Pohl et al., 2021). The sky also offers many avenues for variability in the view. Out of five different items – the weather, diverse impressions of the environment, a vast view, what happens outside, the time – the possibility to see the weather was found to be the most (85%) appreciated function of a view (Hellinga, 2013:p.120). Similarly, Christoffersen et al. (2000), in their study on daylighting and window design, reported that the ability to see the view outside, and appreciate weather conditions, were the most positive aspects of windows according to more than 1800 office workers. Also from an evolutionary perspective, acquiring environmental information on weather and time of day (e.g., changes in sunlight) has had a profound effect on the health and survival of the primitive human (Heerwagen, 1990) in (Tuaycharoen, 2006). Butler and Biner (1989) showed that a view allowing to keep track of time and weather is one of the key factors influencing window preference. This reveals a psychological need to connect with the variability in the outside view. Building regulations, therefore, respond by establishing minimum requirements for views to include environmental information offering

knowledge of location, time and weather (CEN/TC/169, 2018, SLL, 2014). Views with medium or excellent ratings should include people and nature.

People and automobiles have been a highly debated topic in terms of view preference. Many researchers investigating view preferences using view surrogates (Kent and Schiavon, 2020, Tuaycharoen and Tregenza, 2005) have deliberately chosen to exclude stimuli with people according to recommendations by the seminal literature on landscape preferences (Kaplan and Kaplan, 1989). However, there is an underlying bias associated with these studies, as they undermine the evidence that people make the core component towards the vitality, perception, and appreciation of urban environments. By aligning their hypotheses with natural landscape preference research, these studies might have missed the opportunity to better characterise view preference in the built environment. Lessons on how the presence of people contributes towards window view preference can be drawn from the literature in urban design and the seminal works by Jane Jacobs (1961), William Whyte (1980), and Jan Gehl (2011). The social life in the streets of a neighbourhood fosters vibrancy and represents the vital force of cities. Jacobs (1961) suggested a diverse kind of density in urban areas, which attracts people from different age groups and activities of both residential and non-residential nature for a round-the-clock urban vitality. According to Jacobs, the presence of people provides a dynamic and positive energy in the urban environment, facilitated through pedestrian infrastructure and places to sit, and relax. Similarly, Whyte (1980) videoed multiple urban squares in the US to determine patterns of human activity in

public spaces. People were generally found to attract other people. Further elements were the presence and movement of the sun, pedestrian infrastructure, places to sit, variety of building uses, which facilitated the interactions between people in outdoor spaces. Gehl (2011) introduced the concept of soft edges between buildings and outdoors, which allow for more interactive connections and communication. This concept of 'soft edge' best clarifies the role of windows in allowing a two-way view and providing a connection between people inside and outside buildings. Many recommendations exist on the lines of public safety borrowing from Jane Jacob's '*eyes on the street*'. Jacobs suggested that the diverse age groups of people in buildings can enable eyes on the street at all times, e.g., when the young adults go to work, ageing parents could still keep a watch out and contribute towards "*natural surveillance"* (Newman, 1973) or "*passive surveillance"* through windows in urban spaces (CPG, 2019, Auckland Council, 2019).

Similar to this concept, many dense urban commercial areas regulate the design of 'active store fronts' that are permeable and provide a feeling of 'pedestrian' scale. To this end, the activities on the ground floor are aimed to be less private, so that a clear visual connection could be maintained between the indoors and outdoors. In a cyclical way, the presence of people inside and outside buildings serve to support each other in the sense of safety or sensory input. Active fronts also mean active engagement and, therefore, if the building front is shown to be cared for and well maintained it contributes towards people's preference for the space and reduces the

chances of crime, thereby reflecting a sense of ownership. Yet only one guideline (IWBI, 2021) makes a recommendation on the distance between the ground floor window and the edge of road and parking to be a minimum of 7.5 m (25 ft).

Similar to people, traffic flow in a view has been a topic of debate in the past few decades, with proponents of natural landscapes suggesting that automobiles are disliked by observers and should be avoided in any environment. Hester (2013) proposed, in her doctoral research, through a hierarchical multiple regression analysis that the presence of traffic can be a positive contributor to view appraisal (Hellinga, 2013:p.123). Nevertheless, since this finding could not be supported by other research, a method was proposed for view quality assessment in which the presence of cars and traffic would lead to a negative score on view assessment (Hellinga and Hordijk, 2014:p.187). Using a qualitative approach to view appraisal, Mirza (2015) showed that the majority of participants in their study were indifferent to roads and vehicular infrastructure. In a small proportion of respondents, disliked features of roads were more often associated with acoustic preferences in residential windows than in work-related settings (Mirza and Byrd, 2020). Although parked cars are not the most pleasant sight, the positive or neutral effect of roads could be linked to '*locomotive permeability*', supporting the notion that a clear thoroughfare influences impressions of safety in a public space (Stamps III, 2005). Kevin Lynch (1960b) also proposed *'paths'* as critical components of our mental construct or

image of a city, while Camillo Sitte (1965) suggested that these paths could be designed in an artistic manner to instil a pleasurable experience.

Using dynamism and movement in the view as a design criterion will, therefore, require the definition of new indices and a better understanding of the several concepts involved.

2.1.2. *Intra Architectural Features*

Building standards prescribe that the view provision should be benchmarked against a minimum percentage of floor area of the space as 75% (USGBC, 2018) and 95% (BRE Global Ltd, 2018, BRE Global Ltd, 2016) of floor area, by a percentage of building occupancy (FITWEL, 2020), or by number of work desks. The WELL scheme requires 75% of all desks to be within 7.5 m of an atrium or a window with a view to the outside, or 95% of all desks within 12.5m from the peripheral window (IWBI, 2021). The design of a connection between the inside and the outside is encouraged to enhance the well-being of the occupants (International-Living-Future-Institute, 2018, IWBI, 2021).

View direction

Whether the observer is facing the window or not, perpendicular to it or in the opposite direction, greatly affects the amount of view available (Stone and Irvine, 1994). View direction was found to be the determining factor for differences in observers' reported relaxation and excitement (Boubekri et al., 1991). Abboushi et al. (2020) found that the desk layout

(parallel or perpendicular to the window) affected the subject's self-reported interest and view quality rating. The direction in which the observer is facing in relation to the window defines whether the person is able to access the view from within their field of vision, while performing a task in the room (Figure 2.4). The risk of experiencing direct glare can be obviously reduced if one is not facing the window. Accordingly, the WELL scheme (IWBI, 2021) recommends that all computer screens at desks located within 4.5 m (15 ft) from the windows should be oriented within a 20° angle perpendicular to the plane of the façade, in order to minimize glare caused by incoming sunlight. Yet, this is a recommendation not generally embedded within most building guidelines.

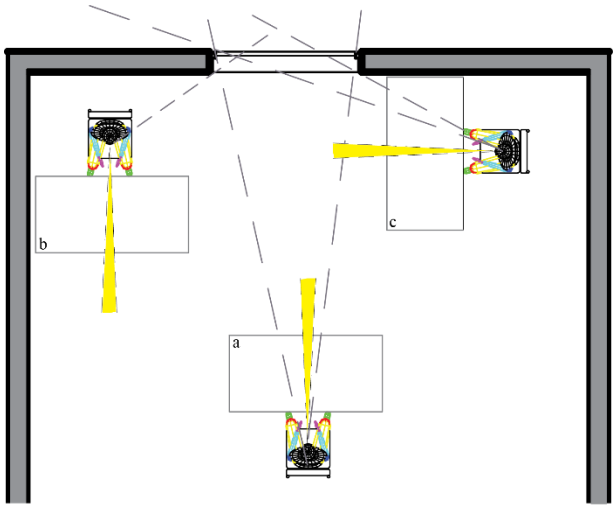


Figure 2.4 View direction in the room. Dotted lines indicate the direction of the window view in reference to the person's orientation and the yellow bands indicate the central 5 degree of visual field when the person is facing forward (Source: Author)

Size of view and position in space: Visual Angle

The window-to-wall ratio (WWR) has long been used as a metric to define the size of windows in response to solar, thermal, acoustic, and visual requirements in buildings. Building regulations on window views, in comparison, are still at their infancy and require including the position of the viewer/observer in relation to the window. In addition, the perceived size of the window depends on both its actual size and the distance of the observer to the window. Therefore, another metric used to define the size of the window is the visual angle. The WWR, the distance from the window and the visual angle perceived by the observer are all linked parameters. To illustrate this concept, Figure 2.5 shows how, within the same WWR, the distance between the observer and the window, and its shape, determine the horizontal visual angle. The WWR – window to wall ratio - is the same in Figure 2.5-a,-b,-c,-d while Figure 2.5- a and Figure 2.5- b are horizontally-oriented windows and Figure 2.5- a and Figure 2.5- d are vertically-oriented windows. The observer 'x' in Figure 2.5- a and Figure 2.5- c is seated adjacent to the window. Observer 'y' in Figure 2.5- b and Figure 2.5- d is seated at a distance from the window. Even when the WWR and position of the observer is the same (in Figure 2.5- a and Figure 2.5- c), the shape of the window affects the visual angle. While, for the same shape of window, and WWR, the position of the observer affects the visual angle of view.

The distance from the window affects the satisfaction with the daylight conditions and the view out (Christoffersen et al., 2000, Verderber,

1986, Heschong Mahone Group, 2003a, Charles and Veitch, 2002), and influences people's preferred window width (Ne'Eman and Hopkinson, 1970) and seating choices in the room (Wang and Boubekri, 2010). Hellinga (2013) suggested a

distance of at least 1.5m from the window in order to properly assess the view out (p.186). Hellinga (2013) tested whether being closer or farther away to/from the window – within 0-2 m and at more than 2+ m – added value to the window view assessment. However, the distance between the workplace and the window was not found to be a significant predictor of view appraisal (p.124). Despite these ambiguities regarding where exactly a person needs to be seated to appreciate the view out of a window, it is obvious that the distance to the window makes the view inaccessible at a position far away from the facade. Accordingly, LEED (USGBC, 2018) recommends that building occupants should be located at a distance that is no more than 3 times the head height of the window so as to benefit from the view out. This implies

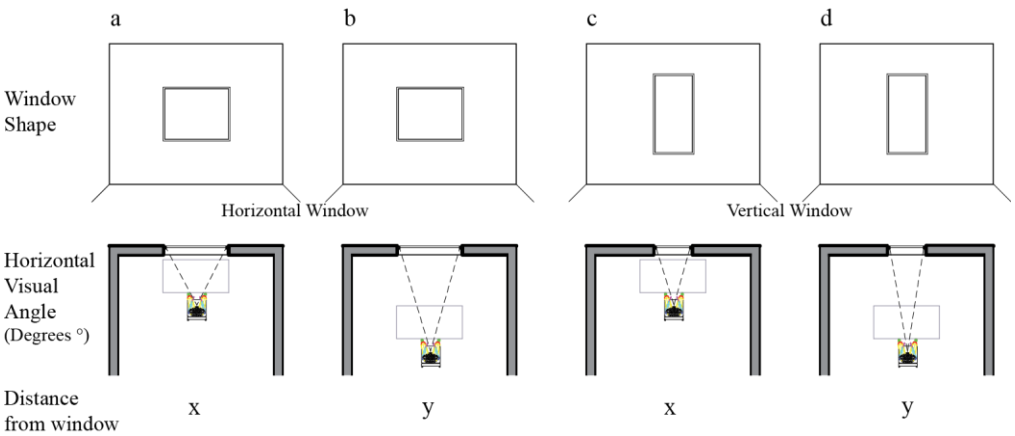


Figure 2.5 Relationship between WWR, distance and horizontal visual angle. The horizontal visual angle of all 'a', 'b', 'c', and 'd' conditions are different. (Source: Author)

that, if the window is vertically orientated, the distance within which occupants need to be seated has to be higher than if the window is horizontal and/or at head height. In other building guidelines, views are assessed for observers seated within 8 m (BREEAM, 2018) and 10 m (WELL v2) from the window. The Fitwel scheme offers the most strict limitations, requiring workstations to be within 6m (20 ft) of unobstructed views (FITWEL, 2020). Proximity to the window has been a significant positive predictor of satisfaction in space and, regardless of where one is seated in relation to the window, the size of the window also determines the amount of view out.

Many studies evaluating the size of the window for the provision of a view out (Markus, 1967, Ne'Eman and Hopkinson, 1970, (Keighley, 1973a, Keighley, 1973b) and visual satisfaction (Ludlow, 1976) have returned inconclusive outcomes on the value and range of window-to-wall ratios. Ne'Eman (1970) proposed 35%, Keighley (1973) suggested 25–30%, and Ludlow suggested the preferred window size at 50–80% of the wall for visual satisfaction. In line with this line of thought, building guidelines proposed window-to-wall ratio (WWR) in relation to occupants' position with respect to the view window. In the SSL, BREEAM International 2016, and BREEAM 2018, the assessment of view size is based on WWR and distance from window(dist), presented as WWR (dist): 20% (for dist. ≤ 7m), 25% (for dist: 8 m-11 m), 30% (for dist: 11 m – 14 m), and 35% (for dist. >14 m). These specifications differ based on building type (e.g., for residential).

Adding to this discussion, Butler and Steuerwald (1991) found that larger windows were more appreciated for preferred scenes and that room

size had a substantive effect on window size preferences. In general, they found that the preferred window size is not a constant percentage of wall surface, but rather it might be smaller for larger rooms. Cetegen et al. (2008) also found a positive non-linear association, plateauing at 50-60% of the relative view size, between view size and the ratings on window view pleasantness and satisfaction with view.

Another common metric to measure the size of the window is the visual angle. To explain the implications and importance of visual angle as a metric to measure view size, Figure 2.6 illustrates the human visual field, and the synchronous operation of two eyes, leading to a combined (binocular) visual field that particularly enhances horizontal vision. In Figure 2.6, the binocular visual field is illustrated in terms of visual angles. As you can see, the central field or fovea – only about 5° (degrees) – is in sharp focus at any given time. Even when only the central visual field is 100% sharp and acute, the para central vision (5°-8°), although not in sharp focus, builds the context or the big-picture of the object that we are looking at out of the window. The peripheral field of the human eye, made up of the near peripheral (5°-30°), the mid-peripheral (5°- 60°), and the far peripheral (5°-110°), builds the context in which the eye is able to detect shape, colour and motion in these visual ranges, respectively. In this context, therefore, the view is primarily experienced through the human visual senses and what is seen in the view depends on what is available for the eye to explore. The visual angle as a metric then neatly explains how much of the visual field is going to be engaged by the view out of the window.

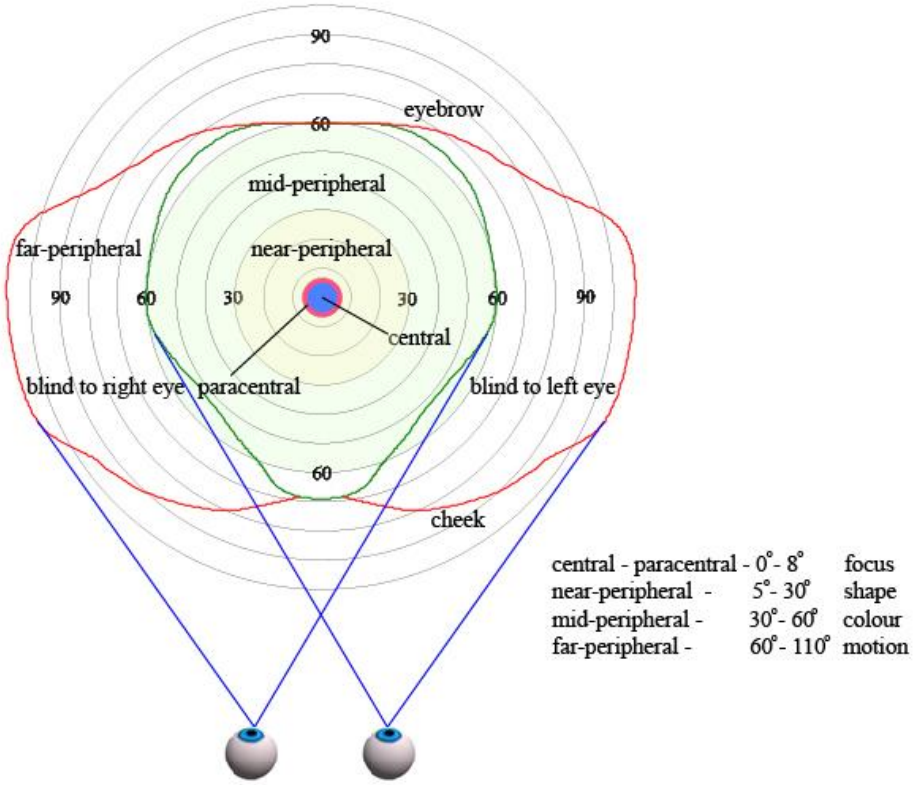


Figure 2.6 Human binocular visual field expressed in degrees from the fixation at 0 degree. Adopted from Boyce (2014:p.44)

On these bases, building regulations suggest a minimum size of view through visual angles. Since two of the building guidelines, LEED (USGBC, 2018) and WELL (IWBI, 2021), refer to the view factor calculations by the Heschong Mahone Group (2003a:pp.47-50), Figure 2.7 illustrates the concept of view factor depending on the (range of) visual angles prescribed in this method. In addition to the visual angle, this method also assigns a value to the view based on whether the content is natural or non-natural, with the former getting a higher score than the latter. The minimum benchmark of view factor (Heschong Mahone Group, 2003a) is 3 for a view credit in both LEED (USGBC 2018) and WELL (IWBI, 2021), meaning that the minimum visual

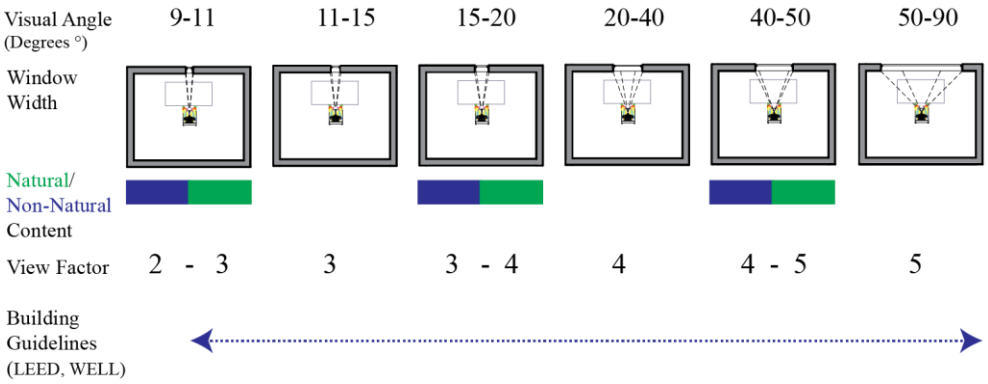


Figure 2.7 View Factor as understood in terms of the range of the horizontal visual angle and natural (green) and non-natural (blue) content of view (Heschong Mahone Group, 2003a:p.50). LEED (USGBC, 2018) and WELL (IWBI, 2021) building guidelines support a view factor of 3 or higher.

angle acceptable is 9° with a natural view and 11° with a non-natural content in the view. While the view factor calculations proposed by the Heschong Mahone Group (2003a) used a visual angle that could be either horizontal or vertical, other building regulations prescribe minimum threshold values for visual angles that are either horizontal (14°) (CEN/TC/169, 2018, SLL, 2014) or vertical (30°) (IWBI, 2021).

Shape and frame of view

Studies comparing the preferred shape of a window found that horizontal views are generally preferred (Dogrusoy and Tureyen, 2007), especially in office environments (Keighley, 1973a, Ludlow, 1976). A horizontally shaped window complements the extent of the horizontal visual field (Figure 2.6) and, therefore, lets the observer perceive the maximum amount of view. However, building guidelines are more concerned with the quality and content of the view than the shape of the window. According to

BREEAM 2018, the view out at seated eye level (1.2m–1.3m) must contain landscape or buildings (rather than just the sky) (BRE Global Ltd, 2018). The EN 17037(CEN/TC/169, 2018) and the SLL (2014) recommendations state that the minimum view content should contain at least two layers, landscape with sky or ground. The WELL standard (IWBI, 2021) suggests that, as a minimum, the view should feature the sky or the ground layer. However, as discussed in the previous section (Section 2.1.1), the number of layers in the view are often based on the exterior context in which the building and the window are placed. Nonetheless, considering the emphasis given in building regulations to the inclusion of more layers, vertically-oriented windows are often favoured. Markus (1967) suggested that a vertically-oriented window may capture more variability in the view, but this is also dependent on the position of the observer. Markus explained that for a bed-ridden patient, the change in visual angle may be too small for a vertically-oriented window to maximise the variation in view. Therefore, the shape of the window should primarily be dictated by the objectives of the design. Additionally, the height of the window may have repercussions on the overall depth of the space that defines the view access, according to LEED (USGBC, 2018).

Moreover, Markus (1967) found that people occupying the lower floors of a multi-storey building preferred to have views on ground activities, in comparison to the floors above. The study posited that this may be due to their sense of familiarity with their view of the ground. The challenge for shaping and orienting windows may also shift according to the views available on the different floors of the building. For windows aiming to frame

a view of the ground, the windowsill level would have to be designed accordingly. Verderber (Verderber, 1986) found that the distance from the window and the sill height led to feelings of inadequacy in relation to the window. Similarly, viewing the sky from lower floors may require raising the top of the window to get maximum vertical exposure. However, the placement of the view, and framing it in a shape, depends on the available view on the site, and currently no methodology exists to include this in the design process.

Choice of window pane and shading devices

A clear scene is the most preferred view out of a window. Yet, in architectural practice, there are multiple choices of external and internal shading devices, as well as types of glass that could be used in the windows. Research to this end has consistently demonstrated that a clear view is always preferred over a view that is hindered by patterns or tints in the glazing, as they might alter the quality of the view seen by the observers. Building regulations respond to this by suggesting that the view glazing should be clear, neutrally-coloured, and should not have any frits, fibres, patterned glazing or tints (CEN/TC/169, 2018, USGBC, 2018).

Standards in the design of shading devices also reinforce the importance of *visual contact* with the outside world as '*the capacity of the solar protection device to allow an exterior view when it is fully extended*' (BSI, 2021:p.20). This is affected by the lighting conditions during the day. As explained in Section 2.1.1, solar penetration can cause visual and thermal

discomfort. In response, researchers are testing blind materials that allow for a view out while the blinds are closed (Konstantzos and Tzempelikos, 2017). Konstantzos et al. (2015) proposed a new view clarity index for shading fabrics, based on the shading material, openness factor, and the visible transmittance of the fabric shade. This index varies in range from 0 (diffused shading) to 1 (no shading).

The utility of using fabrics instead of blinds can be based on consideration of many other factors, such as incidental radiation, darkening performance required, glare control, privacy (especially at night), visual contact with the outside, daylight utilization and visibility of colour (BSI, 2021). Figure 2.8 illustrates the concept, whereas the choice of blind, roller, horizontal and vertical, may hinder the view clarity in open and fully closed positions. The percentage of the opening of the blind will affect the quality of view accessible to the observer.

There are other limitations towards achieving an open uninterrupted

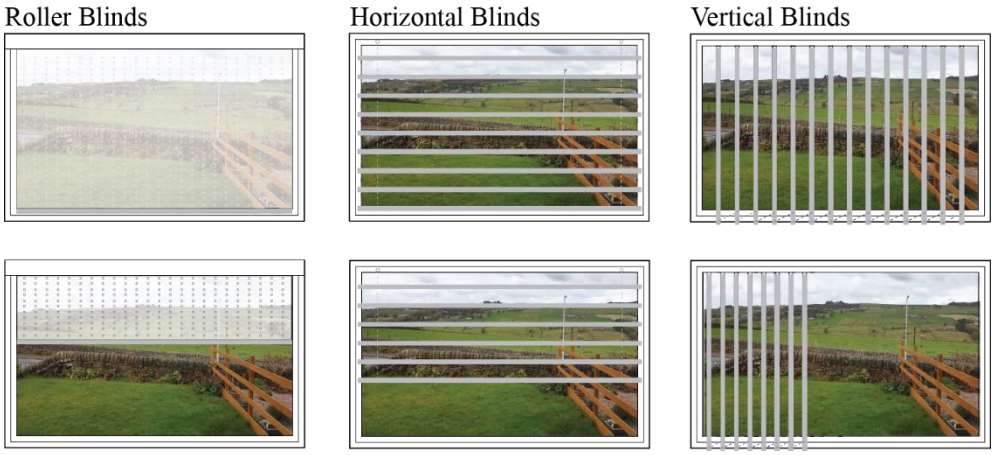


Figure 2.8 Concept to illustrate the choice of blinds limits the view accessible by the observer (Source: Author)

view in a given window. The tinting properties of glass – e.g., thermochromic or electrochromic glass – may affect the colour perception of the viewed scene. The material properties – e.g., the strength of glass-pane and the associated costs of glass – contribute towards the selection of the width and height of glass panes that compose a window. For example, as illustrated in Figure 2.9, a window may be designed with glass panes of different widths, and supported by mullions of specific thicknesses and materials, also known as the frame factor, the ratio of glazing to frame. The design of window mullions is important because the density and thickness of a mullion could break the view and make it look incoherent (Keighley, 1973b, Markus, 1967). The horizontal bands in the mullion also break the view. For example, a horizontal band of window mullion that conceals the horizon (Figure 2.9 - c)is generally much less preferred than if it occurred within a layer of landscape (Figure 2.9-a,-b,-d). This is also dependent on the viewer's position in the space and the visual angle, to assess which parts of the view are being

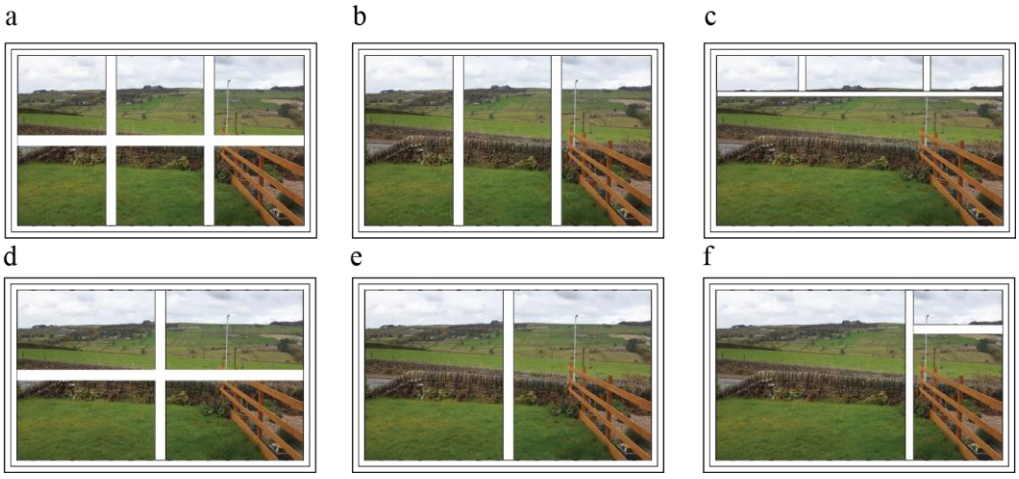


Figure 2.9 Mullions in the window divide view (Source: Author)

obstructed (IJsselsteijn et al., 2008).

External shading devices are sometimes integrated into the building envelope. More recently, adaptive facades can respond to changing environmental conditions and multi-objective user demands (e.g., daylight, glare), simultaneously. However, the more prominent these facades become, the less view is visible of the outside, altering both view clarity and quantity.

2.1.3. *Concurrent interest in window views*

Since the start of this doctoral research in 2017, several other studies have investigated topics related to the characterisation of window views. Some of the questions may have overlapped and are, therefore, important to include in this review of the existing literature on window view preferences and associated behaviours.

The most important development in this domain has been the launch of the already mentioned EN 17037 code that incorporates a specific criterion for view out (CEN/TC/169, 2018). This design guideline sparked a lot of interest in research on the topic (Kuhlenengel et al., 2019, Waczynska et al., 2021, Kent and Schiavon, 2020).

Kuhlenengel et al. (2019) used the EN 17037 framework to test for its impact on student performance in reading and mathematics within real classrooms. They found that the number of layers is a significant predictor of reading achievement, based on the view interest and human activity in the view. They also concluded that outside distance of view was inherently

related to the number of layers and, therefore, a redundant metric. The increased horizontal visual angle corresponds to high window surface areas and might result in excessive solar exposure. Vásquez et al. (2019) also analysed the responses of children to a classroom environment through interviews and drawings and concluded that natural features in views were more preferred by them. The preference for specific features in the view, however, changed with age. Since the distance from the window changes the visual perception, view distance could be enhanced by using photographic material.

Kent and Schiavon (2020) used the framework presented in EN 17037 (CEN/TC/169, 2018), with window view surrogates in a laboratory setting, and analysed subjective ratings on three variables: connection to the outside; visual content; and visual privacy. They repeated the study through an online survey platform to compare the results. Their findings suggest that nearby natural features can be incorporated into the view even when long distance views are not available. Subjects in this study were required to infer and rate temporal information from photographs of scenes – e.g., sky and weather condition, time of the day, visual contact with other dynamic information seen outside. Study participants were also required to rate visual privacy from these images, defined as the "*unwanted feeling of being observed by people from the outside on a frequent basis*" (p.8). The stimuli, however, did not include any presence of people.

Waczynska et al. (2021) adopted an experimental simulated approach, based on EN17037, to collect subjective assessments of view

preference. They found similarity of assessment on the number of layers but not on the horizontal view angle. They concluded that, for the same view, subjective evaluations from human subjects were lower in comparison to assessments based on the mathematical model derived from EN17037.

In other workplace studies, view factors have been found to have significant and positive effects on occupants that have access to windows (Achoba et al., 2020). Views with street activity and green elements at ground level were shown to have a similar rating on preference and restoration to that of a view of the sky (Masoudinejad and Hartig, 2020). In her doctoral research, using both subjective preference rating and physiological measures in an experimental lab setting, Won Hee Ko (Ko et al., 2020b) showed that the perception of thermal comfort was also affected by the presence of a natural window view in the space. Ko et al. (2020a) have also been working on a view assessment framework, the final publication of which is not available at the time of the writing of this thesis. In a study on vernacular Chinese windows, Zhang et al. (2019) found that the type of view out significantly impacted the selection of window shape, although natural features within the view diminished this effect. They recommended that even if energy requirements guide the window-to-wall ratio, the shape of the window should be designed in response to the view out.

With new technologies and internet accessibility, ICT-based methods have started to be used in window view assessment. van Esch et al. (2019) used an online survey to evaluate office workers' perception of their own view out of the window. They measured the effect of naturalness and

environmental properties of views – including prospect, refuge (Appleton, 1975) and the four preference indicators (Kaplan and Kaplan, 1989) – on productivity and restoration. They found that environmental properties predicted restoration outcomes more than the naturalness of the view. Using an online survey, Nezamdoost and Nezhad (2020) asked patients in health-care settings in four cities – Portland, Boise and Phoenix in the United States, and Mashhad in Iran – to evaluate samples of pre-selected photographs of window views collected from the web. They confirmed that long-distance and natural views, especially featuring water, were most preferred. However, certain aesthetic qualities of urban environments also make them likeable. They showed that, in urban views, industrial settings and cars were least preferred.

Recent research on window views has also drawn its attention to using new visualisation media for experiments. In a doctoral research on outdoor views, Francisca Rodriguez (Rodriguez, 2021) proposed a new method to characterise urban views, and their dynamic lighting component, in a Virtual Reality (VR) environment. Through a series of methodological procedures derived from computer science, she developed the ability to visualise dynamic lighting conditions in VR (Rodriguez et al., 2020, Rodriguez et al., 2021b). In simulations of outdoor views under dynamic lighting, participants rated the view higher on preference, recovery, and imageability. Positive ratings toward views were strongly mediated by the presence of luminous changes as presented in the VR environment (Rodriguez et al., 2021a).

A further doctoral thesis on window view perception using VR was conducted by Fedaa Abd-Alhamid (2020). She developed a method to evaluate window view perception in a virtual environment (Abd-Alhamid et al., 2019). Using multiple outcome measures, including subjective assessments and physiological measurements, a significant effect of distance from the window on view perception was detected (Abd-Alhamid et al., 2020). The sky component was only visible next to the window and played an important role in view quality evaluation. An objective measure of stress relief showed a 71% reduction in skin conductance when participants in the VR were located closer to a window than at the far end of the simulated room.

Following up on this method, Flor et al. (2021) tested the aspect of view clarity through ETFE double skin facades and found that clear glazing received the highest ratings on view perception and emotional measurements. Using VR, another study on subjective assessment of windowed spaces (Moscoso et al., 2020) concluded that window size affects people's spatial perception. While Yeom et al. (2020) tested task performance and psychological satisfaction in VR spaces with differently-sized windows. They found that, although a WWR of 60% was the most beneficial for both outcome measures, the results varied as a function of solar orientation.

Petersen et al. (2020), in a recent VR study, used short videos to simulate the view out of three different settings. They found that, although natural content was always preferred over urban scenes, particularly through

large windows, the presence of mixed features (urban + natural) led to lower perception of privacy in all three settings. The paper aimed to compare a calculated score of visual privacy and view out based on Purup et al. (2017) with the score received by test participants. The method used an area-based weighting mechanism, where different components of view are broken down by the area they occupy within the frame. Subjective ratings were collected on each element in the scene and multiplied to its weight (area) to create a cumulative score. Elements such as buildings, trains and roads were perceived as bringing a higher risk of privacy issues.

Lisa Heschong's recently-published book '*Visual delight in architecture'* has made a profound case for daylight and view out as a necessary component of our lives (Heschong, 2021). In her book, Heschong weaves through biological, historical and cultural narratives on our connections with, and needs for, views outside. There are many observations and reflections within this thesis that share similar intent and inspiration to those that can be found in her book.

2.1.4. ***Extraordinary circumstances***

Most of the research on window views examines typical real-world circumstances, with most building guidelines being specific to office and learning environments. There are often distinct or differentiated guidelines for window views in other settings, for example those that imply prolonged periods of forced or voluntary confinement such as prisons and trauma

centres in hospitals. Due to their specific programmatic needs, and the barriers to participant accessibility, these building functions are mostly under-studied. Some of them may not even have windows, due to design or security constraints, therefore making it difficult to draw an analogy with a windowed environment.

During the course of this doctoral research, a world-wide pandemic broke out threatening the pursuit of the work, but also presenting an unprecedented and extra-ordinary opportunity. The sudden outbreak of the SARS-CoV-2 virus across the globe in the first half of 2020, in fact, imposed strict confinement and social distancing measures in many countries, as a means to limit the spread of the coronavirus disease (COVID-19) and reduce pressure on public healthcare systems (Wilder-Smith and Freedman, 2020). In some countries, even if no lockdown had been imposed, many people chose to stay at home and limit their contact with others (Chauhan and Singh, 2020). While these measures have helped to contain, at least partially, the spread of the pandemic, several questions have emerged in terms of the impacts that the lockdown might have had on the wellbeing of people.

For example, personal space encroachment (Wang et al., 2020), solitary living for extended periods of time (Odriozola-González et al., 2020, Mackolil and Mackolil, 2020), working, schooling or exercising from home, etc., may have blurred the conventional notions of space and time, while reduced social contact might have affected people's feelings. With respect to this research, the social distancing measures enforced during the first half of 2020 offered the opportunity to study a condition of lockdown and help

investigate the characteristics of confined environments, especially in relation to the views and connections with the outside. From an evolutionary perspective, human beings have spent most of their time in outdoor environments. Therefore, different forms of confinements may elicit a response especially in terms of their relationship with the windows. Some examples of literature studies under extraordinary circumstances are described below.

In many experimental studies on window views, a baseline condition is set to be a windowless environment, to be compared with the one with a view out (Stone, 1998, Jamrozik et al., 2019, Ko et al., 2020b). In 17th century England, a tax on windows was imposed (UK Parliament, 1696). The tax stands as a testament of the role of building regulations on human health. The tax was originally intended to impact the wealthy owners of buildings with large windows. However, it ended up striking the poor who could not pay for a window. This led to new buildings being erected without any windows, while windows in existing buildings were being bricked up. The tenets of these windowless environments faced gruesome consequences for 150 years (Blakemore, 2018). Nonetheless, the window tax resulted in the coining of the term '*daylight robbery'* and became the first known time when the strategic design of windowless environments led to poor health and mental conditions in the society (Crook, 2021). Even today, remnants of the tax can be found in the form of blocked-out windows in historic buildings across England (Figure 2.10).



Figure 2.10 Window tax resulted in plastered windows, London, 2021. (Source: Author)

Although contemporary building regulations encourage and enforce the design of windows for daylight, some tasks and environments are prone to less proximity to windows. Nichols (1977:p.76) found that 91% of the survey respondents without window views in their workplace travelled outside their office, or through other areas in the building, to a window with a view out. They also found that 20% of the respondents frequently made a trip outside from a windowless environment. Workers made more non-work-related trips away from their desk if they did not have a window in their workspace. 67% of survey respondents without windows admitted having no effect on the lack of connection with the outside world based on the floor of the building, while 60% of those who had worked in a windowed space said it made a difference to them, with a preference to work closer to the ground floor. 72% of building occupants with claustrophobic tendencies stated that windows were important to them. Nagy et al. (1995) found that survey

participants from underground offices rated the importance of having a view much higher than those from conventional workspaces. Windows and views in spaces provide the necessary sensory stimulation that humans need to prevent experiencing placid and boring environments. A lack of windows, therefore, might result in adverse psychological consequences, with research showing that occupants of windowless offices decorated them with more than twice as many visual materials (Heerwagen and Orians, 1986) and saw their jobs less positively than those occupying spaces with windows (Finnegan and Solomon, 1981).

People who are not able to access the outside may mediate their relationship with the external environment through the window. Musselwhite (2018) studied the effect of view out on elderly residents who were house-bound. The study found that residents use the dynamics and stories from the people visible in the view to relate with them and generate new narratives. There is a need for both expected and new accidental information in the view for these residents, which they enjoy observing through the window. Similarly, Baird and Bell (1995) recalled the accounts of the preferences expressed by a leukaemia patient in an oncology ward during their weeks of isolation and the relationship formed with the view out of the window.

A window with a view out has been demonstrated to affect patients' experiences in hospital environments (Ulrich, 1984, Verderber, 1986, Verderber et al., 1987, Keep et al., 1980, Gbyl et al., 2016). The movement towards evidence-based design in healthcare (Cama, 2009) started with

Ulrich (1984), who compared the positive effect of views of a natural scenery (trees) on the recovery of 23 patients from gallbladder surgery with respect to patients, in similar conditions, who were assigned to a room with a view of a brick wall. Ulrich showed that, in comparison to the wall-view group, the patients with the tree-view had shorter post-operative hospital stays, had fewer negative evaluative comments from nurses, took fewer moderately strong and strong medication, and had slightly lower scores for minor post-surgical complications.

Verderber (1986) showed colour photographs to staff and inpatients of physical medicine and rehabilitation (PMR) units from 11 hospitals. Verderber noted that the most preferred window views among patients and staff were those of plants, the surrounding neighbourhood, people and those that provided information about outside activities. In contrast, window views of architectural features (i.e., concrete buildings) or monotonous views were not preferred. Similar results were found by Nezamdoost and Nezhad (2020), who ran an analogous study in two different countries by showing hospitalised patients photographs of outdoor views.

Literature on the perception of windows in prisons and correctional facilities is scarce. However, Moore (1981) showed that prison cells with window views of grass and trees were associated with fewer prisoner sick requests.

It is rather unconventional to include residential buildings in this category of space typologies. However, residential areas have their own challenges in two ways. Firstly, the idea of privacy is usually attributed to a

residential context (Saunders and Williams, 1988, Mallett, 2004), although the expectations of residents may differ based on their circumstances (Willems et al., 2020) and desire to connect with the members of their community (Parsell, 2016). Of those who live in multi-storey buildings, people prefer to live in apartments at a height taller than their neighbouring buildings to provide privacy (Yuen et al., 2006). People often prefer to live in the highest apartment in a building for the same reason (Conway and Adams, 1977). More than 50% of 173 survey respondents in Hong Kong said that they closed their blinds and curtains for privacy (Siu-Yu Lau et al., 2010). When privacy is the most important aspect, blinds can hinder daylight access and view out. The study also revealed that, while people prefer to have a view out of the living room, most people keep their curtains shut in the bedroom (Siu-Yu Lau et al., 2010).

People living in mid to high rise apartment buildings might feel physically disconnected from the outdoors. A recent study measuring the brainwave patterns associated with emotional states found that the effect of green cover in the view was more pronounced in residents of higher floors (Olszewska-Guizzo et al., 2018). Within high-rise buildings, parents are usually less satisfied in higher floors as they are less likely to be within supervision and calling distance of their children on the ground outside (Pollowy, 1977:p.152). In another study, residents of high-rise buildings were more satisfied if they physically interacted with the outside and neighbourhood, and the satisfaction with housing was higher in low-rise residents who liked their housing and neighbourhood better (Nahemow et al., 1977:p.177).

2.2. Theories supporting window view preference and behaviour

The understanding of window view preference draws on literature from different disciplines, including (but not restricted to) environmental psychology, psychology, vision, urban design, and planning, building design and human behaviour. Nasar (1997) defined an aesthetic response to a stimulus as the *'favourable evaluative effect experienced in relation to the environment'* (p.153). As seen in Figure 2.11, the three areas of literature that this section draws upon are the *subjective preference appraisals* of outdoor landscapes, *personal dispositions* (emotional and cognitive) in relation to the view outside and physiological responses, and changes in *behavioural gaze response* to the view. Most of our current understanding of window views draws on theories anchored in landscape preferences, based on the properties of outdoor views. In order to understand how a person views the outdoor scene from a window, it is useful to understand how their gaze behaves in response to the environment (e.g., how long one looks at a scene or what features attract their gaze more often). In addition, a person may have predispositions to react towards an environment based on their socio-cultural backgrounds and/or past experiences, for example, feelings of aversion or fondness based on previous knowledge (Mirza, 2015). Since these themes are all related to how people appraise and react to outdoor views, there will be overlaps in the ideas discussed, with the common denominator being the responses and behaviours of humans.

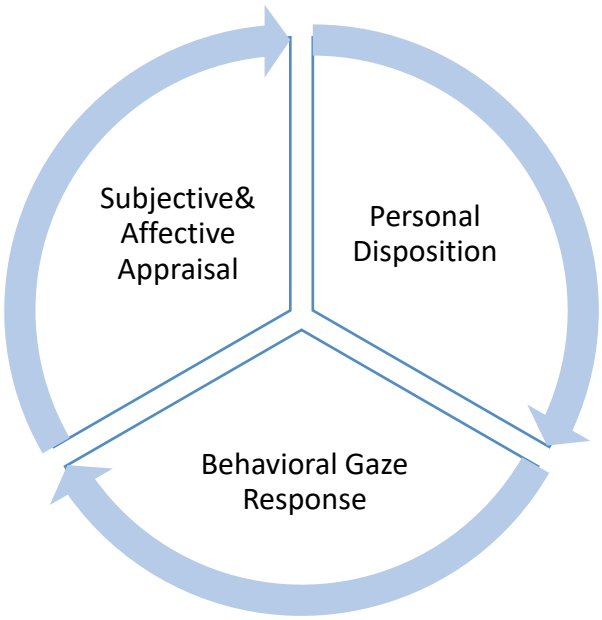


Figure 2.11 Theoretical paradigms informing window view preference studies (Source: Author)

2.2.1. ***Subjective and affective appraisal of landscapes***

The proponents of theories on the affective appraisal of the environment attempt to identify patterns of preference across different groups of people, for different types of views. This section discusses some of the most popular studies supporting the current knowledge on landscape preference.

Light reflected from an object and reaching the eye is perceived and processed by the brain. According to one perspective on the perception of scenes, this implies that one has to first perceive an object and then the brain will classify it; thereby, perception precedes classification (Mitrovic, 2013). Based on this, the eye is tasked with passing information to the brain. Along

this line of thought, Gibson (1986) posited in his theory of '*affordance*' that the quality of the environment is 'directly' perceived by a human based on its affordances. Gibson (1950) theorized that an observer's own culture, experience and expectations have no effect on their perception. Rather, it is the properties of the environment to afford a reaction. This concept of affordance of food, shelter and shade, found in the natural environment, led to the further development of other evolutionary theories.

Such evolutionary theories anchor on the idea that humans have a predisposition to prefer landscape features through "*genetic inheritance"* (Nelson et al., 2001:p.316). This plays a central role in the development of the biophilia hypothesis (Wilson, 1984) and in theories such as the prospect-refuge (Appleton, 1975), savannah (habitat) (Orians, 1980), information processing (Kaplan and Kaplan, 1989), attention restoration (ART) (Kaplan, 1995), and stress reduction (SRT) (Ulrich, 1991). While all of these theories are important contributors to the scientific discourse, the most frequently cited in window view preference research are presented below in greater detail.

Appleton (1975) explained that environments allowing humans to see without being seen are favoured due their evolutionary benefits from the hunter-gatherer stage of development. *Prospect* (the ability to see) and *refuge* (hiding spot) have been used as predictors for landscape preference in many studies. A contemporary analogy is being able to see someone from the window, without necessarily wanting to be seen back, for example a window looking over a busy street (Figure 2.12). *Prospect* is often translated to the

depth of field/view or openness of the view, which translates to the brain's predisposition to prefer scene depth (Nag et al., 2019). While open and long-distance views are preferred (prospect), the interpretation of a hiding space (refuge) in contemporary window views is rather reversed. In the original interpretation of *refuge*, a hiding spot would enable the person to seek protection in the physical space against enemies and weather. Conversely, having elements with refuge-like elements in a window view might lend to a negative implication, with higher emotional exhaustion and apprehension in office workers (van Esch et al., 2019). Even within natural settings, research has found that environments with high levels of prospect and low levels of refuge are restorative, but the opposite (that is, high refuge and low prospect) led to attention depletion and negative moods during a walk in a forest (Gatersleben and Andrews, 2013). In outdoor urban environments,

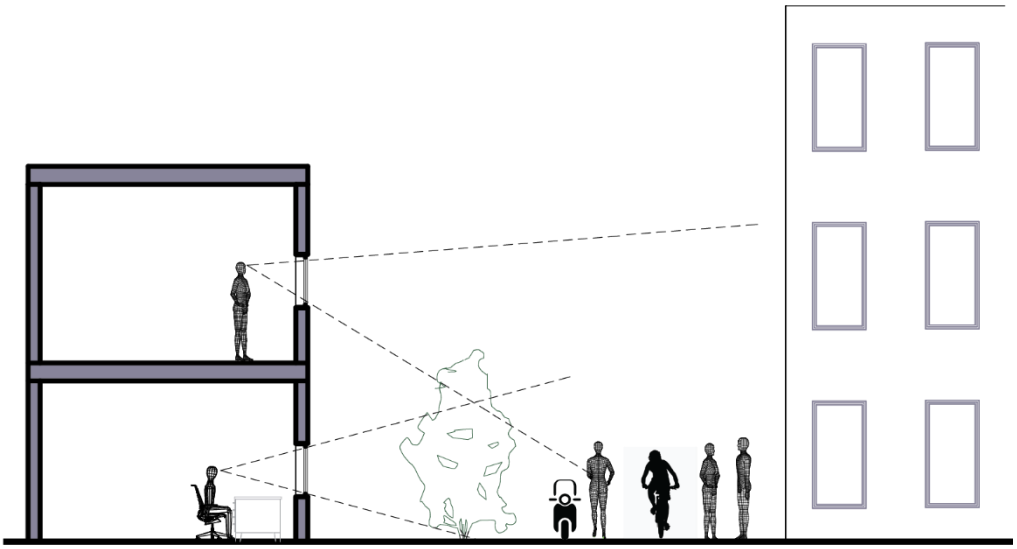


Figure 2.12 Prospect and refuge: The window and screening elements such as the tree provides sufficient barrier to 'hide' and observe the 'prospect' of outdoor street scene (Source: Author)

hiding spots offer perceptions of danger and feelings of fear (Gatersleben and Andrews, 2013). Existing evidence on the role of refuge, therefore, appears to be conflicting (Stamps III, 2008a, Stamps III, 2008b) and operationalisation of variables tends to be inconsistent (Grahn and Stigsdotter, 2010).

Another psycho-evolutionary model for natural scene preference was proposed by Stephen Kaplan and Rachel Kaplan at the University of Michigan in the 1980s. Since the University of Michigan stood at the core of the Earth Day movement, it is not surprising that, through the joint efforts of students and faculty, proposals for natural landscape preservation came out of this institute. Kaplan and Kaplan (1989) reinforced Gibson's concept of '*affordance*', characterising it as '*what the perceiver would be able to do in the setting* (p.32)'. Kaplan and Kaplan (1989) argued that the spatial configuration of a scene – i.e., the three-dimensional inferred space – depends on the evaluation of the possibilities of action in the landscape. Even in the speedy rating of scenes, a preference ranking is only possible because of the perceived evaluation of what the scene is permitting one to do. Kaplans' cognitive-based preference theory (Kaplan and Kaplan, 1989, Kaplan et al., 1989), captured by the landscape preference matrix (Figure 2.13), posits that people tend to prefer environments that are understandable and that offer opportunities for exploration. They theorized that these preferences derive from evolutionary pressures on our ancestors, for whom the ability to gather and use information was one of the greatest strengths and, consequently, a matter of substantial concern. Through an analysis of preference patterns over many different studies, the Kaplans developed the

landscape preference matrix by identifying four predictor variables based on spatial configurations, two of which (coherence and legibility) help one understand the environment, while the other two (complexity and mystery) encourage its exploration.

Environmental Comprehension	**Coherence**: Understanding and making sense of the environment
	Legibility: Identify distinctiveness – a means to safely navigate the 3d scene and thus being able to find one's way back
leads to ⬇	
Environmental Exploration	**Complexity**: The interest potential in the scene, that which prevents boredom.
	Mystery: the promise of discovering additional information

Figure 2.13 Landscape Preference Matrix. (Kaplan and Kaplan, 1989:p.53)

Several studies have borrowed metrics from the landscape preference matrix. Stamps III (2004), however, posited that the methods used in these studies were inconsistent and tainted with subjective interpretation, making the results irreproducible. This study also found that there is insufficient evidence to support the application of these variables in urban settings. The validity of the variables, therefore, would need more reliable measures, especially in the built environment, where these models might not be directly applicable. Nonetheless, coherent views are generally appreciated for the way the whole scene appears. In fact, coherent urban window views are known to cause less apprehension and more restoration in office workers

(van Esch et al., 2019). Complex views have been recommended in some view guidelines (CEN/TC/169, 2018), although the relationship between preference and complexity still requires clarification. Complexity refers to the '*variety or diversity in a stimulus pattern*' (Berlyne, 1960:p.38) and higher complexity stimuli generally elicit more interest than low-complexity stimuli (Berlyne, 1963). The term 'complexity' is generally used synonymously with variability, environmental richness, and diversity, thus with a positive meaning. The term environmental clutter is more often used when giving a negative connotation. Studies have found that complex natural views were preferred over complex urban scenes when office workers were shown pictures of external environments (Kaplan et al., 1972). It also appeared that more distant views were able to provide a greater variety of objects to look at in the scene and were consistently preferred over close-up views that offered less elements to explore. However, complexity is known to have an inverted-U curvilinear shaped relationship with preference (Nasar, 1997, Wohlwill, 1968, Vitz, 1966). Generally, too little to see leads to a boring experience; too much might become an overstimulation. The results from complexity studies similarly pose issues of methodological inconsistency and are conditioned by the definition and measurement of complexity (Nadal et al., 2010). Since windows play an important role to provide environmental stimulation, the content of the view out may need to be moderately complex to be preferred. Studies confirm that views with a high level of mystery may also incite a feeling of fear of crime, especially in cities. In essence, every

theory needs to be contextualised in the contemporary design discourse before direct adoption.

Kaplan (1995) further developed the idea of preference for natural landscapes into their *attention restoration theory* (ART). Kaplan and Kaplan (1982) distinguished between effortful 'voluntary' attention (also called directed attention), and the less demanding 'involuntary' attention. These two types of attention are based on William James's distinction between involuntary and voluntary attention (James, 1892). Involuntary attention, renamed by Kaplan (1995) as fascination, is based on interest, and implies that people attend to visual patterns without a lot of effort (Kaplan and Kaplan, 1981). In addition to involuntary attention, the Kaplans (1989; Kaplan, 1995) considered three other components integral to the analysis of what makes an environment restorative: being away, the view must have extent, and compatibility between the environment and one's purposes (Farley and Veitch, 2001). The Kaplans posited that natural views required less effortful attention and, therefore, were deemed to be more restorative.

Similarly, Ulrich's (1983) psycho-evolutionary framework claimed that contemporary human beings have no restorative responses or preparedness for most man-made settings. Several studies have confirmed the potential benefits of natural views through experimental research (Berto, 2005). However, Ulrich and Kaplans' stance on the preference for natural over man-made settings started the discourse that described and tested for the differences between the two environmental settings. Higher preferences for natural over urban views are thought to be mediated by perceptions of

greater restorative potential in natural environments (Beute and de Kort, 2018, Hartig and Evans, 1993, Kaplan and Kaplan, 1989, Purcell et al., 2001, van den Berg et al., 2003, Menardo et al., 2021). Along this line of thought, Hartig et al. (1997) developed a scale to measure the perceived restorative potential of an environment (PRS), which has also been used in subsequent studies (Negrín et al., 2017, Staats et al., 2016). However, research has shown that scenes rated as highly restorative are not necessarily those that are more preferred (Peron et al., 2002). In fact, restoration might not always predict environmental preference (Han, 2010), while not many studies have addressed the challenge of assessing the effects of urban built environments (Hidalgo et al., 2006) (Lindal and Hartig, 2013). Lindal and Hartig (2013) found a positive influence of architectural variation on restoration likelihood, with a negative effect of building height and density. While it was found that polarity between urban and natural features may caution to select the adequate stimuli for the correct objective of research, among others, Staats et al. (2016) showed that a busy street is not the best example to compare with a natural environment, especially to measure the restorative potential of urban environments. These methodological issues persist, for example, if stimuli perceived as most restorative are selected as natural scenes, and those with low rankings of perceived restorativeness are added to the urban selection for comparison (Berto et al., 2008).

Within landscapes, some features have shown to drive preference irrespective of the context and environmental conditions. In a pilot study run with Dutch students, Hellinga (2013) found that having the sky in the field of

view contributed most to feelings of pleasantness. Natural or urban views containing water received higher ratings than similar views without water (Swanwick, 2009). Herzog (1985) provided a useful review of the information processing approach to water preferences, drawing on the work of the Kaplans, Gibson's affordances and Appleton's prospect and refuge theories. Water is so often preferred that it is generally omitted from landscape preference studies (Kaplan and Kaplan, 1989). Good quality water, fast flowing, and in large bodies, are generally preferred over swamps and small ponds (Lothian, 2000, Ellsworth, 1982), and dirty unkempt water bodies (Hellinga, 2013). Previous studies have shown that landscape preference is positively related to the presence of trees in great canopy size (Hernández and Hidalgo, 2005). However, specifically in looking out of a window, trees may block light, occlude other objects, cause damage to property, prevent gardening, etc. The preference for trees is said to be more intense in areas with little or no tree cover, but gradually decreases in places with existing trees (Jiang et al., 2015). Therefore, people's previous experiences, desires and expectations may inform their interest in, and preferences for, more nature cover in views.

2.2.2. *Gaze Behavioural response: Preferential Looking Paradigm*

Eye gaze is intrinsically linked to human social preference decisions from birth onwards (Emery, 2000). Gaze shifting is one of the many bodily mechanisms suggesting attention or interest in an object. Other indicators of

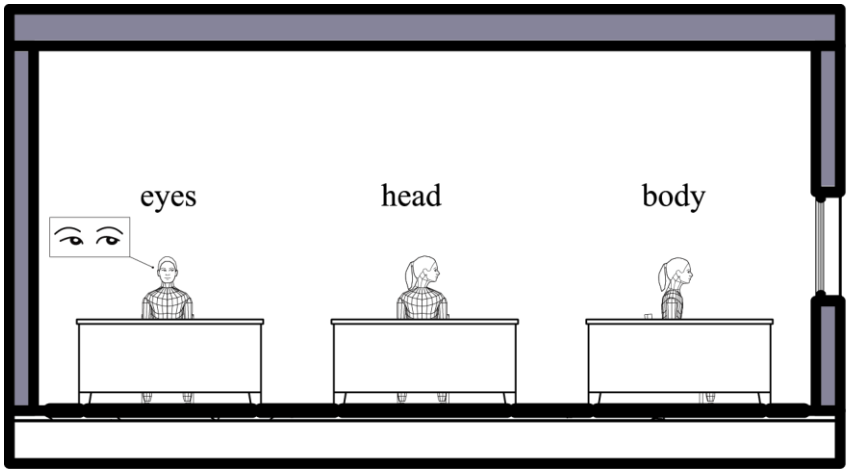


Figure 2.14 Attentional cues towards the window on the right. Adopted from Emery (2000:p.583).

attention direction (and, therefore, interest) are head turning, body turning, finger pointing and weight shifting (Liao and Shimojo, 2012, Emery, 2000), which provide sufficient cues of interest in an object or scene (Figure 2.14). In this research, primary emphasis is given to gaze behaviour as a link to attention allocation and will be discussed further. The eyes have long been considered the *windows to the soul*. Although gaze is the primary source of information from the eyes, seeing objects involves many sources of information (Gregory, 1994:p.10). It includes knowledge from previous experience, involving other senses: touch, taste, smell and hearing. This understanding is closely in line with Gombrich's proposal of perception, in which he stressed "*the beholder's share"* of perception as reported in Chandler and Munday (2020). Gombrich suggested that *"reading an image, like the reception of any other message, is dependent on prior knowledge of possibilities; we can only recognize what we know*" (Chandler and Munday, 2020). This line of thought has not been well received by some evolutionary

psychologists and empiricists, who wanted to generalise the individual preferences to 'genetic footprints' (Mitrovic, 2013). The viewer, however, is "*cognitively active, not passive"* (Gregory, 1994:p.10). The eye is not just a receiver, it is an extension of the brain, and perception is not only an active process, but is also conditioned by our expectations. Therefore, "*to see is always to see something out there"* (Mitrovic, 2013:p. 72).

In order to see, however, we need light. The human eye lets in light through the pupil, the image is turned upside down and back to front through the lens and is projected onto the retina. The neural system responsible for vision is triggered at this stage. The retina, also described as the "*outgrowth of the brain"* (Gregory, 1994:p.61), is packed with light-sensitive cells, called rods and cones. Rods and cones translate the light stimuli into electrical signals transferred via the optic nerve to the human visual cortex region of the brain. In the central region of the retina, the *fovea*, cones are packed together, and are responsible for acute image representation (Figure 2.15). The light reaching the eye needs to fall directly on the fovea for the most acute vision. This is why the human eye needs to *"foveate"* towards a target in order to see it (Holmqvist et al., 2011:p.21).

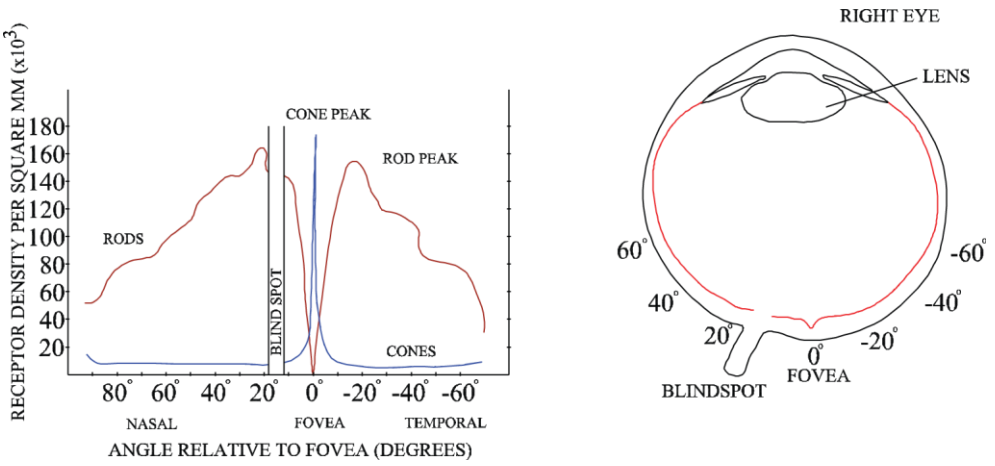


Figure 2.15 The fovea region of the eye has a high density of cones for greatest visual acuity in the central 0-5 degrees. Adopted from Wandell (2012).

Indeed, light entering the eye allows for the visual system to be stimulated. However, light also has non-visual effects on human physiology and behaviour. Another type of receptor, spread across the retina along with the rods and the cones, is the intrinsically photosensitive retinal ganglion cell (ipRGC)(Boyce, 2014). The ipRGC is known to influence the human circadian timing system, also known as the circadian clock (Andersen et al., 2012). For a review on the function of the eye and its role in visual and non-visual perception, please refer to Boyce (2014:pp.43-111).

An objective record of where one is looking can be obtained from measuring eye position and movements. In real world scene perception, humans selectively seek out information in the visual environment pertinent to perceptual, cognitive, or behavioural goals (Findlay and Gilchrist, 2003). Like many other species, humans use a *saccade and fixate* strategy to sample visual scenes. *Saccades* are ballistic eye movements around the image at a rate of 2-3 occurrences per second. Between saccades, the position of the

eye is comparatively steady, and during these periods, known as *fixations* (lasting anywhere between tens of milliseconds up to several seconds), visual information is gathered for processing by the brain (Henderson, 2003, Holmqvist et al., 2011:p.21).

When viewing a scene, the eye does not wander just anywhere and everywhere, but to locations that depend on the "*composition, and on the objectively and subjectively judged informativeness*" (Hochberg, 2007:p.263). While the centre of the retina is crucial for image perception, its edge is sensitive only to movement. Detection of movement is vital to survival in humans. From an evolutionary perspective, moving objects could be both food and/or danger, requiring rapid response. When a movement is detected by the edge of the retina, a reflex is generated. Gaze is directed to shift to a new location based on what has been seen in peripheral vision (Kean and Lambert, 2003). The centre of the eye is rotated so that the foveal region is now facing the object requiring attention. Saccades, therefore, are essential to vision. Through a saccade, the eye fixates on a new object in the scene, to focus on the image such that it is always projected on the foveal region of the retina (Gregory, 1994). Consequently, eye movements are important to understand what processes trigger attention. Currently, there are four accepted frameworks for addressing this question.

The first model suggests that gaze is guided by image characteristics, such as local intensity or colours (Itti and Koch, 2000). This approach is supported by saliency models, derived from algorithms that employ computed image features to predict human attention (Borji et al., 2013).

These models depend entirely on image features. Since the earliest models (Itti and Koch, 2000), these have been developed into sophisticated deep convolutional neural networks, known to resemble the human visual system (Kietzmann et al., 2019). Experimental evaluations of complex scenes showed that more fixations occur within areas expected by the salience model than would occur by chance (Foulsham and Underwood, 2008). As an example, research has shown that image salience can play a role in view preference (Valtchanov and Ellard, 2015) and visual comfort (Le et al., 2017). Le et al. (2017) showed that unnatural properties of urban images (e.g., repetitive patterns) resulted in higher discomfort, and were accompanied by a relatively large haemodynamic response, characterised by an increase in blood flow, volume, and oxygenation, measured in the visual cortex region of the brain using functional magnetic resonance imaging (fMRI). Research examining psychological benefits of outdoor views also demonstrated that non-straight surfaces, borders, shades, yellow-green rather than blue-purple objects, and scenes containing both high and low saturated colours, predicted higher preference (Kardan et al., 2015, Berman et al., 2014).

A second approach opposed to saliency features underpinning attention (and preference) posits that, during free viewing, human gaze is mainly directed by the associated meaning and the semantic content of the scene (Henderson et al., 2009, Nyström and Holmqvist, 2008, Rider et al., 2018). The notion of attributing meaning to a scene based on its prior knowledge (at least a part of it) makes this non-computable, contrary to the previous model (Teufel et al., 2018). Recent studies have demonstrated the

role of meaning in directing gaze movements (Henderson and Hayes, 2017, Peacock et al., 2019, Henderson et al., 2018). However, the idea of meaningful gaze allocation is not new, as the earliest studies in this domain showed how semantically inconsistent or incongruent objects in a scene attracted longer attention in comparison to semantically consistent ones (Loftus and Mackworth, 1978, Berlyne, 1963, Berlyne, 1958, Berlyne and McDonnell, 1965). Loftus and Mackworth (1978) found that a semantically inconsistent object in a scene was not just fixated for longer, but also triggered a sooner reaction, almost immediately as it appeared. A semantic inconsistency elicits eye movements, even before the object is fully recognized because it may contain "*greater meaning*" (Peacock et al., 2019) and be "*more informative*" (Loftus and Mackworth, 1978). Alternatively, longer fixations may also suggest that these objects require more attentional resources to process (Friedman, 1979). This undoubtedly suggests that a moving target in the window view, that is not a part of the usual scene, would almost immediately attract attention. Whether semantics or saliency play a more important role than other processes in attention allocation is an ongoing debate (Pedziwiatr et al., 2019). Henderson et al. (2020) demonstrated that, while saliency features attract gaze early, later meaning-based perception of scenes leads to overall evaluation. The relative dominance of semantic properties may also depend on, and be mediated by, the viewer's ongoing task (Spotorno and Tatler, 2017, Yarbus, 1967, Hoppe and Rothkopf, 2019).

Studies focusing on consumer behaviour also described the relationship between visual attention and subjective choices. A marketing packaging study revealed that the time spent attending visually to a product predicts whether we buy it or not (Gidlöf et al., 2017). Observers' search strategy differed based on brand consumer choice, and the intra-brand and inter-brand saccades were higher for the chosen product (Pieters and Warlop, 1999). Computational models of this process suggested that fixations on a stimulus predict preferences for binary (yes/no) (Krajbich et al., 2010) and multiple choices (Krajbich and Rangel, 2011). While these studies provide an important bridge between preferences and visual attention, however, there is no empirical evidence that they also consistently apply to scenes of real-world built environments, where choices in the visual field might be more complex.

While previous models suggest that gaze behaviour may be related to image properties, meaningful associations, or choices in the scene, one perspective suggests that gaze may reveal the personal predispositions and biases of the observer. Studies investigating natural landscape preferences have found differences in gaze strategies based on participant types (De Lucio et al., 1996). Using a principal component analysis, they identified participants who had a more complete gaze scanning behaviour. They referred to them as having a 'field-independent' type of search strategy (Witkin and Goodenough, 1981), that is common in more field-independent participants (Conklin et al., 1968). Different people have different search strategies, as characterised in their gaze with those showing no obvious

connection to specific content in the scene accounting for 19% of the variance in fixation distributions. Gaze behaviour may also reveal personal inclinations and personality traits (Kaspar and König, 2011, Maran et al., 2020, Rauthmann et al., 2012). Additionally, other biases in human gaze exist, such as more fixations in central locations (Tatler, 2007), preference for human faces (Guy et al., 2019), and alphanumeric content such as text or numbers (Tatler et al., 2011).

2.2.3. ***Personal Disposition***

A person's (emotional) disposition, has been defined as the "*long-term emotions and a tendency to do or think or feel particular things when the right circumstances occur*" (Akhavan Farshchi, 2006:p.7). As reported in the previous section 2.2.2, gaze behaviour might be related to personality or personal disposition. Similarly, one's demographics, areas of expertise, cultural and religious affiliations, as well as past experiences, have been known to affect subjective appraisals of outdoor scenes (Nezamdoost and Nezhad, 2020, Herzog et al., 2000, Staats et al., 2016, Kaplan and Herbert, 1988, Hägerhäll et al., 2018, Mirza, 2015).

Sreetheran and van den Bosch (2014) found that an individual's personal attributes – i.e., ethnic origins, gender-related experiences, past events in space, and social incivilities – might evoke negative preconceptions, especially fear of crime in urban spaces (e.g., parks). The expectations and 'affordances' of green urban spaces change for many people, especially

women, where they may feel safer in the presence of other people (Macnaghten and Urry, 2000). In urban settings, the company of another person tends to make a difference in preference and restoration likelihoods in young adults (Staats et al., 2016). Preference ratings in natural urban settings are also known to be mediated, simultaneously, by the perceived senses of privacy and safety (Lis et al., 2019). While plant density increases privacy and preference, it creates sheltered and shady places that lend to fear of crime (Lis and Iwankowski, 2021).

Similar to De Lucio et al. (1996), who identified participants who had a distinct gaze behaviour (as described in Section 2.2.2), Echevarria Sanchez et al. (2017) found that differences in participant's personal self-reported auditory and visual dominance, are reflected in their appreciation for the urban environment. The auditory dominant participants, according to their research, turned their head to look directly at the source, and for a longer time than those that were visually dominant.

Past experiences not only inform personal preferences, but also determine how new an environment or condition appears. This concept known as 'novelty', or new information in the view, is known to incite interest and, accordingly, gaze behaviour (see Section 2.2.2). Hidalgo et al. (2006) found that novelty was significantly different across all categories of scenes. Novelty was consistently higher in attractive urban spaces. Similarly, they found that the urban spaces assessed as 'being-away' were rated as more attractive. This could imply that unfamiliar spaces are considered more interesting than the mundane everyday environments seen on a daily basis.

These findings suggest that the link between novelty and familiarity is complex, especially its effects on preference formation. According to Liao and Shimojo (2012), *"a preference decision is not made instantly at a moment in time, but rather it is a gradually evolving dynamic, somatic and (at least initially) implicit process"* (p.291). Consequently, while preference for scenes may decrease as the novelty diminishes, preference may also increase based on familiarity. Much research has focused on discovering the role of familiarity in affective appraisals of outdoor scenes (Brenda and Herrenkohl, 1977, Herzog et al., 1976, Imamoglu, 2000, Kaplan and Herbert, 1988, Purcell et al., 2001, Swanwick, 2009). In window view research, the literature on this topic is sparse, owing to the reason that a person may be relatively familiar with the view out of their window. Since human beings are creatures of habit, and it is easier for us to process those objects that are familiar, with 'fluency' (Reber et al., 2004) and familiar-to-our-habitat information (Berlyne, 1958), it is unclear if the proverb *familiarity breeds contempt* could be applicable in window view appraisal.

Research has shown that childhood experiences with nature also mediate preferences for window views in one's adulthood (Mirza et al., 2012). Apart from general preferences for nature, variations in cultural structures of humans versus nature are also related to *psychological closeness* to nature. For example, rural European American adults are less prone than Menominee Native American adults to describe personal relationships with plants and wildlife (Bang et al., 2007). An individual's relatedness to nature is defined as their "*subjective feeling of being a part of,*

and in relation to, the natural world" (Nisbet et al., 2009, Mayer and Frantz, 2004). Reasoning about human–nature associations could have consequences on our understanding of pro-environmental attitudes and behaviours (Mackay and Schmitt, 2019). Variations between individuals, such as their reported connection to nature, may also be attributed to differences in the perceived restorative potential of scenes (Menardo et al., 2021).

Children prefer high variability stimuli in comparison to adults (Munsinger, 1966). Some studies have found human predisposition for natural views to be varying across age groups (Meidenbauer et al., 2019), specifically in school children (Kuhlenengel et al., 2019). Lindemann-Matthies et al. (2021) found that children's nature connectedness (measured as their time spent in nature and on plant care) was positively associated with feelings of comfort and learning satisfaction in school.

2.3. Methods used to study view preference and behaviour

Based on the literature studies reviewed in the previous sections, a window view can be considered as preferred when it draws interest and attention towards it. Under this definition, therefore, view preference is inherently composed of two elements of measurement: preference and associated behavioural or attentional response towards it. At a general level, view preference in windows could be appraised using the following techniques:

- *subjective* assessment, i.e., asking people to evaluate the view out of the window quantitatively
- relevant *environmental measures* that affect observers' preferences, through field notes, photographs, drawings or maps.

Behaviours associated with the view can be documented and interpreted by:

- *physiological* records of where observers are looking at, and their scanning behaviour, and/or
- *verbal measures* designed to tap into behavioural and physiological responses.

The subjective assessment of preferences in natural landscapes is an already established area of study (see, for example, the review of the literature performed by Mirza, 2015, and Lothian, 2000). These methods have been known to produce incoherent and irreproducible results due to the subjectivity of the researchers and of the participants involved in the process. Subjective rating is prone to biases (Poulton, 1977). The built environment often poses different challenges that the assessment protocols designed to measure natural landscapes cannot fully capture. As an example, people are generally omitted from studies measuring visual preference in natural landscapes, whereas literature in urban design suggests that the presence of people makes the places more likeable and livelier. This is one of the many challenges that limit direct application of landscape preference models to a study aimed at assessing window view preferences in the built environment. A more pressing issue with these studies is that they solely rely

on one method of capturing people's perception and preferences. The aim of this review of methods is, therefore, to identify study approaches that mutually benefit from using two or more means to capture data on preference and associated behaviours, instead of relying on just one from previous studies, which could inherently bias the results. In this way, a more robust measure (or combination thereof) of view preference can be obtained.

As reported in recent research, new techniques are necessary to advance our understanding of window views. For example, Mirza (2015) adopted a qualitative method, called the active perception technique. Based on Kevin Lynch's mental mapping techniques, study participants were asked to take a photograph of their view out of a window and to draw the important features to assess its qualities (Lynch, 1960). Comparisons were drawn with the contents of the photograph, thus revealing the elements that composed a cognitive construct. This technique provided many useful insights into people's associations with the view out of their window. However, this method is heavily reliant on the participant's ability to draw, and on the researcher to carry out a fair unbiased comparison with the contents of the photograph. Any new technique can add value to the knowledge of window view design. However, studies benefitting from multiple methods have shown to reach a better understanding of the phenomenon.

In addition to techniques used to measure preference and behaviour, there are different approaches towards data collection. One approach

captures a person's relation with their own window view, *in situ*, asking study participants questions about their perceptions and the qualities of their own view. These are known as *field studies*. Another approach is to measure participants' preference for a variety of *view surrogates*, i.e., representations of views often in the form of photographs, either printed or projected onto a screen, to better understand what they prefer. This could be carried out in the participant's own usual space, as well as within a controlled viewing environment. A third approach consists in selectively choosing one or more view conditions under which the study participants are invited to perform certain tasks, such as a *controlled laboratory condition* with a view out, which is not the participant's natural habitat. There are merits and weaknesses of each approach, and these will be discussed in the following sections.

2.3.1. ***Field Studies***

Researchers measuring *in situ* perceptions through field studies ask participants what they like in the view and what draws their attention via questionnaires, or assess the quality of the view themselves, if the view is accessible. Some studies use view surrogates to ask participants which category of those scenes is the closest match to the view out of their own window. The scale and scope of the study determines the instruments to be used.

Manning performed the first known field study in offices on windows and the importance of views (Manning, 1965). The study used preliminary

interviews in the form of focused group discussions to seek important elements from participants and to inform the design of a questionnaire. Two questionnaires were administered, one close to the time when participants moved into a new building, and another after 10 months of occupation. Markus (1967) surveyed 400 office workers using a questionnaire to record and compare the view qualities out of their windows. Markus reported the first known results along the lines of number of layers in view and dynamic qualities of the view outside. Nichols (1977) administered a questionnaire to 60 participants in urban office buildings, to assess the importance of view, enclosure, and the impact of height on people. Kaplan (1993) mailed 1000 surveys to office employees, to get 615 returns. The mail indicated that the project involved "*seeing whether plants and nature can be helpful*" to deal with the daily hassles of life (p.197). The five-page survey included questions on satisfaction with the view and the ability to look out. A checklist was provided to respondents including potential features that could be seen out of the window, which the researchers later organised into built and natural categories. Open-ended responses gave a flavour of people's aspirations for a window and features of view when they were present.

Researchers have also tried to match the view out of respondents with predefined window categories. Tennessen and Cimprich (1995) explored the content of the window view in the residential context of dormitories. They categorized the view out of the window by taking photographs and asking an independent group of subjects to evaluate them. Subsequent analysis depended on this categorization. Kaplan (2001) collected responses

from 188 mailed surveys in low-rise apartments, with questions on characteristics of view and weather. The questionnaire asked respondents to match their own window view with a set of 40 photographs and to rate them on preference. The aim stated on the survey was "*to understand how trees and bushes and lawns and flowers relate to how people feel*" (p.514). The questionnaire included both closed and open-ended questions. Similar to the method used by Kaplan (2001), Elzeyadi (2012, 2021) asked 175 university staff to assess 12 photographs using a sorting technique. They proposed a Poor View Quality (PVQ) metric for evaluating the view out of the window based on its composition and elements.

Researchers have also investigated window views as a part of a larger study on different indoor parameters. Christoffersen et al. (2000) carried out a post-occupancy evaluation with 1800 office workers. They documented view features by offering a choice from a list of elements, and positive and negative aspects of windows. Heschong Mahone Group ran two large studies in office (2003a) and school (2003b) environments to investigate features that affect performance and wellbeing. Aries (2005, Aries et al., 2010) used a 43-item questionnaire to "*understand how office users experience present-day office environments and what they think is important"* (p.535). They used a panel of independent observers to evaluate photographs of the view out based on 'view quality' (on a 5-point scale) and 'view type' (natural or urban) for further analysis. Hellinga (2013) conducted an office study to "*investigate to what extent different variables influence satisfaction with the lighting and outside view in real office environments*" (p.63). Study participants were

asked to fill in a questionnaire asking about different features of the view that make it pleasant or unpleasant. A hierarchical regression analysis was carried out with these variables to devise a daylight and view evaluation method (Hellinga and Hordijk, 2014). Lottrup et al. (2013) used a questionnaire to evaluate the response of occupants to the presence of greenery in a view within a work environment. Matusiak and Klöckner (2016) administered a survey with university staff and students at their own workplaces and evaluated the view out of their window on a four-point scale. They took photographs of the view out of the respondents' window to evaluate the aesthetical quality and composition (of view) by an independent group of assessors.

As these studies show, common methods of data gathering and evaluation in field surveys might include asking participants to rate their view subjectively, or request to select from a list of (pre-selected) variables from which evaluative properties can be ascribed to views. Alternatively, independent subjects could be used to evaluate the view quality, either based on photographs or pre-selection of images to match the view quality against a set criterion. Since it is convenient to reach participants at their own workspaces, recent studies have started to incorporate online surveys as a research tool. van Esch et al. (2019) used an online survey methodology using a questionnaire to reach office workers. The questionnaire asked participants to rate their own window views on several indicators, e.g., on naturalness and environmental properties. Nezamdoost and Nezhad (2020) and Kent and Schiavon (2020) also showed a collection of pre-selected photographs via an

online survey to participants recruited via the internet to evaluate the observers' perception of photographs of external views.

2.3.2. *Experimental Conditions using Window Surrogates*

Since the content of views is difficult to control, in order to compare evaluations across participants, even in a controlled laboratory setting, view surrogates are often used (Tuaycharoen and Tregenza, 2005). The use of slides or photographs to assess individuals' preferences for particular views is widely accepted (Kaplan and Kaplan, 1989) in the landscape preference literature. This method may, in fact, be preferable to on-site evaluations since it reduces the effect of contextual factors, such as weather and other variables, which are constantly changing in real views.

Perception and preference studies use different measurements for gathering preference evaluations, requiring participants to rate, rank or sort the stimuli presented. Rating is done via different methods, most commonly using Likert or visual analogue scales. Ranking and sorting allow for comparative judgements before final selection. They might, however, be rather time-consuming and could impose a limit on the number of stimuli and participants. Affective judgements (see Section 2.2.1) easily capture common patterns of perception across different environments. Preference is a type of affective judgement (Kaplan and Kaplan, 1989). For ease of use, single-scale rating of preference on an analogue scale is simple to understand and is less time-demanding (Sung and Wu, 2018).

2.3.3. ***Physiological measures***

Different physiological and psychological correlates of environmental preference, including brain activity (Norwood et al., 2019) and internal cognitive processing mechanisms driving attention (Orquin and Mueller-Loose, 2013, Browning et al., 2020), have been used in environmental perception studies. Research has shown activation of specific brain regions, that is, of posterior cingulate cortex region and an overactive amygdala region, in response to urban environments corresponding to effortful attention (Norwood et al., 2019). Visual attention is considered a precursor to choose in unfamiliar environments and is known to be directed to goal-relevant stimuli within the scene (Orquin and Mueller-Loose, 2013). In this context, eye movements instantaneously reflect cognitive and decision-making processes (Kahneman and Frederick, 2002) and could, therefore, represent a robust means to investigate visual preferences in urban environments, in addition to more traditional subjective methods.

Physiological measurements are one of the few effective ways to evaluate observers' reactions towards a stimulus (Ulrich et al., 1991). Two of the earliest eye movement studies using pictures of natural scenes identified that fixations are clustered around areas of interest (Buswell, 1935, Yarbus, 1967), generally called *centres of attention*, and that *eye gaze patterns* change depending on the viewer's task and demands of attention (Buswell, 1935, Holmqvist et al., 2011). As such, we fixate on what we are giving attention to (Eckstein et al., 2017).

A positive association between the number of saccades and the elicited interest in a scene has been documented in the literature (Kaspar and König, 2011). Research calls for differentiation between two kinds of exploratory gaze behaviours: one that is *specific* exploration aimed to secure important information for the observer; and, a *diverse* type of exploration that has an affective emotion-arousing basis (Wohlwill, 1968, Berlyne, 1963). While the latter could be involved in the preferential-liking dimension of appraisal, the former suggests interest in the scene through active attention allocation.

Interest has been associated with preference (Tuaycharoen, 2006), thus prompting research on human gaze behaviour in relation to interesting images. Using eye-tracking measures, Kaspar & König (2011) found that subjects who rated an image as interesting showed significantly shorter fixation durations and a higher number of saccades, in comparison to those subjects who did not. Other studies have shown that high-level aspects of a scene, as captured by interest, are highly efficient in guiding eye movements, and that the competition to scan other image regions of interest might lead to reduced fixation durations (Onat et al., 2014). Concurrent to this research, studies have recorded eye-tracking measures in urban streetscapes (Noland et al., 2017, Hollander et al., 2020, Spanjar and Suurenbroek, 2020) and in response to architectural features (Li et al., 2021), further reinforcing the opportunities that can be gathered using physiological measurements.

Consistent with field studies, where views are assigned an ‘urban’ or ‘natural’ category, differences in view types have been investigated via eye-

tracking (Berto et al., 2008). Berto et al. (2008) showed that eye movements related to urban scenes were characterised by a higher number of fixations and larger saccade amplitudes (eye travel distance), when compared to natural scenes. These results were replicated by Valtchanov and Ellard (2015), Franěk et al. (2018), who also included comparisons with urban scenes featuring historical buildings, and then by Martínez-Soto et al. (2019). In the literature, longer fixation durations have been found when scenes are perceived as natural (Cottet et al., 2018). Night-time cityscapes have shown a positive correlation between eye-tracking measures (fixation duration and scan path length) and preference (Kim et al., 2013). These findings are, however, not necessarily consistent with other studies that have measured view interest while considering view type.

Collecting eye-tracking measures (ETMs) in a laboratory setting requires an observer to be seated in front of a display with a remote eye-tracker that measures the eye movements while images are observed on a screen. This method offers a direct link to objectively recording how people see the world. However, as with many measuring techniques, eye-tracking carried in the lab may not fully correspond to gaze behaviour in real world scenes, particularly when a head rest is used to restrain the observer's head position.

2.3.4. ***Qualitative Verbalisation***

In order to gather further insights into the cognitive processes accompanying the scanning of a view, 'a thinking aloud' method is often used to elicit verbalized thoughts (Cottet et al., 2018). This approach offers additional data to understand the embodied nature of viewing behaviour by linking different sources of information, capturing how the human mind and body (and gaze) react to an environment. However, concurrent verbalization might alter eye movements during the viewing experience, where "*speech is time-locked to gaze*" (Holmqvist et al., 2011:p.101). Therefore, *retrospective* reports can be generated post-presentation, as structured interviews.

Qualitative research on window view preference has shown that study participants' personal stories and associations are reflected in their open-ended narratives. Mirza (2015) used a drawing technique to assess observers' cognitive representation of the view out of the window. Hauge (2013, 2015) explored qualitatively the narratives of the views with families in two different cities and found that people had personal associations with their windows. However, open-ended responses are often difficult to interpret, requiring rigorous analysis that need to go beyond simple frequency counts of data (Braun et al., 2020, Braun and Clarke, 2013).

2.4. Summary

When people are inquired about their subjective appraisal of a space inside buildings, the proximity to a window, its affordance for the daylight

and the view out consistently emerge as the most important contributors towards their satisfaction with the space (Matusiak and Klöckner, 2016, Christoffersen et al., 2000, Markus, 1967, Heschong Mahone Group, 2003a). Historically, access to windows, daylight and views has been considered a valued characteristic of buildings (UK Parliament, 1696), and have been repeatedly emphasized for the benefits they bring in healthcare settings (Nightingale, 1859). However, the effect of a view out on human behaviour is still an unresolved question. The view out may attract attention and provide environmental stimulation, but it might also entail distraction from visually demanding tasks. As the review discussed in this chapter has shown, the rigorous investigation of window views has been more systematic in the last four decades of research. A series of reflections on the main findings is presented below.

2.4.1. *Reflection on building regulations*

- Views with a greater number of layers are generally the most preferred. The number of layers is a function of the distance from outdoor objects and is, therefore, related to the density of the site. This presents a case for urban environments where little is known about views when distance between buildings is not in control of the designer.
- Dynamism and movement attract interest and attention in windows. Due to the dominance of methods based on

quantitative subjective assessments mostly using static images, dynamic features of views, which are transients based on time and space, have not been properly addressed in current research. Temporal information is dependent both on what is available and what is experienced by the people through their view.

- There are many indicators of visual preference in outdoor views, based on content, composition, and elements within the scene. However, all of these indicators rely on subjective assessments, either quantitative or qualitative. There may be an inconsistency between what people say they like and what they actually observe in the scenes that lead to their evaluation of views (Matusiak and Klöckner, 2016). Therefore, a more robust measure of window view preference is required so as to relate human gaze behaviour with subjective preference.
- Most guidelines and research studies have used the ground floor window as a reference, where the most adjacent layer is the ground, followed by the landscape and then the sky. However, in floors above the ground, the most reachable layer is often the landscape layer, while inter- and intra-architectural variables might determine whether the sky or the ground will be visible.

2.4.2. ***Reflection on Theories***

- Psychophysical and psychological approaches can be used to measure a person's affective response; that is, the preference for a given scene. These methods rely heavily on the design of environments that mimic our ancestral savannah-like landscapes. However, personal dispositions and observers' experiences are not accounted for in these measurements. The current design question is to understand and address people's desires in response to modern challenges.
- Within a complex scene, it is highly likely that different thoughts are processed simultaneously, as the observer scans the scene and previous memories are brought into light. Therefore, compartmentalisation of complex scenes into categories – urban and natural, as if the person was viewing them independently – could yield answers for individual objects in a view, but not necessarily the whole scene, and this could affect the generality of findings. In the current era of climate change and the known benefits of greening urban spaces, this kind of compartmentalisation might further segregate the two environments that should instead co-exist. Naming a view that has a tree in it as natural further raises questions on the definitions of urban views.

- There is a recent imperative to quantify all aspects of view preference into automated systems. Recent literature comparing computational approaches with human perception shows that there is a significant difference in view quality parameters. Human ratings differ significantly from the computational evaluation of views (e.g., using EN17037) (Waczynska et al., 2021), for example when they are based on personal experiences.
- People's experiences in different environments – e.g., ones that they have not experienced before – may not be adequately mimicked in a simulated setting. If one has never been bed-ridden for months, it is difficult to speak for those conditions. People who live in tall buildings, similarly, have very different experiences from those who live in the two floors closest to the ground. These settings are difficult to measure and replicate as they are specific and, therefore, not directly transferable to the general population.

2.4.3. ***Reflection on Methods***

- Previous landscape preference studies have some methodological limitations due to the type of stimuli and participants used, and subjectivity in the analysis. A robust

study methodology that is replicable by other researchers is, therefore, required.

- Different techniques, quantitative and qualitative, in controlled laboratory conditions or in field studies, have been used in the past. Under laboratory settings, it is important to emphasise the need for controls in order to accurately measure a phenomenon. Conversely, in field studies, it is key to consider that there are many variables at play that are difficult to control in a real environment. However, although individual methods have their own relative strengths and weaknesses, a triangulation of methods and data holds the best promises for a more thorough understanding of the effects under investigation.
- Very often, research studies have focused on student populations. Drawing inferences for non-student populations is, however, difficult, especially in the light of long-term associations with window views and the role of familiarity.
- Natural views are generally preferred over non-natural ones, but grass and open lands, in the absence of trees, or close-up trees blocking the view, are sometimes negatively associated with aesthetic evaluations. If gaze towards natural views is mediated by the involuntary attention associated with the scene, there might be mechanisms related to preference (and

interest (Kaspar and König, 2011) mediating gaze behaviour that are worthy of exploration.

- Literature suggests that there are several mechanisms driving gaze behaviour in outdoor environments, especially image statistics. The application of image properties in real world complex environments that are ever evolving, however, may not be practical.

2.4.4. ***Research design***

In response to the findings from the literature, this research aims primarily to address the major gap identified: uncovering the relationship between window view preference and gaze behaviour. In addressing this aim, other research questions arise. For example, it is unclear how the dynamic content of a scene could lead to view appreciation. While it is known that familiar outdoor places have some relationship with preference, no robust evidence can be found in the literature with respect to one's own window view. There may be other personality traits – e.g., how one relates with the environment, amongst others – that may affect people's interaction with the view. In addition, as discussed earlier, there might also be extraordinary circumstances that are hard to measure, evaluate, and compare with more conventional conditions. The summary of findings from this literature review, on which the structure of this research has been based, is presented in Figure 2.16.

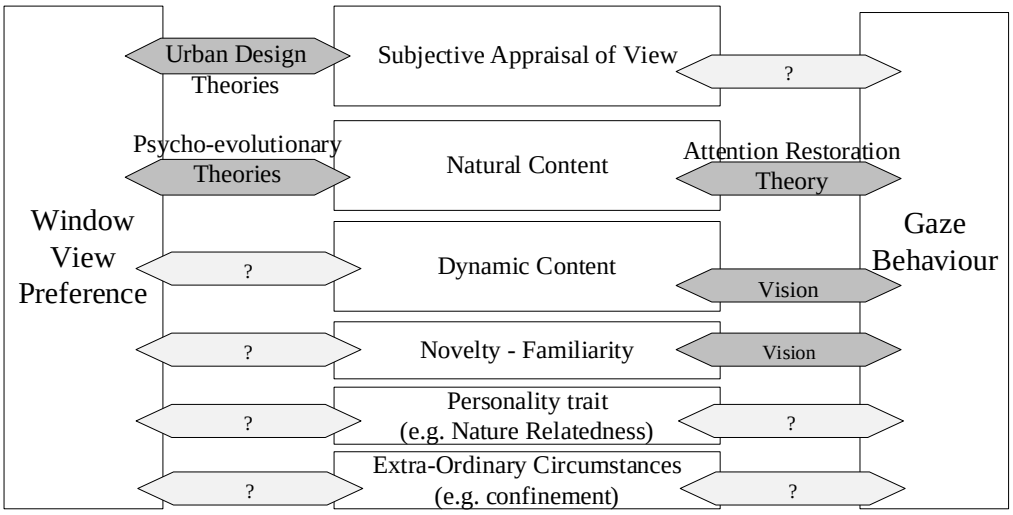


Figure 2.16 Summary of findings: existing research gaps in the relationship between window view preference and gaze behaviour (Source: Author)

Instead of univocally selecting a research approach – quantitative assessments or qualitatively verbalizations – to reach a better understanding of view preference, a more objective measure of behavioural response is required. In fact, it is hypothesised that a more human-centric metric of preference and gaze behaviour could be the missing piece that could relate both constructs in the context of window views. The complexity of outdoor views requires a more holistic approach, benefiting from the merits of both quantitative assessments and qualitative reasoning associated with attention, interest, and preference in views.

Further to this, due to the uncertainty of controls over of the view outside – e.g., it changing overtime, temporarily or permanently, in terms of density and content – it is important to assess how people respond to external views as a whole, irrespective of natural or urban content, and

focusing on designing windows accordingly. Therefore, although the literature stands on either side of a natural and urban divide, there is a potential to draw findings from both sides of the fence to benefit our understanding of a comprehensive construct: a view out of the window.

The aim of this research is to investigate the relationships between preference and behaviour associated with the view out of the window. Accordingly, the studies on which this doctoral research is organised are based on two types of methods: *experimental* (Study 1 and 2) and *survey* (Study 3 and 4). The structure of this thesis is comprehensively presented in Figure 2.17.

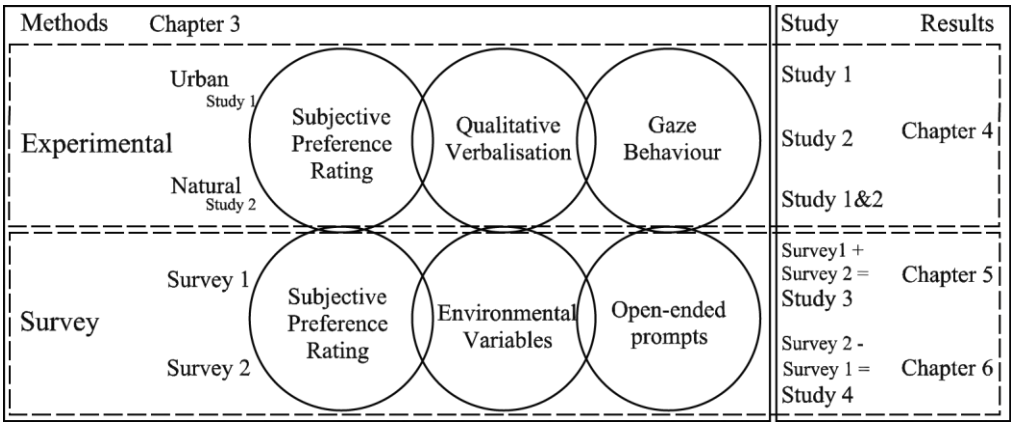


Figure 2.17 Structure of the thesis (Source: Author)

Studies 1 and 2: these studies aimed to explore preferences for visual scenes by primarily collecting and analysing three types of data within a controlled laboratory setting: subjective preference ratings, eye-tracking measures, and verbal reasoning associated with preferences. Study 1 used urban stimuli to explore view preference. In order to test for reliability of

findings, and to contextualise the findings within the literature, Study 2 used a within-subject design but using natural stimuli. Results were compared and discussed in light of other personality attributes related to participants.

Studies 3 and 4: these studies aimed to investigate reasons for preferences for in situ real windows views, using an online survey method. The survey featured a questionnaire on subjective preference ratings and qualitative open-ended responses on window and view attributes that were noticed and liked/disliked. Study 3 drew from all the data collected, while Study 4 focused on a specific comparison between a pre-pandemic condition (Survey 1) and a period of lockdown (Survey 2).

Chapter 3 presents the methods used in this research in further detail.

3. Methods

This chapter presents a description of the methods employed in this research and their integration. Figure 3.1 presents a schematic flow chart of the experimental set up and the variables measured across the two different methods. The first section, Section 3.1, presents the experimental method used in Study 1 and in Study 2. Section 3.2 illustrates the online survey method, which has been used in Study 3 and Study 4.

This research measured view preference using a multi-method approach by collecting both quantitative and qualitative data. Empirical research on subjective preferences is, generally, challenging to undertake (Holmes and Zanker, 2012). This difficulty is rooted in the diversity of subjective preferences that contribute to the aesthetic experience (Berlyne, 1971). The intricacy of measuring subjective preferences often encourages

researchers to adopt either a *reductionist* (e.g., questionnaire) or a *qualitative* (e.g., verbal reasoning)

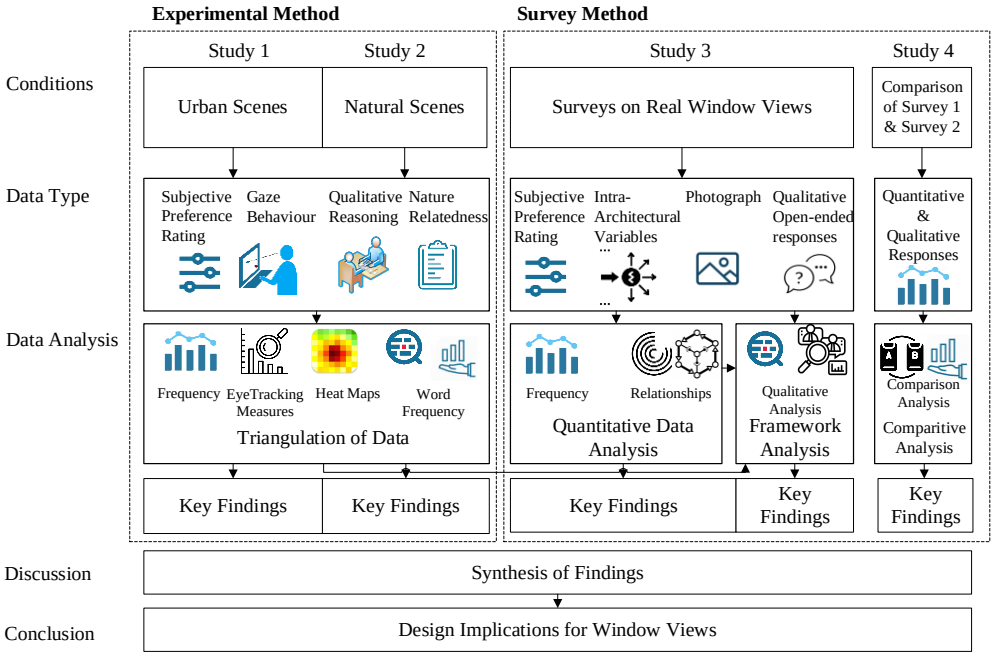


Figure 3.1 Flow chart of the methods used in the study (Source: Author)

approach (Al-Akl et al., 2018). These, however, can offer only a partial understanding of the complex underlying principles driving view preference. On these bases, this research design addressed the 'comparability of questions' by simultaneously collecting quantitative and qualitative data on view preference (Axinn and Pearce, 2006).

In addition to the subjective preference ratings, separate independent variables have been collected according to the two methods described below.

3.1. Experimental Method

The experimental method sought to address the first specific objective of this research: *finding a robust measure of view preference*. In order to study the relationship between gaze behaviour and preference while sampling images of outdoor views, eye position can be recorded via eye-tracking measures (ETMs) (see Section 2.2.2. and Section 2.3.3. for further background details on this technique), graphically visualising changes (e.g., via heat maps) or extracting numerical data for quantitative analysis (Holmqvist et al., 2011). Heat maps, also known as attention maps, allow visualising the general distribution of gaze points across an image, using colours to depict the time spent on different locations (Holmqvist et al., 2011:p.238). Since no accepted method exists to detect the relationship between gaze behaviour and view preference, the method conventionally used by eye-tracking studies to record outdoor scenes viewing under fixed time periods was adapted from Valtchanov and Ellard (2015) and from Franek et al. (2018).

3.1.1. ***Participant Sampling***

For Study 1, 32 participants were recruited from University of Nottingham students and staff, using convenience sampling, during April – May 2019. This sample size is consistent with previous studies on visual perception and discomfort glare response (Tuaycharoen and Tregenza, 2007, Kent et al., 2016, Chamilothori et al., 2018, Rodriquez and Pattini, 2014). As

suggested in the literature (Field and Hole, 2003), under controlled laboratory conditions, samples of this size can allow the detection of effects of large magnitude (e.g., Cohen's $d > 0.8$), based on established benchmarks (Cohen, 1988). In Study 1, the majority of participants identified themselves as female (65.6%). All participants had normal or corrected-to-normal visual acuity and, when questioned, reported no history of ocular ill health, nor any developmental or pathological visual disorder. 25 participants (78.2%) were right-eye dominant. Participants were naive to the purpose of the experiment.

Six months after the conclusion of Study 1, all participants who had taken part in the experiment were contacted again and were given the opportunity to participate in a new experiment. 15 people (out of 32 contacted) volunteered to take part in Study 2. Seven participants identified themselves as female. They all reported normal or corrected-to-normal vision and no previous history of neuropsychological disorders. For participation in this second study, subjects were told that the purpose of the experiment was to replicate the previous experiment with a new set of stimuli to test the reliability of the findings. The type of stimuli was not mentioned in the introduction to Study 2.

3.1.2. *Visual Stimuli*

Photo-based materials have been widely used as visual stimuli in landscape preference studies (Tuaycharoen and Tregenza, 2005, Al-Akl et al.,

2018, Kaplan and Kaplan, 1989) since they allow for control of confounding variables, hence reducing the effect of contextual factors (e.g., the weather) (Pitt, 1979), although some research has suggested that participants could discount these factors when evaluating view quality (Matusiak and Klöckner, 2016). As such, 40 images of real-world views depicting urban elements, and including buildings, streets and facades, were used as visual stimuli in Study 1. These were acquired from the open access McGill Calibrated Colour Image Database (Olmos and Kingdom, 2004). Given the focus of Study 1 within urban environments, images with prominent naturalistic elements, such as trees and water bodies, were deliberately excluded from this experiment. However, the sky and some natural elements (e.g., branches) and urban landscaping features integrated into buildings (e.g., vegetated balconies) were inevitably present in some images. Tables 4.1 - 4.4, featured in Chapter 4 of this thesis, present the entire image sample used in Study 1. For Study 2, another set of 40 images with natural content were acquired from the same open access database. A variety of natural views were selected to offer a wide range of scene depth, greenness, water content, and human presence (see Table 4.11 for the image sample in Study 2).

The use of pre-published photographs, selected from a larger dataset, minimised researcher bias while issues of variability in image quality were removed by using pre-calibrated images. The details of the calibration process have been documented by the authors of the image database (Olmos and Kingdom, 2004), which follow the method developed by Párraga (2003). This method includes the description of camera settings, in order to avoid

possible artefacts introduced by changes in the depth of field, and focal length. It describes how the gammas and spectral sensitivities of the cameras' sensors were measured, and how the images have been gamma-corrected; how the cameras' spectral sensitivities were measured within the visible spectrum (400 - 700 nm); and finally, the process through which gamma-corrected RGB images can be converted into images that model the responses of the L, M and S cones of the human visual system. Further specifications on the calibration process can be found on the McGill Vision Research website (Kingdom, 2015).

It is, anyway, acknowledged that, while the use of these pre-calibrated images offers a variety of visual stimuli and scene depth, they cannot be considered as fully representative of the views that an observer will look out of an actual window. This is an inherent experimental limitation that has also been considered when evaluating the potential transferability of the results of this research.

3.1.3. *Experimental Apparatus and Procedure*

Study 1 and Study 2 received ethics approval and were compliant with the requirements of the General Data Protection Regulation (GDPR, 2016). Each participant was required to take part in the experiment during normal office hours. Participation involved informed consent for the data to be collected and analysed in line with the study's granted ethical approval (Appendix A-1). Before the start of the experimental procedures, participants

were provided with information about the experiment (Appendix A-2) and were offered a chance to ask questions. They signed the consent form to participate in the study. Each participant then filled out a pre-test information questionnaire on their demographics and general well-being (Appendix A-3). This was followed by a psychomotor vigilance test (Evans et al., 2019) presented on the screen to record and mark any discrepancies in the data due to participant's attention deprivation (Lim and Dinges, 2008). Since the literature suggests that each individual has a single dominant eye (Mapp et al., 2003), in order to record eye-tracking monocularly, each participant's dominant eye was also determined using the 'hole-in-card' test (Durand and Gould, 1910).

The experimental procedure required participants to provide preference ratings of view surrogates (*preference rating task*) while their eye movements were tracked, and to offer qualitative verbal reasoning for their evaluations (*pile sorting task*). Adobe Photoshop CS6 was used to linearly rescale the images to 1024x768 pixels for the preference rating task. For a qualitative appraisal of the images through pile sorting, the images were printed on matt photographic paper (10.16 x 15.24 cm). Following this, participants were requested to fill a brief questionnaire to measure their personal dispositions and relationship with nature (*nature relatedness score*) (Appendix A-5). At the end of the experiment, participants were debriefed about the procedure and were offered the opportunity to ask further questions. Details of each of the three types of data collected is explained below:

Preference Rating Task

The visual stimuli were presented using the PsychoPy 2.0 software package (Peirce, 2007, Peirce, 2008) and displayed on a 20-inch calibrated CRT monitor (Iiyama Vision Master Pro 514; resolution 1,024 x 768 pixels, background luminance 45 cd/m^2). The luminance response of the monitor was linearized with respect to the digital representation of the image, and 14-bit resolution was obtained with a Bits++ stimulus processor (CRS, Cambridge, UK). Images occupied the full extent of the monitor.

Monocular eye movements were recorded at 500 Hz with an EyeLink 1000 infrared eye-tracker (SR Research Ltd, Ontario, Canada). Raw gaze positions were converted to degrees of visual angle using the data from a nine-point spatial calibration procedure carried out at the beginning of each block of evaluations. Details of the calibration process are provided in Appendix A-6. In order to reduce participant fatigue and maintain experimental accuracy, the eye-tracker was recalibrated at approximately 10-minute intervals (Goldberg and Wichansky, 2003). This also allowed the participant to have a break, and therefore, to maximise the number of stimulus presentations with no blinks. Each participant completed one practice block followed by four experimental blocks, each featuring 10 images. Discounting the data from the practice block (the images featured in the practice block are provided in Appendix A-7), a total of 40 responses were gathered per participant. At a frequency of 500 Hz, 450000 data points were collected per participant per image. Each participant viewed each image only

once to prevent recognition and learning effects (Renninger and Malik, 2004, Kaspar and König, 2011).

A balanced Latin Square design was used to determine the sequence of blocks (Field and Hole, 2003). Every block always featured the same ten (10) distinct images, and within each block the order of presentation of the ten (10) images was randomised for each participant. Each image was only presented once throughout the entire experiment. Participants were asked to observe the scene on the screen as if it were a real view and provide, on a visual analogue scale, a rating of view preference, this being defined as "*how much you like the scene for whatever reason you may have"*. This definition derives from previous studies on environmental preference (Kaplan et al., 1972, Herzog, 1989, Herzog and Shier, 2000), whereas 'preference' was used in its noun form for expressing how much the participants 'liked' a view.

The participant sat in an electrically-lit room (2.26 m x 3.96 m) (Figure 3.2 - a) and the view position was secured using a chin and forehead rest with a viewing distance of 0.655 m from the CRT monitor (Figure 3.2-b). At the onset of the experiment, each participant was asked to read a set of instructions on the screen, including the above definition of preference, the use of the rating scale (described here below), and an explanation of the experimental procedure. During the experiment, the researcher was present in the same room as the participant but remained out of the field of view.

A white central fixation dot on a uniform grey background, which functioned as a fixation trigger, started each block of evaluations.

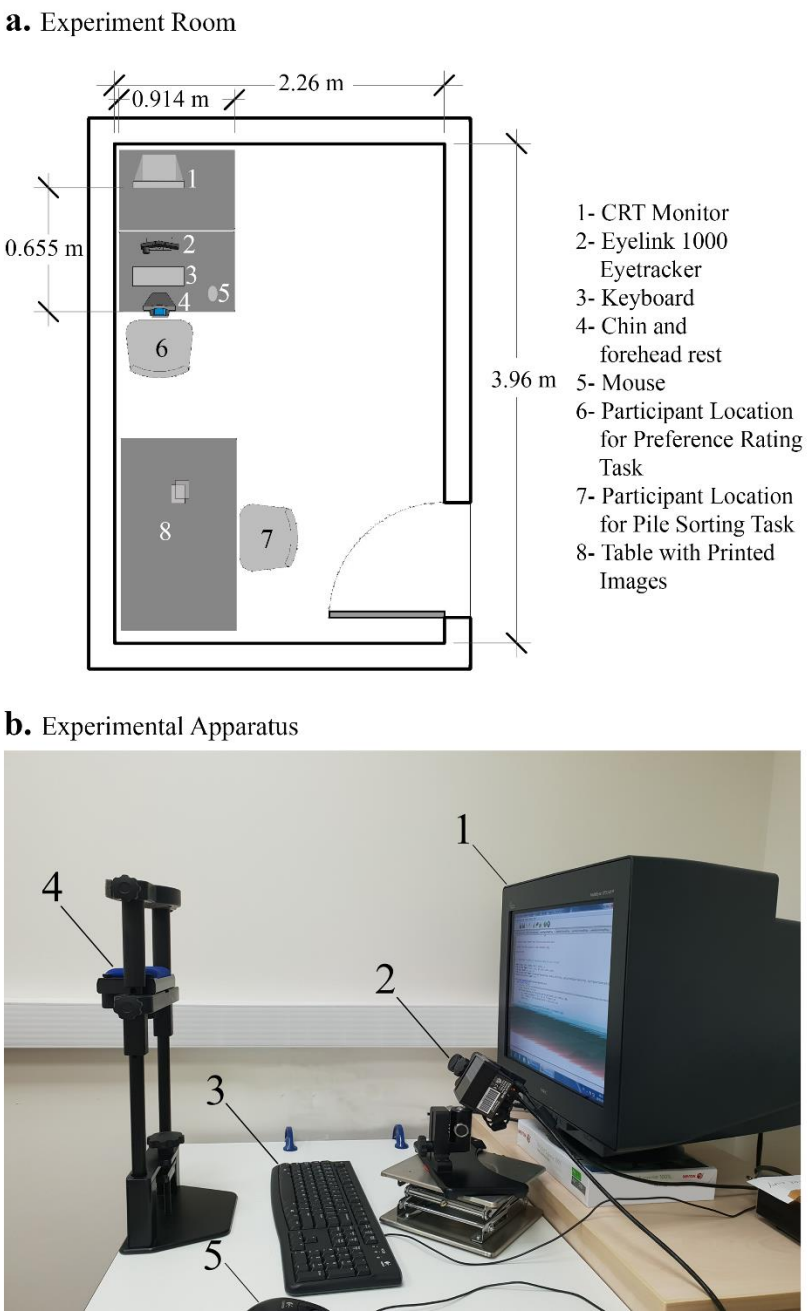


Figure 3.2 Experiment Room and experimental apparatus (Source: Author)

Participants fixated on the dot in the centre of the screen and were instructed to press any key on the keyboard to trigger the stimulus sequence. Each image was individually presented for 15 seconds (Valtchanov and Ellard, 2015, Franěk et al., 2018, Herzog, 1984, Herzog, 1985, Herzog, 1987), after which it was replaced automatically by an evaluation screen where

participants could give their preference rating. Evaluations were given using a visual analogue scale (VAS), where participants had to indicate with a mouse click the point on the scale that they felt best represented how much they liked the scene (Sung and Wu, 2018, Wewers and Lowe, 1990). The scale comprised a horizontal line anchored by two descriptors at each end, “Least Preferred” and “Most Preferred”, each also marked by the values of 0 and 1 to offer a numerical reference, without any gradation marks in between. No slider was present on the VAS to avoid a central anchor bias. Once their rating had been given, participants could press any key on the keyboard to restart the presentation sequence.

Pile Sorting Task

A pile sorting task was designed and utilised to address the potential limitations of subjective evaluations (Matusiak and Klöckner, 2016, Noland et al., 2017, Mirza and Byrd, 2020), and to identify characteristic features of views that could mediate individual preferences. Participants were presented with photographic cards featuring the 40 images previously seen on the CRT monitor. They were then asked to sort their three most preferred and their three least preferred views from the randomly ordered pile and to discuss these selections, verbally explaining the reasons for their choices.

Nature Relatedness

The Nature Relatedness Scale (NRS) is a self-reported measure of the affective, cognitive, and experiential aspects of an individual’s relation with nature (Nisbet et al., 2009) (Appendix A-5). Items in the scale are based on

three sub-themes (Appendix A – 5B). The first sub-theme, 'self', is a representation of one's internalized identification with nature, e.g. "*My relationship to nature is important to who I am*". The second theme, 'perspective', is an external reflection of one's nature-related worldview, e.g. "*I feel very connected to all living things and the Earth*". The third sub-theme, 'experience', is based on familiarity with the physical natural world based on prior experience, e.g. *"My ideal vacation spot would be a remote, wilderness area".* Participants filled out their responses, with each element evaluated using a 5-point Likert scale.

3.1.4. ***Data Analysis: Study 1***

Subjective data were anonymised using a Participant ID. All dependent variables, preference ratings and ETMs, were associated with an Image ID for further analyses using SPSS Statistics (version 25.0) (SPSS, Chicago, IL).

Preference Rating and Eye-tracking Measures

Data derived from the Visual Analogue Scale were tabulated against each image, creating a matrix of 32 x 40 preference ratings.

Eye-tracking data files were imported into MATLAB (The MathWorks Inc., 2017) to analyse gaze position. The internal software associated with the EyeLink 1000 eye-tracker was not utilized with the objective of reproducibility of outcomes. Instead, an open-source software for event detection (Nyström and Holmqvist, 2010) was used to derive unbiased ETMs

for quantitative analyses. In Study 1, focusing on urban views, the following oculometric response variables were recorded via eye-tracking measures: Number of fixations; Number of saccades; Mean fixation duration; Mean saccade amplitude; and, Mean saccade duration. In addition, in MATLAB, heat maps (gaze maps) were generated by weighting the cumulative number of fixations with time and superimposing them on the images for a visual representation of attention (Holmqvist et al., 2011:p.238).

Statistical Tests

For each eye-tracking measure, a further 32 x 40 matrix was created, mean averages were calculated, and individual measures were prepared for statistical analysis in SPSS Statistics (version 25.0). Each eye-tracking measure was tested to ascertain whether they met the conditions for parametric analysis (normality, homogeneity of variances, linearity and independence). Natural logarithmic transformations were performed if data were non-normally distributed and second-time testing of normality was conducted. Since the oculometric response variable Mean fixation duration (raw data and log-transformed) violated the assumptions for parametric analysis, non-parametric Mann-Whitney tests were used to analyse the raw data. All other responses – Number of fixations, Number of saccades, Mean saccade amplitude, and Mean saccade duration – did not violate the conditions for parametric analysis, therefore t-tests were performed on these data.

For the evaluations provided by participants, the experimental data were divided into two groups. Since the VAS yielded a preference rating

between 0 and 1, the mean value of preference ratings across all participants was calculated, and this threshold value, the 'grand mean', was set as a cut-off point. A continuous dependent variable (preference rating) was, therefore, converted into a binary variable (most preferred / least preferred) in order to measure the relationship between subjective preference and eye-tracking measures.

Two indicators were used for the statistical analysis of eye-tracking data: the significance of statistical tests at the α level of 0.05 and the effect size. To estimate the practical relevance of the differences detected in each eye-tracking measure for 'most preferred' and 'least preferred' views for parametric t-tests, Cohen's *d* values of 0.2, 0.5, and 0.8 were used as benchmarks of, respectively, small, medium, and large effect sizes (Cohen, 1988). The Pearson's *r* coefficient was used to estimate the magnitude of the differences detected in the non-parametric statistical tests, calculated from the standardised z scores. Values of *r* were inferred to range between small ($0.1 \leq r < 0.3$), medium ($0.30 \leq r < 0.50$) and large (≥ 0.50) effects (Rosenthal, 1991, Field, 2009:p.57). For $d < 0.2$ and $r < 0.1$, effects were considered of negligible magnitude and, therefore, not practically relevant.

Qualitative Data

The three most preferred and three least preferred images were identified for each participant within the 32x40 matrix of preference ratings. This step afforded a direct comparison between quantitative and qualitative data. The verbal reasoning data associated with each image selected in the

pile-sorting task were coded as 'least preferred' and 'most preferred' using NVivo-12 (QSR, 2019). Using the 'word frequency count' feature in NVivo-12, a list of words most frequently used to describe the images was populated. This list was further subdivided into: (a) elements in the images (i.e., specific nouns); and, (b) adjectives (descriptors). These were finally organised in word frequency tables.

3.1.5. *Data Analysis: Study 2*

Data gathered from each participant were assigned a corresponding Participant ID (1-15). All preferences were associated with an Image ID (i1-i40). Data from subjective ratings and eye-tracking measures were organised in a 15*40 (participant*image) matrix using SPSS Statistics version 25.0 (SPSS, Chicago, IL). Since all dependent variables were measured at a continuous level, the means across the data were used for subsequent analysis.

MATLAB 2017a (The-MathWorks-Inc., 2017) was used to analyse ETMs data. In order to present unbiased interpretation of gaze metrics (Holmqvist et al., 2011, Andersson et al., 2017), an open-source software package for event detection (Nyström and Holmqvist, 2010) was adopted to derive eye movement statistics from three eye-tracking measures: Number of fixations; Number of saccades; and, Mean fixation duration. Heat maps (HMs) were created by weighting the total number of fixations with time and superimposing them on the images in MATLAB.

Statistical Tests for View Preference

To compare differences in ETMs based on view preference, the mean-split method was used to undertake two types of data analysis. In the first step, the preference ratings for all images and for all participants were combined to derive a 'grand mean' for the entire group. This grand-mean was used as a benchmark to divide the sample into two categories: 'most preferred' and 'least preferred' views. Subjective preference ratings and ETMs (Number of fixations, Number of saccades, and Mean fixation duration), identified for each Image ID, were systematically tested to confirm whether they met the conditions for parametric analysis (Field, 2009). When ETMs violated the assumptions required for parametric tests, non-parametric Mann-Whitney tests were used. Otherwise, independent samples t-tests were run to compare the differences in gaze between least and most preferred views for Number of fixations, Number of saccades, and Mean fixation duration. Inferences were based on the estimation of the statistical significance – *p*-value at the alpha level of 0.05 – and the magnitude of effect size, using the Cohen-*d* coefficient based on established benchmarks (respectively, 0.2, 0.5, and 0.8 for small, medium, and large effects) (Cohen, 1988).

In the second step, the mean preference across all images was calculated separately for each participant and used as a threshold to sort 'most preferred' and 'least preferred' views. This analysis considered individual differences in view preference and enabled the researcher to

compare ETMs for the images that were most and least preferred by each participant. A difference score was calculated for each ETM and tested for normality. Shapiro-Wilk tests confirmed normal distributions of data for Number of fixations (p= 0.062), Number of saccades (p= 0.066) and Mean fixation duration (p= 0.890), and boxplots did not show any outliers. Within-subject differences in ETMs were tested using (related) t-tests. To estimate the magnitude of the differences detected for each ETM between most preferred and least preferred natural views, the r coefficient was calculated (Field, 2009, Rosenthal, 1991). Inferences were based on the detection of statistical significance (p-value) and on estimation of effect sizes (r) based on established benchmarks (with 0.1, 0.3 and 0.5 marking, respectively, small, moderate and strong effects (Cohen, 1988)).

Pile Sorting Analysis

Selections of the three most and the three least preferred views given by each of the 15 participants were tabulated. Verbal reasoning data for both most and least preferred views were coded in the NVivo-12 (QSR, 2019) qualitative data analysis software. Using the Word Frequency Query feature in NVivo-12, lists were generated featuring the words and the descriptors that participants most frequently used to refer to the images they had selected as their least and most preferred choices.

3.1.6. *Comparison between View Type*

Study 1 and Study 2 focused on experimentally measuring view preference of urban and natural images, respectively. For the purpose of conducting a repeated-measure within-subject analysis between the two studies, the data gathered from those 15 participants taking part also in Study 2 were extracted from Study 1, and a 15*40 matrix for each dependent variable was created. All ETMs dependent variables were measured on a continuous scale. For each dependent variable, two conditions were identified: urban (Study 1) and natural (Study 2). In this way, data were matched for each participant via Participant ID and imported into SPSS Statistics (version 25.0).

For each pair of variables, a difference score statistic was generated. The distribution of each difference statistic was inspected for normality and for outliers. The difference scores between natural and urban views were normally distributed, as assessed by Shapiro-Wilk's tests for Number of fixations (p= 0.723), Number of saccades (p= 0.779), and Mean fixation duration (p= 0.551). Boxplots were used for detecting outliers. No data points were more than 1.5 box-lengths from the edge of their box, as identified by SPSS Statistics. As the assumptions of normality were met, within-subject (related) t-tests were used for comparing the ETMs associated with the urban and natural views.

Similar to the data analysis procedure for natural views (see Section 3.1.5), the ETMs data for urban scenes were re-evaluated using each

participant's preference ratings to split views into 'most preferred' and 'least preferred' categories. Difference scores for each ETM were populated and inspected for normality and outliers. Shapiro-Wilk tests confirmed normal distributions for Number of fixations (p= 0.370), Number of saccades (p= 0.926), and Mean fixation duration (p= 0.125). Visual inspection of box-plots did not show any outliers. Within-subject (related) t-tests were then run on the urban views data. Inferences were based on the estimation of statistical significance (p-value) and magnitude of effect size (r).

In addition, the relationship between the reported NRS scores in each viewing condition – i.e., for urban (NRS_{urban}) and natural ($NRS_{natural}$) scenes – and gaze behaviour was analysed. NRS scores ranged from 0 to 5. The NRS scores were collated to calculate a sum score for each participant (Nisbet et al., 2009). In order to analyse relationships between ETMs and NRS, a Pearson's product-moment correlation analysis was run with the NRS score as an independent variable. Estimation of the Pearson r coefficient was based on the previously mentioned benchmarks from the literature (Cohen, 1988).

3.2. Survey Method

3.2.1. *Survey Design*

To respond to the second specific objective of this research – that is, *to identify what features of window views influence preference* – a global online survey was designed to record and analyse participants' assessment of their own window views. The research question that this method intended to

address was: which features of windows and views influence appreciation for participant's own views? Existing quantitative and qualitative research on window views has often been restricted to geographic regions. Previous studies employing university students as participants report results that are bound to a particular locality (city), especially in urban environments where certain features of the environment may be commonly experienced (Mirza, 2015). These results often have the limitation of only capturing the key features of that city and people's experiences associated with them, while overlooking the overarching constructs related to window view perceptions. As a consequence, there is a need to expand the scope of current knowledge on window view preferences and facilitate transferability of findings to different socio-environmental contexts.

For this purpose, during the period between 21 October 2019 – 22 January 2020, an international survey (Survey 1) was hosted online on the Soscisurvey platform (SoSciSurvey, 2019). A second survey (Survey 2) ran between 5 April 2020 – 4 May 2020 (see Section 3.2.2 for further details on Survey 2). The original survey was structured into 24 questions, ranging from exploring window characteristics to perceptions of view familiarity, preference, satisfaction, etc. The presented questions were based on a review of the literature focused on window view preference (Christoffersen et al., 2000, Farley and Veitch, 2001, Hellinga and Hordijk, 2014, Heschong Mahone Group, 2003a, Matusiak and Klöckner, 2016). A summary of the questions and scales used is presented in Table 3.1. These surveys differed from most previous studies in the literature as the participants were asked to

take a photograph of their view out, so that a visual representation of the view in question was also documented. In order to better understand the relationships and tangible interactions with the window, open-ended options in multiple choice questions were included, while participants could also explain what they specifically noticed, liked or disliked, in their view in the form of free text. This was considered particularly valuable to record qualitative explanations as a proxy for participants' behaviour with respect to their windows and views.

Table 3.1 Survey questions and scales

Question	Scale	References
Location (Country/town)	Text	(Elzeyadi and Batool, 2017)
Floor	Underground, Ground, 1, 2, 3,4,5, other __	(Nichols, 1977, Haber, 1977, Manning, 1965)
Time Spent	Less than 3 months, 3 – 6 months, Between 6 months and 1 years, 1-3 years, More than 3 years	
Time of the year		
Time of the day		(Kent et al., 2014)
Direction of view	N, E, S, W, NE, NW, SW, SE	(Batool, 2014)
Window elements	Glass, Yes/No/Maybe Wire mesh Yes/No/Maybe External Shading, (e.g., louvers, overhangs, etc.) Yes/No/Maybe Internal Shading, (e.g., blinds, curtains, etc.) Yes/No/Maybe Any other shading device Yes/No/Maybe Tinted Glass Yes/No/Maybe	(Batool, 2014, Konstantzos et al., 2015, Cetegen et al., 2008, Inkarojrit, 2005)
Shading Control	yes, no, does not apply	

Question	Scale	References
Reasons for Blind Operation	Let daylight in Tell me how the weather is outside Tell me the time of day Increase or decrease the ventilation Provide light to plants Let me observe other people and activities outside Provide good lighting in the space Provide a view out Allows me to look away from my task (e.g., computer screen) Let me interact with something/someone on the other side of the window Other _____	(Wang and Boubekri, 2011, Inkarojrit, 2005, Christoffersen et al., 2000) (Cetegen et al., 2008)
Distance to the window	Adjacent to Window 1 m (1- 3 ft) 1-2 m (4- 6 ft) away More than 3 m (7 ft+) away Other	(Keskin, 2019) (Hellinga, 2013)
Window View Preference	least preferred – most preferred	(Kaplan, 2001)
View Familiarity	not at all familiar – extremely familiar	(Herzog et al., 1976)
Satisfaction with the size of the window	least satisfied – most satisfied	(Moscoso et al., 2020)
Satisfaction with view out of the window	least satisfied – most satisfied	(Cetegen et al., 2008, Christoffersen et al., 2000)
Satisfaction with your usual location relative to the window (s)	least satisfied – most satisfied	(Wang and Boubekri, 2010)
Satisfaction with the size of the room with respect to the window	least satisfied – most satisfied	(Moscoso et al., 2020)
Positive Window	None Tells me the time of day Lets daylight in Tells me how the weather is outside Provides light to plants Allows me to look away from my task (e.g., computer screen) Allows fresh air into the space Provides good lighting in the space Provides a view out	(Christoffersen et al., 2000) (Christoffersen et al., 1999)

Question	Scale	References
	Lets me observe other people and activities outside Lets me interact with something/someone on the other side of the window Other ____	
Negative Window	None Allows too much heat Allows too much sunlight Provides too much cold draft in winter Activities outside distract me Allows too much noise from the street Causes annoying glare Can't see the ground Can't see the sky Reduces the ability to freely furnish the space Provides poor working light Allows others to see inside Other _____	(Christoffersen et al., 2000, Christoffersen et al., 1999)
What is it that you like about this view through the window? What do you especially notice when you look?	Open Ended	
What is it that you dislike about this view through the window?	Open Ended	
COVID-displacement Could you please add some details on your interaction with your window?	Yes-No Open Ended	

3.2.2. ***Survey 2 during the COVID-19 pandemic***

A few months after the data collection of Survey 1 was completed, a lockdown was imposed in many parts of the world in response to the spread

of the SARS-CoV-2 virus. This offered an opportunity to collect new data to compare with the existing dataset and investigate any impact that such a radical change to the ways of working and living, and interactions (or lack thereof) with the external environment, might have had on window perception. The same survey was opened for four additional weeks on 5 April 2020 (Survey 2), when the global response on containment strategies was at its peak (Hale et al., 2020a). Since the term 'lockdown' has been interpreted and implemented differently across the world, the *stringency index* (Hale et al., 2020c) was used as a comprehensive measure of government responses to the COVID-19 outbreak. Throughout the administration period of Survey 2, this index ranged between 66.2 and 91.5 in average (on a scale of 0–100) in 37 out of the 38 the countries from where data were gathered (Hale et al., 2020a), and between 54.48 and 75.12 from participating US states (Hale et al., 2020b). Please refer to Appendix F for a complete breakdown of this metric.

The survey questionnaire was deliberately kept the same as Survey 1. In addition, at the end of the survey, two questions were added (Question 25 and 26) to qualitatively assess any reported difference in perception due to the COVID-19 lockdown. An analysis was drawn comparing the responses between Survey 1 (Pre-COVID-19) and Survey 2 (during-COVID-19) and the methods for this comparative analysis are presented in Section 3.2.7.

3.2.3. *Ethics and data protection*

The original survey received ethics approval from the University of Nottingham, Faculty of Engineering, Ethics Committee in October 2019. Participants were recruited using snowball sampling via various international networks, including email listservs and social media. Anyone over the age of 18 could participate in the survey by signing an online consent form in compliance with the ethics statement and privacy protection regulations (GDPR, 2016) (Appendix C presents the complete survey as hosted on the website). The survey host platform Soscisurvey (SoSciSurvey, 2019) was selected due to its compliance with the GDPR regulation (GDPR, 2016), specifically for hiding information on digital signatures and meeting data localisation requirements, and for its data management protocol, which many available software/websites did not guarantee. Since the participants were asked to upload a photograph of their view out of the window, it was critical that personally identifiable information was not collected, to avoid possible triangulation, as advised by the GDPR.

3.2.4. *Survey instrument*

Following the consent form, a series of initial questions aimed at gathering information on the setting from where the survey was responded, while all subjective evaluations were measured on a visual analogue scale. To further explore the responses provided, the survey featured multiple-choice questions on various window features and gave participants the opportunity

to express open-ended comments in the form of free text. Table 3.1 lists the question topics and the scales used. The questions were kept brief to prevent biases associated with response fatigue (Choi and Pak, 2005). The survey took approximately five minutes to complete.

3.2.5. *Data Collection: Study 3*

Study 3 includes the analysis of all the data collated from the two surveys. Over the two periods, the survey link was clicked 4467 times and 745 complete responses were registered, 507 during Survey 1and 238 Survey 2. After visual inspection of the photographs uploaded in the survey, some had to be eliminated if the photograph was either unclear or did not show a clear view out of the window. This reduced the dataset to 720 valid responses, which were retained for the analysis of Study 3.

Photographs

Participants were asked to upload a clear photograph of their view out. Asking respondents to upload a photograph ensured they actively engaged with the survey, and that their answers could be contextualised with respect to the actual view out of their own window.

Quantitative Responses

As a part of the survey, the quantitative response questions varied in their type and measuring scale, including the use of a drop-down menu, selection from a list, free text responses, and multiple-choice questions.

Table 3.1 lists the different aspects of window and view attributes that were addressed in the questionnaire.

Initial questions on participants' location – e.g., nearest town and country – allowed to contextualise the findings, and to test for any cross-cultural differences. Information was gathered on the orientation of the window and whether there were any window elements present in the view. A question on the device used to take the photograph allowed the researcher to evaluate the quality of the images. Participants were asked how far they were seated with respect to the window, how long they had occupied the space, and on which floor of the building they were located.

Using a visual analogue scale (Sung and Wu, 2018), core questions asked the respondent their level of preference, familiarity, and satisfaction with their view out of the window. Since previous studies on window views employed the construct of 'satisfaction' with the view out (Christoffersen, et al., 2000, Markus, 1967), this was included in this survey to better characterise individual perception. Familiarity was also identified in the literature as a construct that has been less explored in window view research. The questionnaire also assessed participants' self-reported satisfaction with the size of the window, with the room's size with respect to the window, and with the location of the participant with respect to the window in order to contextualise the effect of the nearby environment.

Finally, the survey used a multiple response approach to identify the window attributes, and their interactions, that positively and negatively contributed towards preference formation. Two questions asked participants

to select up to three aspects of windows that were considered positive and negative, respectively. Questions on blind/curtain access, and the reasons for opening them, were also posed.

Qualitative Textual Responses

Survey of participants' *in situ* experience with their own view offers the opportunity to capture the aspects that most matter to them with respect to their environmental settings. By incorporating qualitative responses, the collection of data can tap into behavioural and psychological aspects, uncovering interactions with windows and views, yet maintaining openness and flexibility (Braun et al., 2020).

The inclusion of qualitative responses in a survey (e.g., open-ended questions) is often helpful and worth of consideration (Ainley et al., 2018), although a thorough analysis of these data is less common (Rich et al., 2013, Arditi et al., 2020) and rarely goes beyond frequency counts of occurrences of constructs (Braun et al., 2020, Braun and Clarke, 2013). Whether used for cross-validation, contextualization, or both, (semi-)open questions have the potential to expand on previous findings and facilitate the elaboration of new theories and psychological constructs (Wijngaards et al., 2019). Previous qualitative research (Hauge, 2013, Hauge, 2015) has shown that the meanings associated with the function of windows can vary significantly between countries and cultures. Qualitative research on views has proved to be effective in revealing mental constructs related to windows (Mirza, 2015). However, it is useful for participants to be close to their window when they

are responding to the questions, so that they are banking less on their memory for recollection.

By including open-ended response questions on what people like and dislike in views, the survey also offered an alternate prospect to capture perceptions and what participants notice in the view. Textbox 1 shows the free text questions.

> Q23. What is it that you like about this view through the window? What do you especially notice when you look?
> Q24. What is it that you dislike about this view through the

Textbox 1. Free text questions in the survey

3.2.6. *Data Distribution*

The distribution of data from the 720 responses is provided in Table 3.2 below. The responses were spread over 50 countries but were mostly collected from the UK (36.8%), USA (11.4%), Portugal (6.5%), Belgium (6.4%) and Poland (5%).

Table 3.2 List of countries of participation (in alphabetic order)

#	Country	Frequency	Percentage (%)
1	Australia	12	1.7
2	Austria	4	0.6
3	Belgium	46	6.4
4	Bulgaria	1	0.1
5	Cambodia	1	0.1
6	Canada	15	2.1
7	Chile	3	0.4
8	China	1	0.1
9	Croatia	1	0.1

#	Country	Frequency	Percentage (%)
10	Cyprus	2	0.3
11	Czech Republic	3	0.4
12	Denmark	8	1.1
13	Egypt	3	0.4
14	Estonia	3	0.4
15	France	13	1.8
16	Germany	9	1.3
17	Greece	17	2.4
18	Hong Kong	1	0.1
19	Hungary	6	0.8
20	India	1	0.1
21	Indonesia	1	0.1
22	Ireland	4	0.6
23	Israel	3	0.4
24	Italy	29	4.0
25	Japan	2	0.3
26	Latvia	1	0.1
27	Lebanon	2	0.3
28	Luxembourg	1	0.1
29	Malaysia	3	0.4
30	Mexico	11	1.5
31	Netherlands	9	1.3
32	New Zealand	2	0.3
33	Nigeria	1	0.1
34	Norway	1	0.1
35	Pakistan	24	3.3
36	Poland	36	5.0
37	Portugal	47	6.5
38	Romania	2	0.3
39	Saudi Arabia	1	0.1
40	Singapore	1	0.1
41	Slovakia	1	0.1
42	Slovenia	3	0.4
43	South Africa	1	0.1
44	Spain	26	3.6
45	Sweden	5	0.7
46	Switzerland	3	0.4

#	Country	Frequency	Percentage (%)
47	Thailand	1	0.1
48	Turkey	2	0.3
49	UK	265	36.8
50	USA	82	11.4

Based on the UN – Continent classification (United Nations, 2019), each country was designated to a continent (Table 3.3). Most responses were received from Europe (75.6%) and North America (15.0%).

Table 3.3 Distribution of participants according to continents

Continent	Frequency	Percentage (%)
Africa	5	0.7
Asia	46	6.4
Europe	544	75.6
North America	108	15.0
Oceania	14	1.9
South America	3	0.4

Several intra-architectural variables were also recorded in the survey. In terms of floor level, the majority of responses were received from people located between the ground floor (33.2%) and the first floor (31.0%) (Table 3.4).

Table 3.4 Distribution of responses according to floor level

Floor	Frequency	Percentage (%)
Ground	239	33.2
Floor 1	223	31.0
Floor 2	117	16.3
Floor 3	46	6.4
Floor 4	34	4.7
Floor 5	23	3.2
6 floors and above	32	4.4
Underground	6	0.8

For orientation of windows, the location of participants was generally evenly distributed among cardinal directions, although with most responses from the North (18.3%) and East (16.3%) (Table 3.5).

Table 3.5 Frequency distribution based on window orientation

Orientation	Frequency	Percentage (%)
North	132	18.3
North East	56	7.8
East	117	16.3
South East	63	8.8
South	105	14.6
South West	63	8.8
West	114	15.8
North West	55	7.6

Table 3.6 shows the participants' position with respect to the window. The majority was seated adjacent or within one meter from the window (52.7% in total).

Table 3.6 Participant's location with respect to the window

Distance of usual location from the window	Frequency	Percentage (%)
Adjacent to Window	146	20.3
1 m (1- 3 ft)	233	32.4
1-2 m (4- 6 ft) away	247	34.3
More than 3 m (7 ft+) away	94	13.1

The distribution of time spent by participants in the space was spread unevenly, with most people having spent more than 3 years (39.9%), followed by those who had spent 1-3 years (21.7%) and then those who had only occupied the space for less than 3 months (18.1%) (Table 3.7).

Participants were asked to provide additional information about any elements that may be present in the view (while taking the photograph). The

majority signalled the presence of glass (81.4%) and other shading devices (Table 3.8).

Table 3.7 Time spent in the space at the time of the survey

Time spent in the current space	Frequency	Percentage (%)
Less than 3 months	130	18.1
3 - 6 months	82	11.4
Between 6 months and 1 year	65	9.0
1-3 years	156	21.7
More than 3 years	287	39.9

Table 3.8 Window elements present in the view while taking the photograph

Window element	Yes (%)	No (%)	May be (%)
Glass	586 (81.4)	115 (16.0)	18 (2.5)
Wire-Mesh	67 (9.3)	618 (85.8)	31 (4.3)
External Shading	107 (14.9)	558 (77.5)	50 (6.9)
Any other shading	183 (25.4)	496 (68.9)	39 (5.4)
Tinted Glass	63 (8.8)	628 (87.2)	24 (3.3)

3.2.7. ***Data Analysis: Study 3***

All quantitative data from the 720 valid responses were imported in MS Excel for data sorting, and then analysed through SPSS Statistics (version 25.0). Qualitative responses from Questions 23 and 24 (what participants liked/disliked about the view) were extracted based on Participant IDs and imported into MS Excel, initially, and then into NVivo-12 (QSR, 2019) for a thorough analysis. Window view preference was considered as one of the independent variables.

Initial quantitative tests were run to verify if the data met the assumptions for parametric analysis. Although the tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk) were both significant, visual inspection of the boxplots and histograms revealed skewness in the data and the presence of outliers. Rather than deleting outliers, as they seemed to present valid cases (i.e., participants with a reasoned justification for their differences in perception), non-parametric tests were used to analyse the responses. This is generally considered a more resilient approach to treat data with outliers (Field, 2009). The Kuskal-Wallis H test is a one-way ANOVA analysis on ranks that can be used to compare two or more groups. Intra-architectural variables, such as the distance from the window and floor level, were compared on window view preference using these tests.

The emphasis of the inferential analysis was placed on the significance of the statistical tests (at the α level of 0.05) and on the effect size, thus providing a standardised measure of the practical relevance of the differences and influences detected. The effect size was estimated by the Pearson's coefficient *r*, calculated from the z scores. The interpretation of the outcome was derived from published benchmarks, with values ranging from negligible (r <0.1) to small (0.1≤ r <0.3), medium (0.30 ≤ r <0.50) and large (≥0.50) (Cohen, 1992, Field, 2009:p.57).

Relationship between satisfaction, familiarity, and view preference

In addition to intra-architectural features, the survey aimed to test the relationship between the constructs of 'satisfaction' and 'preference' for

the view out of the window. Other variables related to familiarity and the characteristics of the internal space were also collected in the survey. To test the correlation between the measured satisfaction with view, size of the window, size of the room, familiarity and window view preference, the assumptions for the parametric tests were verified. Although the pairs of correlations met the required conditions (collinear relationship) and were both measured on a continuous visual analogue scale with word descriptors at the extremes, the variables did not have normal (or close to normal) distribution, being instead all negatively skewed (Table 3.9).

Table 3.9 Normality tests for variables (***= statistically significant at $p < 0.001$)

Variable	Kolmogorov-Smirnov	Shapiro-Wilk
Window View Preference	0.113***	0.926***
Familiarity: Window View	0.183***	0.827***
Satisfaction: The size of the room with respect to the window	0.112***	0.929***
Satisfaction: View out of the window	0.096***	0.936***
Satisfaction: The size of the window	0.123***	0.913***
Satisfaction: Your usual location relative to the window (s)	0.082***	0.954***

One of the potential solutions to be able to use parametric tests (Pearson correlations) is to transform the data and to re-test for normality and for the presence of outliers. However, this approach comes with a degree of uncertainty. This is because the analysis of transformed data is harder to interpret and the interpretation depends on the scale in which each variable is measured (Tabachnick and Fidell, 2013:p.120). The logarithmic

transformation recommended for skewed data compresses high values and spreads low values by expressing the data points by order of magnitude (McCune and Grace, 2002). The idea of eliminating the outliers was not considered, due to the unexpected, yet valuable, nature of these data. It is important to stress out, in fact, that the data points and their corresponding textual explanations showed that these ratings were, in fact, valid. For this reason, data transformation was not performed, and non-parametric Spearman's correlations were instead run on the data. The results of Spearman's rank correlations were interpreted based on the benchmarks proposed by Ferguson (2009:p.533): $\rho > 0.2$, meaning a practically relevant effect; $\rho > 0.5$, signalling a moderate effect; and $\rho > 0.8$, corresponding to a strong effect, and the statistical significance of the effect is measured at $p < 0.05$.

Composite features of windows

Previous research has shown that the most important functions of windows for building occupants are to provide access to daylight, view out, and ventilation. This survey, however, intended to also identify other features influencing view appreciation (see Necessary Condition Analysis below), and the potential combination of positive and negative window attributes. This question derives from the awareness that many meanings and functionality features might be ascribed to windows by building occupants (Hauge, 2013, Hauge, 2015). Therefore, an analysis of the

'composite', positive and negative, features of windows could enable a more holistic understanding of the perception expressed by building occupants.

Questions were framed so that survey respondents could select up to three features that they considered positive or negative about the window. The statements relative to the positive features are illustrated in Textbox 2.

Which of the following statements do you find the most positive about the window?
(Please read all options before checking maximum 3 answers)
No more than 3 answers
A. None
B. Tells me the time of day
C. Lets daylight in
D. Tells me how the weather is outside
E. Provides light to plants
F. Allows me to look away from my task (e.g., computer screen)
G. Allows fresh air into the space
H. Provides good lighting in the space
I. Provides a view out
J. Lets me observe other people and activities outside
K. Lets me interact with something/someone on the other side of the
window (free text)

Textbox 2 Statements on positive window attributes

Textbox 3 lists the statements offered to select up to three negative features of windows. Again, in response to this statement, a new variable was created that represented the combination of options selected by participants.

The (up to three) selections made by each participant were later combined using a MATLAB code. Each composite feature was ascribed to the

Participant ID and imported into SPSS for further analysis. In addition, to facilitate visualisation of the combinations of these variables, sunburst charts were created in MS Excel 2016.

Which of the following statements do you find the most negative about the window?
(Please read all options before checking maximum 3 answers)
No more than 3 answers
A. None
B. Allows too much heat
C. Allows too much sunlight
D. Provides too much cold draft in winter
E. Activities outside distract me
F. Allows too much noise from the street
G. Causes annoying glare
H. Can't see the ground
I. Can't see the sky
J. Reduces the ability to freely furnish the space
K. Provides poor working light
L. Allows others to see inside
L. Other

Textbox 3 Question asked in relation to the negative window features or attributes

In order to create the sunburst charts, for each combination of three variables, one variable was held as the anchor, at the centre of the sunburst chart, the remaining two were visualised in two radial concentric circles, such that the inner circle was a combination of the anchor variable and one more variable, and the outer circle represented the combination of the three variables. The value of combination, read inwards from the outer circle, shows how the outer rings relate to the inner rings. A sunburst chart was

created for all variables of positive and negative features. Figure 3.3. illustrates a sample sunburst chart with one of the variables, at the centre of the figure. The colours in the legend correspond to the second circle of the sunburst chart. Two sunburst charts are discussed in depth in the Results (see Section 5.2.1 and Appendix D for the full list of sunburst charts).

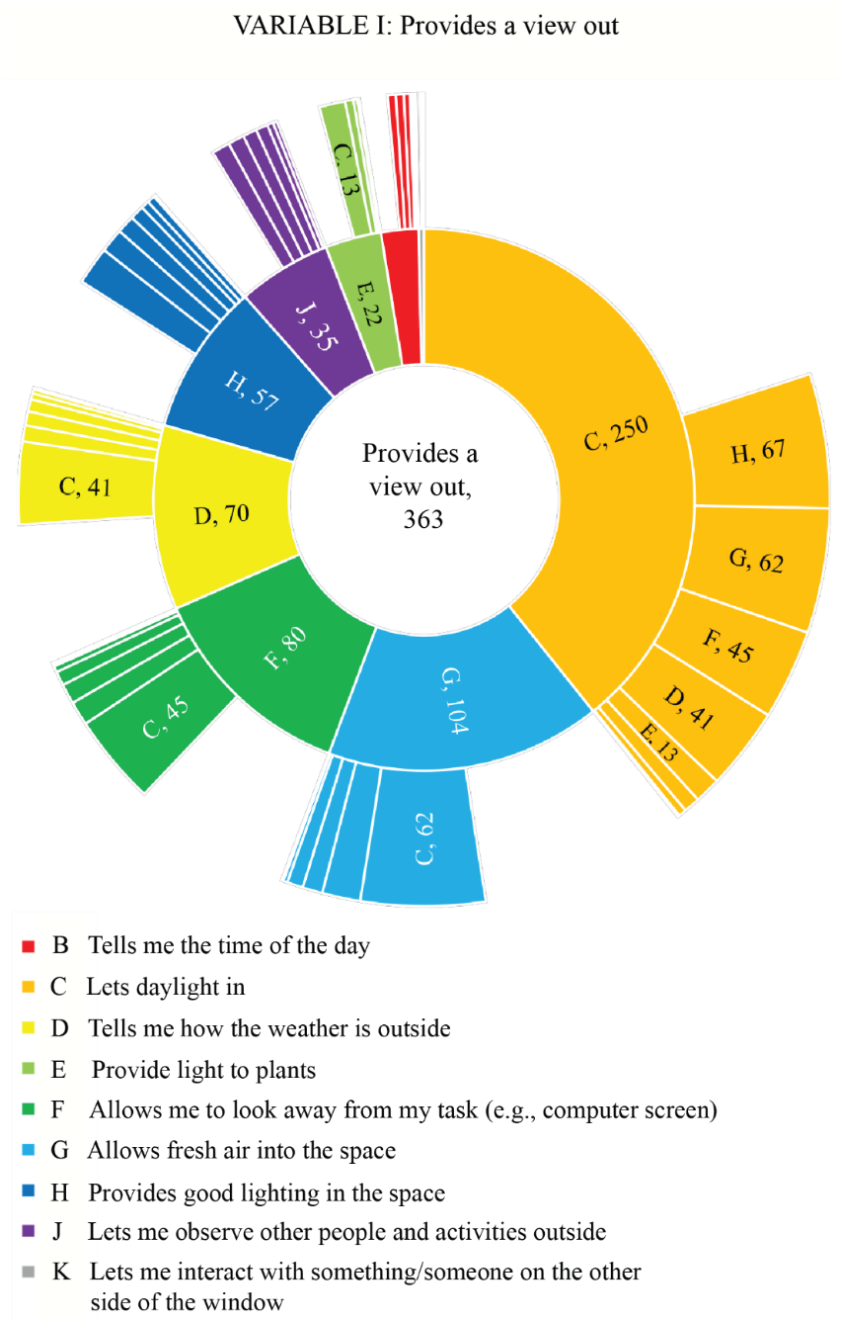


Figure 3.3 Example illustration of a sunburst chart (Source: Author)

Among the positive window attributes, the anchor variable (presented in the centre) and most frequently selected feature was 'lets daylight in', which, consequently, had the highest number of combinations. Among the negative window attributes, the feature 'provides too much cold draft in winter' was selected as the anchor variable. These two sunburst charts represent the most emergent composite features of windows, as perceived by building occupants.

Necessary Condition Analysis

Once the combinations of variables have been analysed, another goal was to identify the impact of selection of each window feature on the dependent variable 'window view preference'. A Necessary Condition Analysis (NCA) approach was chosen for this purpose (Dul, 2020). In line with the original research question (what factors influence view preference in real window settings), the necessary condition analysis can offer valuable insights beyond a conventional statistical approach.

In conventional statistics, the most common interpretation of 'X causes Y' often implies that 'X produces Y' although, in fact, it means that a change in 'X' results in a change in 'Y'. If the presence of 'X' ensures the presence of 'Y', this is known as the 'necessity logic' (Dul, 2016). Other common constructs used to explain this logic are: 'X is necessary for Y'; 'X enables Y'; and, 'X is needed for Y'. Crucially, none of the methods used to test the predictors of preference seem optimal for a proper analysis of the hypothesized 'necessary-but-not-sufficient' relationship. The main

disadvantage of previous research adopting this logic is the use of 'average-based' methods; for example, the regression line is a best estimate across different data points. In doing so, the general pattern of relationship suggested by the necessary condition hypothesis is, effectively, ignored. Therefore, regression-based methods are fit for testing the general inference ('if X, then Y on average'), but they are not meant for testing the 'necessity assumption' ('there is no Y without X') (Dul, 2016).

The interpretation of the 'necessary but not sufficient' logic is best visualised in a two-dimensional X-Y plot, where 'X' increases towards the right, and 'Y' increases along the vertical axis. If a variable 'X' is necessary for window view preference, there should be no response in the top left corner, which means that there should be no survey participant (or, at least, they should be very few) who did not select 'X' as a positive feature of view/window, having rated the view high on preference (Figure 3.4). This requires a different analytic approach than the classic correlational analyses, which is offered by NCA (Dul, 2016, 2020). Therefore, by using NCA, the positive (and negative) attributes/variables can be identified that, when selected, result in high (or low) window view preference. The NCA focuses on single independent variables that are necessary-but-not-sufficient for an outcome to occur. This is particularly relevant as the average effects, demonstrated through the multiple regressions, do not allow for a direct interpretation of an individual variable's role in window view preference.

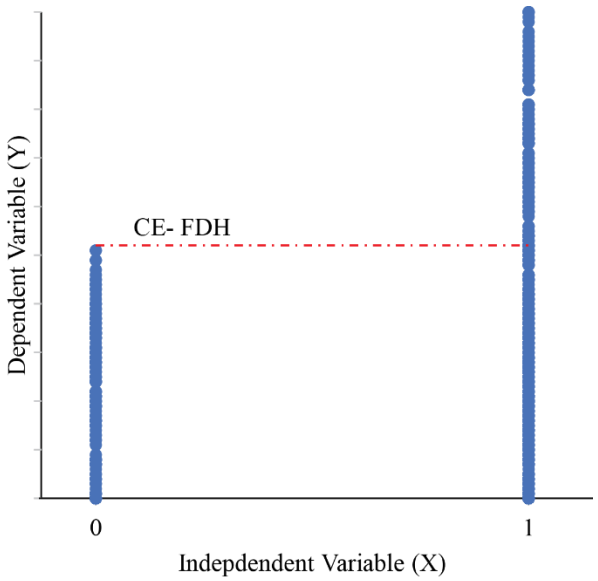


Figure 3.4 Sample scatter plot for Necessary Condition Analysis and the CE-FDH (Ceiling Envelopment–Free Disposal Hull) line drawn to emphasize the data (Dull, 2016, 2020).

In statistics, the correlation analysis is commonly used, since it was introduced by Francais Galton (Stigler, 1989), to predict an outcome from a single or multiple variables. However, necessary (but not sufficient) conditions exist in real life. For example, taking the GRE (Graduate Record Examination) is a necessary condition for admission to graduate school, but a high or low GRE score does not guarantee school entrance. In other words, a necessary condition, if present, allows the outcome to be produced but does not produce it. This dichotomous interpretation can be modified to a continuous interpretation, for example, a certain level of necessary condition is required for a certain level of outcome variable. For example: the presence of variable 'X' is necessary but not sufficient for a certain level of outcome (e.g., view preference, variable 'Y'). Necessary condition analysis, introduced by Jan Dul (2016), has recently been adopted by studies in multiple

disciplines including psychology (Karwowski et al., 2016), and environmental modelling (Ben Jabeur, 2020), to identify necessary-but-not-sufficient conditions required for an outcome. The NCA is both a statistical and a visual method of analysis.

The NCA draws a ceiling line above the observations in the space of the observations. The ceiling $Y = f(X)$ separates the area of Y with cases and that without cases, provided that X exists. The ceiling line approach is different from the traditional correlation analysis, which instead draws a line through the middle (average) of the dataset. One proposed method to draw the ceiling line is called the Ceiling Envelopment–Free Disposal Hull (CE-FDH) (Dul, 2016)), a non-decreasing step-wise linear line ('step function') (Dul, 2020:p.58) through the upper-left observations of a scatterplot, with X or Y as discrete variables. The X is plotted on the horizontal axis, and Y is plotted on the vertical axis of a two-dimensional plot.

Since the independent variables are discrete (variable selected/not selected), the CE-FDH line is used in this research. The CE-FDH does not allow points above and beyond the line and creates the largest empty space above the line. The measure of significance is accounted for through a *p*-value of less than 0.05 (Fisher, 1935) as an indicator of whether the observed effect is a result of random chance (Dul et al., 2020).

The effect size (*d*) of a necessary condition is the area of the 'empty' zone above the ceiling line divided by the area of the 'scope', which is the total area where data could exist given the full range of values of X and Y. The NCA looks at the empty zone where data is not present, then computes and

draws the ceiling line. Thus, the larger the effect size, the lower the ceiling line, and the larger the limit that X puts on Y. The effect size of a necessary condition can take the values between 0 and 1. Dul (2016) suggests that effect sizes of $0 < d < 0.1$ can be considered a small effect, $0.1 \leq d < 0.3$ a medium effect, $0.3 \leq d < 0.5$ a large effect, and $d \geq 0.5$ a very large effect.

Therefore, Dul et al. (2020) recommend that three conditions must be satisfied for considering a variable being a necessary condition: (a) theoretical underpinning or basis; (b) effect size $d > 0$; and (c) a p-value lower than 0.05. A detailed description of the procedure needed to run a necessary condition analysis, as recommended by Dul et al. (2020), is presented in Appendix E.

Blinds and Curtain Operation

Survey participants were asked if they had access to, and control over, blinds and/or curtains. Table 3.10 provides a breakdown of the frequency of responses. Participants were also asked their reasons for opening their blinds and curtains by selecting their top three choices. Textbox 4 lists the options presented to the participants in the survey.

If the blind/curtain on your window is shut, why would you open it?
(Please read all options before checking maximum 3 answers)
A. Let daylight in
B. Tell me how the weather is outside
C. Tell me the time of day
D. Increase or decrease the ventilation
E. Provide light to plants
F. Let me observe other people and activities outside
G. Provide good lighting in the space
H. Provide a view out
I. Allows me to look away from my task (e.g., computer screen)
J. Let me interact with something/someone on the other side of

Textbox 4 Reasons for blind/curtain opening

When looked independently, the most frequently selected reasons were to 'let daylight in' (78.9%), followed by 'provide good lighting in the space'(44.9%), 'provide a view out'(40.4%), and to 'tell me how the weather is outside'(32.6%). Table 3.11 lists the frequencies of each variable selected individually.

Table 3.10 Response access and operation on blinds/curtains

Response	Frequency	Percentage (%)
Yes	590	81.9
No	98	13.6
Does not apply	32	4.4

Table 3.11 Reasons for opening blind/curtain

Variable	Frequency	Percentage (%)
Let daylight in	568	78.9
Tell me how the weather is outside	235	32.6
Tell me the time of day	48	6.7
Increase or decrease the ventilation	124	17.2
Provide light to plants	74	10.3
Let me observe other people and activities outside	86	11.9
Provide good lighting in the space	323	44.9
Provide a view out	291	40.4
Allows me to look away from my task (e.g., computer screen)	87	12.1
Let me interact with something/someone on the other side of the window	6	0.8

Framework Analysis on Qualitative Responses

Framework analysis was applied to suit the constructionist approach used with thematic analysis. Qualitative responses from the survey can add richness and offer new insights to the data (Braun et al., 2020). Qualitative data, particularly in surveys, however, often pose challenges to identify patterns across datasets for different reasons. Firstly, the questions give a structure to the responses collected. Secondly, responses are short, therefore, data are potentially 'bitty' instead of long flowing narrative (Braun and Clarke, 2013:p.227). This limits the application of more commonly-used study methods, such as thematic analysis. What follows is, therefore, a detailed account on how framework analysis was applied to this study.

As detailed by Gale et al. (2013), framework analysis is appropriate for studies lending themselves to inductive or deductive inquiry and is not married to any one epistemological, ontological, or methodological paradigm. The framework analysis is a systematic and flexible approach to analysing qualitative data. This method is different from the thematic framework common in other analysis, as it is not only based on the emergent themes from the data, but also on the a-priori knowledge and concerns of the researcher. Its pragmatic approach helps manage qualitative datasets and provides ease of collaboration, while maintaining transparency across multiple team members (Parkinson et al., 2016).

Ritchie and Spencer (1994) identify four types of research questions that can be addressed through a framework analysis approach to qualitative data:

(1) *contextual*: identifying the form and nature of what exists;

(2) *diagnostic*: examining the reasons for, and causes of, what exists;

(3) *evaluative*: appraising the effectiveness of what exists; and,

(4) *strategic*: identifying new theories, policies, or actions.

The research questions on what people like and dislike in their views and what do they notice in their view (see Textbox 1, in Section 3.2.5) fit both within the 'contextual' and 'diagnostic' categories, as the aim is not just to understand the nature of view preference but, through these responses, to characterise what drives preference for people in their real window views. The framework acts as a place holder for data to be mapped upon. The combination of a-priori issues and emergent ideas (Ritchie and Spencer,

1994) incorporates the best approach to answering the research questions. In order to better understand and to develop analytic patterns across the entire dataset (Braun et al., 2020), data was treated as one whole, instead of tackling two questions separately.

Use of Computer Assisted Qualitative Data Analysis Software

Qualitative researchers are often divided on the benefits of using Computer assisted qualitative data analysis software (CAQDAS), in comparison to manual sorting, or using word processors or spreadsheets. There are a few elements to consider when making this decision: first, the theory guiding the analysis; and, second, the aims and objectives of the study. In this research, the manual method was used at the initial stages of data treatment, and the analysis was later moved to a CAQDAS package, NVivo-12, that is fully integrated with the framework analysis method (Bazeley, 2002). NVivo-12 not only allowed treatment, storage and sharing of data, while also allowing tracking of thoughts and stages of the analytic process.

Method

The framework analysis was completed in six steps (Spencer et al., 2003):

(1) Familiarisation, or 'immersion' (Ritchie and Spencer, 1994), involved the researcher to 'get to know' and gain a full grasp of the data, by reading scripts and taking notes. A secondary means of familiarisation was carried out through an AI-

powered Thematic Analysis (Medelyan, 2021) that captures the meaning of phrases, grouping similar ones into themes. Using machine learning algorithms offered a quick means to get hold of a gist of the trends in data (Arditi et al., 2020) using an 'in vivo' or verbatim coding (Saldaña, 2016). In vivo coding is a type of coding that uses literal words used by participants for labelling and sorting data into themes. By taking multiple approaches in data familiarisation, the researcher felt immersed in people's experiences with their window views, getting a sense of some of the important issues emerging from the data.

(2) Text-based manual coding was then used on a printed copy of scripts with a wide right-hand margin for codes and notes (Saldaña, 2016:p.19). A code is a *word* or *brief phrase* that captures the essence of '*why you think a particular bit of data may be useful*' (Braun and Clarke, 2013:p.207). Using the 'splitter method' (Saldaña, 2016), data was split into smaller 'codable moments'. A list of 90 initial codes were identified. A coding book was kept in MS Excel, including a description of each code. As codes accumulated, and the analysis progressed, the code book assisted the discussion between the researcher and the supervisors. Data was imported in NVivo-12. Half of the data set was, then, coded using codes 'repeatedly' (Saldaña, 2016:p.79). Codes were subsumed into

broader codes and data re-coded, in an iterative process, until each code could be defined as an independent entity or construct.

(3) A meaningful framework was created, upon which all data could then be coded, and themes developed. Developing themes from codes is an active process, creating meaning from the codes. This is akin to an artist sculpting marble, rather than an archaeologist digging something up (Braun and Clarke, 2013:p.225). The framework is a consequence of emerging themes in the data along with a priori knowledge (Ritchie and Spencer, 1994). This step sets the framework analysis apart from other forms of thematic analysis, where the researcher's prior knowledge of the literature feeds into the coding scheme in a direct and transparent manner. Codes were grouped into categories and then grouped into main themes (Saldaña, 2016). Visualisation techniques, and several iterations, helped to derive distinct codes that addressed the research questions.

(4) The final framework consisted of 4 categories (see Section 5.3). Data was mapped onto this framework, indexed into themes and distinct sub-themes. Data that did not fit into the framework was coded as 'other' code. Although indexing seems like a tagging procedure, it is really a thoughtful process

as it demands attention and continuous refinement of the framework.

(5) Charting involved making data summaries and extracting meaningful data excerpts for each theme into a table in MS Excel. Photographs of views associated with the excerpts were also indexed separately.

(6) In the mapping and interpretation stage, the researcher found patterns and associations in the data. Ritchie and Spencer (1994) describe this process as one that includes the description and clarification of concepts, establishing relationships and developing 'bottom up' explanations in data, in light of the research questions.

As Parkinson et al. (2016) wrote:

> *'Qualitative research is not accessing experience directly; rather, our findings are a consequence of intersubjective meaning making through imagination, interpretation, and conceptual input, which we use in all qualitative research'.* (p.122)

Issues with Qualitative Research Methods

In qualitative research, it is important to meticulously describe each step of the process involved in the study, making sure that interpretations of data are supported by the data itself (Spencer et al., 2003). As the principal investigator, the researcher (author) completed all parts of the study, including all data collection and analysis, and discussed with the supervisors

as the sounding board. Her background in architecture and having conducted other experimental quantitative studies on window view preferences, gave the researcher the role of the 'insider' on the topic, which can be read as advantageous for identifying complex relationships between variables, but could also entail researcher bias. The researcher's presumptions, prejudices, and prior experiences in the field might have had an influence on the interpretation of data, as it is critically recognised in the field of qualitative research (Altheide and Johnson, 1994). In order to make sure that the interpretation of data was a true reflection of participants' responses, data were interpreted in multiple ways of coding, manual and using CAQDAS, using an AI algorithm, and followed a systematic framework analysis method in NVivo-12, where the themes (presented in Section 5.3) were closely linked to the data.

3.2.8. *Data Distribution and Analysis: Study 4*

Within this doctoral research, Study 4 focused on analysing whether window perceptions differed between a 'normal' (pre-COVID 19) situation (Survey 1) and an extraordinary condition such as that experienced during the period of social distancing imposed by the COVID-19 pandemic (Survey 2). There were 507 complete responses in Survey 1 and 238 responses in Survey 2. Since participation to Survey 1 was not a condition for exclusion to Survey 2, an overlap in respondents cannot be ruled out. However, the possibility that sample values from participants to Survey 1 be related, or

somehow paired or matched, with those for Sample 2 appear to be marginal. For this reason, independent sample statistics were conservatively used to analyse the data.

The data were exported from the SoSciSurvey.de host website into Microsoft Excel (2016) and SPSS Statistics (version 25.0) (SPSS, Chicago, IL) for graphical visualisation and for quantitative and qualitative analysis of responses. A dichotomous variable was created to identify responses that were pre-pandemic (Survey 1) from those that were collected during the pandemic (Survey 2). Since the data were featured with outliers, thus not fulfilling the criteria for parametric tests, the non-parametric Mann-Whitney U test was considered appropriate to assess the differences between the two groups. Specific constructs were framed to detect differences in the perception due to the change in condition, focusing on familiarity with the window; preference (i.e., like or dislike) for the view out of the window; satisfaction with the view out of the window; satisfaction with the size of the room with respect to the size of the window; and satisfaction with the participant's location with respect to the window.

The emphasis of the inferential analysis was placed on the significance of the statistical tests (at the α level of 0.05) and on the effect size, this providing a standardised measure of the practical relevance of the differences detected between the two surveys. The effect size was estimated by the Pearson's coefficient *r*, calculated from the z scores. The interpretation of the outcome was derived from published benchmarks, with values ranging

between negligible (r <0.1), small (0.1≤ r <0.3), medium (0.30 ≤ r <0.50) and large (≥0.50) (Cohen, 1992, Field, 2009).

In addition, two questions specific to Survey 2 were also analysed in Study 4. To interpret and contextualise any difference in perception detected in the quantitative analysis, responses to multiple-choice questions and open-ended comments on window features were explored using qualitative approaches. More specifically, the open-ended comments were analysed using coding techniques through NVivo-12 (QSR, 2019, Creswell, 2018), where categories of responses were initially identified as themes. Following this, a second and third analysis of the data led to the identification of emergent themes, these presented as frequency tables.

Data Distribution

Survey data was collected from 44 countries in Survey 1 (N= 507) and 38 countries in Survey 2 (N = 238). The United Kingdom, United States, Italy, Spain, Pakistan, and Belgium totally accounted for, respectively, 57.2% and 76.5% of the responses in the two surveys. The majority of responses were received from the northern hemisphere, experiencing the winter season in Survey 1 (96.8%) and spring in Survey 2 (99.1%). The only exceptions were Australia (12 responses), New Zealand (2 responses), Chile (3 responses) and South Africa (2 responses) in Survey 1, and Indonesia (1 response) and Australia (2 responses) in Survey 2. In Survey 1, responses were given mostly in the afternoon (53%) and the morning (21%), followed by mid-day (17%), evening (7%), and night (2%). In Survey 2, respondents gave their answers in

the morning (39%), and then in the afternoon (30%), mid-day (20%) and evening (11%). The orientation of windows in both surveys were almost equally distributed between cardinal points.

Distribution of participants' floor level location was similar in the two surveys. In Survey 1, most responses were given by people working or living on the first three floors of their building (78%); i.e., ground floor (26%), first floor (34%), and second floor (18%). In Survey 2, most respondents answered the survey from a location closer to the ground (82%), with ground floor accounting for 30%, and the first and second floors representing 33% and 18% of the total. The distance of the participants to the perimeter was consistent between the two surveys, with 90% of respondents sitting in proximity (within 2 meters) of the window.

In interpreting the distribution of the data, it must be remembered that Survey 1 could have been responded to while at a workplace or from home, while data for Survey 2 were collected from people that could have been confined at home due to government-imposed lockdowns or due to voluntary self-isolation.

4. Laboratory Studies

4.1. Study 1 – View Preference in Urban Scenes

This study was designed to explore the extent to which subjective preference ratings concur with the selection of, and the reasons for, preferred views, and if such ratings are associated with characteristic patterns of gaze behaviour. More specifically, in order to identify the key factors that influence view preference in an urban environment, this study aimed to respond to the following questions: (i) What features or elements are preferred in urban views?; (ii) Are there characteristic patterns of gaze behaviour associated with visual preference in urban views?

Three types of data were gathered to gain insight into the mechanisms underlying viewers' preference (Campbell and Fiske, 1959) for urban scenes: 1) subjective preference ratings of views; 2) eye-tracking measures taken during scene viewing; and, 3) qualitative reasoning for

preferences. Based on the methods presented in Chapter 3, the research materials and results of this study are presented in the following sections.

4.1.1. *Subjective Preference Ratings*

Results from the Shapiro-Wilk test (p= 0.878) and visual inspection of histograms and Q-Q plots confirmed that the subjective preference rating data were normally distributed. Tables 4.1-4.4 feature the 40 images, together with their ID number, the mean preference rating given by the participants, and their standard deviation. The four tables present a block of 10 images each for ease of editing and presentation. It must be reminded that, in the experimental procedure, the images to be featured in each block were randomised for each participant. Across the entire sample, the 40 images had a mean preference rating of 0.45 (SD= 0.115, range of 0.182 - 0.669).

A test for internal consistency of view preference was performed to evaluate the reliability of the preference rating (Field, 2009). To do this, all measurements were randomly split into two halves and the mean preference rating for each of the 40 images was calculated based on each half sample. The two sets of 40 mean-per-setting scores were inter-correlated for preference using a Spearman-Brown reliability test. This resulted in a test coefficient of 0.906 (Brown, 1910, Spearman, 1910) suggesting high reliability.

A comparison was made between the most and least preferred views given in the preference rating task and the participants' pile sorting selection of most preferred and least preferred views (individual participant's selection of views are listed in Table 4.5). These two tasks produced very consistent results, with images i34, i36 and i28 being the three most frequently preferred views in both the preference rating and the pile sorting task (Table 4.6). Conversely, images i1, i10 and i12 resulted, with similar frequencies, as the three least preferred images in both tasks.

Table 4.1 Image sample with preference rating (mean, standard deviation (SD) and Confidence Interval (CI)) (image 1-10)

View		Preference Rating		View		Preference Rating	
ID	**Image**	**Mean**	**S.D. [CI]**	**ID**	**Image**	**Mean**	**S.D. [CI]**
i1		0.182	0.185 [0.118, 0.247]	i2		0.262	0.172 [0.203, 0.323]
i3		0.453	0.225 [0.375, 0.532]	i4		0.349	0.220 [0.273, 0.425]
i5		0.447	0.279 [0.351, 0.545]	i6		0.240	0.156 [0.186, 0.294]
i7		0.345	0.231 [0.265, 0.425]	i8		0.355	0.217 [.280, 0.430]
i9		0.405	0.209 [0.333, 0.478]	i10		0.271	0.221 [0.195, 0.348]

Table 4.2 Image sample with preference rating (mean, standard deviation (SD) and Confidence Interval (CI)) (image 11-20)

View		Preference Rating		View		Preference Rating	
ID	**Image**	**Mean**	**S.D. [CI]**	**ID**	**Image**	**Mean**	**S.D. [CI]**
i11		0.511	0.188 [0.447, 0.577]	i12		0.299	0.217 [0.224, 0.375]
i13		0.407	0.207 [0.336, 0.480]	i14		0.398	0.261 [0.308, 0.489]
i15		0.489	0.204 [0.418, 0.560]	i16		0.422	0.192 [0.356, 0.489]
i17		0.455	0.254 [0.367, 0.544]	i18		0.405	0.221 [0.329, 0.482]
i19		0.497	0.186 [0.433, 0.562]	i20		0.506	0.195 [0.439, 0.574]

Table 4.3 Image sample with preference rating (mean, standard deviation (SD) and Confidence Interval (CI)) (image 21-30)

View		Preference Rating		View		Preference Rating	
ID	**Image**	**Mean**	**S.D. [CI]**	**ID**	**Image**	**Mean**	**S.D. [CI]**
i21		0.443	0.209 [0.371, 0.561]	i22		0.453	0.244 [0.369, 0.538]
i23		0.356	0.244 [0.272, 0.442]	i24		0.363	0.193 [0.296, 0.430]
i25		0.510	0.244 [0.426, 0.595]	i26		0.424	0.260 [0.334, 0.514]
i27		0.409	0.187 [0.345, 0.475]	i28		0.636	0.193 [0.570, 0.704]
i29		0.555	0.203 [0.485, 0.626]	i30		0.334	0.257 [0.245, 0.423]

Table 4.4 Image sample with preference rating (mean, standard deviation (SD) and Confidence Interval (CI)) (image 31-40)

View		Preference Rating		View		Preference Rating	
ID	**Image**	**Mean**	**S.D. [CI]**	**ID**	**Image**	**Mean**	**S.D. [CI]**
i31		0.332	0.205 [0.262, 0.404]	i32		0.330	0.199 [0.261, 0.399]
i33		0.390	0.229 [0.311, 0.469]	i34		0.661	0.180 [0.599, 0.724]
i35		0.574	0.170 [0.515, 0.633]	i36		0.668	0.126 [0.625, 0.713]
i37		0.451	0.249 [0.365, 0.538]	i38		0.555	0.157 [0.501, 0.610]
i39		0.547	0.210 [.474, .621]	i40		0.613	0.158 [.558, .668]

Table 4.5 Selection of most preferred and least preferred views in the pile sorting (left) and preference rating (right) task

	Pile Sorting Task						Preference Rating Task					
PPID	+1	+2	+3	-1	-2	-3	+1	+2	+3	-1	-2	-3
1	**i36**	i29	i34	i9	i32	i2	**i36**	i18	i28	i1	i10	i7
2	i35	i26	i40	i3	*i18*	*i12*	i7	i17	i24	*i12*	i14	*i18*
3	i36	**i34**	**i29**	*i22*	i1	*i20*	i14	**i34**	**i29**	*i22*	*i20*	i26
4	**i5**	i36	i20	i30	i12	i8	**i5**	i28	i22	i9	i6	i18
5	**i40**	i35	**i13**	*i1*	i32	*i7*	**i13**	i35	**i40**	*i1*	i2	*i7*
6	i36	i38	i29	i26	i10	i4	i25	i3	i37	i5	i6	i20
7	i24	i35	i26	*i12*	i6	*i1*	i5	i36	i9	*i12*	*i1*	i30
8	i28	i21	i11	i1	*i5*	i3	i31	i35	i37	*i5*	i17	i2
9	i29	i40	i15	i22	*i1*	*i4*	i34	i39	i36	*i1*	*i4*	i8
10	i39	**i19**	i29	i22	*i4*	*i26*	i18	**i19**	i15	i1	*i4*	*i26*
11	i36	**i40**	**i34**	*i8*	*i2*	*i1*	**i40**	**i34**	i29	*i1*	*i8*	*i2*
12	**i5**	**i28**	**i20**	*i1*	i8	i16	**i5**	**i20**	**i28**	*i1*	i33	i7
13	**i11**	i17	i15	i1	i4	*i30*	**i11**	i21	i14	i39	i24	*i30*
14	**i34**	i18	i36	*i26*	i4	*i22*	i19	i36	**i34**	i7	*i22*	*i26*
15	**i34**	**i28**	i25	*i1*	*i6*	*i10*	**i28**	**i34**	i22	*i10*	*i6*	*i1*
16	i26	i18	i13	*i6*	i12	i14	i20	i22	i28	i8	i17	*i6*
17	i18	i40	**i34**	*i30*	i31	i23	i5	i29	**i34**	i1	*i30*	i6
18	i28	i40	i39	*i12*	i17	*i1*	i13	i37	i5	*i1*	*i12*	i2
19	**i26**	i36	i20	i1	i10	i30	i37	i11	**i26**	i10	i2	i18
20	i39	i28	i38	*i1*	*i10*	i6	i34	i40	i13	*i1*	*i10*	i7
21	**i25**	i36	**i34**	i32	*i1*	*i7*	**i34**	**i25**	i5	*i1*	i2	*i7*
22	**i29**	**i36**	i17	*i10*	*i37*	i26	**i29**	**i36**	i40	i23	*i37*	*i10*
23	i40	i20	**i36**	i1	i2	*i5*	i28	**i36**	i33	*i5*	i8	i24
24	i29	i40	i36	*i26*	i22	i31	i15	i39	i34	i1	*i26*	i10
25	i40	i15	i39	*i1*	i32	i22	i29	i36	i38	*i1*	i4	i31
26	i29	i17	**i15**	i23	i27	i4	i39	**i15**	i38	i2	i31	i1
27	i35	i36	i25	i4	i9	i10	i34	i39	i28	i4	i9	i30
28	**i36**	i5	i17	*i26*	i23	i4	i17	**i36**	i35	i1	i10	*i26*
29	**i25**	**i26**	**i28**	*i10*	i1	i3	**i26**	**i25**	**i28**	*i10*	i12	i29
30	i17	i34	i21	i1	i5	*i10*	i30	i28	i33	*i10*	i13	i2
31	i28	i15	i16	i2	*i1*	*i6*	i36	i11	i25	*i1*	*i6*	i2
32	**i36**	i18	i34	i26	i23	*i10*	i35	i14	**i36**	i1	*i10*	i22

Note. The text highlighted in orange bold and in yellow italic indicates consistent selection by individual participants across the two tasks, respectively for most preferred (orange bold) and least preferred (yellow italic) views. Each row represents a participant (PP_{ID})..

Table 4.6 Frequencies of the three most and least preferred views in preference rating and pile sorting tasks

Most Preferred Images	Sorting Task (N)	Preference Rating Task (N)
i36	14	10
i34	9	10
i28	9	9
Least Preferred Images	Sorting Task (N)	Preference Rating Task (N)
i1	18	18
i10	9	10
i12	5	5

4.1.2. *Gaze Behaviour Characteristics*

To test whether view preference was associated with a particular pattern of oculomotor response, the lowest and highest rated images (i.e., least preferred and most preferred) were analysed using eye-tracking measures to search for significant and practically relevant differences between views.

Heat Maps and Foci of Attention

In order to identify foci of attention in the views, heat maps (HMs) were plotted for each image. The three most frequently selected images, for both the most preferred and the least preferred categories, across the entire dataset are presented in Figure 4.1. Viewing behaviour was observed to be different between the least and most preferred images.

Figure 4.1A shows the heat maps superimposed on the three least preferred views. The yellow, green, and blue colours represent – in descending order of occurrence – the amount of gaze points that were directed towards specific parts of each image. These heat maps are

characterised by scattered hotspots. For example, in image i10, attention is drawn towards the various faces of people printed on the posters. Figure 4.1B presents the heat maps relative to the three most preferred images. The majority of hotspots are formed towards the centre of the image and on textual information. No other centres of attention are evident in the most preferred images.

A. Most Frequently Selected Images in the Least Preferred Category			
Image	i1	i10	i12
P.R.	0.182	0.271	0.299
Image			
HM			
B. Most Frequently Selected Images in the Most Preferred Category			
ID	i36	i34	i28
P.R.	0.668	0.661	0.636
Image			
HM			

Figure 4.1 Three most frequently selected images in the Least (A) and Most (B) preferred categories, preference rating (P.R.) and heat maps (HM) of eye-tracking data recorded over 15 seconds. Image size is 1024 x 768 pixels.
Note. In the heatmaps, the yellow, green, and blue colours represent, in descending order of occurrence, the number of gaze points directed towards specific parts of the image.

These differences in gaze behaviour seem to suggest that, in least preferred views, the gaze becomes more focused on specific, and more clearly defined, centres of attention.

Eye-Tracking Measures

Eye-tracking measures provided the opportunity to determine if there was a characteristic oculomotor signature associated with subjective preference ratings. As expected, a statistically significant positive correlation was detected between the Number of fixations and the Number of saccades across all images (Pearson's r= .970, n= 40, p< .001). That is, the number of times the participants' gaze moved (saccade) to a new point of attention (fixation) was consistent for a fixed duration of stimulus display (15 seconds).

Figure 4.2 presents an illustration of the raw eye-tracking measures for view preference, comparing least and most preferred images (n= 40), as explained in Section 3.1.4. Levene's test indicated equal variances between data groups (F= 0.812, p= 0.373). The t-tests showed that the Number of fixations (Figure 4.2-a) was significantly higher for most preferred (n= 27, M= 40.029, SD= 2.818, 95% CI: 38.914, 41.144) than for least preferred (n= 13, M= 38.042, SD= 2.107, 95% CI: 36.769, 39.316) views (t(38)= -2.251, p= 0.030, d= 0.799). The Number of saccades (Figure 4.2-b) was significantly higher for most preferred (M= 42.726, SD= 2.440, 95% CI: 41.761, 43.691) than for least preferred (M= 40.470, SD= 2.240, 95% CI: 39.116, 41.822) views (t(38)= -2.811, p= 0.008, d= 0.960). For Mean fixation duration, visual inspection of Figure 4.2-c suggests that this might be longer in least preferred views than in

most preferred views. Statistical analysis of the data via a non-parametric Mann-Whitney test (as data were not normally distributed), however, revealed no statistically significant differences (U= 126, p= 0.153), although a practically-relevant effect size of small magnitude could be detected (r= -0.225). A similar result was obtained when comparing least and most preferred views for Mean saccade duration (t(38)= 0.876, p= 0.387, d= 0.307) (Figure 4.2-d). Finally, no significant (p= 0.866) or practically relevant (d= 0.056) differences could be detected between least and most preferred views for Mean saccade amplitude (t(38)= 1.170) (Figure 4.2-e).

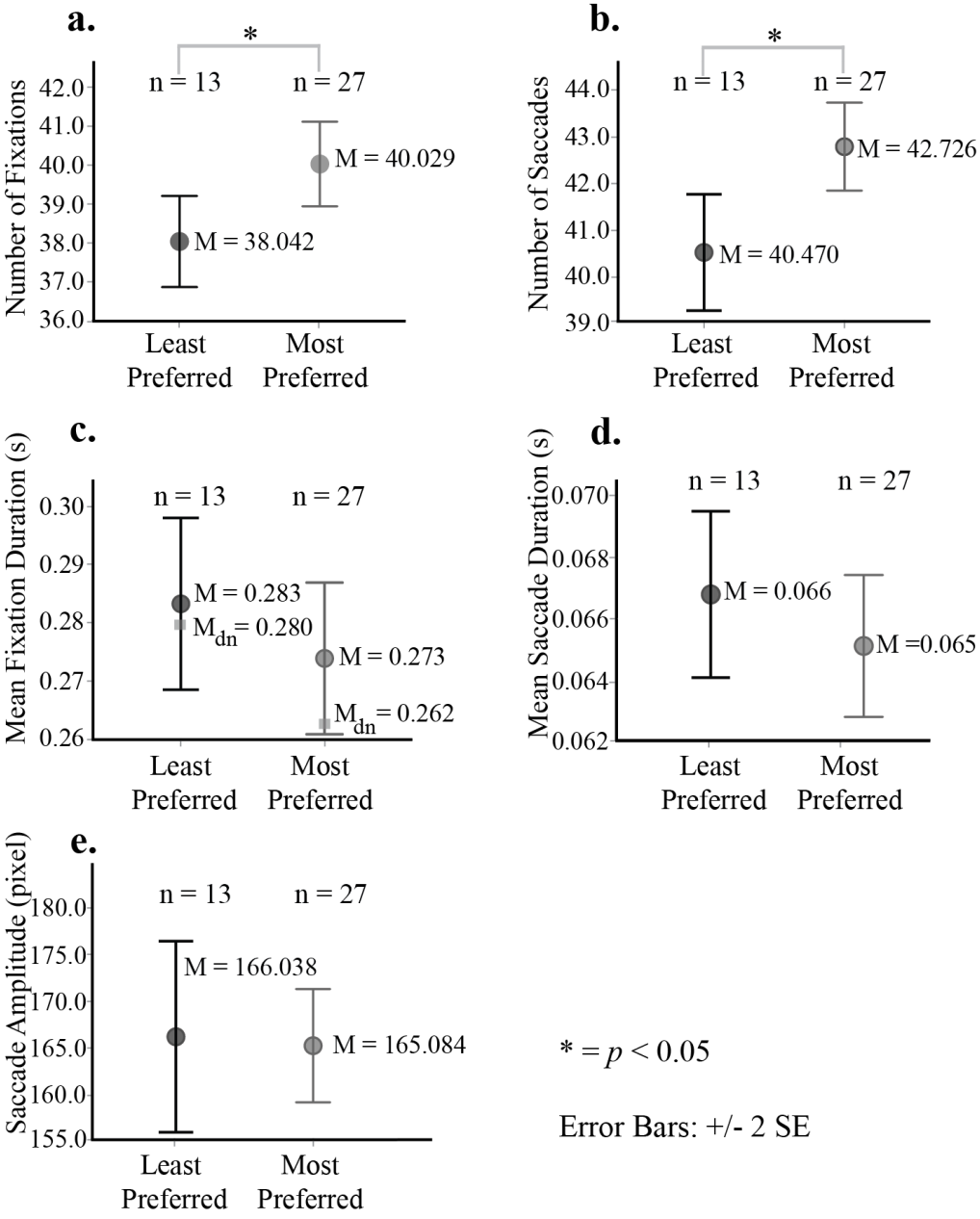


Figure 4.2 Display of eye-tracking measures for view preference: (a) Number of fixations; (b) Number of saccades; (c) Mean fixation duration; (d) Mean saccade amplitude; and, (e) Mean saccade duration.

Note. Error bars represent standard errors.

A statistically significant inverse relationship was found between Number of fixations and Mean fixation duration (r= -0.843, n= 40, p< 0.001), as presented in Figure 4.3.

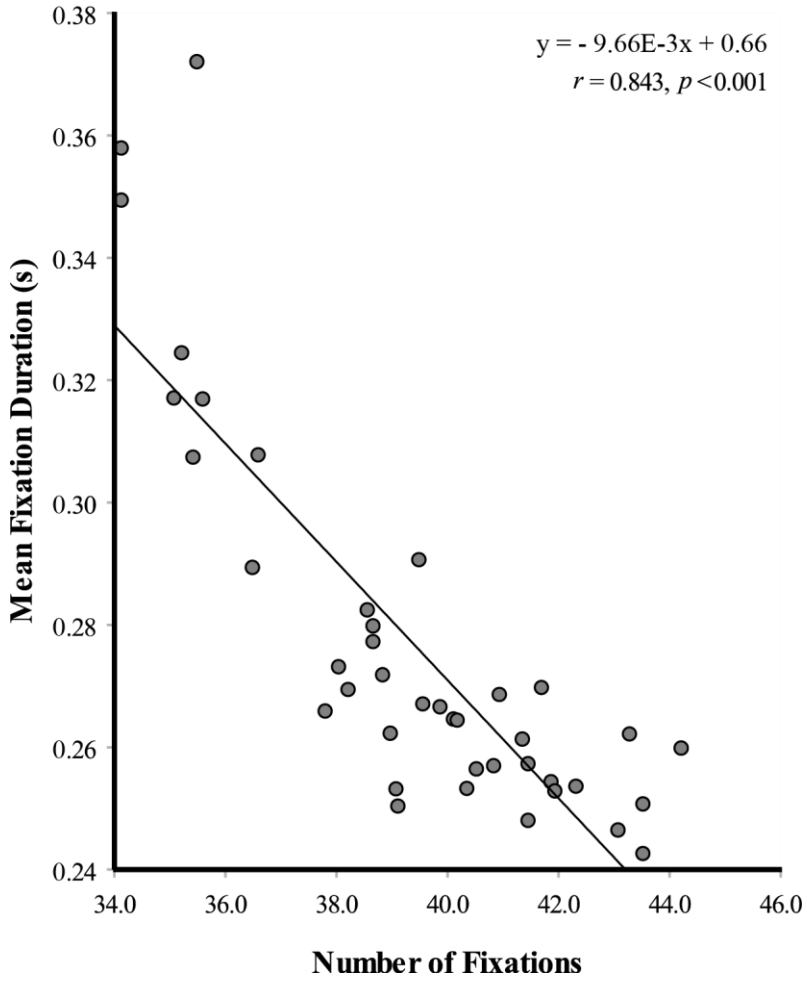


Figure 4.3 Relationship between two eye-tracking measures: Number of fixations and Mean fixation duration.
Note. The plot features data from the entire dataset, where each dot represents an individual view. Number of fixations range from 34.120 to 44.207 and Mean fixation duration ranges from 0.243s to 0.372s.

The statistically significant differences in Number of fixations in most preferred and least preferred views lead to postulate that most preferred views are associated with more gaze movements. A Pearson product-moment correlation was run to determine the relationship between Number of fixations and Preference reference rating for each image (Figure 4.4). The correlation between these variables was not statistically significant (r= 0.102, n= 40, p= 0.529). The three more frequently selected most preferred views

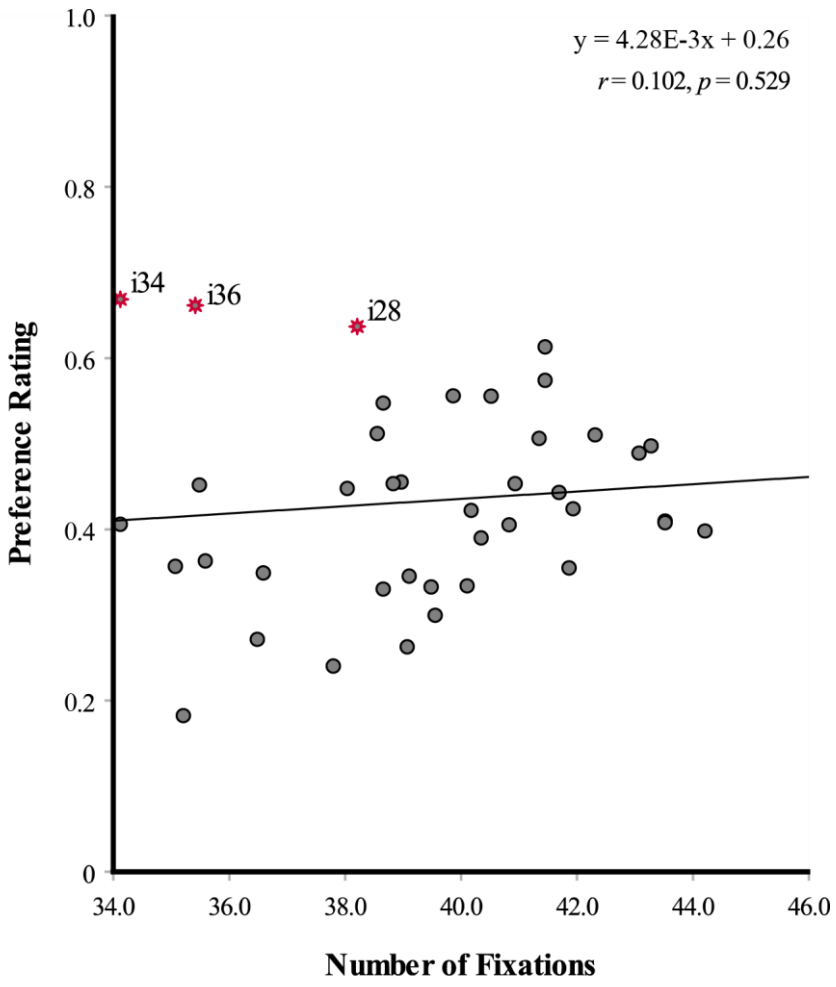


Figure 4.4 Relationship between Number of fixations and Preference rating of each view(n_v = 40). Red highlighted marks indicate images i34, i28 and i36.

(i36, i34, i28) scored highly in preference ratings but evoked a lower Number of fixations. These three views also produced atypical verbal descriptors from the participants, as discussed in the following section.

4.1.3. *Verbalisation of View Preference*

An analysis of the verbal reasoning data from the pile sorting task revealed that each image was associated with specific words. Although participants were only asked to explain the reasons for their three least

preferred and the three most preferred views, different words appeared in the word frequency counts to identify the elements in the images (Table 4.7).

Table 4.7 Frequencies of specific words: elements in views (ordered alphabetically)

Words	Least Preferred (N)	Most Preferred (N)
building	37	38
car	16	0
colours	25	39
graffiti	19	4
people	11	18
traffic	7	0
window	11	17

A comparison was drawn between the words used to identify elements in the most and least preferred views. In terms of key recognisable elements, participants identified in both groups the presence of: 'building', 'colours', 'graffiti', 'people', and 'window'. 'Car' and 'traffic' were never mentioned when describing the most preferred views but were frequently cited in the least preferred views (16 and 7 times, respectively). 'People' occurred more often in the most preferred views (18 times vs. 11 times in least preferred) while 'graffiti' was mostly associated with least preferred views (19 occurrences vs. 4 for most preferred). The presence of a 'building' in a view was mentioned almost equally (37 and 38 times) in the two groups. The word 'window' occurred both in the most (11 times) and in the least preferred (17 times) views. For example, when observing image i12, participants focused on the window and, in their verbal descriptions, suggested an interest in seeking more information from people's presence or activities inside the spaces, e.g. "*would have liked to see what was inside*",

"*you can't see any people in them*", and "*there should have been curtains or lighting through the windows*". It is noteworthy to mention that participants often referred to the physical characteristics of buildings, such as the care of maintenance or lack thereof, which, subsequently, might have affected the overall preference rating of the view. With this respect, when coloured graffiti appeared on a wall, in the absence of a pattern or an order, their presence was associated with lack of maintenance, e.g., "*colours thrown on the wall, no pattern or regularity*" (i26) and "*more of a tag than artwork*" (i23) when views were least preferred. 'Rust' and damage to building materials were also seen as specific signs of 'disrepair' and 'lack of maintenance' (i1 and i6). Some elements such as a road safety cone in the scene (i6) was seen to present a potentially 'hazardous condition' for humans and therefore disliked and considered 'unsafe for people' by participants. Conversely, in most preferred views, an orderly presentation of colour on a wall was positively assessed by participants suggesting, for example, that "*with the graffiti at this distance you can see the order*" (i28).

The adjectives used to describe the least preferred and most preferred views were also collected. Table 4.8 lists the most frequently used descriptors to characterise the views in both groups. The least preferred views have been depicted with terms such as 'unsafe', 'nothing', 'don't', and 'depressing', possibly entailing that the scenes did not afford potential exploration. Conversely, the words more often used to describe the most preferred views.

Table 4.8 Frequencies of adjectives and descriptors for all views selected as most preferred and least preferred (ordered alphabetically)

Least Preferred		**Most Preferred**	
Words	**Frequency (N)**	**Words**	**Frequency (N)**
depressing	11	clean	28
don't	16	good	35
nothing	12	relaxed	12
unsafe	11		

included 'clean', 'good' and 'relaxed', possibly implying desirability and interest in a view, or scenes that had more to offer to the participants. Additionally, the words more frequently used to describe exclusively the three least preferred views (images i1, i10 and i12) and the three most preferred views (images i36, i34 and i28) based on mean preference rating, were inspected in order to explore the presence of specific points of interest. These are presented in Table 4.9 and differ from the words listed in Table 4.8 (instead referring to *all* views selected as most and least preferred). In the three least preferred views, mentions were found of the 'picture' and the 'posters' (image i10), 11 and 8 times, respectively. Furthermore, the words 'dirty' and 'abandoned' (mentioned 6 and 4 times) were also used to describe these scenes. For the three most preferred views, the words 'natural', 'plants', 'flowers' and 'organic' were used 8, 6, 3, and 2 times, respectively. Even though the most prominent feature of image i28 is a row of bikes, participants noticed the 'organic' pattern on the wall. Similarly, in images i34 and i36, participants particularly noticed the presence of naturalistic elements in the scene, mentioning the 'plants' and 'flowers' outside the building and on the balcony.

Table 4.9 Adjectives and descriptors exclusively used for three most preferred and the three least preferred views (ordered alphabetically)

Three Least Preferred		**Three Most Preferred**	
Words	**Frequency (N)**	**Words**	**Frequency (N)**
abandoned	4	flowers	3
dirty	6	natural	8
picture	11	organic	2
posters	8	plants	6

4.1.4. *Quantitative Analysis without Naturalistic Elements*

Figure 4.4 shows that three views (i36, i34, i28) had lower Number of fixations despite being highly rated on preference. It must be remembered here that the sample of images used in this study featured urban scenes, although the verbal descriptors evoked by the participants referred to naturalistic properties, as described in Section 4.1.3 and illustrated in Table 4.9.

To study whether the presence of naturalistic elements had any impact on preference, these three images (i36, i34, i28) were removed from the sample of 40 images and the statistical analysis of eye-tracking measures data for view preference was run again. In fact, among all the 40 views of the dataset, i36, i34 and i28 were the only images for which participants had explicitly mentioned naturalistic features of views in their verbalisations.

With the new sample of 37 images, significant differences were found for Number of fixations between most preferred (M= 40.598, SD= 2.337, 95% CI: 39.611, 41.584) and least preferred (M= 38.042, SD= 2.107, 95% CI: 36.769, 39.316) views (t(35)= -3.232, p=0.002, d= 1.149). The effect size of

the differences detected increased from 0.799 to 1.149 with respect to the original sample of 40 images (Table 4.10). A similar increase in effect size was also detected in the differences between most preferred (M= 43.076, SD= 2.354, 95% CI: 42.082, 44.071) and least preferred (M= 40.469, SD= 2.239, 95% CI: 39.116, 41.823) views (t(35) = -3.269, *p*=0.002, *d*= 1.135) for Number of saccades.

Using the reduced dataset of 37 images, a Pearson correlation (two-tailed test) was also run to determine the relationship between the Number of fixations and Preference rating (Figure 4.5). A positive correlation of medium strength was observed between these variables (*r*= 0.42, n_v= 37, *p*= 0.009). This indicates that when naturalistic elements were removed from the sample of urban views, the relationship between oculometric and preference data was stronger.

Table 4.10 Inferential data for the statistical tests when excluding images i34, i36 and i28

	Number of Fixations		**Number of Saccades**	
	p-value	Effect size (Cohen's *d)*	*p*-value	Effect size (Cohen's *d)*
40 images	<.05	0.799	<.05	0.960
37 images	<.01	1.149	<.05	1.135

d< 0.1= negligible; 0.1 ≤*d*< 0.3= small; 0.30 ≤d< 0.50= medium; *d*≥ 0.50= large

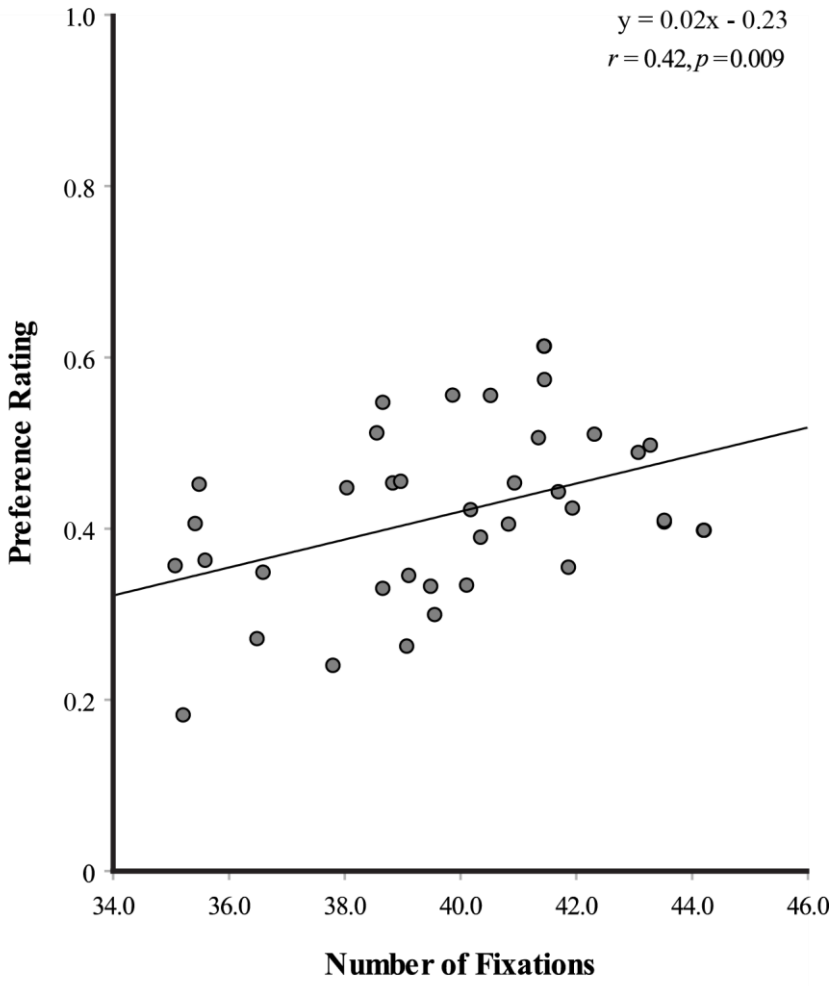


Figure 4.5 Relationship between Number of Fixations and Preference Rating for Reduced Dataset. $n_v = 37$.

4.2. Study 2 – View Preference in Natural Scenes

To characterise gaze correlates of view preference across natural and urban scenes, a two-step approach was taken. First, an analysis was conducted on three types of experimental data on natural views: 1) subjective preference ratings; 2) qualitative reasoning; and, 3) eye-tracking measures captured during scene viewing. Second, a comparison was drawn between these data and those collected in a previous experiment in which gaze characteristics associated with
view preference while the same participants looked at urban scenes were investigated (Study 1 – Section 4.1). Thereafter, differences in gaze behaviour associated with urban and natural views were further examined in the context of participants' reported attitude towards nature, as measured by their self-reported nature relatedness score (NRS) (Nisbet et al., 2009).

4.2.1. *Preference Rating*

Table 4.11 presents the 40 images (i1-i40) of natural views together with the mean (PR), standard deviation (S.D.). and confidence intervals ($C.I._{min}$-$C.I._{max}$) of the subjective preference ratings given by participants. Results from the Shapiro-Wilk test and visual inspection of histograms and Q-Q plots confirmed that, across all images, preference rating data were normally distributed with a skewness of -0.647 (*SE*= 0.374) and kurtosis of -0.198 (*SE*= 0.733).

Table 4.11 Subjective preference ratings for all natural images

Image ID	View	PR	S.D.[CI_{min}-CI_{max}]	Image ID	View	PR	S.D.[CI_{min}-CI_{max}]
1		0.565	0.192 [0.468, 0.663]	2		0.567	0.248 [0.468, 0.663]
3		0.612	0.136 [0.547, 0.677]	4		0.705	0.209 [0.600, 0.811]
5		0.363	0.200 [0.262, 0.464]	6		0.704	0.192 [0.607, 0.801]
7		0.632	0.230 [0.515, 0.749]	8		0.650	0.153 [0.573, 0.727]
9		0.501	0.190 [0.450, 0598]	10		0.586	0.147 [0.511, 0.661]
11		0.585	0.157 [0.506, 0.665]	12		0.646	0.184 [0.553, 0.739]
13		0.682	0.128 [0.617, 0.747]	14		0.688	0.133 [0.621, 0.755]

Image ID	View	PR	S.D.[CI_{min}-CI_{max}]	Image ID	View	PR	S.D.[CI_{min}-CI_{max}]
15		0.584	0.133 [0.621, 0.755]	16		0.655	0.223 [0.543, 0.768]
17		0.477	0.209 [0.372, 0.583]	18		0.675	0.168 [0.590, 0.760]
19		0.504	0.171 [0.418, 0.590]	20		0.653	0.139 [0.583, 0.723]
21		0.721	0.157 [0.641, 0.800]	22		0.679	0.144 [0.606, 0.751]
23		0.558	0.216 [0.449, 0.667]	24		0.667	0.191 [0.571, 0.764]
25		0.481	0.227 [0.367, 0.596]	26		0.435	0.234 [0.317, 0.554]
27		0.510	0.228 [0.394, 0.626]	28		0.668	0.129 [0.603, 0.733]

Image ID	View	PR	S.D.[CI_{min}-CI_{max}]	Image ID	View	PR	S.D.[CI_{min}-CI_{max}]
29		0.681	0.161 [0.599, 0.749]	30		0.624	0.173 [0.537, 0.711]
31		0.677	0.142 [0.605, 0.749]	32		0.681	0.148 [0.606, 0.756]
33		0.719	0.157 [0.511, 0.669]	34		0.590	0.157 [0.511,0.669]
35		0.527	0.285 [0.383, 0.671]	36		0.588	0.151 [0.512, 0.664]
37		0.501	0.186 [0.407, 0.595]	38		0.465	0.210 [0.359, 0.572]
39		0.551	0.199 [0.451, 0.652]	40		0.580	0.169 [0.495, 0.665]

A test for internal consistency was performed to evaluate the reliability of the preference ratings (Field, 2009). To do this, measurements were randomly split into two halves and the mean preference rating across the 40 images was calculated for each half sample. The two sets of 40 mean-per-setting scores were inter-correlated for preference using a Spearman-Brown reliability test. This resulted in a test coefficient of 0.786, suggesting

acceptable reliability (Brown, 1910, Spearman, 1910), and a Cronbach's alpha of 0.852 (Field, 2009).

A comparison was made between the most and least preferred views selected in the preference rating and in the pile sorting tasks (individual selections of views for each participant are listed in Table 4.12). These two tasks produced consistent results, with views i4, i33, and i6 being the three most preferred views (Table 4.13). Similarly, views i5, i35, and i27 were the three least preferred images in both tasks. Table 4.14 shows these more frequently selected ‘most preferred’ and ‘least preferred’ natural views and their associated heatmaps (HMs).

Table 4.12 Selection of most preferred and least preferred views in the pile sorting (left) and preference rating (right) tasks in Study 2 for each participant.

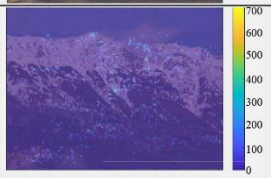
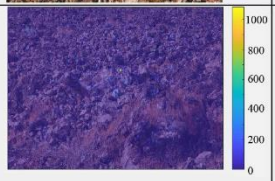
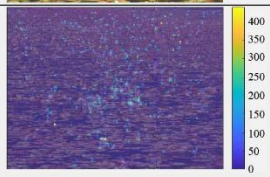
	Pile Sorting Task						Preference Rating					
PP_{ID}	+1	+2	+3	-1	-2	-3	+1	+2	+3	-1	-2	-3
1	i20	i7	i22	*i25*	*i27*	*i5*	i21	i4	i31	*i5*	*i25*	*i27*
2	i33	**i29**	**i7**	*i35*	*i19*	i11	**i7**	**i29**	i12	i27	*i19*	*i35*
3	i3	**i29**	**i13**	*i5*	i6	*i15*	**i13**	i28	**i29**	*i15*	i4	*i5*
4	i30	i8	**i21**	i19	*i27*	i5	**i21**	i14	i2	i26	i38	*i27*
5	**i11**	**i4**	i34	i25	i26	i19	**i4**	**i11**	i14	i35	i5	i27
6	**i4**	i29	**i24**	i8	i19	i27	**i4**	**i24**	i21	i25	i17	i23
7	**i6**	i16	**i33**	*i24*	i11	i35	i4	**i6**	***33***	i35	i26	i24
8	i40	i33	i36	*i5*	i35	i11	i27	i16	i18	i30	i2	i5
9	i23	**i6**	i28	i25	*i38*	*i5*	i30	**i6**	i22	i37	*i5*	*i38*
10	i36	i34	i27	i38	i29	i17	i21	i33	i7	i9	i35	i5
11	i32	i30	**i7**	i5	i6	i11	i36	i26	**i7**	i16	i17	i9
12	i40	**i33**	i38	i5	i15	i23	***i33***	i39	i22	i2	i17	i6
13	**i35**	i22	**i2**	*i5*	*i1*	i19	***i2***	**i35**	i6	*i5*	i37	*i1*
14	i1	i32	i34	i25	i38	*i29*	i4	i16	i6	i36	i26	*i29*
15	**i2**	**i4**	i33	i5	i1	*i26*	i8	**i2**	**i4**	i39	i38	*i26*

Note: The text highlighted in orange bold and in yellow italic indicates consistent selection by individual participants across the two tasks, respectively for most preferred (orange bold) and least preferred (yellow italic) views. Each row represents a participant (PP_{ID}).

Table 4.13 Frequencies of the three most preferred and the three least preferred views in the preference rating and pile sorting tasks

Most Preferred Views	**Preference Rating Task (N)**	**Pile Sorting Task (N)**
i4	6	3
i33	3	5
i6	4	2
Least Preferred Views	**Preference Rating Task (N)**	**Pile Sorting Task (N)**
i5	7	9
i35	4	4
i27	4	3

Table 4.14 More frequently selected 'most preferred' and 'least preferred' natural views and their heatmaps (HMs). Image size is 1024 x 768 pixels.

A.	**Most Preferred Images**		
ID	i33	i4	i6
Image			
HM			
B.	**Least Preferred Images**		
ID	i5	i27	i35
Image			
HM			

Note. In the heatmaps, the yellow, green, and blue colours represent, in descending order of occurrence, the number of gaze points directed towards specific parts of the image.

4.2.2. *Gaze Behaviour Characteristics*

To test whether view preference was associated with a particular pattern of oculomotor response, the least preferred and most preferred natural views were analysed using eye-tracking measures (ETMs) to test for significant and practically relevant differences in gaze behaviour between images.

Using the grand-mean-split on preference rating, an independent sample t-test was conducted as the data fulfilled the conditions for parametric tests. The test did not find statistically significant differences in the number of fixations between least and most preferred views ($t(38)= 1.300$, $p= 0.133$), although an effect size bordering practical relevance was detected ($d= 0.202$). Similarly, no statistically significant differences were found between most and least preferred views in the number of saccades ($t(38)= 1.162$, $p= 0.252$), but a small effect size was detected ($d= 0.368$). Differences in mean fixation durations were also not significant ($t(38)= 0.065$, $p= 0.948$, $d= 0.021$). Therefore, for the oculomotor responses considered, the grand-mean (group) split method did not lead to detect any significant differences in gaze behaviour between most or least preferred natural views.

A within-subject (related) t-test was then used to determine whether statistically significant differences between ETMs could be detected based on *individual* participants' preference ratings when observing their own 'most preferred' and 'least preferred' natural views. Data are presented as mean ± standard deviation, unless otherwise stated. In the most preferred view

category, participants' gaze was characterised by a significantly higher number of fixations (26.820 ± 6.342) compared to the least preferred (25.802 ± 5.728) natural views (t(14)= 4.334, *p*= .001, *r*= 0.757)(Figure 4.6-a). Similarly, the number of saccades was significantly higher for most preferred (38.049 ± 6.020) than for least preferred (36.953 ± 5.312) natural views (t(14)= 2.871, *p*= .012, *r*= 0.609)(Figure 4.6-b). Finally, a tendency was found for mean fixation durations to be higher for the least preferred (0.390 ± 0.053 s) than the most preferred (0.377 ± 0.045 s) natural views (Figure 4.6-c); this difference failed to reach statistical significance but a practically relevant size of effect was detected (t(14)= 2.001, *p*= .065, *r*= 0.472).

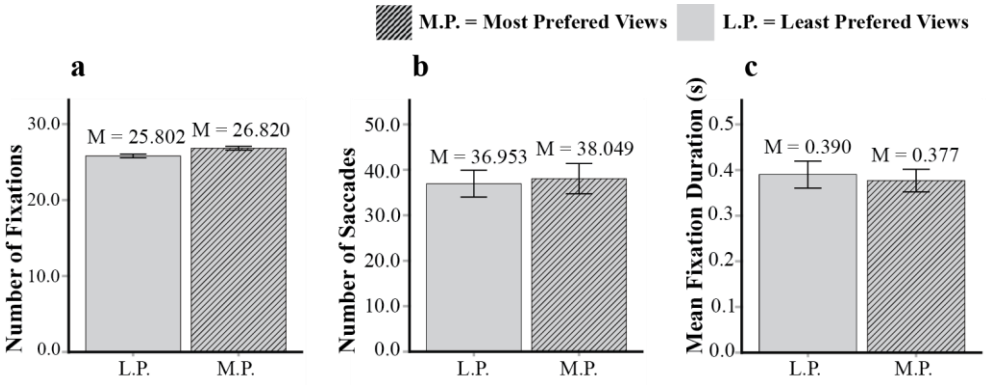


Figure 4.6 Bar plots comparing eye-tracking measures for most preferred and least preferred natural views, for all participants (n_p = 15) and all views in the sample (n_v = 40). LP = Least Preferred Views, MP = Most Preferred Views. a = number of fixations, b = number of saccades, c = mean fixation duration. Error Bars represent +/- 2 *SE*.

4.2.3. ***Word Descriptors of View Preference***

Analysis of the verbal reasoning data revealed that the most and the least preferred natural views were associated with generic words illustrating features or attributes of the scenes (Table 4.15).

Participants mentioned the words 'colour', 'mountain' or 'hill', 'people' or 'human', and 'sky', and these were more frequent in most preferred views. The 'natural' features and presence of a 'tree' and 'water' were also mentioned in both categories.

Table 4.15 Frequencies of words associated to the most and least preferred views (ordered alphabetically)

Word	Most Preferred	Least Preferred
colour	13	5
mountain/hill	12	2
natural	10	8
people/human	14	9
sky	7	1
tree	11	7
water	10	7

The word 'people' was mentioned often as a gateway to perceiving activities, e.g., participants stated that having people "*around you* […] *indicates this is a place you can go and there's life there"*, etc. Even when people were not actually visible in the scene, human intervention was observed as a reassuring presence, e.g., "*although there are no people in it, it has signs of human activity"*. Conversely, in least preferred views, human presence was associated with visibly difficult or threatening environments, e.g., "*people inside the picture are struggling to climb*".

The word 'colour' was often used to refer to landscape features in most preferred views, the "*colour represents harmony between sand and water*", chromatic qualities, "*vibrant colour*" and, composition in the scene,

e.g., "*very nice mix of colours*". In least preferred views, negative connotations of colour were mentioned as "*no particularly nice colour either*", "*the colour doesn't look nice*", or *"mundane colour, bland*".

In most preferred views, participants noticed the patterns in the 'sky' and just being able to "*see the sky*" was mentioned as a reason for preference. For example, a scene was preferred when described as "*what you would see when you lie down on grass and looking up at the sky through trees*". In contrast, "*boring, featureless sky*" was also noted. Participants who liked "*being close to water*" and preferred the "*seaside and clear water*" recalled previous "*nice memories of seaside*", mentioning 'water' in most preferred views. However, when the body of water was not considered clean, and "*not taken care of*", its presence in the scene was not preferred. The presence of a 'tree' was often mentioned. Some participants mentioned the "*changing colours*" of leaves in most preferred views and "*no leaves on trees*" in least preferred views. Similarly, emphasis on 'natural' characteristics was frequent. Views with distant landscapes including a 'mountain' or 'hill' were highly favoured and, therefore, they were mentioned more often in the most preferred category.

The terms used to explain preference of views in the two categories allowed the exploration of the reasons for view selection. Table 4.16 lists the most commonly recurring adjectives and descriptors used to illustrate most and least preferred views.

Table 4.16 Adjectives and descriptors for the most and least preferred views (ordered alphabetically)

Most Preferred	Frequency	Least Preferred	Frequency
changing	6	barren	6
holiday	5	can't	10
home	5	difficult	6
peaceful	8	inhospitable	4

The most preferred views were described as "*peaceful*" and reminiscent of "*holiday*" destinations. Some views reminded the participants of "*home*", while others were representative of "*changing*" colours and seasons. In contrast, the least preferred views were perceived as "*difficult*" landscapes that were "*inhospitable*", "*barren*", not supporting life and where participants "*can't*" navigate through the space or see much further.

4.3. Study 2 - Comparison Between Natural and Urban Views

The data collected in the two experimental studies (Study 1 and Study 2) were compared to measure any difference in subjective preference ratings and ETMs across two view type conditions: natural and urban scenes. All descriptive summary statistics are provided below as mean ± standard deviation, unless otherwise stated.

4.3.1. *Subjective Preference Ratings*

A within-subject paired-sample t-test was used to determine whether there was any statistically significant (*p*-value) and practically relevant (effect size) difference between the preference ratings for natural and urban views

for the same 15 participants. There were no outliers in the data, as assessed by boxplot inspection for values greater than 1.5 box-lengths from the edge of the box. The assumption of normality was not violated, as assessed by Shapiro-Wilk's test (p= 0.252). Participants' subjective preference ratings were significantly higher for natural (0.598 ± 0.071) than urban views (0.448 ± 0.096), with a practically relevant effect size (t(14)= 5.618, p<.0001, d= 1.450 (large effect)). Figure 4.7 presents the distribution of preference ratings for each participant across the two view type categories (error bars show 95% confidence intervals).

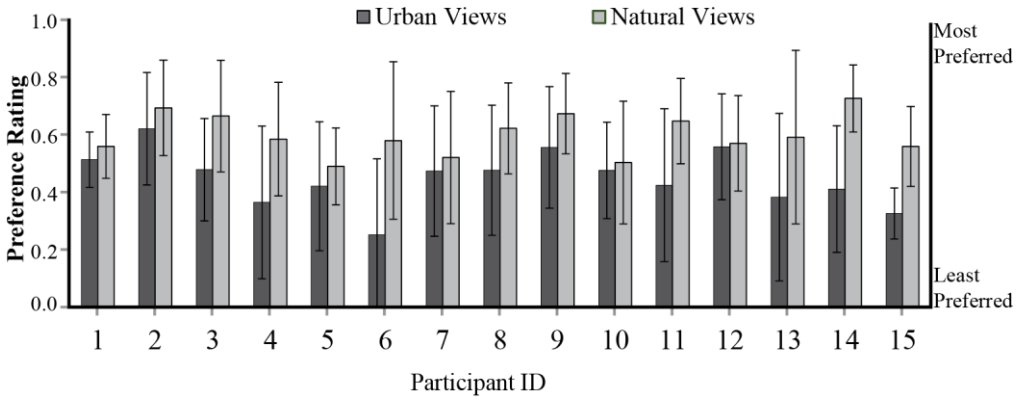


Figure 4.7 Distribution of preference ratings for urban and natural views. Error bars show 95% Confidence Intervals.

4.3.2. *Eye-Tracking Measures*

Different scenes – natural and urban – might engage viewers through distinct types of directed attention and fascination (see Section 2.3.3).

In Study 1, it was found that most preferred urban views were associated with greater visual exploration, with higher numbers of fixations and saccades. However, these gaze characteristics reversed when urban

scenes were perceived as featuring natural contents, with a lower number of fixations compared to other preferred urban views. This led to the hypothesis that gaze behaviour might be driven by view type as well as preferences toward urban or natural environments.

View Type

As illustrated in Figure 4.8, participants' gaze was characterized by a significantly higher number of fixations for urban views (42.325 ± 4.785) compared to natural (24.724 ± 6.697) views (t(14)= 9.696, *p*< .001, *d*= 2.503). The number of saccades was also significantly higher for urban (44.740 ± 4.848) compared with natural (35.448 ± 6.539) views (t(14)= 3.933, *p*= .001, *d*= 1.016). Conversely, urban views showed significantly lower mean fixation duration (0.256 ± 0.045 seconds) than natural (0.385 ± 0.052 seconds) views (t(14) = 15.496, *p*< .001, *d*= 4.001). These results demonstrate that there is a significant and practically relevant difference in gaze behaviour elicited by the two view types.

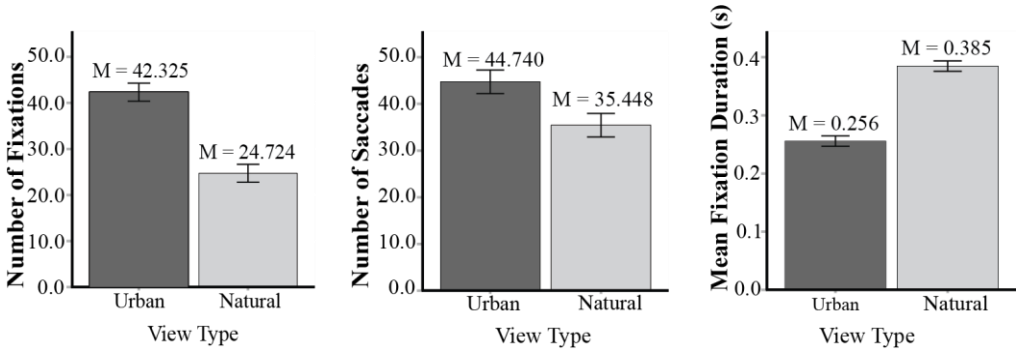


Figure 4.8 Differences in eye-tracking measures elicited by urban and natural views, n_v= 40. a = number of fixations, b = number of saccades, c = mean fixation duration. Error Bars represent +/- 2 *SE*.

View Preference

The mean-split method, based on the grand-mean of the group, was used to determine if significant differences in ETMs could be found in the same group of participants (n= 15), based on whether – across the full sample of 40 images – the urban views had been previously rated as most preferred (n= 27) or least preferred (n= 13). Based on the results of Shapiro-Wilk tests ($p< 0.05$), the number of fixations, number of saccades, and mean fixation duration did not fulfil the conditions for normality. A non-parametric Mann-Whitney U test was, therefore, run to detect differences in these ETMs between most and least preferred urban views. The median number of fixations for most preferred (43.800) and least preferred urban views (41.600) was significantly different (U= 247.000, z= 2.066, p= .039, r= 0.327), using an exact sampling distribution for U. Differences in number of saccades were also significant between most preferred (median = 46.067) and least preferred (median = 43.933) urban views (U= 250.000, z= 2.167, p=0.029, r= 0.343). Conversely, no significant differences in the medians were detected for mean fixation duration between most preferred (median = 0.236) and least preferred (median = 0.248) urban views (U= 111.000, z= -1.863, p= 0.064, r= 0.294).

Similar to the analysis performed for natural views, within-subject (related) t-tests were also conducted for urban scenes to determine whether there was a statistically significant difference between ETMs when participants observed 'most preferred' and 'least preferred' views, based on their own preference ratings (Figure 4.9). The ETMs associated with three out

of 40 images of the sample were eliminated from the analysis, since participants had identified the presence of naturalistic features in these views (Batool et al., 2020) (Study 1 – Section 4.14.). Within the remaining sample of 37 urban images (n_v), consistent with the results for natural scenes, most preferred urban views were characterised by a significantly higher number of fixations (43.728 ± 4.252) as opposed to the least preferred (42.455 ± 4.780) urban views (t(14) = 2.214, *p*= .044, *r*= 0.509). Similarly, the number of saccades was significantly higher for most preferred (45.960 ± 1.141) than the least preferred (44.703 ± 1.286) urban views (t(14)= 2.207, *p*= .045, *r*= 0.508). Conversely, no statistically or practically significant difference in mean fixation duration was detected between the least (0.253 ± 0.0382 s) and most preferred (0.252 ± 0.0481 s) urban views (t(14)= 0.143, *p*= .889, *r*= 0.038).

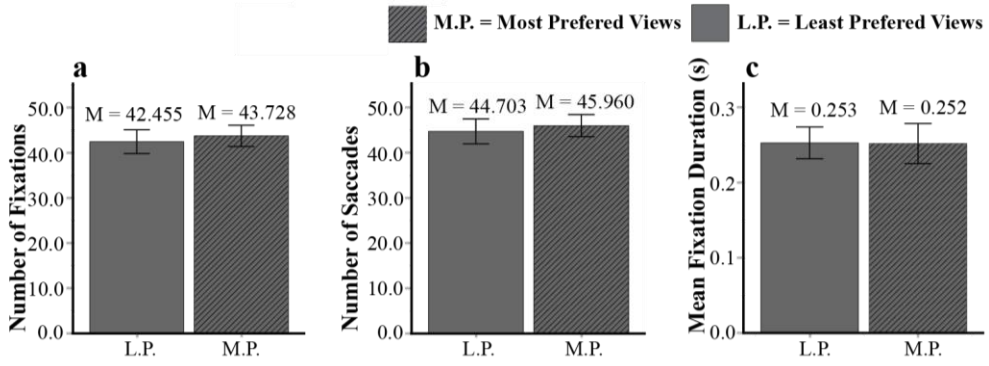


Figure 4.9 Bar plots comparing eye-tracking measures between most and least preferred urban views, n_v = 37, n_p = 15. LP = Least Preferred Views, MP = Most Preferred Views. a = number of fixations, b = number of saccades, c = mean fixation duration. Error Bars represent +/- 2 *SE*.

4.3.3. *Personality Traits and Gaze Behaviour in Urban and Natural Views*

Self-reports of nature relatedness (NRS) scores were collected across the two experiments, for urban (NRS_{urban}) and for natural views ($NRS_{natural}$). In urban views, the NRS score was inversely related to exploratory gaze behaviour (that is, the number of saccades). This was supported by a statistically significant and negative value for the Pearson's product-moment correlation for number of saccades (r= -0.784, p< 0.005) (Figure 4.10), with NRS explaining 61% of the variance. For the same participants, observing natural views elicited an opposite response in gaze behaviour based on reported NRS scores. Nature relatedness, in fact, was significantly positively correlated with number of saccades (r= 0.615, p= 0.015), explaining 37.8% of the variance (Figure 4.11). The participants who explored natural scenes more (as shown by the higher number of saccades) also had higher NRS scores.

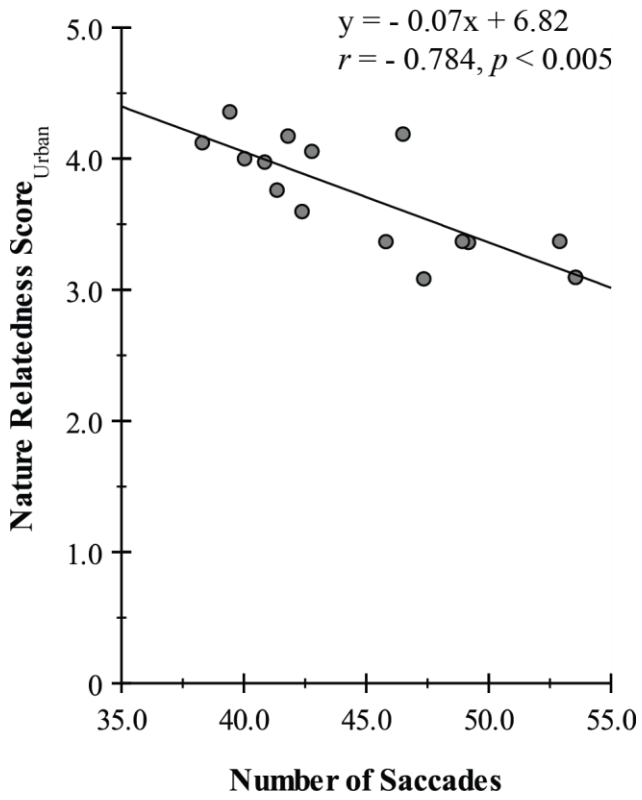


Figure 4.10 Correlation between number of saccades and NRS score in urban views

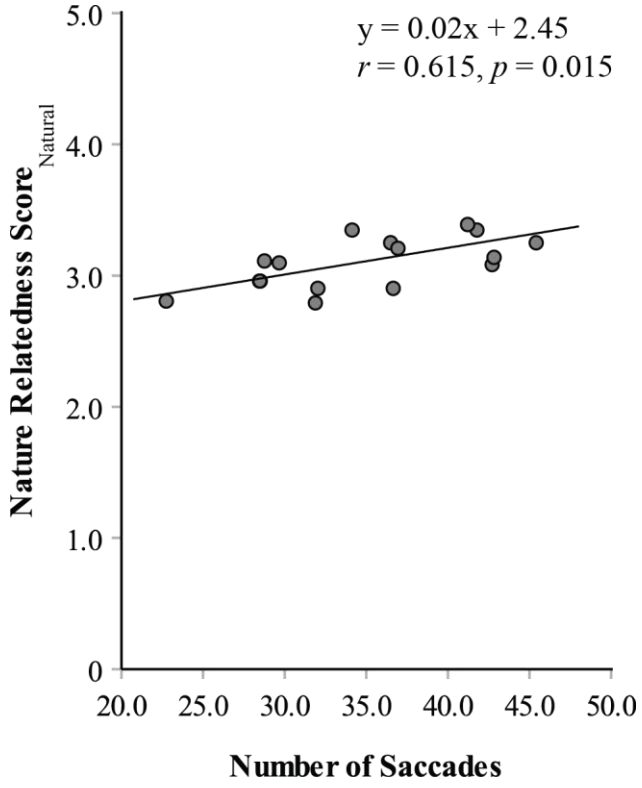


Figure 4.11 Correlation between number of saccades and NRS score in natural views

5. Preference in Real Window Views

5.1. Introduction

The perception and the utility of window views may differ between real buildings and laboratory conditions. In fact, the number of variables in operation in a real-world window view might be numerous and uncontrolled. However, as mentioned in Chapter 2, there are several features of windows and views that are known to play a part in preference formation. By asking participants to rate their window view in an instance when they are in contact with it, the effect of any difference due to seasonality, time of day and year, weather could be overcome, according to what Peter Boyce calls "*perceptual constancy*" (Boyce, 2014):

"*When considering how we perceive the world, the overwhelming impression is one of stability in the face of continuous variation. As the eyes move in the head and the head itself moves about, the retinal images of objects move across the retina and change their shape and size according to the laws of physical optics. Further, throughout the day, the spectral content and distribution of daylight changes as the sun moves across the sky and the meteorological conditions vary. Despite these variations, our perception of objects rarely changes. This invariance of perception is called perceptual constancy. The evolutionary advantage in being able to recognize a tiger as a tiger over a wide range of lighting conditions is obvious."* (p.83)

Collecting data and investigating real-time preference *in situ* reduces many potential biases inherent to other experimental methodologies (Killingsworth and Gilbert, 2010). For this reason, an online survey method was adopted to reach respondents in their own building and enquire about their relationship with the window and the view out (as illustrated earlier, in Section 3.2). The survey was designed to address the following specific research questions:

1. How do inter and intra-architectural features inform window view preference?
2. How does the window view preference relate with familiarity and satisfaction with the view and with the location within the room?
3. What are the positive and negative features of windows that are perceived in relation to window view preference?

4. How do these features influence window view preference (e.g., in terms of like/dislike and appreciation)?
5. What are the underlying reasons for liking or disliking the view out of a window?
6. What do people notice in their own views?

The results of this survey analysis are presented in the following sections. Section 5.2 presents the quantitative results from the first four questions, while the thematic analysis of qualitative responses using a framework analysis (as discussed in 3.2.7) approach is discussed in Section 5.3.

5.2. Quantifying View Preference

5.2.1. *Inter and Intra-architectural Features*

Differences in window view preference were initially tested based on the continent/country of location of the participant in order to account for environmental and socio-cultural influences. Although the sample size was markedly unevenly distributed – 'Africa' (n=5), 'Asia' (n=46), 'Europe' (n=544), 'North America' (n=108), 'Oceania' (n=14), 'South America' (n=3) – an exploratory Kruskal-Wallis H test was run to investigate if there could have been detectable differences in window view preference based on continent. Distributions of scores were not similar for all groups, as assessed by visual inspection of boxplots. Median window view preference ratings scores (n = 720) were significantly different between groups, χ^2 (5) = 11.972, p= 0.035.

Pairwise comparisons were performed using Dunn's (1964) procedure. Bonferroni corrections were applied in consideration of the experiment-wise error rate caused by the alpha level inflating across multiple tests carried out with the same hypothesis. The adjusted *p*-value is presented in the results. This post hoc analysis revealed a (marginal) statistically significant difference in window view preference between the responses in Oceania (*Mdn*= 94.00) and Europe (*Mdn*= 72.00) (*p*= 0.052, adjusted significance), but not across any other continent group combination. As a further exploratory exercise, another variable was created based on the location. The Global Horizontal Irradiance, a measure of the total daylight received (Pierson et al., 2021), was retrieved from an online database (PVGIS, 2021) for each location. A Spearman's rank correlation between window view preference and Global Horizontal Irradiance (GHI) returned a negative trend, but this was not statistically significant: r_s = -0.038, p = 0.318.

Further intra-architectural features, such as location of the participant with respect to the window and building floor level, were investigated to test for differences in window view preference. A Kruskal-Wallis analysis revealed that ratings of window view preference were not statistically different due to the location in the room, χ^2 (3) = 1.659, p= 0.646. However, the satisfaction with the location with respect to the window differed significantly based on how far the participants sat from the window: 'adjacent' (n = 146), 'within 1 meter' (n = 233), 'within 1-2 meters' (n = 277), and 'more than 3 meters' away (n = 94). Median ratings of satisfaction with participant's location with respect to the window (here, satisfaction with location) were statistically

different between the locations where participants sat, χ^2 (3) = 29.345, p< 0.0005. Pairwise comparisons were then performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons (adjusted *p*-values are presented here). The post hoc analysis revealed statistically significant differences in median satisfaction with location ratings between: 'adjacent to window' (77.00) and '1-2 meters' (67.00) (p= 0.019); 'adjacent to window' (77.00) and 'more than 3 meters' (59.50) (p < 0.0005); 'more than 3 meters' (59.50) and 'within 1 meter' (73.00) (p < 0.0005); 'more than 3 meters' (59.50) and 'within 1-2 meters' (67.00) (p = 0.023). No significant differences could be detected among other comparisons. These results suggest that, as expected, the differences in satisfaction with the location are more pronounced as the person is located farther away from the window.

To compare the differences in view preferences based on building floor level, and to analyse samples of comparable size, the data was combined in three groups: 'ground' (n= 239); 'floor 1-2' (n=340); and, 'floors 3 and above' (n= 135). Since the ground floor offers multiple connections with the outside, this was intentionally kept as a separate layer of information. The height of trees in cities often reaches up to the second floor, and therefore floors 1 and 2 were grouped together as one layer of information. Participants who stated to be located 'underground' (n=6) were removed from this analysis. A Kruskal-Wallis test was conducted to determine if there were differences in window view preference between participants located on the 'ground', 'floors 1-2', and 'floors 3 and above'. Distributions of window view preference data were similar for all groups, as

assessed by visual inspection of a boxplot. Median window view preference ratings were significantly different between the groups, $\chi^2(2) = 12.751$, p= 0.002. Pairwise comparisons were then performed using Dunn's (1964) procedure with Bonferroni corrections. The post hoc analysis revealed statistically significant differences in median window view preference ratings between the 'ground' (77.00) and 'floor 1-2' (71.00) (p= 0.015); and between the 'ground' and 'floors 3 and above' (65.00)(p= 0.004). No significant differences were detected between 'floors 1-2' and 'floors 3 and above'.

Further tests were conducted to analyse differences in satisfaction with the size of the room based on the floor on which each participant was located. A Kruskal Wallis test returned no significant differences detected, $\chi^2(2) = 0.819$, p= 0.910.

The results of these tests emphasize the complexity of different inter- and intra-architectural features that could contribute towards the rating of window view preference.

5.2.2. ***Preference, Satisfaction and Familiarity***

A Spearman correlation test was conducted to assess the relationship between the independent variable, window view preference, and the following dependent variables: familiarity with view; satisfaction with the window view; satisfaction with size of window; satisfaction with location with respect to the window; and, satisfaction with the size of the room. The

Spearman method was selected instead of a Pearson correlation since the data was skewed.

As shown in Table 5.1, there was a statistically significant strong positive correlation between window view preference and satisfaction with the window view, $r_s(718)= 0.738$, $p< 0.0005$, $R^2= 0.545$ (Figure 5.1-a). Similarly, the familiarity with the view out of the window and view preference were positively correlated, $r_s(718) = 0.324$, $p< .0005$, $R^2 = 0.105$ (Figure 5.1-b). The correlation between satisfaction with the location with respect to the window and the view preference was also positive, $r_s(718) = 0.450$, $p< 0.0005$, $R^2 = 0.203$. Window view preference was positively correlated with the satisfaction with the size of the window, $r_s(718)= 0.331$, $p< 0.0005$, $R^2= 0.110$, and satisfaction the size of the room, $r_s(718) = 0.295$, $p< 0.0005$, $R^2 = 0.087$.

Table 5.1 Spearman correlation coefficients (**= correlation is statistically significant (2-tailed))

	Window view preference	Familiarity with view	Satisfaction: Size room	Satisfaction: View	Satisfaction: Size Window	Satisfaction: Location with respect to window
Window view preference	1.000	.324**	.295**	.738**	.331**	.450**
Familiarity with view	.324**	1.000	.251**	.274**	.313**	.321**
Satisfaction: Size room	.295**	.251**	1.000	.296**	.525**	.451**
Satisfaction: View	.738**	.274**	.296**	1.000	.334**	.408**
Satisfaction: Size Window	.331**	.313**	.525**	.334**	1.000	.399**
Satisfaction: Location with respect to window	.450**	.321**	.451**	.408**	.399**	1.000

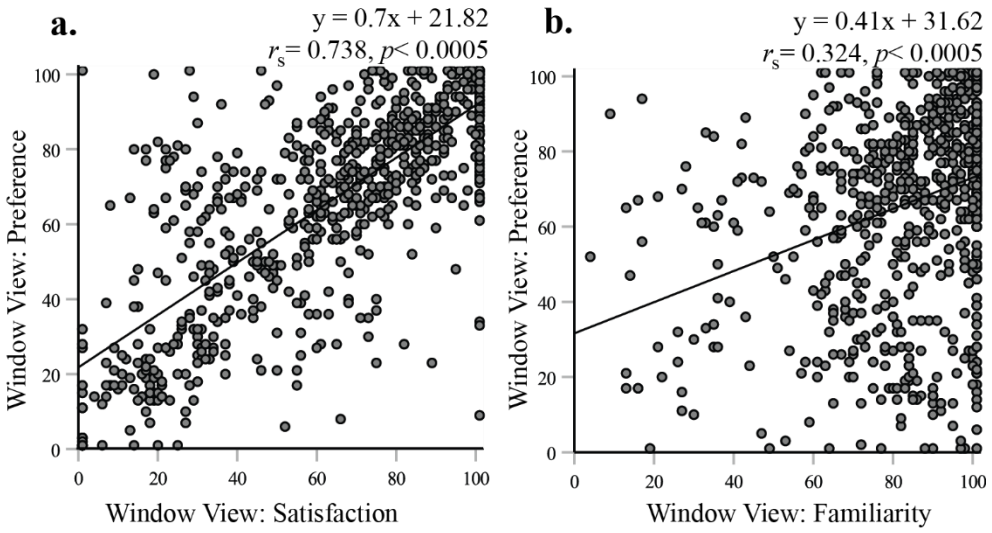


Figure 5.1 Scatterplots of familiarity and satisfaction with the view out and window view preference

5.2.3. ***Necessary Conditions for Window View Preference***

The Necessary Condition Analysis (Dul, 2016) was applied using the NCA package version 3.1.0 in R (Dul, 2015). Two positive features of windows were found to be necessary-but-not-sufficient for window view preference. These statistically significant conditions for window view preference were: 'lets me observe other people and activities outside' (p < 0.001, d = 0.240) with a medium effect size (Figure 5.2); and, 'tells me the weather outside' (p = 0.01, d = 0.100) with a medium effect size (Figure 5.3). Figure 5.2 and Figure 5.3 show the CE-FDH lines with no data point above them. The vertical axis in the plot shows that, when participants selected these attributes as positive features of windows, a minimum threshold value of window view preference could be reached in this sample.

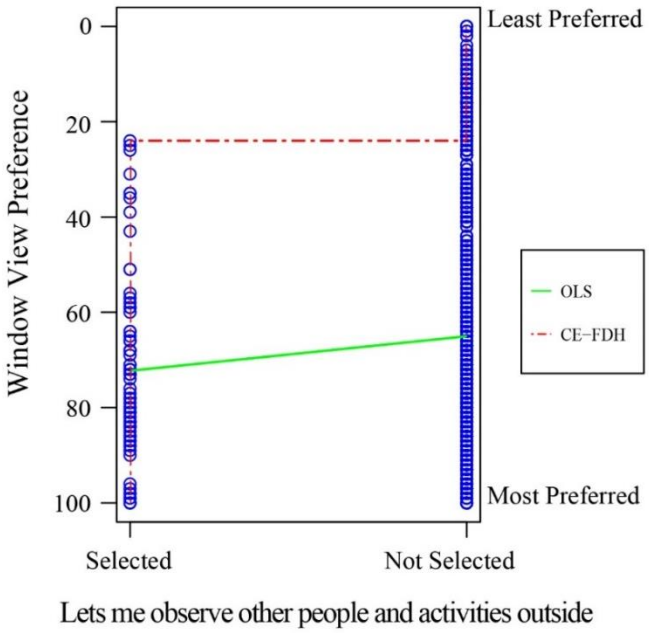


Figure 5.2 NCA - Ceiling line for the variable 'lets me observe other people and activities outside'; CE- FDH = Envelopment – Free Disposal Hull and OLS = Ordinary Least Squares regression line, drawn for reference. n = 720.

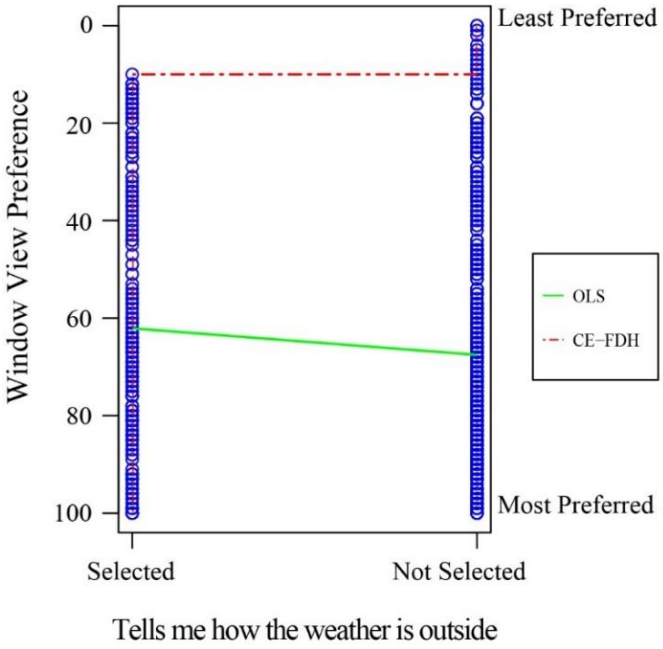


Figure 5.3 NCA - Ceiling line for the variable 'tells me the weather outside'; CE- FDH = Envelopment – Free Disposal Hull and OLS = Ordinary Least Squares regression line, drawn for reference. n = 720.

5.2.4. ***Composite Window Features***

To measure the inter-relationships between different window attributes, composite data containing three features of windows that were considered positive and negative, respectively, were collected and analysed. The following diagrams offer an opportunity to explore the influences of different features of windows in relation to other attributes, as opposed to appraising a window feature in isolation.

A distribution of the frequency of most frequently selected positive features is provided in Figure 5.4.

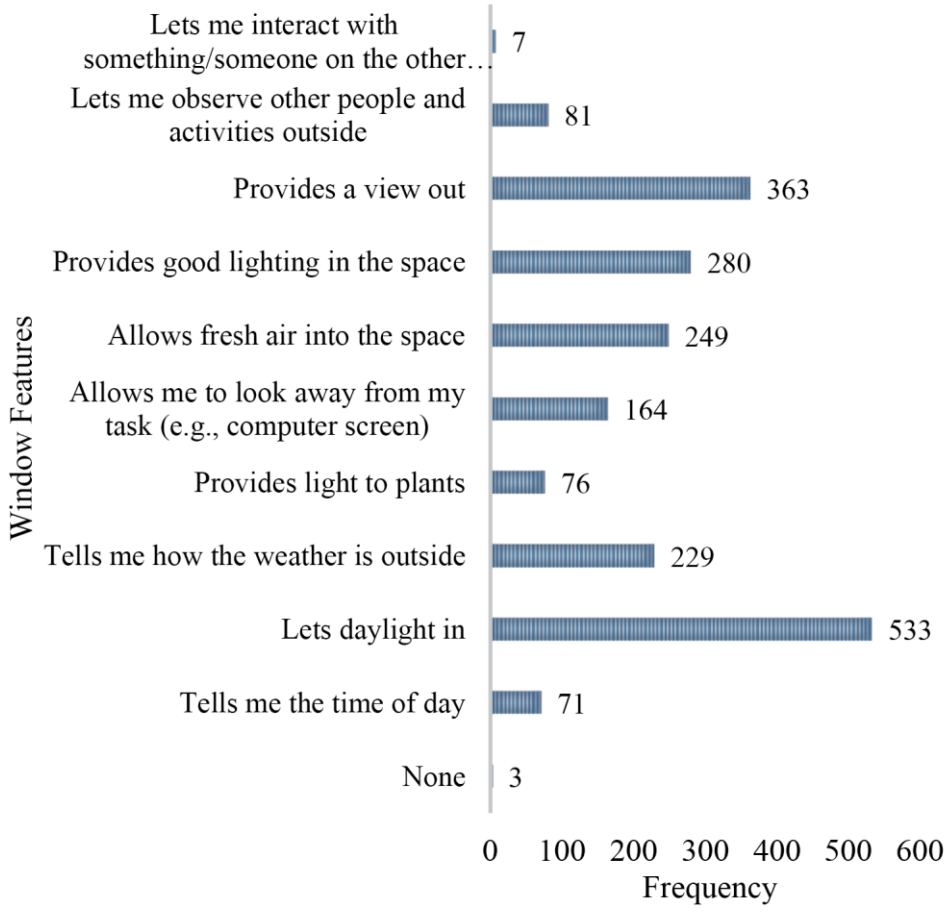


Figure 5.4 Frequency distribution of positive window features

The most frequently selected positive features included: ‘lets daylight in’, ‘provides a view out’, ‘provides good lighting in the space’, and ‘tells me how the weather is outside’.

Table 5.2 shows the top ten most frequently selected combinations of positive features. Letters are assigned to features for ease of reading. Nine out of ten combinations include the feature ‘lets daylight in’ (marked by the letter C) and five combinations also present ‘provides a view out’ (letter I) and ‘provides good lighting in space’ (letter H). The top three most frequent combinations are:

- ‘lets daylight in’* ‘provides a view out’ * ‘good lighting’
- ‘lets daylight in’ * ‘provides a view out’ * ‘allows fresh air into space’
- 'lets daylight in’ * ‘provides a view out’ * ‘allows me to look away from task’.

Table 5.2 Top ten positive variables associated with windows

Positive Variable Combinations	Frequency
C.I.H	67
C.I.G	62
C.I.F	45
C.G.H	41
C.I.D	41
C.H.D	31
C.G.D	25
C.D.B	22
C.H.F	19
I.G.H	19

Note. B = Tells me the time of day; C = Lets daylight in; D = Tells me how the weather is outside; F = Allows me to look away from my task (e.g., computer

screen); G = Allows fresh air into the space; H = Provides good lighting in the space; I = Provides a view out.

Figure 5.5 illustrates the combinations of positive window features selected alongside variable C, 'lets daylight in', which represents the most selected positive feature of windows across all participants. This feature is shown as the centre anchor of the sunburst chart, and the figure illustrates how other features have been selected in relation to this variable, alongside each other. To better illustrate the information provided by the sunburst chart, take the example of variable I, 'provides a view out', and then the features: H, 'provides good lighting in space'; G, 'allows fresh air into space', D, 'tells me how the weather is outside'; and F, 'allows me to look away from the task'. Although daylight and good lighting of space are important features of windows, the function of a window is perceived in conjunction with other features such as ventilation (possibly associated with operable windows), and establishing a connection with the outside (knowledge of weather, taking a break from task, and a view out). While light in the interior space is often only associated to human activities, participants also selected provision of light to plants. As windows are favoured for bringing daylight in, they are simultaneously liked for the connection they provide to people and other activities outside.

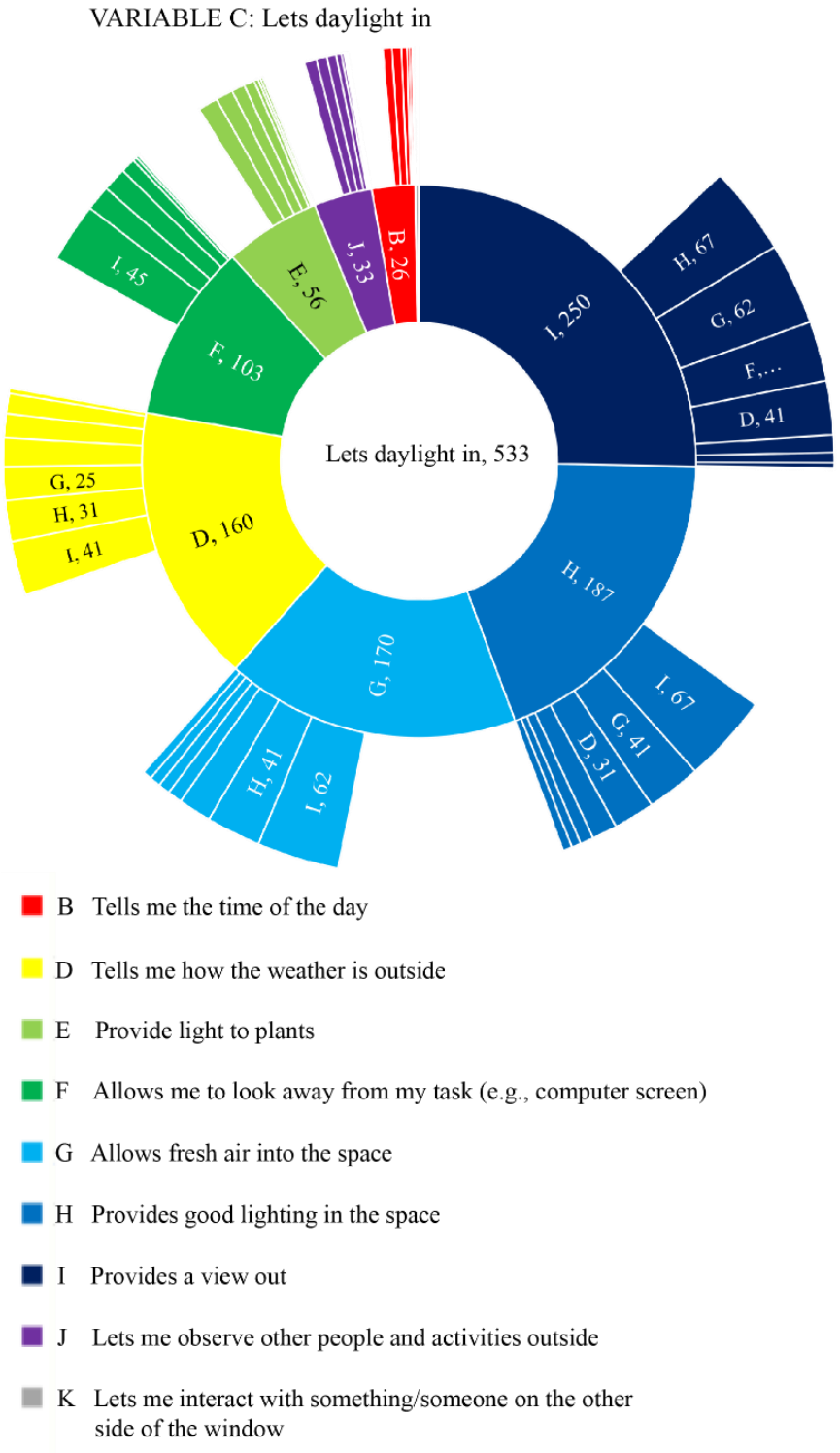


Figure 5.5 Combinations of positive window features selected alongside *'lets daylight in'*

Figure 5.6 displays the distribution of the negative window features selected with, in decreasing order of frequency: 'provides too much cold draft in winter', 'none', 'allows others to see inside', 'allows too much noise from the street', and 'causes annoying glare'.

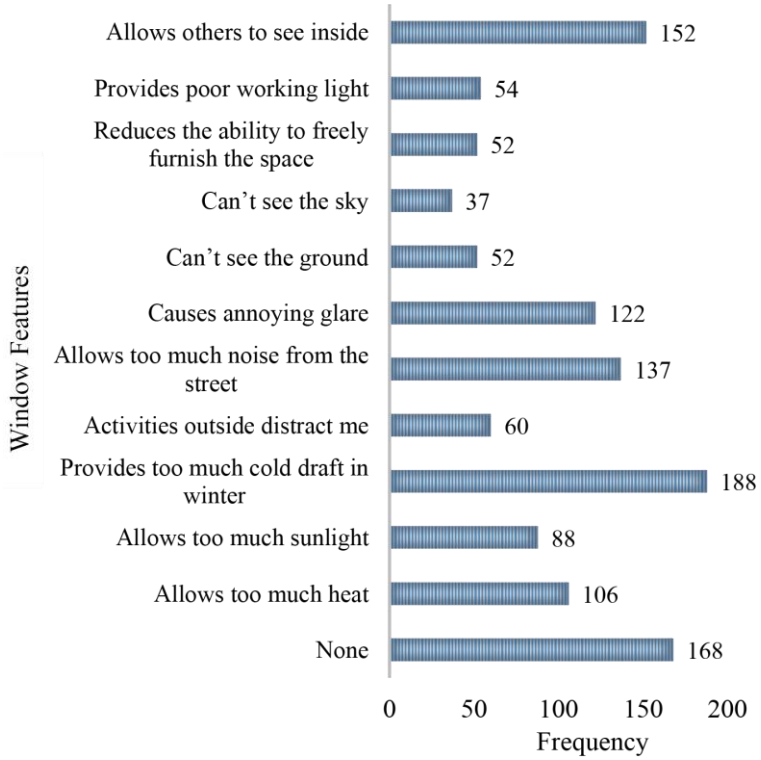


Figure 5.6 Frequency distribution of negative window features

Other than positive features, participants also selected some negative attributes, although most participants reported 'None' (13.8%). Six more variables were selected as the top negative features as follows, in decreasing order of frequency: 'provides too much cold draft in winter' (6.0%); 'allows others to see inside' (4.2%); 'allows too much noise from the street' (3.6%); 'allows too much heat' (3.2%); 'can't see the ground' (2.6%); and 'allows too much sunlight' (2.4%).

Out of the 142 combinations of selections for the top three negative features, Table 5.3 lists the seven most selected variables in isolation, and then the top ten combinations of variables indicated as a negative attribute of windows.

Table 5.3 Frequency of negative window attributes

Negative Variable Ccombinations	Frequency
A	165
D	43
L	30
F	26
B	23
G	19
C	17
D.F	12
L.D	12
D.G	11
B.D.F.	9
D.K.	9
B.D.	8
D.E.F.	8
L.D.G.	8
L.C.G.	7
B.C.	5

Note. A = None; B = Allows too much heat; C = Allows too much sunlight; D = Provides too much cold draft in winter; E = Activities outside distract me; F = Allows too much noise from the street; G = Causes annoying glare; K = Reduces the ability to freely furnish the space; L = Allows others to see inside.

The most selected feature of windows that negatively affected the participants was ‘provides too much cold draft in winter’. This feature was selected mostly in combination with: ‘allows others to see inside’; ‘allows too much noise from street’; ‘allows too much heat’; ‘causes annoying glare’; and, ‘allows too much sunlight’ (Figure 5.7).

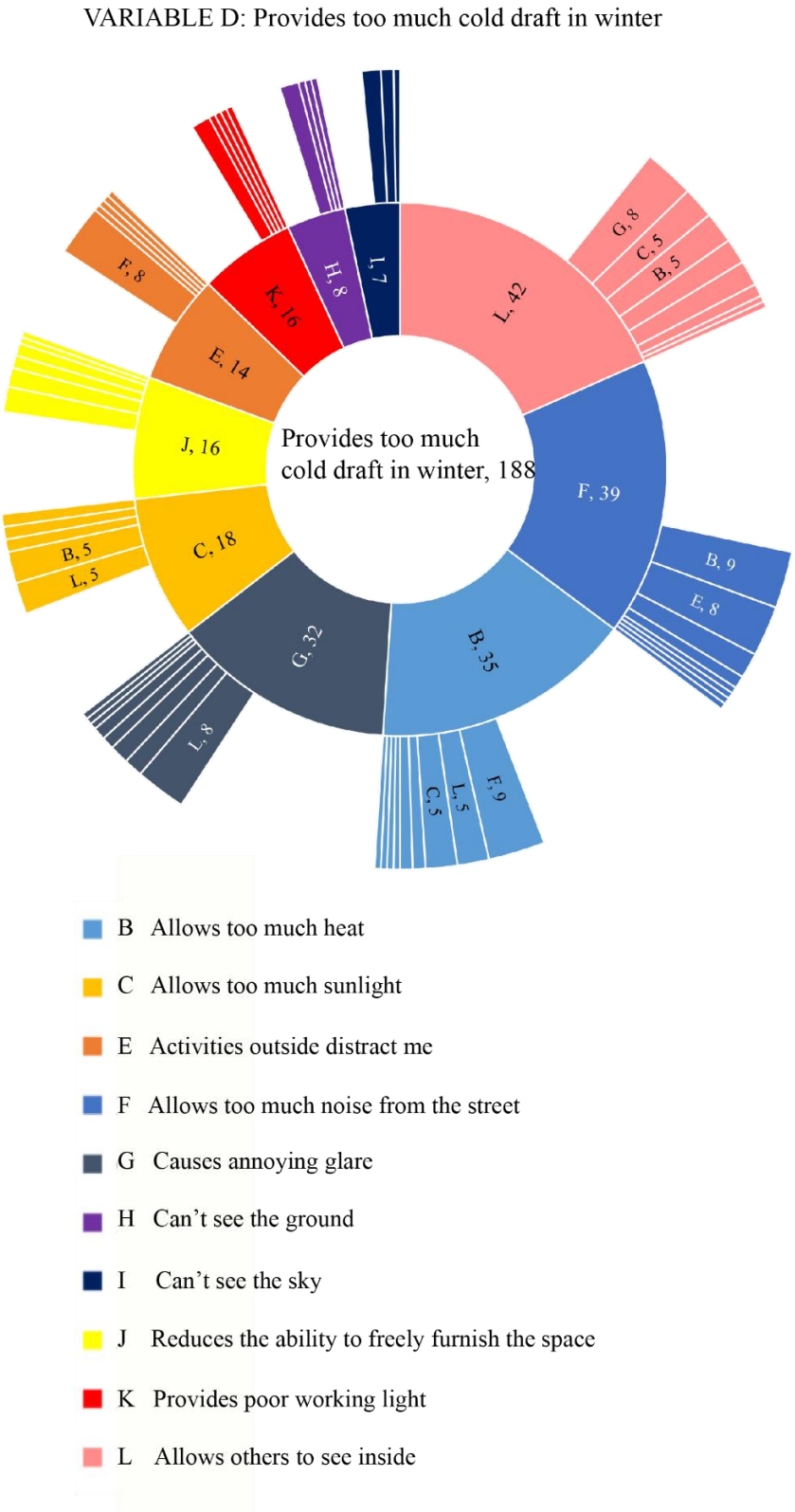


Figure 5.7 Combinations of negative features selected alongside *'provides too much cold draft in winter'*

5.2.5. ***Reasons for Operation of Blinds and Curtains***

Figure 5.8 shows that window blinds were opened to increase the level of lighting, e.g., to 'let daylight in' (30.84%) as well as to 'provide good lighting in space' (17.54%). This was followed in frequency by 'providing a view out' (15.80%) and to 'tell the weather outside' (12.76%). To 'tell the time of the day' received very few selections (2.61%), as to 'interact with something/someone on the other side of the window' (0.33%). Respondents also included the following free text comments to better characterise their interactions with blinds/curtains: *"watch the birds feeding in my garden and the field beyond"; "there are no blinds or curtains"; "the shading devices allows all of the above choices, even when closed. I keep the shade down to give me privacy from the street"; "never close the blinds"; "let the cat look outside"; "conservatory window always open";* and *"because there is no glare or low sunlight".*

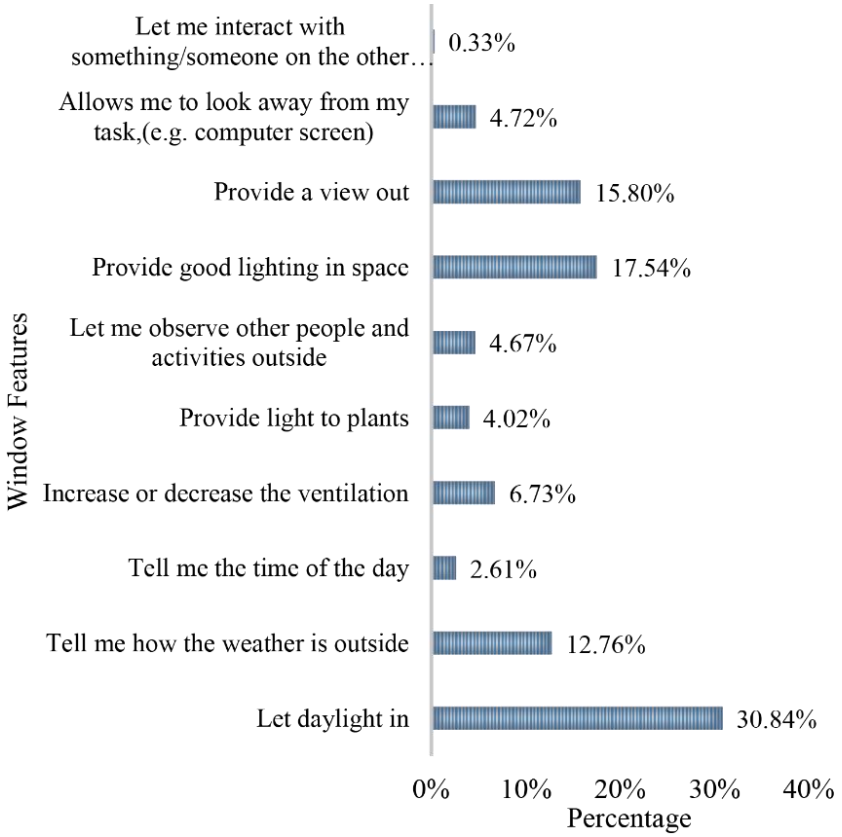
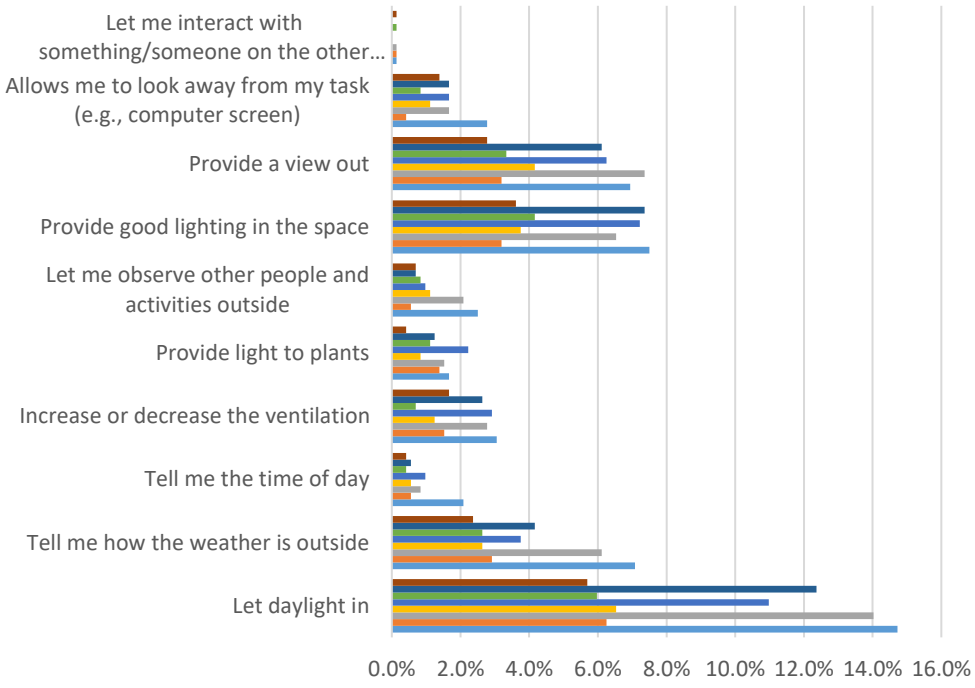


Figure 5.8 Window blind opening reasons

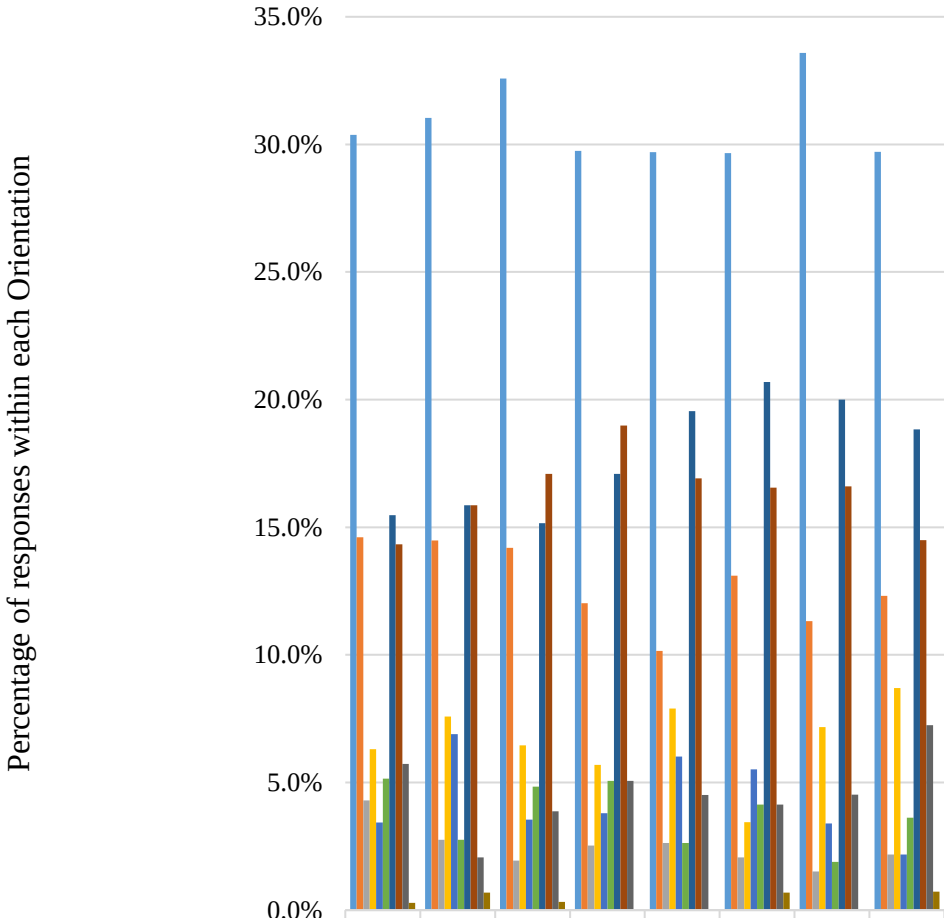
Table 5.4 provides a detailed breakdown of responses on blind operation according to the orientation of the window. Further to this, to make useful interpretation of the data, the responses were weighted within each orientation (Table 5.5). Based on this weighting, 'let daylight in' was the most frequently selected option in the West although with percentages of distribution evenly spread across other orientations. Also, for the other most frequently selected reasons for opening blinds, no substantive differences could be detected based on cardinal point.

Table 5.4 Orientation and reasons for blind opening



	Let daylight in	Tell me how the weather is outside	Tell me the time of day	Increase or decrease the ventilation	Provide light to plants	Let me observe other people and activities outside	Provide good lighting in the space	Provide a view out	Allows me to look away from my task (e.g., computer screen)	Let me interact with something/someone on the other side of the window
North West	5.7%	2.4%	0.4%	1.7%	0.4%	0.7%	3.6%	2.8%	1.4%	0.1%
West	12.4%	4.2%	0.6%	2.6%	1.3%	0.7%	7.4%	6.1%	1.7%	0.0%
South West	6.0%	2.6%	0.4%	0.7%	1.1%	0.8%	4.2%	3.3%	0.8%	0.1%
South	11.0%	3.8%	1.0%	2.9%	2.2%	1.0%	7.2%	6.3%	1.7%	0.0%
South East	6.5%	2.6%	0.6%	1.3%	0.8%	1.1%	3.8%	4.2%	1.1%	0.0%
East	14.0%	6.1%	0.8%	2.8%	1.5%	2.1%	6.5%	7.4%	1.7%	0.1%
North East	6.3%	2.9%	0.6%	1.5%	1.4%	0.6%	3.2%	3.2%	0.4%	0.1%
North	14.7%	7.1%	2.1%	3.1%	1.7%	2.5%	7.5%	6.9%	2.8%	0.1%

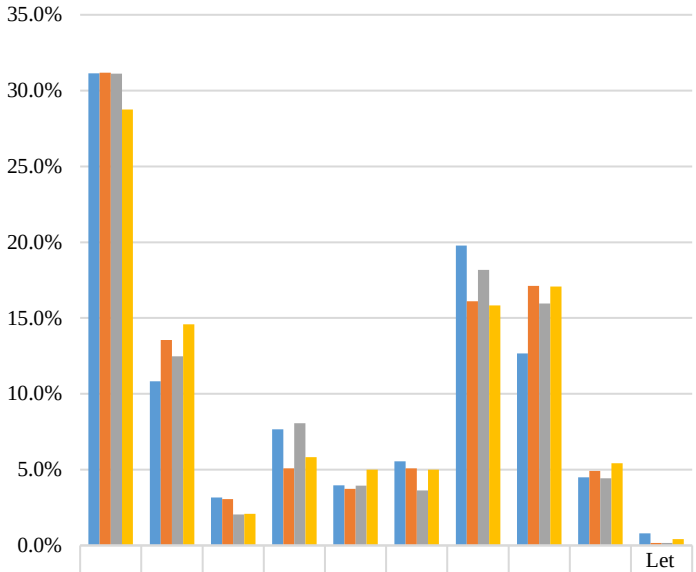
Table 5.5 Reasons for opening blinds and curtains as a factor of orientation



	North	North East	East	South East	South	South West	West	North West
Let daylight in	30.4%	31.0%	32.6%	29.7%	29.7%	29.7%	33.6%	29.7%
Tell me how the weather is outside	14.6%	14.5%	14.2%	12.0%	10.2%	13.1%	11.3%	12.3%
Tell me the time of day	4.3%	2.8%	1.9%	2.5%	2.6%	2.1%	1.5%	2.2%
Increase or decrease the ventilation	6.3%	7.6%	6.5%	5.7%	7.9%	3.4%	7.2%	8.7%
Provide light to plants	3.4%	6.9%	3.5%	3.8%	6.0%	5.5%	3.4%	2.2%
Let me observe other people and activities outside	5.2%	2.8%	4.8%	5.1%	2.6%	4.1%	1.9%	3.6%
Provide good lighting in the space	15.5%	15.9%	15.2%	17.1%	19.5%	20.7%	20.0%	18.8%
Provide a view out	14.3%	15.9%	17.1%	19.0%	16.9%	16.6%	16.6%	14.5%
Allows me to look away from my task (e.g., computer screen)	5.7%	2.1%	3.9%	5.1%	4.5%	4.1%	4.5%	7.2%
Let me interact with something/someone on the other side of the window	0.3%	0.7%	0.3%	0.0%	0.0%	0.7%	0.0%	0.7%

Although the location of respondents with respect to the windows varied substantially, and was highest within 1-2 meters from the window, Table 5.6 shows the distribution of responses related to blind operation for each distance category. While providing daylighting was the most important reason for opening blinds, as participants were located away from the window, the reason for operating shading systems shifted slightly, with an increase in 'tell the weather outside', 'allow to look away from task' and 'provide a view out'. As the distance between the observer and a window increases, the need to connect to the outside seems to gain more importance over access to sunlight and lighting.

Table 5.6 Reasons for opening blinds compared to location in relation to window



	Let daylight in	Tell me how the weather is outside	Tell me the time of day	Increase or decrease the ventilation	Provide light to plants	Let me observe other people and activities outside	Provide good lighting in the space	Provide a view out	Allows me to look away from my task (e.g., computer screen)	Let me interact with something/someone on the other side of the window
Adjacent to Window	31.1%	10.8%	3.2%	7.7%	4.0%	5.5%	19.8%	12.7%	4.5%	0.8%
1 meter (1- 3 feet)	31.2%	13.6%	3.1%	5.1%	3.7%	5.1%	16.1%	17.1%	4.9%	0.2%
1-2 meters (4- 6 feet) away	31.1%	12.5%	2.1%	8.1%	3.9%	3.6%	18.2%	16.0%	4.4%	0.2%
More than 3 meters (7 feet+) away	28.8%	14.6%	2.1%	5.8%	5.0%	5.0%	15.8%	17.1%	5.4%	0.4%

5.3. What Makes a View Preferred? A Qualitative Framework Analysis

Out of the 720 respondents, 693 (96.3%) filled out two qualitative open-ended questions on what they liked and disliked in their view, and what they particularly noticed. Nasar (1990) argued that "*evaluation is central to our perception of, and reaction to, the environment*"(p.42). This section presents the analysis derived from a framework analysis of open-ended responses, which have been structured in four broad themes.

Theme 1: Preference for dynamism and variation

Theme 2: Environmental predictors of physical view

Theme 3: Hindrances and challenges limiting view appreciation

Theme 4: Sense of attachment with the window view

5.3.1. *Theme 1: Preference for dynamism and variation*

This study identified three levels of dynamic changes that attract a person's attention and can drive fondness for their view out of the window: 1) transient; 2) recurrent; and, 3) seasonal changes.

Transient changes

Transient changes are the momentary variations that occur over a brief duration; these can be either related to nature or triggered by humans. The participants noticed specific features of human activity in their windows. These ranged from pedestrian movements to the passing of automobiles (cars and trains), as well as the presence of people in other buildings and on

the street. The respondents stated that *"noticing passers-by, traffic...etc"* and activities on the street added to the likeability of the view: *"Usually if I'm looking out the window it's to check on what is going on outside (usually due to noise on the street) or to observe the weather".* Movement of cars and trains in the view attracted their attention: *"There is a train station nearby and I like to watch the trains go by"; "The cars in the highway and the city around"; "Sometimes, a historical train that works during the summer weekends can be seen passing in the background".* Participants also expressed their interest and motivation in observing neighbours and their actions: *"I can observe movements and daily tasks neighbours perform. Could seem creepy, but I find it inspiring in many ways. It allows me to observe in detail bodily movements which I often find relaxing and thought provoking";* and, *"It overlooks the street which allows me to be aware of what's happening outside, in some cases even tell who's at the door. It is also a good distraction from the silent life indoors".* Respondents reported also observing other people in neighbouring buildings: *"I can clearly see the other offices and people are working which gives me motivation".*

Momentary changes are also triggered by the presence of wildlife and birds in the external environment. Participants noticed the movement of birds, and other animals in the view, as well as the swaying of leaves and waves in water bodies: *"I like watching the birds, rabbits, ducks and other wildlife. I can see other villagers walking their dogs past the end of the garden. I like hearing the birds sing and listening to the sounds of nature".* The presence of trees and vegetation in the view might be felt to increase the

opportunities of encounters with animals: *"I can see birds and squirrels and the leaves moving on the trees".* The presence of wildlife also offered cues/sense of time of the year: *"it lures me outside, rewards me with sightings of birds and other wildlife. It gives me a time that bats start to forage"*, an experience that might change over the course of the year: *"eventually I can see all sorts of animals pass by".* This expectation encouraged participants to create opportunities for birds and other animals to visit their surrounding environment more often: *"The wild birds feeding mainly on the food I provide in the garden. Sheep in the field and the crows flying over it. I watch the birds feeding in my garden and the field beyond".* Interestingly, some natural movements of trees and water in response to the wind also gave a sense of the weather condition: *"I can see big trees and how they move when it's windy like today, gives a good sense of the wind and the weather with just a glance."*

Table 5.7 shows some of the photographs of window views from the transient change theme posted by respondents. Participants often sought a rich mixture of both human and nature related variations in their view: "*I like the view of the two trees in my garden and that I can watch birds that sit in them when I need to rest my eyes away from my computer. I also like that I have a slight view of the street and some of my neighbour's gardens, so I can see other people and things going on outside."* Although these photographs do not necessarily capture the dynamic changes described, the cognitive benefits of interacting with nature are well established. This might have significant implications on the design of buildings, particularly in urban

environments, as respondents have shown to strongly favour the presence of birds, high trees, flowering plants and water features.

Table 5.7 Cases of photographs highlighting transient changes

human related change			
nature related change			

Recurrent (anticipated) changes

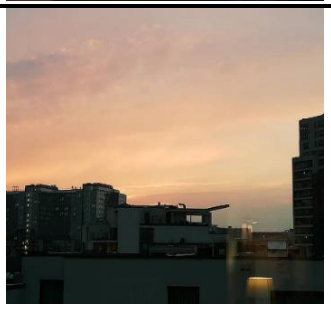
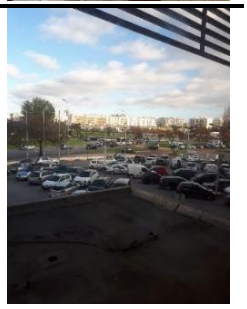
Recurrent changes refer to the variations in the view due to cycles of light, weather, and colours in the sky on a daily and seasonal basis. Light and the rhythms of the sun are fundamental to survival, and this is clearly reflected in the participant's responses: *"I can see the sky and tell time of the day by the position of the sun".* Some windows are able to offer a night view of the sky as well, therefore providing continuous access to stimuli: *"At night, when I look up through it, I can see the stars (one window adjacent/above my bed). And since it is facing South, I can see both sunrise and sundown. It's a diagonal window so I can easily look up towards the sky and go stargazing at night."* The sunset is another moment of the day that is much appreciated: *"I love when the sun is shining at the sunset, and I can see the light coming through the room and changing positions as the time passes".* Participants

also appreciated a view towards night lighting: *"The view shows the RTBF (national radio and TV) tower. At night, it shows different colours (from blue to red). It's like Christmas all around the year!".*

Another aspect associated with daily rhythms was the sky condition, e.g., its changing colours due to sunrise and sunset and the dynamic patterns in clouds due to the variations in the weather. The sky offered dynamism throughout the day: *"The sky over the castle is constantly changing and always beautiful, … gives a sense that the world keeps on turning regardless of whatever is happening here inside the building"*; and, *"the sky gets really pretty at the end of the day and I can see all the colours from the sunset in the sky".* Participants actively watched and observed the sky: *"The sky, especially in the morning. This window is where I get my daily dose of sky watching";* and, *"I love skies - I could spend hours just looking up".* Some of this sky watching could be attributed to knowledge of weather: "*I can see the sky and weather when it rains or snows"*; *"the weather so I can see how my commute will be";* and, *"I tend to notice the sky first and the weather condition - Sunny/Cloudy".*

Although the rotation of the earth offers a cyclic rhythm that marks every day, the position of the sun and the conditions of the sky and weather also give cues of the seasons. Table 5.8 shows a few examples of photographs from participants who mentioned these qualities in their views.

Table 5.8 Daily recurrent changes: examples of window views

Light			
Sky			

Seasonal changes in nature

The appreciation of a view might be associated with a long-term experience, where the participants shared elements of views experienced throughout the year, or referred to a different time of the year. Although some respondents mentioned the current weather outside, most responses were related to the overall experience of the view and not linked to a specific moment in time. For example: *"over longer time periods one can see the seasons change".* Critically, the natural content of outdoor views, such as a tree, holds greater potential to embrace changes over the course of time as opposed to, say, a lamp post. The changing colours of the natural foliage, for instance, provide an ever-changing physical element that allows for new information to be found in the view and a connection to be established with

the outside. Trees that change colour with seasons were much appreciated: *"During fall, the changing colours of leaves is a spectacular view. In winter, we have our very own winter wonderland with the snow. So throughout the year, it's just amazing to just see outside!"; "The nature, the changing colours of the trees with each season"; "It's a sight in the countryside without any buildings. The fields change every year, sometimes twice or more times a year"; "The arrival of spring brings lovely colours and textures to the trees and flowers".* Due to the change in foliage over the year, especially with deciduous trees, the content of the view, and its fullness, also varies: *"I like the way the view changes through the seasons. In winter, when there are no leaves on the trees, you can see all of our village and the next (Plumtree) and across to Nottingham. In the summer, we are surrounded by a lot of trees, and we can feel quite enclosed, in our own little space. At night you can also see all the lights of the city and the wheel when it is there in winter";* and, *"I look at the size of the trees and how they change with the seasons. In April, the oaks let me see the sunset".*

Another element that marks seasonal changes is the growth and flourishing of nature, which develops a connection with the elements in the view: *"I love my view - especially the trees. I love watching it bud and then the leaves grow in the spring and the colours in the autumn";* and, *"the view is onto an enclosed space, no public access or traffic noise and no one overlooking it. It feels private, my little corner of the world. It looks onto our garden we created from nothing, and we have watched the sapling grow into a strong tree. It's a connection to the outside and the outside has been co-*

created by us and nature". Due to the changing patterns of nature, the view is not only changing but it provides something new to observe on a regular basis: *"There is a lot of seasonal change with the plants in the neighbouring gardens and they are well maintained so there is always something new to look at when I return home".* Table 5.9 shows some examples of views from participants who mentioned the aspect of seasonality in their responses.

Table 5.9 Colours in nature as a reflection of seasonality



5.3.2. ***Theme 2: Environmental predictors of view preference***

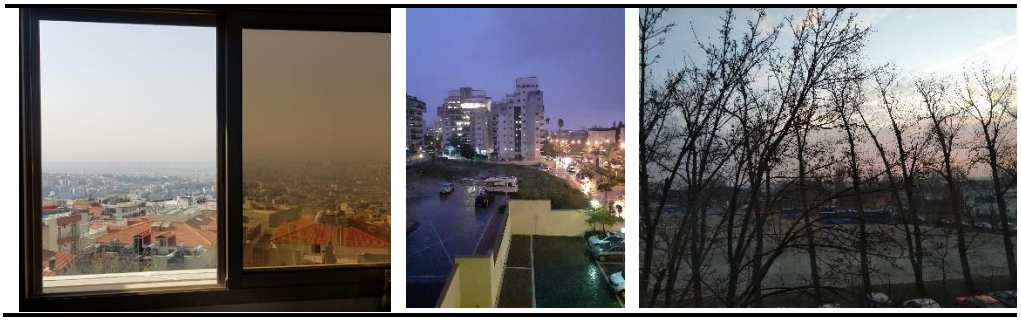
Visual openness

Visual openness in a view is afforded by the height of the window, the topography of the site, and the density of nearby natural and built structures, when one is able to look far into the distance, towards the '*horizon*', or '*down below'*. People who experience openness in the view enjoyed *'long distance'* scenes and the opportunity to see outside without being seen. Participants whose window afforded a view above others, could also report a variety of elements, e.g., *"Open space that permits to enjoy a perspective"* and a *"wide view".* Openness offered multiple points of interest for participants to notice, for example: *"being able to look down onto the plain below…and also enjoy*

that on good visibility days I can see several towns over; "eyes wander from residential hills on the left to the residential flat areas close to the airport"; and, *"watch the sunset from that window".*

Inevitably, having an open view also gives the feeling of being protected from overlookers. For example, being able to see far was often associated with leaving the "*curtains open"*, while being located on a high floor was considered a positive attribute as "*no one else can see in"* as opposed to 'a ground level' window where such level of privacy could not be possible. One participant explained that: "*the trees give me privacy from people on the road below, as well as houses across the road - I don't feel looked in on at all."* Table 5.10 illustrates examples of views from participants who identified the theme of visual openness.

Table 5.10 Visual openness: examples of views

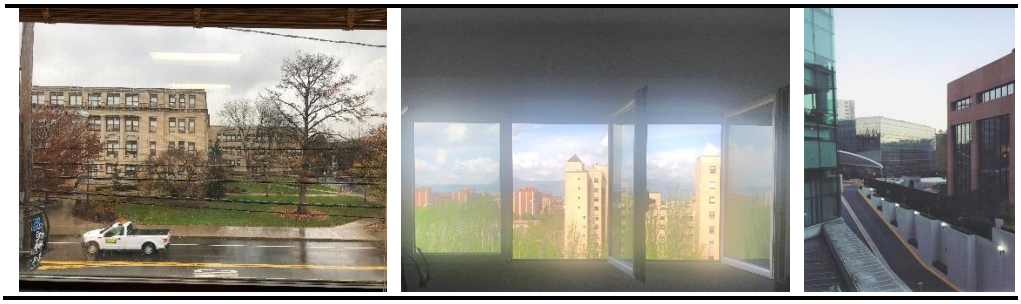


Complexity and diversity

A complex view is one that offers multiple points of interest. In this context, results from the open-ended question/s emphasised that a complex view can be an influential factor for window view preference. In fact, participants often associated being able to view several elements in the view as a positive attribute. The participants enjoyed 'points of varied interest' and

being able to 'see everything' from their window. Many respondents mentioned different elements in the view that came to their attention, for example: "*I love the sky, I love the trees (especially when blooming in spring there is a beautiful cherry tree), I enjoy the architectural detailing of the building across the street*". Other participants mentioned both the physical and transient elements in the view, such as: '*trees, mountains, buildings and the street. I can see people and even children making noise from the school at the bottom of my building".* Table 5.11 illustrates some views with multiple points of interest, as mentioned by participants.

Table 5.11 Examples of views with complexity and multiple points of interest



Legibility and landmarks

Window views with physical landmarks are noticed and appreciated. These landmarks can range from being very personal to holding cultural/historical value, and from natural elements to urban monuments. Some participants noticed a popular landscape feature, e.g., a river in their view, by stating: "*I love being able to see Tagus Tiver"* and "*I can see the river Thames"*. The landmark could also be local, such as *"the historic brick townhouse"* or a known monument such as *"the castle"* or *'the stone gatehouse, built in 1550, that housed Mary Queen of Scotland and James I".*

Sometimes people noticed the diversity of building landmarks belonging to different time periods, e.g.: *"The variety of building types, from historic monuments (Christian Science Church, in the distance) to modern (One Dalton) or not-so-modern (Prudential Tower) high-rise buildings"*; or, *"The modern high-rise building looming above the historic brick townhouses."*

Table 5.12 shows some examples of views with landmarks.

Table 5.12 Examples of photographs with landmarks in view



5.3.3. *Theme 3: Hindrances and challenges limiting view appreciation*

Endogenous aspects

There are various aspects that might hinder or limit window view appreciation while inside spaces. These window properties could not only refer to their visual qualities, but may also include, for example, thermal discomfort due to draft or heat, and/or acoustical noise from the outside. Some participants states that their older historical window panes have low insulation properties, for example; "*an uninsulated single pane metal frame window in a historical building so it gets quite cold."* Some windows offered poor thermal and acoustic barriers, e.g.: "a*llows the room to heat up during*

the summer. Additionally, during busy times of the day, it allows for noise pollution and causes disturbance when trying to work or sleep." Many times, respondents highlighted the noise of cars on the street, but also trains, public transport, loud pedestrians, and noise from nearby buildings, such as a children's school.

Another internal limiting factor may be that, although a window and (potentially) a view is present, people might not be able to appreciate it because either the windowsill is too high, there is glare due to the sun in the field of view, or a feeling of lack of privacy lends to closing the blinds/curtains. Participants sometimes stated to often close the blind in response to the glare from the sun: *"reflecting off the windows on the opposing facade is often very bad. I often close the blinds as a result (and then forget to open them again for days/weeks at times)".* People may be able to allow more sunlight in and access the view out when appropriate controls are designed and exercised in the space to block out the glare. Similar comments were referred to the issue of privacy: "*People could see in my flat (ground floor) so I put a transparent plastic on the glass, to keep the light but avoid the view: so I have to stand up close to the window to see everything outside*." Interestingly, the risk of invasion of privacy is often considered with issues of visibility in urban views.

The line of sight of the observer in their usual location with respect to the window might also be problematic when they are unable to see the view outside, e.g.: "*The window is a bit high (you can't see the view unless you stand up), otherwise, you see the sky*"; and, the "*window is placed too high in*

the space. I do not see the ground." Participants location within the room, e.g., an excessive distance from the window, can obviously also impact their access to the view.

Sometimes, the access to window operation or blinds/curtains also caused frustrations with the window, especially in the presence of glare. External blinds or façade elements can provide a permanent obstruction to the view. One participant explained this, by stating that: *"the window is covered with louvers for daylighting and solar heat gain control. While the light in the space is great, the louvers obstruct a significant portion of the view. I'd like to remove the bottom two or three louvers so that I can see more of the view"*. Lack of control was also associated with view clarity and window operability, for instance, when the window needed to be cleaned but could not be opened: "*My dislike is that I can't clear the external glass"*; and being *"Unable to clean the outside and it is inoperable."*

Table 5.13 illustrates samples of photographs when one or more endogenous aspects hindered access to the view.

Table 5.13 Examples of endogenous aspects limiting view appreciation



Exogenous aspects

The exogenous aspects that could lead to a lower appreciation of the view, or hinder view preference, are multi-fold. Among these, the lack of dynamism often led to dislike. Examples of static or boring views included those that did not offer interesting features, such as 'parked cars'. Participants identified the desire to have more green or natural elements in the view, e.g., "*very urban, would prefer more natural settings"*, or just that some of these features were there but did not change: "*no connections with human beings due to limited view. It is very monotonous and limited - the evergreen trees never change during the year and there is no view of activity or people due to screening of trees and short-range view, meaning the ground is not visible."*

Having 'just trees' in sight was, however, disliked, particularly when the trees were obstructing a more dynamic view on the other side, or they did not show changes over the course of the year. Extremely dense tree cover and flourishing vegetation were, in fact, less desirable in instances where they obstructed sunlight, blocked views, or provided too much shade: "*Holly tree and eucalyptus tree in my garden prevent an open view of the mountainside and field. But I need the trees to provide cover for the birds, so I cannot have both. The trees win"*; and, *"(the view) is almost covered with a bush right next to it. I was hoping the bushes were a bit further away."*

People expect, and sometimes desire, to see other people in outdoor views and, for this reason, they also prefer to be able to see the ground level where most activities take place. When identifying what they disliked about

their view, some participants mentioned: "*there is not much view of ground level from the window"*; *"I wish I could also see the ground"*; and, *"I don't like that you usually don't see that much of people going about".*

Neglect in the design of the environment, or in the maintenance of the outdoors, also resulted in disliked views. For example, participants stated it was unpleasant to see through windows overlooking ill-designed rear facades of buildings or back-alleys: *"Uninteresting, industrial looking wall, boring view into the side of the building"; "Very industrial view, grey and concrete"; "It's an alleyway between the backs of two buildings so isn't very pretty/interesting"; "I dislike that I see the rear of a pub which isn't so attractive, and you can see the air conditioning units. Would like to see more people passing by and more greenery".* The presence of electric wires in the view was also not liked: *"There is a power pole and transformer and wires that clutter the view"*; and, "*the outdoor elements (neighbouring houses and telephone wires) are ugly".* Abandoned, old factory buildings, in condition of disrepair or where maintenance and cleanliness was not dealt with properly, were also not appreciated: *"The lack of an attractive view - the buildings around where I work are drab. Unattractive buildings in the view"*; "*The horrible building opposite. Ugly, dirty and old-fashioned"; "The view of the roof of the neighbouring building that is an old warehouse or factory or something, not used anymore".* Lack of care in the design and upkeep of the built and natural environment also resulted in dislike of view.

For the views overlooking a street or road, it was noticed that there are times when there is a lot of traffic: *"During busy hours the main road on*

the other side of the first row of trees can get very congested in both directions"; *"The road where traffic sometimes can be annoying"*; and, *"It can sometimes show a lot of traffic".*

A further hindering aspect of view appreciation was the presence of a perceived obstruction in the scene towards something that the observers know or expect: "*the buildings obstructing the view"*; and, "*the amount of sky the adjacent building obstructs".* They may or may never have experienced this 'other view', yet they only perceived the object as a barrier rather than an element of interest: *"The British Geological Survey has its headquarters to the right of the view and whilst the building has been updated in the last few years, in the winter it is much more visible through the trees and I sometimes think the view would be much nicer if it wasn't there and you could see across fields for miles".* The attraction to water bodies, such as the sea, in natural scenes is generally very strong, so that when one is aware of it being in the distance view, anything that stands in the way appears to be an obstruction: *"If the building in the view were not there, I could see the sea from the window".*

Table 5.14 presents a few examples of photographs where exogenous features hinder view appreciation.

Table 5.14 Example of exogenous hindrances in view appreciation



5.3.4. *Theme 4: Sense of attachment with the view outside*

This theme highlights the sense of attachment with the view outside experienced by the participants due to their contact and familiarity with the view and its elements.

Sense of belonging and ownership

Participants having spent time in the area depicted in the view expressed a sense of belonging associated with having watched the same view over time: *"I like how it adds to the feeling of "home" to me, the view through it is a reminder of a calm and stable life"*; *"I love seeing out across our huge lawn. I love our treeline"*; and *"tells me I am home"*.

When the view overlooked a garden, a sense of the time and effort invested in it emerged. With this, a sense of ownership was enhanced, because participants described an element that belonged to them or existed because of them: "*This is the view of my garden, which was fully landscaped*

two years ago to create a safe play space for the children. It gives me joy every time I see it"; "The view is onto an enclosed space, no public access or traffic noise and no one overlooking it. It feels private, my little corner of the world. It looks onto our garden we created from nothing, and we have watched the sapling grow into a strong tree. It is a connection to the outside and the outside has been co-created by us and nature"; "The birds and other critters who come to feed on the seed that I put out for them"; "It is a picture of my garden, and it gives me great pleasure to see that all the effort I put in to making it is worthwhile. It also allows me to see the seasons passing and watch the birds coming and going to the feeders. It is a peaceful view, and it allows me to see my neighbour over the fence when she is at the top of her garden". Participants, therefore, took pride in their own garden and the energy invested in it, not just because it was a view of any garden but through an element of ownership.

People may develop bonds with places or locations that are important to them, such as their home, neighbourhood or their favourite landmark. These results describe how the attachment with the view out of a window may provide a plethora of benefits to participants, ranging from familiarity, to sense of rootedness and positive moods. Table 5.15 illustrates some views expressing this theme.

Table 5.15 Example of views expressing a sense of belonging and ownership



It feels great to look at it

A sense of appreciation and knowledge emerged in some of the responses, ranging from experience of time to the changes that the view brings with it: *"It is ever changing as it is a 180 degree view of the Indian Ocean. I see dolphins and little boats*. *I can see my kids on the beach from that window and all the local kids doing junior surf lifesaving on Sundays. I see the sunset every night. It grounds me, refreshes me, lifts my soul and makes me feel well. I miss this view whenever I am away from home*"; and, *"The water/lake outside is the best thing to just stare at during the summers. During fall, the changing colour of leaves is a spectacular view. In winters, we have our very own winter wonderland with the snow. So, throughout the year, it's just amazing to just see outside!".*

Sometimes people need to look out to take a break from the indoors and they know the view can offer that. Their view: *"overlooks the street which allows me to be aware of what's happening outside or in some cases even tell who's at the door. It is also a good distraction from the silent life*

indoors" Respondents reportedly spent time looking at their view: *"It can be distracting because it is so interesting";* and *"I like the view of the two trees in my garden and that I can watch birds that sit in them when I need to rest my eyes away from my computer".*

Table 5.16 shows examples of photographs in this category.

Table 5.16 Example of views where participants felt good looking outside



Active information gathering from outdoors

When indoors, windows can act as the media for establishing a connection with the outside world and, from time to time, allow the gathering of important information. Such information might be sought at regular intervals, for example in case of an event outside, or it could be due to surveillance over other members of the household: "*it provides a connection to what my kids are doing (home office), so I can work while they are playing".* The information could also be linked to the presence of other people, as a means of reassurance: *"When it's dark you can see the lights in the other offices reminding you that you are not the last person at work".* Participants kept an eye out for information they actively seek in their day to

day lives: "*I can see the main gate of my house and I know who is around my house , generally I keep an eye on my kids while playing with other neighbours' kids and cycling on the main road. I can also keep an eye on my servant, drivers and gardeners*"; and, "*Usually if I'm looking out the window it's to check on what is going on outside (usually due to noise on the street) or to observe the weather*".

Respondents stated that they can make plans and schedule their day according to the information sought from the view out of the window, e.g., the presence of other people, or knowledge related to the weather based on the clothes of the passers-by: *"I can see my friend's house slightly knowing that he is home saving me time in case I want to make plans. Also, the view on the street allowed my parents to keep an eye on me in the past"*; *"I especially notice walking people, how they are dressed, which allows me to choose my clothes"*; *"I like to have a wide scene which my current windows provide. I can clearly see the other offices and people are working which gives me motivation*"; and, "*The weather so I can see how my commute will be, activities in downtown below".* Table 5.17 shows examples of photographs related to this theme.

Table 5.17 Examples of photographs where participants stated to gather information from the window view



5.3.5. *Dichotomies identified within the themes*

There are potentially conflicting constructs nested within the identified themes and sub-themes. Although a potential limitation or hindrance might be recognised by participants in accessing or appreciating the view out of their window, having a view may have, nonetheless, nurtured their positive attitude towards the outdoor environment. The main recognised dichotomies are presented below.

View out vs. Privacy: I like to watch people, but they look back

Participants often mentioned that they noticed the movement of people, pedestrians, and cars through their windows. One of the challenges of being able to look at people through a transparent pane of glass is that they can also look back. Therefore, although people's presence could be appreciated, especially in urban streetscapes, some respondents showed to be sensitive to the issue of the breach of privacy. However, this could possibly be counteracted by the use of blinds and curtains as a temporary

measure. In fact, the view preference rating was hardly affected by this issue, possibly because the presence and movement of people might have brought life to their view. Table 5.18 lists some sample cases where this dichotomy was identified by the participants in their open-ended responses, along with a photograph of the view out their window.

Table 5.18 Excerpts and photographs where both connection with people outside and visual privacy were identified

Q#23 – open-ended: - I Like and notice	Q#24 open-ended: I Dislike	View Photograph
I can see my kids on the beach from that window and all the local kids doing junior surf lifesaving on Sundays	*Passers-by can see in because our garden hasn't been established yet - - Mostly I noticed that passers-by get embarrassed when they realise we are watching them stare at our house*	
The fact we are 3 in the same room with this view so we can share about what we see or ear. " it snows" ," it's raining" , "have you seen this guy?"	*People can see my screen from the street, my boss too.*	
It provides a connection to what my kids are doing	*my office is visible from the street (although screened somewhat by trees and shrubs).*	
Sometimes I can see people walking along the street or on the parking. Sometimes when I am close to the window, I also see parents guiding their children to the school, which is 50 meters away, same street.	*People could see in my flat (ground floor) so I put a transparent plastic on the glass, to keep the light but avoid the view: so I have to stand up close to the window to see everything outside.*	
I have a slight view of the street and some of my neighbour's gardens so I can see other people and things going on outside.	*I also slightly dislike that some of my neighbours have a direct line of sight into this room from their own windows*	

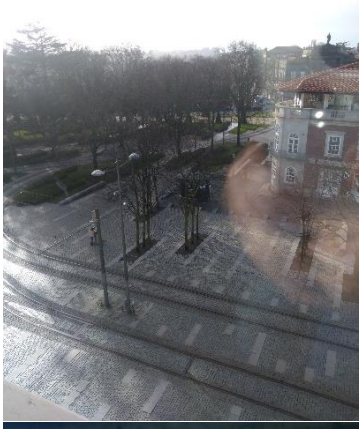
Q#23 – open-ended: - I Like and notice	Q#24 open-ended: I Dislike	View Photograph
I can observe movements and daily tasks neighbours perform. Could seem creepy, but I find it inspiring in many ways. It allows me to observe in detail bodily movements which I often find relaxing and thought provoking.	*I dislike that everyone can have a clear view through my window. When changing clothing, I always need to make sure the curtains are shut whilst having minimum daylight through the space.*	

Visual vs. Thermal comfort: Access to view or draft/heat

Participants who appreciated the view out sometimes also complained of the poor thermal performance of their window. Although a view to the outside and the ingress of sunlight might be appreciated, especially with large windows, the risks of thermal discomfort was recognised as a disadvantage and a hindrance towards sitting close to the window. Table 5.19 lists some of the responses from the participants who highlighted the aspect of thermal discomfort related to their view.

Table 5.19 Excerpts and photographs from the dichotomy between thermal discomfort and view

Q#23 – open-ended: - I Like and notice	Q#24 open-ended: I Dislike	View Photograph
It's great because it's large and on the north side of the building so solar gains are minimal.	*It is an uninsulated single pane metal frame window in a historical building, so it gets quite cold*	

Q#23 – open-ended: - I Like and notice	Q#24 open-ended: I Dislike	View Photograph
I like to have wide seen which my current windows provide it. I can clearly see the other offices and people are working which give me motivation	*In the summertime it makes you hotter and sweat*	
It is good to distract my eyes of the computer monitor.	*It lets cold air enter by the winter and the hot air by summer.*	
I mostly use this window to see who may have pulled up in my driveway	*No dislike of view only the awful draft*	
The feeling of interacting with nature due to the existence of a park opposite to my place.	*During the summertime, it allows too much heat and sunshine to penetrate, thus making it difficult for me to study.*	

Q#23 – open-ended: - I Like and notice	Q#24 open-ended: I Dislike	View Photograph
It is a picture of my garden and it gives me great pleasure to see that all the effort I put in to making is worthwhile. It also allows me to see the seasons passing and watch the birds coming and going to the feeders. It is a peaceful view, and it allows me to see my neighbour over the fence when she is at the top of her garden.	*As it faces north west I only get sunshine through the window at the height of summer so it is quite a cold place to sit. It can be a bit grey and depressing in the depths of a wet winter day, but the evergreen plants mitigate that to some extent.*	

Glare vs. View out

Participants complained at times of the 'sun' or 'glare' in their field of view. This often led them to close their blinds or curtains. Due to the low angles of the sun, direct glare is an issue mostly in the East and West orientations, although sometimes reflections due to external polished surfaces can also cause annoyance from other directions. This might be a conflicting issue with the desire to have a view of the horizon and to observe the changing colours of the sky, for example at sunset. Table 5.20 presents some of the cases where this dichotomy was highlighted.

Table 5.20 Excerpts and photographs from the dichotomy between glare and view

Q#23 – open-ended: - I Like and notice	Q#24 open-ended: I Dislike	View Photograph
Mixture between natural and built elements. Clear view of the sky and the sun path	*In mid-season need to carefully adjust the shading to avoid glare on a clear day (which however does not happen that often in our northern climate)*	
The one tree outside the window!	*The glare from the sun reflecting off the windows on the opposing facade is often very bad. I often close the blinds as a result (and then forget to open them again for days/weeks at a time).*	
The elm tree and campus lawn, I can control glare and heat gain with blinds	*nothing*	
Trees and sky when the blinds are open Look at nature makes happy and relaxing	*We have to close the blinds very often because of the glaring sun and reflections on the monitor.*	
A view up the coast, best when the weather is wild and huge waves are throwing spray 10 or 15 m into the air	*There is nothing I dislike about the view, but the window leaks a bit in strong onshore winds and in the mornings while we are lying in bed in summer, it can be too bright and glary if there is no cloud early in the morning.*	
Sunset at the end of the day	*When the sun is low, it can be blinding*	

Q#23 – open-ended: - I Like and notice	Q#24 open-ended: I Dislike	View Photograph
Over longer time periods one can see the seasons change. Can see my children play. I enjoy watching the sky, clouds and weather (my research field is daylight).	*The only issue with the window is orientation. Facing west, the glare and direct sunlight can be too much in the afternoon. Blinds help to control this well.*	

6. Differences of Perception due to Extraordinary Circumstances

The outbreak of the SARS-CoV2 pandemic at the beginning of 2020 resulted in many countries imposing social distancing measures on people. After the conclusion of Survey 1, the online survey was reopened between the 5th of April and the 4th of May 2020 (Survey 2) to enable collection of data on window views during a month when the restrictions following the pandemic were at their peak. This chapter reports on the comparison of data gathered between the two time periods, Survey 1 and Survey 2, as a means to explore any differences of perception that may be attributed to the social distancing measures imposed during the COVID-19 lockdown period. This study provides an example of extraordinary circumstances that may

significantly impact people's perceptions and behaviours in relation to their windows and the view out.

6.1. Window Perception

Survey 2 was structured on the same 24 questions of Survey 1, ranging from exploring window characteristics to perceptions of view familiarity, preference, satisfaction, etc. Two additional questions were added at the end of Survey 2 to enable respondents to provide further free-text comments on the conditions experienced due to the pandemic. The full survey can be found in Appendix C.

The response frequency to Question n. 5 on the time participants had occupied their current place (that is, the physical location from where the survey was responded to, e.g., the desk) is reported in Figure 6.1.

The data show similar distributions between the two surveys, with most participants in Survey 1 (37%) and Survey 2 (45%) having occupied the place from where they were evaluating their window and its view for more than 3 years. There was, however, a 16% frequency increase in the 'less than 3 months' category in Survey 2 (from 13% to 29%). It might be hypothesised that this could be linked to people providing their responses from a 'new' setting with respect to the window, either due to a physical readjustment or to a difference in perception.

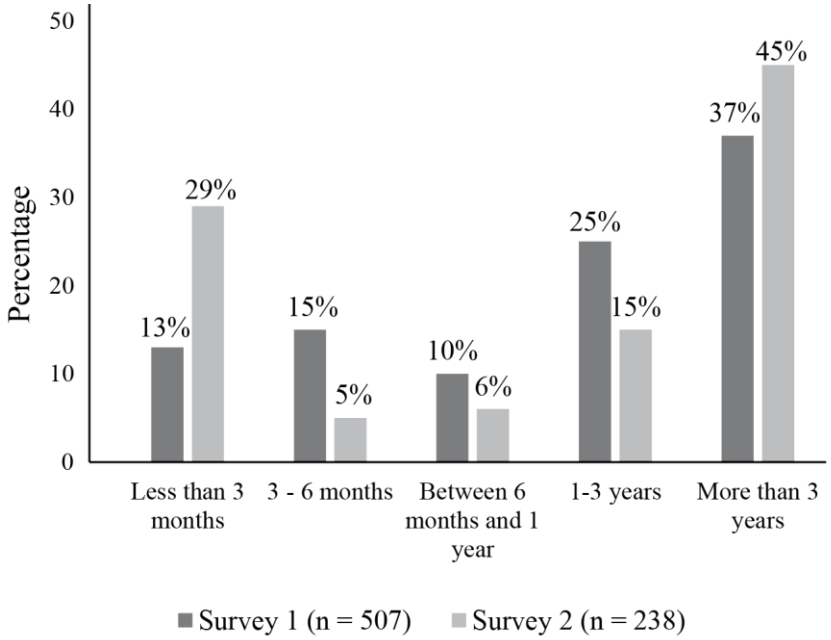


Figure 6.1 Time of occupancy: response frequency to the question: 'How long have you occupied the place (e.g., desk)?'

Table 6.1 presents the inferential data from the comparison of responses between Survey 1 and Survey 2. The table provides – for the complete dataset and for all category scores of window perception analysed (that is, view preference, view familiarity, satisfaction with view, etc.) – the medians (M_{dn}) and interquartile ranges (IQR), the means (M) and standard deviations (SD), the median difference (ΔM_{dn}, Survey 2 vs. Survey 1) between the groups and the outcome of its statistical significance (NHST, *p*-value calculated with a two-tailed test), the Mann–Whitney test statistic (U), and the effect size (*r*). These results are graphically illustrated through box plots in Figure 6.2.

The results of the inferential tests indicate that differences across the independent variables between the two surveys are statistically significant,

with effect sizes of substantive magnitude for all rating variables on window view: familiarity (p= 0.007**, r= 0.10)(Figure 6.2-a), preference (p= 0.001***, r= 0.12)(Figure 6.2-b), and satisfaction (p= 0.000***, r= 0.14) (Figure 6.2-e). No statistically significant or practically relevant difference was found between the ratings of satisfaction with the size of the window (p= 0.441n.s., r= 0.03)(Figure 6.2-c) and with the size of the room with respect to the window (p= 0.092n.s., r= 0.06)(Figure6.2-d). Conversely, satisfaction with the location of the respondent relative to the window was significantly and substantively higher in Survey 2 (p = 0.006**, r= 0.10)(Figure 6.2-f).

Table 6.1 Independent sample Mann-Whitney U test on window perception

		Survey 1 (N= 507)		**Survey 2 (N = 238)**				
		M_{dn} (IQR)	M (SD)	M_{dn} (IQR)	M (SD)	ΔM_{dn}^{NHST}	U	Effect size (r)
Window View	Familiarity	88.00 (26)	81.36 (21.27)	93.00 (22)	86.10 (17.24)	+5.0**	67752.0	0.10
	Preference	70.00 (43)	63.29 (28.20)	76.50 (28)	71.20 (22.78)	+6.5***	69406.5	0.12
	Satisfaction	64.00 (53)	59.88 (30.31)	73.00 (31)	69.31 (24.78)	+9.0***	70466.0	0.14
Satisfaction	Size of window	78.00 (28)	75.01 (22.43)	80.50 (30)	77.32 (19.86)	+2.5 n.s.	62439.5	0.03
	Size of room with respect to window	74.00 (32)	70.86 (24.14)	79.00 (33)	74.13 (22.92)	+5.0 n.s.	64941.0	0.06
	Location with respect to window	70.00 (35)	65.14 (25.05)	73.00 (29)	71.14 (21.84)	+3.0**	67794.0	0.10

***p<0.001, **p<0.01, *p<0.05, n.s.= not significant (p≥0.05)
r<0.10 = negligible; 0.10≤r<0.30 = small; 0.30≤r<0.50 =moderate; r≥0.50 = large
Shaded cells indicate practically-relevant (substantive) effect sizes

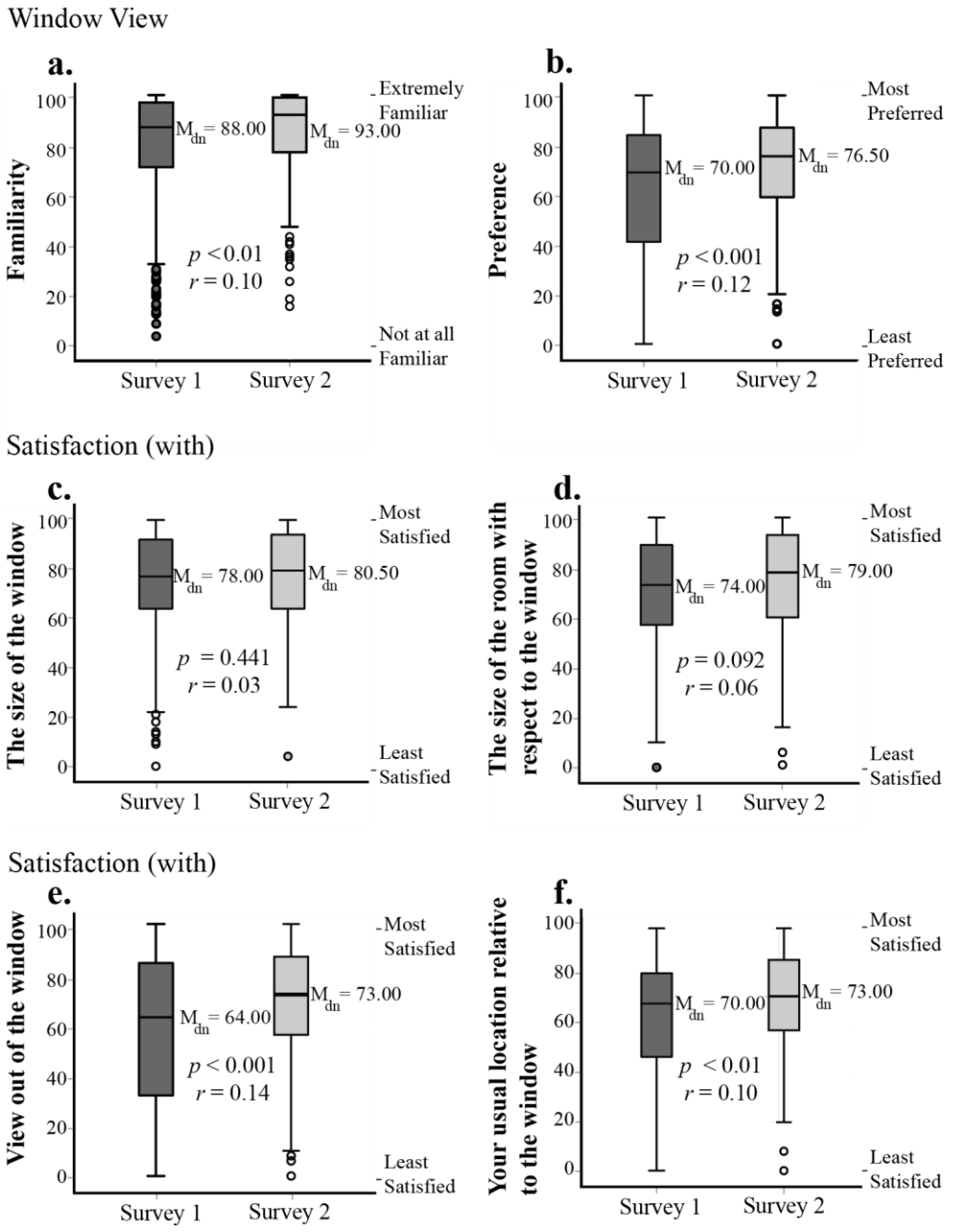


Figure 6.2 Boxplots of the inferential data for the variables listed in Table 6.1; circled data points correspond to outliers. Sample size (n) in Survey 1 = 507, and Survey 2 = 238.

These data indicate that, during the COVID-19 lockdown period, respondents felt more familiar and satisfied, and expressed a higher preference (like), with their view outside. They also expressed a higher satisfaction with their location with respect to the window. To further

investigate the results of the statistical tests, the responses to multiple-choice questions related to different categories of window features, and the comments given by respondents in the form of free text, were thematically analysed.

6.2. Window Features

6.2.1. *Positive Features*

In response to a multiple-choice question on the positive features of the window (Question n. 21), participants were asked to select their top three choices. The frequency of each statement in the two surveys was compared to explore the reasons behind the detected difference in perception. Table 6.2 summarizes the results. When looking at the differences in the frequency of choices, Survey 2 recorded an increase in responses for the provision of a view out (+10%), for allowing fresh air into the space (+10%), and for looking away from the task (e.g., PC screen) (+8%). Conversely, the positive window features that in Survey 2 had a lower frequency of recurrence than in Survey 1 were related to information about the weather outside (-16%), the time of the day (-6%), and letting daylight in (-4%).

Table 6.2 Perception of positive window features

	Survey 1 (N = 507)		***Survey 2 (N = 238)***		***Difference***
	N	**%**	**N**	**%**	**%**
Provides a view out	236	47%	36	7%	+10%
Allows fresh air into the space	159	31%	98	41%	+10%
Allows me to look away from my task (e.g., PC screen)	104	21%	69	29%	+8%
Provides good lighting in the space	185	36%	102	43%	+7%
Lets me interact with something/someone on the other side of the window	2	0%	6	3%	+3%
Lets me observe other people and activities outside	57	11%	26	11%	0%
Provides light to plants	59	12%	21	9%	-3%
Lets daylight in	382	75%	169	71%	-4%
Tells me the time of day	61	12%	14	6%	-6%
Tells me how the weather is outside	186	37%	49	21%	-16%

In order to contextualise these results, it must be considered that Survey 2 was run at the beginning of the northern hemisphere spring, this may have had a role in the higher perceived importance of the window as a source of ventilation. The reduction in perceived need for knowledge of the weather and time of day might, however, be ascribed to the fact that many people were either not allowed to go outdoors or voluntarily chose to stay at home during the time of Survey 2. Therefore, the weather and time may not have played as an important role in daily activities as they did at the time of Survey 1.

To further investigate the increase in perceived importance of looking out of the window in Survey 2, for its view or to move the gaze away from the task, the open-ended comments that some respondents added to their answers in the category of 'other' were explored. Nine comments were provided by respondents to the survey, implying that the windows were used to '*interact with a neighbour* (3 instances), *'blur the boundary between inside*

and outside' (1 instance), '*see wildlife'* (1 instance), and to '*interact with nature'* (4 instances).

6.2.2. ***Blinds and Curtains***

Blinds and curtains play a mediatory role between the window and the outside. To understand how often and why participants used blinds and curtains, two questions were asked. The first question in this category (n. 12) asked the participants about their ability to control the shading (e.g., blinds and curtains). 79% of participants answered positively to this question in Survey 1 and 87% in Survey 2, an increase of 8% between the two surveys. This was followed up by another question (n. 13) exploring the reasons behind the opening of the blinds and curtains. The results are summarised in Table 6.3.

Table 6.3 Reasons for opening a blind/curtain

	Survey 1 (N = 507)		***Survey 2 (N = 238)***		***Difference***
	N	**%**	**N**	**%**	**%**
Provides a view out	182	37%	114	49%	+12%
Allows me to look away from my task (e.g., PC screen)	52	11%	39	17%	+6%
Provides good lighting in the space	218	44%	113	49%	+5%
Provides light to plants	52	10%	28	12%	+2%
Lets me observe other people and activities outside	57	11%	31	13%	+2%
Allows fresh air into the space	85	17%	43	18%	+1%
Lets me interact with something/someone on the other side of the window	5	1%	2	1%	0%
Lets daylight in	397	83%	188	81%	-2%
Tells me the time of day	42	9%	9	4%	-5%
Tells me how the weather is outside	191	39%	57	25%	-14%

The blinds/curtains were opened most frequently to let daylight in and provide good lighting of the space in both surveys. In Survey 2, a 12% increase from Survey 1 was recorded for providing a view out, followed by the opportunity to look away from a task (6%). The most evident decrease in statement selection was related to the information on the weather outside (-14%), followed by operating the blinds to connect with changes in time of the day (-5%). These results are, therefore, consistent with those related to the positive aspects of window features. There was a small positive difference (+2%) in the use of windows for observing people and activities outside. However, one should consider that, in Survey 2, there may have been limited observable activity outside due to the lockdown.

6.2.3. ***Negative Features***

To get a balanced view of window perception, another question was asked on the negative features of windows. Table 6.4 shows the list of statements that participants could select in response to the multiple-choice question on the negative features of the window, in their space (n. 22).

When comparing the results from the two surveys, the most relevant differences were detected for the statements related to windows providing excessive draught (-11% in Survey 2) and for the “none” category (+8%). However, the decrease in the frequency of responses related to cold draughts might be attributed to the change in season, for most participants

from winter to spring. Conversely, it is interesting to see more people not expressing any negative thoughts about their window in Survey 2.

Table 6.4 Perception of negative window features

	Survey 1 (N = 507)		***Survey 2 (N = 238)***		***Difference***
	N	**%**	**N**	**%**	**%**
None	105	21%	69	29%	+8%
Other	30	6%	18	8%	+2%
Allows too much heat	72	14%	37	15%	+1%
Reduces the ability to freely furnish the space	36	7%	18	7%	0%
Allows too much sunlight	64	12%	29	12%	0%
Causes annoying glare	85	17%	41	17%	0%
Activities outside distract me	44	9%	18	8%	-1%
Allows others to see inside	108	21%	48	20%	-1%
Can`t see the sky	29	6%	9	4%	-2%
Provides poor working light	42	8%	15	6%	-2%
Allows too much noise from the street	103	20%	42	17%	-3%
Can`t see the ground	45	9%	12	5%	-4%
Provides too much cold draft in winter	147	29%	44	18%	-11%

Potential effects of seasonality, for example, due to the change from summer to autumn rather than winter to spring, could not be further explored since only few responses were received from countries located in the southern hemisphere.

6.2.4. ***Differences due to the Lockdown***

At the end of Survey 2, two additional questions were asked that were not originally included in Survey 1. These questions were added to offer to participants the opportunity to, *qualitatively*, elaborate on the changes to their daily habits and behaviours that had been imposed, voluntarily or due

to external restrictions, by the lockdown. Firstly, the respondents were asked if their conventional workspace arrangement or location had been affected or not by the COVID-19 lockdown (Question n. 25). The second question (n. 26) was open-ended and invited the participants to explain the changes, if any, that they had made.

Out of a total of 238 responses, 34.5% (N=82) of the participants gave an affirmative answer to Question n. 25. For those that did not report a change in workspace arrangement or location, although not required by the survey, many participants added a comment that their situation had not changed since they already worked from home, or were not working at all, during the lockdown period. It must be noted that – based on the results of an additional Mann-Whitney U test run only on Survey 2 responses (N=238) – having reported a change in workspace arrangement did not have any statistically significant effect on the distributions of window perception responses for Survey 2, as presented in Table 6.1.

The analysis of qualitative responses enabled bridging the missing gaps in answers and provided a personal perspective on the function of windows at the time of Survey 2. Table 6.5 summarises the results of the content analysis, revealing specific trends in any change of behaviour.

Table 6.5 Themes in the content analysis of stated changes for Survey 2

In relation to the window, participants	***Frequency (N = 82)***	***Percentage (%)***
Left the blinds/curtains open more regularly or for longer	23	28.0%
Appreciated/noticed the view more	21	25.6%
Looked out more often	20	24.4%

Left the window open more regularly or for longer	17	20.7%
Took regular breaks from the task to look out	16	19.5%
Established a new connection with outside sounds, such as birds	9	11.0%
Are located away from the window, but walk up to it for breaks	5	6.1%
Appreciate the daylight more often	5	6.1%
Started an innovative activity through this new relationship with window	4	4.9%
Used the balcony more often	2	2.4%
Are looking out less because of less people/activity	2	2.4%
Don't look out because of others' privacy	2	2.4%

The participants stated that they left the blinds/curtains open for longer, and more regularly opened them, than before the lockdown (28%). While some respondents had a higher appreciation of their view out (25.6%), others specifically stated that they looked out of the window more often (24.4%). Some participants responded that they opened the window more often, or for longer periods of time (20.7%). They took regular breaks from the task at hand by looking out of the window (19.5%), even if they had to walk up to the window (6.1%). Some were more aware of the sounds outside the window, e.g., nature and street life (11%), and stated to appreciate having daylight through the window during the lockdown more often than before (4.9%). While privacy is a known issue in the design of windows (Markus, 1967), only a few participants declared that they intentionally did not look out, or let the blinds down, to avoid invading their neighbours' privacy (2.4%).

In four cases (4.9%), participants came up with creative ways to engage with their external world; two are worth mentioning. One participant shared that they started an item exchange scheme via ropes in the neighbourhood through their window. This is an interesting example demonstrating how a window can act as an *agency* for people's connection, not just visually but also in material form, triggering a new sense of community. Another example is of an international collaboration, where a photographer started recording his relationship with his own window daily. He then proceeded to invite the world, with the slogan 'from my window to yours', to share window views with others via the web. This has been a recurrent phenomenon during the COVID-19 lockdown, where people all over the world have started sharing their window views, and lived experiences, on various social media (e.g., Facebook). A growing number of photographs have been posted in response to these calls (Duriau, 2020, Hakim, 2020). Conversely, many people have also started to post 'silent messages' (Mccluskey, 2020) on their windows to communicate with their neighbours.

We know that many businesses moved to online practices since the start of the lockdown (Finn, 2020), meaning that many people were working from their homes. Among the 82 respondents that declared to have changed their workspace arrangement or location, the textual data analysis revealed that 67 (81%) moved their desk closer to a window. Among the responses provided by these 67 participants, Table 6.6 summarises the stated reasons for having chosen a desk location closer to the window.

Table 6.6 Reasons for locating the desk closer to the window

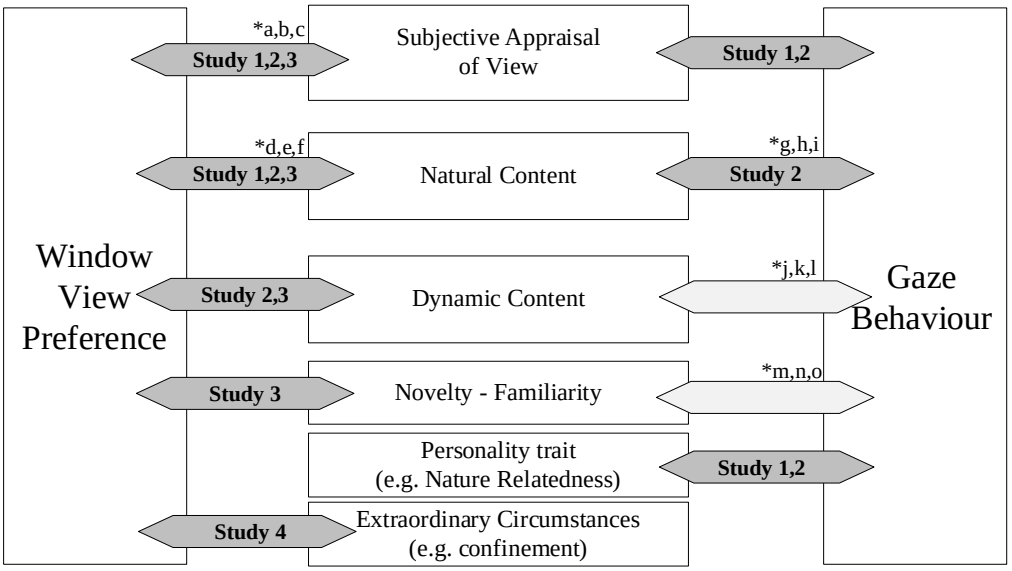
Reasons	***Frequency (N= 67)***	***Percentage***
To get daylight/sunlight	19	28.4%
To have a view out	18	26.9%
To look out	11	16.4%
To get fresh air	7	10.4%
Connect with people outside	5	7.5%
Rearranged to larger windows	5	7.5%
As a replacement for going out	3	4.5%
To be seen	2	3.0%
Receive solar gain	2	3.0%
Check weather/time	1	1.5%

The content analysis revealed that the underlying reasons for locating close to a window were provision of daylight/sunlight (28.4%), the ability to have a view out (26.9%), to look out (16.4%), to access fresh air (10.4%) and to be able to visually connect with people or neighbours (7.5%). A few participants relocated their workspace from another location in the house to be next to a larger opening (7.5%). Some respondents thought that setting up their workspace closer to a window would compensate for not being able to go out (4.5%), while only a few participants located themselves closer to the window to be seen by neighbours (3.0%), to warm up with solar gains (3.0%), or to check the weather and time of day (1.5%).

7. Discussion

This section combines existing knowledge on window views with the new findings from this research in order to provide significant and relevant evidence that a *relationship exists between window view preference and gaze behaviour*: the stated aim on which this doctoral study had been structured. In Chapter 2 (Figure 2.16), specific links were identified between window view preference and gaze behaviour and gaps in the literature were identified in response to the aim of this research. Studies 1 to 4 contribute to fill fundamental gaps in our understanding of the relationship between window view preference and gaze behaviour, and their results are used to develop a discussion of the findings. Figure 7.1 illustrates the existing relationships between window view preference and gaze behaviour, as light grey links. The literature supporting these relationships are also summarised

in the figure (References a-o have been included to remind the reader). The dark grey links in Figure 7.1 reveal the relationships revealed through this research, through Study 1 – 4.



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Figure 7.1 Summary of the relationships revealed between window view preference and gaze behaviour. Light grey links are known links in literature while dark grey links identify relationships revealed through this research. References to existing studies are identified as *.

The following sections, therefore, present the findings from this research in response to its two specific objectives:

- To define a robust measure of preference in window views
- To identify what features of window views influence preference.

7.1. Gaze Behaviour: An Objective Measure of Window View Preference

Physiological measures, such as the dynamics of gaze, can provide valuable insights into a person's attention, awareness, and information processing behaviour (Buswell, 1935, Yarbus, 1967, Holmqvist et al., 2011). Eye position and eye movements can be accurately tracked and reliably measured using a range of techniques that have been described in Section 2.2.2. Several studies have demonstrated a link between the characteristics of the scene and the gaze behaviour of an observer (Berto et al., 2008, De Lucio et al., 1996, Dupont et al., 2014).

Given the growing interest towards the potential benefits of outdoor views, it is important to consider the impending interrelations between their physiological, psychological, and aesthetic features (Schroeder, 2011).

7.1.1. *Gaze Correlates of View Preference: Number of Fixations and Number of Saccades*

To investigate which gaze measures better correspond to view preference, a range of oculomotor parameters have been recorded in this research, including among others the number of fixations, number of saccades, and mean fixation duration (eye-tracking measures or ETMs). These ETM parameters have then been visualised employing a series of techniques such as gaze heat maps (HMs). Gaze measures such as the number of fixations and the number of saccades capture how gaze changes and can help to investigate exploratory behaviour in preferred views.

The findings from Study 1 and from Study 2 indicate that the most preferred views, both urban and natural, might be characterised by frequent exploratory gaze movements that seek to capture more information within a given observation time period. In earlier research, Kaspar and König (2011) had found that when a scene was rated high on interest, participants' gaze was more exploratory, characterised by a higher frequency of saccades. Frequent shifts of gaze, characterized by an increased number of saccades to gather visual cues, are usually associated with participants being less likely to skip over information on the preferred element in a scene (Pieters and Warlop, 1999).

A higher number of fixations in the same observation time is attributed to an increased capacity to recognise the elements in the image (Duchowski, 2017) and more visual scanning (Dupont et al., 2014). Since the number of saccades and number of fixations are highly correlated – e.g., a

value of Pearson r = 0.970 was detected in this research; see the analysis presented in Section 4.1.2 – a higher number of saccades also implies more searching and information gathering (Goldberg and Kotval, 1999). Initially, in Study 2, when participants observed natural scenes, no significant differences were detected in gaze behaviour between most and least preferred views, when the overall grand-mean preference rating derived from the entire group of participants was used as a cut-off value. Yet, some effect sizes bordering practical relevance could be detected (p = 0.133, d = 0.202; See analysis presented in Section 4.2.2). However, when each participant's own preference rating was used to categorise views into their most and least preferred, significant differences in oculomotor responses were consistently found for both natural and urban scenes. This highlights the importance of considering individual differences in subjective preferences when analysing gaze patterns. Although it has been common practice in the literature to use a separate panel of participants (Franěk et al., 2018) to select the visual stimuli (Valtchanov and Ellard, 2015) for eye-tracking experiments (Dupont et al., 2015), these results suggest that, in studies involving the evaluation of complex outdoor scenes, the *subjectivity of the content* and *personal preferences* should be taken into account when assessing the factors that drive gaze behaviour.

Frequent gaze shifts as a correlate of interest in the observed view could be explained from the perspective of preference formation. Liao and Shimojo (2012) explain that the decision regarding how much one likes a scene is not made in an instant, but rather an active inspection process

contributes towards preference formation. *"We like, so we look, and we look so we like. This positive loop leads to preference*" (Liao and Shimojo, 2012:p.290). The physiological evidence, therefore, reveals a potential bidirectional interlinked relationship between gaze processes and preferential looking. This understanding leads to another standpoint on window view appreciation; that is, the more a person looks at a view, the more they are likely to like it. In other words, the more a view draws a person's gaze towards it, the more likely it is that they will appreciate it over time. Access to a view is, therefore, not only fundamental to its appreciation, but also it should have qualities that create the opportunities for the gaze to be drawn towards it.

7.1.2. *Gaze Maps - Number of Fixations x Mean Fixation Duration*

Visual representations of oculomotor metrics (gaze or heat maps) were employed to interpret gaze behaviour with respect to view preference. Interpreting gaze maps is, however, a difficult task to infer preference. This has been confirmed by previous research that described the challenges to unambiguously interpret eye-tracking results and offer explanations for gaze behaviour (Noland et al., 2017). As a matter of fact, in preferred views, participants might not necessarily spend time fixating on one 'preferred' location in a scene for it to generate a gaze cluster. However, by measuring gaze statistics, and cross-referencing the data with verbal reasoning of preferences for the same view (triangulation), plausible conclusions could be drawn on what participants looked at (i.e., overtly attended to) and why.

In this research, the triangulation of data guided a careful interpretation of fixation clusters in order to assess whether all fixations were related to the allocation of attention. There is, however, considerable evidence that there are other mechanisms at work to be taken into account, such as the central gaze bias, attraction towards some aspects in the view (e.g., people and text), attraction towards natural content, and a potential degree of redundancy (Tatler et al., 2011). Indeed, the results from this study show that gaze maps considered in isolation are inherently ambiguous tools to identify gaze characteristics in complex views. Hence, they should be considered along with other gaze biases when drawing inferences (see following Section 7.2).

A close inspection of gaze maps, and their triangulation with verbal descriptions, revealed that attention hotspots were also created on elements of specific dislike or that required more deciphering in the scenes. If the consequence of the visual engagement was perception that the scene presented a potentially unsafe condition for other humans, it was disliked and rated low on preference. Therefore, attention hotspots may be created on elements in a scene that demand additional investigation.

Since gaze hotspots are a representation of how long an observer attended to an area in the scene (Holmqvist et al, 2011), it is also an indirect measure of allocation of attentional resources. This finding holds true with previous studies in gaze behaviour, which suggest that incongruent objects or semantically inconsistent elements in a scene hold a person's attention for longer in comparison to semantically consistent ones (Loftus and Mackworth,

1978, Berlyne, 1963, Berlyne, 1958, Berlyne and McDonnell, 1965). Similarly, in a recent study, Li et al. (2021) found that built elements with unique characteristics, which are not in harmony with the surrounding architectural style, are likely to attract people's gaze and evoke adverse psychological reactions.

These findings were derived from static images observed over a fixed period of time in a controlled laboratory setting. Nonetheless, their implications to real windows views are valuable. In a real window view, for example, an unfamiliar object in a scene may draw and attract an observer's attention. Similarly, if an element is perceived as troublesome, or it is seen to pose a threat or be generally disliked, it may hold the observer's attention for some time.

7.2. Gaze Biases Inform View Preference

7.2.1. *Natural Content in Views Elicit Longer (Attention) Fixations*

In Study 1, through the eye-tracking measures, three views (i36, i34, i28) have been identified to exhibit divergent gaze behaviour, evoking fewer fixations despite being the most preferred views (Figure 4.4). Interestingly, participants' verbal reasonings for why they preferred these views were also atypical, in that they explicitly highlighted naturalistic contents. Urban environments that appear more nature-like are often rated more highly on preference (Coburn et al., 2019, Cottet et al., 2018). Although various other urban views in Study 1 were also rated highly on preference, only the three

views where participants noted naturalistic contents evoked this type of gaze behaviour. Thus, although higher preference for a view might not be uniquely driven by naturalistic elements, presence of this content appears to engender a pattern of oculomotor behaviour characterised by fewer fixations. Previous eye-tracking studies comparing natural and urban views reported lower numbers of fixations for natural views (Valtchanov and Ellard, 2015, Berto et al., 2008) attributing this behaviour to the involuntary or effortless attention elicited by natural contents (Kaplan, 1995).

On the basis of this finding, Study 2 employed natural views to further investigate differences in gaze behaviour based on natural or urban contents in a view as supported by previous literature (Berto et al., 2008, Franěk et al., 2018, Valtchanov and Ellard, 2015). Consistent with these studies, this research revealed significantly higher numbers of fixations and saccades, and lower mean fixation durations, when participants looked at urban views compared to natural scenes. In a fixed observation time, a higher number of fixations results in lower fixation duration (Figure 4.3). Critically, research has suggested mean fixation duration as an indicator of perceived naturalness in a landscape (Cottet et al., 2018).

Previous studies have also shown that there could be an attentional bias for natural elements in a scene (Joye et al., 2013). Wilson (1984) posited that humans have an inborn tendency to focus on, and affiliate with, other living things. Termed the *biophilia hypothesis* (Kellert and Wilson, 1993), this attraction to life and lifelike processes can be understood through an

evolutionary perspective. Human gaze may, therefore, instinctively be drawn towards natural contents in the view out of a window.

7.2.2. ***People Seek People***

Consistent with the results of previous eye-tracking studies (Holmqvist et al., 2011, Fotios et al., 2014), participants overt visual attention was attracted by people's faces and their activities – e g., when observers looked inside windows. Since people might be powerful distractors (Herzog et al., 1976), they have often been excluded in the selection of sample images for natural landscapes studies (Pitt, 1979, Kaplan and Kaplan, 1989) and, more recently, for window view research (Kent and Schiavon, 2020). However, in everyday outdoor environments, especially in urban settings, the presence of people is common and unavoidable, and it is usually associated with a positive disposition towards, and evaluation of, the scenes (Twedt et al., 2019).

In this research, it has been revealed that people are not just explicitly seeking out for other people when they are present in the view, but also when they are not, specifically attending visually to the places where they are likely to be found. In Study 1, stimuli with windows not affording a clear vision to the inside of buildings led to reduced preference. This might have emerged because further information could not be obtained about the environment behind a window. Gaze hotspots were formed on or around the windows in the images. Therefore, just observing a window in the wall might not add value to the visual preference although, based on other research

(Sussman and Ward, 2017), this may still contribute to enhance the complexity of the view and draw attention, nonetheless. The absence of other people in the window, however, may lead to a certain level of dislike. In recent research using eye-tracking to understand street design, in fact, it was found that people are always seeking other people (Hollander et al., 2020). This further supports urban design theories, especially Jane Jacob's *eyes on the street* (Jacobs, 1961), whereas the design of windows overlooking streets can encourage perception of safety. It seems that people not only look for people's faces, but also try to find visual cues about their presence from other physical attributes. For example, participants in our studies noticed the lights in the windows featured in the views (e.g., image i27 shown in Table 4.3), and explained through verbal reasoning that it was through the visual clues in the window that a decision was made whether they thought the building was occupied or empty.

Preference for views with natural content was also influenced by the presence of people (Study 2). If the view did not allow further exploration, or presented hazards, it was disliked. These findings are supported by studies suggesting that danger is feared in environments having low level of 'prospect' – consistent with Appleton's Prospect-Refuge theory (Gatersleben and Andrews, 2013) – this having been found to explain around 30% of preference variance in forest settings (Herzog and Kutzli, 2002). This endorses the theory that individuals appraise environments based on how threatening they appear to themselves and to other humans (Lazarus and Launier, 1978, Brosschot et al., 2018). The notion that preference might be moderated by

how other people occupy the view is not new (Nordh et al., 2011), especially for studies in urban environments (see Section 4.1) (Batool et al., 2020, Twedt et al., 2019, Whyte, 1980). Our findings create room for re-evaluating contemporary landscape preference theories under the lens of human presence, especially with more people today living in cities than in natural settings (United Nations, 2019).

As mentioned earlier, according to the biophilia hypothesis (Wilson, 1984), humans have an inherent tendency to affiliate with other living creatures. Interestingly, people affiliate with other people also when looking at a scene out of a window, according to the qualitative responses in Study 3 (presented in Chapter 5). One of the challenges of being able to look at people through a transparent pane of glass, however, is that they can also look back. Therefore, although the presence of people might be appreciated, especially in urban streetscapes, the issue of the breach of privacy might not be tolerated by all. People use blinds and curtains to evade privacy concerns through the window. In fact, 'allows others to see inside' is one of the most common negative features of windows that was reported in this study. This is consistent with previous literature and design recommendations for the use of blinds to preserve privacy, especially at night (BSI, 2021). Inkarojrit (2005) demonstrated that, in a study conducted in an office environment, although blind usage for privacy concerns is less prevalent than other issues such as discomfort glare, it might entail a complete rather than partial blind closure. This is a very crucial concern for the role of windows to afford a view out. If people have a tendency to seek other people, especially in windows, this is

likely to be an issue for window users, regardless of how the window is placed. Giving the building user a sense of control either through blinds or curtains, or through the possibility of changing their position within the room, may allow for a solution although further research is required for a more thorough understanding of gaze behaviour of both building occupants and passers-by.

7.2.3. ***Central Gaze Bias***

Throughout the experiments of Studies 1 and 2, in many views across urban and natural categories, hotspots of attention were located at the image centre although this was not explained by the verbal descriptions of preference. This result could be associated to a central gaze bias (Holmqvist et al., 2011), which can be linked to different phenomena at play (Tatler, 2007), such as: the centre of the screen may be the optimal location for early information processing (Bindemann, 2010); in the current study procedure (Study 1 and Study 2), participants started the exploration from the centre of the screen since this is where they were instructed to fixate at the onset of the experiment; and, the eye has a tendency to re-centre in its orbit, especially when a chin rest constrains the head position. Similar results were also found by Simpson (2021), using mobile eye-trackers during a walk in the streets, emphasising the same central tendency with participants' gaze hovering over the 'horizon' parallel to their eye-level (Simpson, 2021). Thus, in future studies, an alternate approach could be followed as suggested by Rothkegel et al. (2019), projecting the initial crosshair at a random non-

centric location on the screen. It is, however, highly likely that the eye might re-centre to its orbit, hence, resulting again in a central gaze bias.

This finding has important repercussions towards the understanding of view access from the perspective of the building user. In fact, this emphasizes how extremely crucial it is for the content of the outside view to be at the eye-level of the observer. This is going to be the view that is gazed at most often, as a person is unlikely to keep their head turned to look out of a window. An example of this could be the view over a computer screen, or over a working table. According to Abboushi et al. (2020), the influence of desk layout on view quality can result in higher preference rating, specifically in terms of expressing visual interest, for participants seated perpendicular to a window compared to a position parallel to the view. Since it is unlikely that all building occupants are going to be seated facing the windows, accessing a view may require more effort and proactive behaviours, such as head and body turning, or changing location in the space (see Section 6.2.4).

More generally, since human activity and vegetation growth are pinned to the ground, windows that are facing a lower level are more likely to benefit from these elements than those above ground, simply due to the eye's tendency to hover in the centre of the line of sight. Similarly, people located on the floors above ground, and above the height of the trees and vegetation, are less likely to observe them unless their line of sight corresponds to the direction of these features. An example of such a case would be someone sitting next to the window and performing a task that requires looking down. In this way, with their head tilted down, they could be

more able to see elements on the ground than someone looking at a computer screen and located away from the window. At a general level, the content of the view for which the window is framed always requires attention in design. Especially in dense urban centres, framing a window view implies a more holistic approach towards the design of the urban environment.

7.2.4. *Text and Numbers in Time-limited Tasks*

Distinct features of the built environment captured attention in our studies. Gaze hotspots were formed on alphanumeric content (e.g., images i29, i28, i40 in Study 1), for example signage and number plates, in line with previous studies where participants spent more time looking at the text than the picture part of advertisements (Rayner et al., 2001). This might reflect the fact that participants encode much more information (per fixation) from a pictorial than a textual representation and, therefore, need to spend more time reading a text to make sense of it. This also means that the text component of the visual scene draws more attention and is, therefore, worthy of further consideration in the design of urban landscapes.

In real world settings, it could be possible that humans try to infer and gather information about a new environment based on the alpha-numeric contents that they can read or find. Of course, this result is pertinent within the Western world, with participants familiar with the alphabet. The relevance of this finding in the context of other languages (which could be,

instead, communicated through pictograms), and based on a person's familiarity with their structure, requires additional investigation.

7.2.5. *Gaze Bias: Personal Disposition and Nature Relatedness*

An individual's *relatedness with nature* is defined as their subjective feeling of being a part of, and in relation to, the natural world (Nisbet et al., 2009, Mayer and Frantz, 2004). Previous research has uncovered the role of an individual's nature relatedness in pro-environmental behaviour (Mackay and Schmitt, 2019) and subjective wellbeing (Zelenski and Nisbet, 2014, Nisbet and Zelenski, 2011). It has been suggested that differences of perception between natural and urban scenes could be attributed to individual characteristics, such as connection to nature and environmental attitudes (Menardo et al., 2021). In fact, while comparing data from Study 1 and Study 2, an opposite correlation between participants' nature relatedness score (NRS) (Nisbet et al., 2009) and the number of saccades was detected, when observers were looking at urban or natural views. The differences detected may support the hypothesis that individual predispositions – e.g., a desire to connect with nature (Wilson, 1984) (Nisbet and Zelenski, 2011) – might drive gaze exploration. Indeed, previous studies have suggested that gaze behaviour may reveal personal inclinations and personality traits (Kaspar and König, 2011, Maran et al., 2020, Rauthmann et al., 2012), although the relationship between personal relatedness with nature and appreciation of views requires further experimental validation. In past studies on window view preference, demographic indicators have shown

mixed results on their impact on preference for views. For example, Mirza (2015) found a small subsample of their participants who seemed to prefer blocked or closed views based on their childhood level of urbanity. A further investigation of personality traits, including nature relatedness (Nisbet and Zelenski, 2011), may offer a deeper insight into a person's predisposition and priorities in the environment.

A better understanding of oculomotor behavioural biases, therefore, can considerably improve our knowledge on how we look, move our eyes, and where we fixate, during scene viewing (Tatler and Vincent, 2009).

7.3. Inter Architectural Features of Window Views: Aesthetic Qualities

7.3.1. *Meaningful Association with Places 'Away' from the Norm*

In our studies, natural contents in a view, and specifically far distanced scenes, were perceived as most preferred when participants were shown a series of images in a controlled laboratory setting. Confirming previous research on the role of higher-order perception and meanings associated with the objects in the scene guiding preferences (Henderson and Hayes, 2017) and restoration (Menzel and Reese, 2021), natural elements – e.g., mountains, water, distant views with multiple layers of information, etc., (Hellinga, 2013, Markus, 1967, CEN/TC/169, 2018) – were the most preferred natural views. Participants associated their previous memories and experiences with the scenes, and these modulated their expectations from natural environments, especially when they were reminded of 'home' or

'holiday' locations. These findings are in line with the ART (Kaplan, 1995) and SRT (Ulrich, 1991) theories, which suggest that certain characteristics of views (e.g., water or plants) may lead to feelings of 'being away' (ART) and/or positive affective states (SRT). It is likely that people who live and work in cities would relate to natural, savannah-like, landscapes as holiday destinations. This might be dependent on the socio-cultural and environmental background of the participants, as what may appear as a 'being away' place for one person might seem close to 'home' for another, depending on where they live and work, and the geography and topography of the place. This finding has some methodological implications, where participants rate a new view out of a window, or a window view surrogate, based on their previous experiences in similar situations.

7.3.2. ***Diversity and Complexity***

Long-distance views out of participants' own windows (Study 3) lead to a higher probability of finding a variety of information to explore. Previous literature on window views has emphasized the importance of long-distance views with maximum layers of information and openness of scenery (Markus, 1967, Hellinga, 2013, Matusiak and Klöckner, 2016). One psycho-evolutionary account of this preference is given by Appleton (Appleton, 1975), who stated that evolutionary development has led humans to prefer a setting in which, without being seen (refuge), they can see a broad vista (prospect). Such preferences, in fact, might be related to an increase in the chance of survival by affording a vantage observation point and the capability to safely see,

predict, and act in relation to potential predators, prey and mates. Range of vision is, therefore, directly related to survival. Since contemporary humans may not be looking out of their window for survival purposes, at least in work and learning environments, in this research both reasons for disliking short-distance views and liking long-distance scenes leads to another postulation.

A careful observation of photographs of views taken from participants' own windows did not reveal a substantive difference in the physical landscape, but rather differences were mostly related to what was observed and noticed in the view. Therefore, in this research it is posited that long-distance and open views may, more simply, offer a larger variety of information to observers. Even in those views with broader deep scenes, especially of the horizon, not being able to see activities, people, or the ground, appeared to be the missing information that caused participants to dislike their view, or part thereof. A variety of elements, therefore, allows for more numerous possibilities of visual engagement with the scene.

In Studies 1 and 2, scenes containing a variety of information, with colourful patterns and differentiated facades, were preferred more than those with less information due to the higher degree of diversity offered. In this context, an interesting aspect of natural view preference was related to the changing patterns and colours in the landscape, where the appreciation for the view of the sky and for the variety of trees was often associated with the potential they hold for change over time. In previous literature, a preference to see the sky in a window view has been attributed to the knowledge of time of day, weather, and access to daylight with its associated

health benefits (Hansen et al., 2021, Veitch and Galasiu, 2012, Heschong, 2021). Conversely, views with a limited amount (e.g., single layer) of information led to low appreciation, suggesting that view preference might also be mediated by the variety and visible depth of scenes. Long-distance natural views have consistently been rated as highly preferred across different studies (Markus, 1967, Hellinga, 2013, Matusiak and Klöckner, 2016, Tuaycharoen and Tregenza, 2005), although previous literature has not shown robust evidence for a dislike of short-distance natural views.

Another related concept is about complexity in the view, that is known to offer multiple points of interest (Markus, 1967, Collins, 1975). In this research, none of the participants used the word 'complex' to describe their interest in the view. However, based on the definition of complexity (see Section 2.2.1), the construct can be related to the variety of points of interest in a scene. Participants often associated being able to see several elements in the view as a positive attribute. Yet, as explained in Section 2.2.1, there is a level of moderation associated with how much of something is acceptable. Drawing on the inverted U-shape relationship between complexity and preference, too little and too much of something might lead to dislike. In this research, two examples of elements have been intended from this perspective.

In the literature, the presence of cars has often been associated with dislike in scenes, while the view of greenery has frequently been related to positive perceptions. Taking the example of cars, in Study 3 it was found that parked cars were not liked as they were considered too static. Moving cars

added to the variability in a scene. Yet, too many cars, in the form of traffic and high-speed movements, were not perceived positively in the view. Similarly, in scenes with no greenery, participants mentioned that they would rather have a view with green elements in it. Observers looking at a mixed level of greenery rated their views most positively. However, a small but consistent number of participants mentioned that they disliked their view despite having greenery in it, since there was too much greenery and it was blocking other objects, or the view did not change because the greenery was evergreen. Extremely dense tree cover is less desirable in instances where it obstructs sunlight, blocks views, and provides too much shade (e.g., in a garden for plantation). Previous research has shown that green elements are positively perceived until about 40% greenery in the view, after which the relationship reaches a plateau (Jiang et al., 2015). This implies that any element in the view needs to be present in moderation to allow a certain degree of appreciation.

On the contrary, it was observed that seemingly similar views, as presented in the images or photographs, appeared to be full of interest for some participants while they were perceived as dull to others. A close examination of the qualitative reasoning associated with each scene revealed that, when a view does not offer variation and diverse points of interest, it can be perceived as ‘static’ or ‘obstructed’. The perceived obstruction, in this research, has been linked to ‘short-distance’ or ‘blocked’ views and it has been associated with the reasons for disliking a view. It is important to understand how any view was considered ‘blocked’, because view by

definition is the extent of visible components within the scene outside the window. The qualitative reasoning revealed that participants experienced and perceived 'obstructions' in the view when either they were aware of a more pleasant or interesting element beyond the barrier, or there was not much going on in the view to attract their attention. That is, the view was considered too 'static'. Mirza (2015) also found that feelings related to blocked views were mediated by participants' personal association with the context, as well as their demographics and past experiences.

Although the concepts of change, blocked views, distance to elements, diversity, views to the ground and sky, and complex nature have been dealt with in the literature as separate yet interlinked concepts, this research has sought to explain the described phenomena from the perspective of gaze behaviour. If there is not much variety to register in the scene, then gaze is likely to not dwell outside the window. Conversely, if the window view as seen from the location of the user offers multiple points of interest, the gaze will inadvertently be drawn to it and to its various layers of information. This is true for both short-distance and long-distance views.

7.3.3. *Legibility and Landmarks*

Participants often mentioned different types of landmarks – historical, cultural, entertainment, etc. – as the most liked features in their views. Window views with physical landmarks are more legible (Mirza, 2015). As Lynch (Lynch, 1960a) explained, these landmarks can be very personal to holding cultural/historical value, and can vary from being natural elements to

urban monuments. They are more easily identified amongst a host of possibilities and their key characteristic is their singularity, based on their uniqueness or associated memories (Lynch, 1960a). Many cities across the world protect the view corridors to strategic landmarks of historical or cultural significance and have laws in place to prevent developments that might obstruct these view 'cones' (Greater London Authority, 2012, The City of Edinburgh Council, 2019, San Francisco Planning Department, 2011, City of Vancouver, 2011, Downtown Commission, 2007). However, the emphasis in these urban design guidelines has mostly been to maintain cultural visibility, whereas for a person with their own window view, any visible landmark (even simply a restaurant at the end of the street) could appear as their anchor within the community. Although having a view of historical monuments is considered important for participants, this research has found that some landmarks might have an inherent characteristic to attract attention and be noticed more. In this research, examples of these were windmills, wind turbines, Ferris wheels, and lights on buildings and other structures.

7.3.4. *Care and Maintenance*

Across the full sample of images with natural content in Study 2, views of seaside, rivers, and ponds were generally appreciated. Nonetheless, taken as an individual element, the presence of water in itself did not entail higher preference per se, being frequently related to other concepts such as care and preservation that might change perceptions (Purcell et al., 1994).

Buildings were, unsurprisingly, often mentioned in the verbalisation of preference ratings when participants were shown contents with predominantly urban views in Study 1. However, their preference was also associated with their level of perceived upkeep and maintenance. For example, when the presence of graffiti was interpreted as a result of vandalism, buildings were considered as less cared for. Neglect in design or upkeep of the elements in an urban view contributed to the dislike of the scene (Study 3). In many cases, these were buildings of large scale, for example of industrial type, with a precarious state of conservation. Sometimes, these were also facades of buildings with utilities not well designed (e.g., with electric wires). These findings are in line with previous literature that demonstrates that a lack of care, or neglect in upkeep, of buildings is related to lower ratings of preference and less satisfaction (Herzog and Shier, 2000). This construct of care can be related to a sense of ownership, especially when reflected in qualitative descriptions of personal yards or gardens. Research on the role of garden management in crime prevention has shown that level of care and sense of ownership extends over to the level of the community (Troy et al., 2016), while lack of maintenance suggests low social cohesion amongst residents (Crank et al., 2003).

7.4. Dynamic Component of View Preference and Gaze

One of the most prominent findings of this research is related to the types and levels of dynamic changes that attract a person's attention and are associated with the liked features in a window view. Although the variation in

a view is an interlinked concept between many factors that overlap on several fronts, in this research it is understood and described under three broad levels: transient or momentary changes; recurrent or anticipated daily variations; and, seasonal changes in the view.

The context in which the window is located underpins the type of changes that will occur. For example, the movements of people, cars, trains, wildlife, pets and swaying of leaves and branches in response to wind, depend on whether the view is able to frame such events. In any given instance using a photograph or drawing as a means to document a view for subjective appraisals, the transient changes are likely to be missed as they are fleeting moments that are experienced often unexpectedly by the window user. The movement and presence of people, and activities on the ground floor, have been suggested as important layers of views for possibly the same reason (SLL, 2014). In this research, the presence of birds, either in the garden, in flight, or in the distance, seems to add value to the transience of a view. In other studies, it was found that the number and diversity of birds in an area can subconsciously affect satisfaction ratings in urban residents (Hepburn et al., 2021). The cognitive benefits of interacting with nature are well established. Urban design principles would benefit by including measures to increase biodiversity, especially birds, for urban residents to experience from their window views. This could be a challenge because it is known that species diversity, especially for birds, is threatened by urbanisation (McKinney, 2008) and climate change amongst many other phenomena.

Another finding in the context of dynamism sits at the thresholds between transient and daily recurrent changes. When participants selected these features of windows – specifically, 'tells me about the weather outside', and 'to connect with people and activities outside' – their view preference never achieved the least rating. Drawing from the results of the necessary condition analysis (Dul, 2020), these two features of window views were significantly necessary-but-not-sufficient conditions for window view preference with a medium effect. This implies that, although many factors contribute towards liking or disliking a view, when temporal change is perceived, as both these features suggest dynamism in the view, the preference rating does not fall to zero. In fact, knowledge of weather has been shown to influence view appreciation in previous studies from the literature (Manning, 1965). Informative views of the external environment are known to lead to preference (Verderber, 1986, Heschong, 2021, Masoudinejad and Hartig, 2020). Markus (1967) also suggested that, for the two levels of information that have been identified in this analysis, people and activities outside (the ground layer) and knowledge of weather (the sky layer) are important for view preference. This finding has possible design repercussions, whereas both the ground and sky layers should be made available to the observer, with the objective of ensuring higher liking for, and interest in, the view out.

Participants notice the daily rhythm of the day and the cycles of light when inside buildings; windows provide this information. Light is fundamental to visual processing (see Section 2.2.2) and response to changes

in light is evident even in unicellular organisms (Gregory, 1994:p.27). Changes in lighting as a consequence of the earth's rotation around the sun, and atmospheric conditions such as weather patterns, are anticipated changes in the view that are appreciated for their variability. This finding has been confirmed by a recent experimental study in a virtual environment, where luminous changes were correlated with positive perception of views (Rodriguez et al., 2021a). From the point of view of human physiology, this is justified through the human response to the day and night cycles. There are photoreceptors in the human retina, ipRGCs (intrinsically photosensitive retinal ganglion cells), which respond to the quantity, quality, timing, spectrum and history of light exposure received by the eye (Boyce, 2014). This non-visual (or non-image forming) response to light feeds into the circadian rhythms of the human body and contributes to trigger its metabolic wellbeing. Since the circadian rhythmicity of the human body can anticipate these changes in the environment (Roenneberg et al., 2003), lighting variations perceived through the window (Webler et al., 2019, Heschong, 2021), may inadvertently and indirectly be related to a positive perception of views.

The third level of dynamism and variation identified in this study derives from the verbal responses in Study 2, and the open-ended comments in Study 3. Participants used colours of leaves as visual clues for inferring a change of season in natural view surrogates. Conversely, in participants' own reasons for liking and disliking the view out of their window, an overall long-term experience of the view was also demonstrated. There are several

evolutionary accounts of preference for nature or green elements in a view and outdoor environments. In this research, it was found that a sense of seasonality is implicit in observers' perception of natural contents in their view. Participants did not just explain their current situation, but also recalled experiences from other seasons and weather conditions.

This lends towards the idea that, perhaps, when people are looking at a tree through their window, they are perceiving the inherent changes over the course of the life of the tree, which is brought to them through psycho-evolutionary constructs, as well as their previous experience with the contents of the view. There are other accounts of natural features attracting more attention; for example, the degree of variation in texture and information that is available in natural features. However, the seasonality and change in natural views is often implicit and taken for granted. This aspect of nature changing is highlighted when participants have an outdoor view with ever-green elements, and this lends to a degree of disappointment and dislike. The presence of natural or green elements lie on the cross-road of being both physical as well as dynamic components of the view, but they have been included in the dynamic section to elaborate on the lesser known and discussed concept.

Research on gaze behaviour suggests that human gaze is drawn towards other people and natural features in the view. Wilson (1984) posited that humans are drawn towards all things natural. It is possible, therefore, to suggest that dynamism and change are inherent in living features of the environment, including humans, wildlife and foliage. Human gaze is

responsive to change, any kind of dynamism in the view, which is more likely to be caused by one or more of the dynamic features identified in this section, drawing a person's gaze to the window and to the view out. Since the change, variation and dynamism draw attention towards the outside, the view is going to be more noticed. In this light, it may posit that dynamic features of views make them more visible and, thus, more likeable (Liao and Shimojo, 2012) (Figure 7.2).

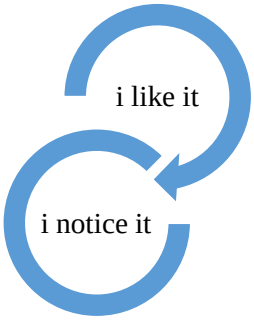


Figure 7.2 Relationship between what is noticed and what is liked in a view (derived from Liao and Shimojo (2012)).

7.5. Intra-Architectural Features related to View Preference

Distance from the window plays an important role in access to the view, and therefore in window view preference. Hence, the relevance of location with respect to the window. Since satisfaction with the location is positively correlated to window view preference, it can be suggested that where one is located will impact their access and appreciation of the view out (Figure 7.3). Being away from the window leads to less appreciation of the view because of sheer accessibility. If you cannot see it, you cannot appreciate it (Verderber, 1986, Heschong Mahone Group, 2003a).

Distance from the window has an indirect effect on window view preference through satisfaction with the location with respect to the window. More people are satisfied when they are closer to the window, and this benefits the building occupants in more than one way. Having a view outside, especially an interesting view, seems to positively affect people's perceptions of both visual (Tuaycharoen and Tregenza, 2007) and thermal comfort (Ko et al., 2020b). Therefore, it is possible that having a view out of the window may play a compensatory role to perceived discomfort, and this is mediated by having an interest in the view outside.

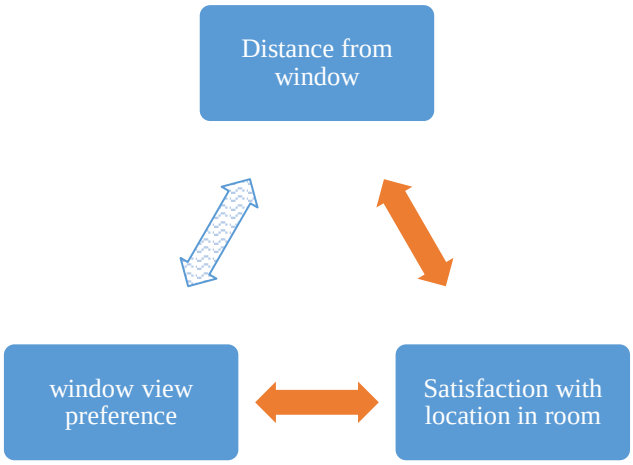


Figure 7.3 Relationship between view preference, satisfaction with location with respect to the window, and distance from the window (Source: Author)

Despite having a view outside, other endogenous factors might limit access to the view, that are related to the window. If the windowsill is too high, for example above a person's eye level when seated, it can inhibit access to the view (Verderber, 1986). Additionally, when there is perceived

glare due to the sun in the field of view, or a risk of invasion of privacy due to passers-by outside, the blinds/curtains might be closed, inadvertently blocking the view. A clear view outside is more appreciated than those with obstructions due to the window design (Abboushi et al., 2020). Therefore, the design of windows, and how much they lend to the building occupants visually accessing the outside, plays a role in the appreciation of the view out.

Window view preference rating drops significantly between participants on the ground floor and those on floors above. There could be multiple explanations for this. First, the ground layer contains most activity and greenery (Markus, 1967), this implying natural and human interactions. Since the higher the floor of the building the more detached it is from the ground, occupants are less likely to observe street activity. Views with activity and green elements on the street have been shown to have a similar rating on preference and restoration to that of a view of the sky (Masoudinejad and Hartig, 2020). Providing a natural view for people that occupy the higher floors could be afforded through vertical gardens and vertical public spaces, especially in dense urban centres. Content analysis of responses to questions posed to residents of high-rise buildings also revealed that they would prefer roof gardens and plazas to improve their view satisfaction (Haber, 1977). Despite not necessarily being public spaces, the presence of sky courts and sky gardens in high rise buildings can allow responding to social, spatial, and environmental needs (Pomeroy, 2016). This is especially relevant since, when people inhabit a public domain, their expectations are different from when they are at home. For example, issues of privacy would not apply in public

parks that are elevated from the ground. This obviously needs further research, although some cities such as Singapore are heavily investing in public infrastructure; case studies can tell us what lessons are being learnt there (Pomeroy, 2016). A view overlooking a sky garden would be as public as a street could get, given the constraints of ownership and use in these buildings. They might offer the dynamism one is looking for on the ground floor.

In this research, a small correlation (Spearman r_s = 0.295) was found between the satisfaction with the size of the room and window view preference. Previously, Butler and Steuerwald (Butler and Steuerwald, 1991) had demonstrated that room size has a substantive effect on window size preferences. In line with this, this research (see Section 5.2.2.) found a moderate positive correlation (Spearman r_s = 0.525.) between satisfaction with the size of the window and with the size of the room with respect to the window. This finding confirms the results from the literature, suggesting that the size of the room can have an indirect effect on the satisfaction with the size of the window. In essence, a space is always experienced in three-dimensions, rather than in plan and section (Butler and Steuerwald, 1991).

Our studies demonstrate that, although blinds are most often opened to let daylight in and improve the lighting of a space, people continuously seek information from the outside, especially to look at the view or know about the weather (Inkarojrit, 2005). This latter reason for blind opening increases as the observer is seated farther away from the window. Access to the view may become more difficult as the distance from the window

increases. Therefore, this suggests that blinds that allow for a clear view out may offer a better solution for occupants seated far away from the windows, and that may have less control over their operation (Konstantzos et al., 2015). This requires further attention from designers, to allow for control but also to maximise view clarity.

7.6. Familiarity, Preference, and Sense of Attachment

In this research, familiarity has been found to be positively correlated (Spearman r_s= 0.324) with window view preference. The popular English idiom 'familiarity breeds contempt' contradicts this notion, and it is important to understand the role of familiarity in human perception. Repeated exposure to stimuli has been shown to increase liking for them (Montoya et al., 2017, Palumbo et al., 2021), by reducing uncertainty and starting a process of habituation (Berlyne, 1960). Humans like to process familiar objects with fluency and ease (Reber et al., 2004). It is the familiarity with objects that triggers "*instantiation of a view"*, where humans are able to use prior information about objects seen at specific view-points to make inferences about the appearance of new, yet similar, objects (Tarr and Kriegman, 2001:p.1984).

This could imply that, the more familiar a window view is, the more it will be liked (Brenda and Herrenkohl, 1977). Kaplan et al. (1988) showed stimuli of outdoor scenes to observers and asked them to evaluate them on familiarity and preference constructs. The study showed that the relationship between familiarity and preference is not straightforward, although

familiarity appears to be a strong predictor of preference (Herzog et al., 1976). In real world applications, a regular user of the window may be more or less familiar with the view out depending on how often one engages with it.

The relationship between what is noticed in the scene, and how familiar one is with it, is also worthy of discussion. Familiarity may mean that, whatever the pattern of the outdoor view, an observer will become used to it over the course of the time spent looking at it. However, with very long exposure, the process of satiation may outstrip the effect of habituation, and the liking might decrease with the boredom felt towards a scene (Montoya et al., 2017, Berlyne, 1974).

Familiarity with objects may also draw on human's innate predisposition towards the working of the natural world. Conversely, in a non-natural world, several anthropomorphic factors play out that may not be familiar, increasing the chances of unfamiliar conditions that may result in less-liked conditions. If one can anticipate the meaning of a scene based on its sense of familiarity, then natural views hold a higher potential to be pre-empted than a busy urban environment. Another paradox is when a new pattern appears in the view.

On the other hand, people may develop bonds with places or locations that are important to them, such as their home or neighbourhood (Hidalgo and Hernández, 2001, Lewicka, 2011). In Study 2, participants mentioned the word 'home' to describe what they liked about the view. Participants in Study 3 took pride in their own garden, and the time and

effort invested in it, not just because it was the view of a garden, but as a facet of ownership. When they described the presence of a garden, they termed it "*my garden"*, which clearly implies a sense of personal connection. These results describe how the attachment with the view out of the window may provide a plethora of benefits to participants, ranging from familiarity and a sense of rootedness to a sense of positive mood as mentioned in previous studies (Scannell and Gifford, 2010).

Respondents to the survey also sought active information from the outdoors. A few participants stated that they chose their clothing based on how other people were dressed. Some people gauged how their commute was going to be based on the weather and traffic in the view. This aspect of decision making based on the window view was further revealed in Study 4 (see Chapter 6) when, during a period of lockdown people's perception of the utility of window to collect active information dropped in comparison to normal times. Since participants were highly unlikely to leave their homes, the knowledge of weather and time was deemed less important than other features of windows. This demonstrates another link to how humans obtain knowledge of the outside through the window, before stepping out of the building. Window views offer a means of information gathering about the external environment, and the more familiar the setting the more rapid this processing is likely to be (Liao and Shimojo, 2012, Tarr and Kriegman, 2001).

7.7. Extraordinary Circumstances

Study 4 presented the outcomes of a comparison between two mostly identical surveys conducted before and during a period of lockdown, lending an opportunity to investigate any difference in the perception of windows. The results showed that the familiarity and satisfaction with the space, and with participant's location with respect to the window, were significantly and substantively higher in the lockdown period (that is, the differences detected were statistically significant and had a practically relevant effect size). This is congruent with previous studies, where familiarity has been shown to play a role in predicting preference in urban spaces (Herzog et al., 1976, Imamoglu, 2000). With a likely increasing number of people working from home (Dingel and Neiman, 2020) during the lockdown, this could mean an overall positive boost in satisfaction with respect to the windows in familiar spaces, and perceived control over the operation of blinds and curtains. The period of lockdown also resulted in a lower negative perception of windows. Access to a window, and to daylight and a view out, can play an important role in the satisfaction with a space. However, further research needs to be carried out before findings can be generalized to work-from-home conditions and its long-term effects.

Preference for, and satisfaction with, the view out of the window was also significantly and substantively higher during the lockdown period. The fact that participants reported that they noticed their view more often, and kept the blinds and curtains open for longer to look out of the window, builds

on the notion that humans feel the need to connect with the outside world. While confinement can have a detrimental effect on the physiological and psychological wellbeing of individuals (Hawryluck et al., 2004, Mackolil and Mackolil, 2020, Glynn et al., 2016), a view out of the window could contribute to alleviate feelings of isolation, just as an interest in the view has been found – among other effects – to increase tolerance to discomfort glare (Tuaycharoen and Tregenza, 2007). These findings, therefore, emphasize that, during a period of confinement, windows are, in fact, *windows of opportunity* that can support the wellbeing of building occupants by becoming a vehicle to connect with the outdoors. This might be especially relevant in light of the risk of further global pandemic outbreaks (GPMG, 2019).

During the period of lockdown, the confinement also seemed to evoke behavioural changes in people, with many locating their work or desk closer to a window for daylight and view out, making the areas adjacent to the facade vital in their use of their spaces. Access to daylight and view out could imply meaningful changes to the design of buildings, e.g., depth of floors in relation to windows. These implications might be extended to other types of enforced confinement, e.g., during curfews, in prisons and in hospitals. Windows are known to be vital in health and palliative care facilities, where access to daylight (Keep et al., 1980, Gbyl et al., 2016) and quality views (Ulrich, 1984) can play a positive role in a patient's recovery time. Accordingly, windows should not be designed only to admit daylight but also for the view out they can afford, giving critical consideration to the line

of sight of the occupants, as previously suggested by Verderber (1986) and CEN/TC/169 (2018). Musselwhite (2018) also found that housebound elderly patients used the activities of people observed through the window to relate with them and imagine stories about those characters. Verderber (1986) showed photographs of views to staff and patients in a hospital and found that the views providing information about people, surrounding neighbourhood and plants, were the most preferred. A condition of confinement – for example, due to hospitalization or a physical condition limiting mobility – could potentially heighten a person's need to connect with the activities outside, as they are unable to engage with these on a regular basis. A view of living things, such as trees and plants, has also been documented to provide positive impacts on prisoners (Moore, 1981). These studies, however, require more robust evidence to support findings on window views in a period of forced or voluntary confinement.

A decrease in negative perceptions due to cold draughts was felt between the two time periods, possibly owing to the seasonal change from the Winter to Spring for the majority of respondents. We know that thermal comfort (e.g., radiative exchanges) plays a part in the experience of windows, consistent with previous literature (Shi et al., 2018). Unfortunately, in many countries, building regulations only partially embrace the multifaceted roles of windows (Boubekri, 2004). In the UK, for example, an effort to minimise heat losses and construction costs (Lewis, 2015) has often led to reductions in window size. Since windows are generally less energy efficient than walls, 'tighter' envelopes with smaller windows are 'encouraged' in energy

efficiency guidelines. Most often, the choice of glazing type, shading devices, and orientation are the main parameters considered to define the size and positioning of the window (Badeche and Bouchahm, 2020). This research suggests that the criteria for the design of windows should give due importance also to occupants' visual and psychological wellbeing (other than including further considerations not included in this study, such as circadian stimulation), which could be clearly ascribed to the window's provision of daylight and a view out.

An increase in the perceived importance of a visual connection with the outside was complemented by the reported role of the window as a provider of information that also contains a social element. Something that, regardless of the level of daylight ingress, a window in the roof (e.g., a skylight) may not be able to fulfil. Wherever possible, a window should be designed to provide a visual connection with dynamic elements in the landscape but, crucially, also with other people. Other research during the COVID-19 pandemic found that views of greenery on the ground floor were associated with lower anxiety levels for apartment dwellers (Dzhambov et al., 2020). High-rise buildings, therefore, might intensify risks of physical distancing. In particular, in this research, the open-ended comments revealed that some participants moved their desk closer to a window as a way to communicate more readily with their neighbours, but also to be seen. Proximity to the window, however, is only one dimension to consider when analysing the means that people have to socially connect with the outside world.

7.8. Composite Features of Windows

A window should not be designed just for one purpose. The most important features of windows identified in the literature are provision of daylight, ventilation and a view out, but the relative significance of these features to building users may vary across the world. There are complex interactions taking place within the environment occupied by each individual. A testimony of such intricacy was revealed when survey participants were asked to select their top three most positive and three most negative window features. Participants chose positive and negative features in 100 and 142 unique combinations, respectively, from 24 variables.

Although daylight and good light in space are important features of windows, the function of a window is perceived in conjunction with other qualities such as ventilation (possibly associated with operable windows) and establishing a connection with the outside (knowledge of weather, taking a break from a task, and a view out). Incidentally, the word window in English is originally derived from 'wind eye' (Baker and Steemers, 2002:p.106), implying its function of providing an active opening towards external environmental patterns. While designing windows and lighting of spaces, the design parameters need to look more holistically at the requirements for the physical, physiological and psychological needs of occupants. With increased research on the benefits of green elements in views (Lottrup et al., 2015), for example, this may be an element to consider since plants and the placement

of greenery and foliage, inside and outside buildings, may require dedicated planning and design considerations (FITWEL, 2020, Chang and Chen, 2005).

The presence of windows is, generally, perceived positively. The most frequently selected negative feature in the online survey (see Study 3, presented in Chapter 5) was 'none', suggesting that participants had nothing negative to report of their window. This was followed by the negative perception associated with 'cold drafts'. In fact, participants who appreciated the view out of the window also sometimes complained of its thermal performance. From a perspective of building science, the insulation properties of windows cannot be matched with that of the wall assembly, so it is expected that an area of opening in the wall will be more exposed to the fluctuations of outside temperature. This is in line with previous studies (Manning, 1965). In a thorough review of the literature related to windows, Veitch and Galasiu (2012) suggested that having no control over the amount of sunlight falling into a space could trigger visual and thermal discomfort. Collins (1975) also showed that the geographical location of a person, and the latitude where they are located, may determine how much sunlight they will appreciate, for example due to the experience of excessive overheating. Window views were not rated low on preference when participants mentioned thermal discomfort issues. Nonetheless, there is clearly a potential antagonism, whereby visual connection with the outside may be sought at the cost of thermal discomfort next to the window. In a recent laboratory study, Ko et al. (2020b) found that, in comparison to a windowless environment, the presence of a view out of the window contributed towards

positive thermal comfort perceptions. This interesting relationship between view out and thermal comfort might be fundamental to building design.

There is another competing issue with the desire to have a view, especially of the horizon or of the changing colours of the sky (Kaplan and Kaplan, 1989): the presence of the sun in the line of sight or its reflections over external (or internal) surfaces and objects (Heschong Mahone Group, 2003a). In this research, participants expressed an aspiration to look out but also complained of phenomena of discomfort glare. There are several personal (Kent et al., 2017) and environmental factors (Pierson et al., 2017) involved in discomfort glare perception that could strongly affect occupants' behaviour (Inkarojrit, 2005), for example, for the closing of blinds. However, research has shown that the blind closing behaviour related to glare might be less frequent and severe than that due to privacy and security reasons (Inkarojrit, 2005). This suggests that, in order to make the view accessible and appreciable in the probability of glare, especially in those orientations that are more prone to lower sun angles, the use of blinds and their control will play a crucial role. In this context, more research is necessary to extend the studies that have shown that people might be more tolerant to discomfort glare if they have an interest in the view (Tuaycharoen and Tregenza, 2007, Tuaycharoen, 2006). This is particularly relevant when considering that other research has suggested a clear preference for a free and open view, instead of the patterned or striped obstructions delivered by blinds (Aboushi, 2021).

8. Conclusion

In response to the missing links highlighted by a thorough review of the scientific literature, the aim of this research was to provide evidence of the relationship between window view preference and gaze behaviour.

A human-centric, gaze-driven, approach to view preference has afforded this research with a novel holistic means to investigate differences in oculomotor responses with respect to most preferred and least preferred, urban and natural views. Evidence has been gathered through a multi-method approach. First, three types of data were collected under controlled laboratory conditions with window view surrogates and analysed through triangulation. These data included: subjective preference ratings; qualitative reasoning of preferences; and, eye-tracking data in the form of quantitative metrics and heatmap visualisations. Based on these rich datasets, inferences

related to the mechanisms underlying view preference and gaze behaviour were derived. Second, evidence was derived from a thorough analysis of the quantitative and qualitative responses related to people's own window views using an online survey methodology.

The sections below summarise the means through which this investigation was carried out, illustrating the outcomes from the analyses of each method, presenting the implications of the findings, and discussing their limitations. Recommendations for potentially fruitful avenues for future investigations are also made at the end.

8.1. Window View Preference and Gaze Behaviour

In Study 1 and Study 2, three types of data were collected and analysed. Study 1 involved a controlled laboratory experiment with participants viewing urban images. Study 2 used a repeated-measures, within-subject, study design and invited 15 out of the 32 participants that took part in Study 1 to view natural images under the same laboratory conditions, following the same protocol as Study 1. Chapter 4 presents the results from Study 1 and Study 2, and a comparison of findings from the two studies. The conclusions to be drawn from these studies are as follows.

Appreciation for natural views is, in general, higher than urban views. In urban views, a higher preference was found to be moderated by the presence of people, orderly presentation of colours, and differentiated built elements that are well kept and maintained. Preferences for natural views

are moderated by various environmental cues – e.g., colours depicting seasonal changes, mountains, trees, water, people, etc. – as suggested by psycho-evolutionary theories such as ART and SRT. Environments perceived as inhospitable or threatening to humans are often the least preferred.

Gaze behaviour depends on view type and view preference. Participants' gaze behaviour differed significantly based on whether they were observing natural or urban scenes. In our sample of participants, observing natural views led to participants' gaze being characterised by lower numbers of fixations and saccades, and longer fixation durations, when compared to urban scenes. In the literature, this difference in gaze behaviour has been attributed to the restorative potential of natural environments. However, in these experiments (Study 1 and Study 2) similar oculomotor responses were found when participants observed their most preferred natural and urban views. Since neurosciences indicate that distinct brain regions are responsible for processing naturalness and aesthetic appraisals (Jacobs et al., 2012), this might suggest that more than one mechanism might be at work during visual scene processing and, therefore, should be accounted for in view assessments.

Visualisation of gaze allocation through gaze heatmaps revealed certain gaze hotspots that could not be explained through verbal reasoning in most preferred views. Common hotpots related to human gaze in the centre of the scene could be attributed to central gaze bias. Other biases in gaze and visual perception are known to be associated with human faces, text and

numbers, and specific incongruent content in the scene. The experiments, in these studies, detected that many heatmaps on their own did not justify the gaze behaviour in most preferred views, thus highlighting the limitation of heatmaps as an independent research tool for studying most preferred views.

Participants' perceived relationship with nature is related to – and, possibly, contributes towards – gaze behaviour. Individual scores of nature relatedness were positively correlated with a more exploratory oculomotor response when looking at natural scenes. The opposite gaze behaviour was detected in urban views. This finding might have important implications on how a building occupant may engage with the view out of a window, depending on how they relate with the external natural or urban environment.

8.2. Real Window Views

In Study 3, data were collected using an online survey over two time periods (Survey 1 and Survey 2). This offered a practical way to reach participants in their own real world setting and offer them a means to report their perceptions of the view out of their window. Participants uploaded a photograph of their window view and responded to quantitative and qualitative questions related to it in the survey. The key findings from the analysis of the data are as follows.

When a window provided knowledge of weather and a connection to activities and people outside, a positive preference rating above a minimum threshold was consistently provided. These conditions can, therefore, be considered as necessary-but-not-sufficient for window view preference. In a design perspective, this implies that, in dense urban environments, a case for enhancing the components of weather knowledge and connection with people and activities needs to be made.

Based on an analysis of the qualitative responses offered by participants, preferences for the view out of the window were found to be driven by the dynamism and change that the view has to offer; this could vary between transient and momentary changes, up to daily and seasonal variations. Consistent with evolutionary theories, the survey revealed that natural features in views are highly preferred. This may be due to the fact that humans are intrinsically anticipating changes in the external environment (day/night and seasonal). People notice the transient and ephemeral qualities of views that may not be inherent in the physical characteristics of form. Natural green elements in urban environments may, therefore, also afford this opportunity.

Preference and satisfaction with the view out are strongly correlated and may be mediated through familiarity with the view. This suggests that real window views could be more appreciated over time. However, negative experiences with the view might play a role in eliciting preference, also based on the observer's interest in what is seen.

Short-distance views could be perceived as obstructions and are generally disliked. These views might not allow for sufficient interest or dynamism, while expectations and awareness of what is behind may contribute to a negative perception. This is also the case with static views, sometimes common in urban environments or in full views of greenery that do not change over time.

Apart from external view elements, internal factors influencing window view access can contribute towards preference. Participants facing away from the window, or placed at a distance from it, might not fully appreciate the dynamism in the view. Blinds and curtains used to minimise glare, and to address privacy concerns, might present further competing issues. Other than the visual experience, thermal sensations associated with cold drafts and overheating can also make it difficult for participants to appreciate the view and appreciate their interactions with the window. Windows need consistently to be designed to address, as much as possible, a combination of different factors, including daylight, ventilation and the provision of a view out.

8.3. The Effect of Confinement

Study 4 focused on a comparative analysis of the data collected in Survey 1 and 2 to identify any differences in perception of windows and the view out between 'normal' circumstances (Survey 1) and a period of

heightened measures of social distancing as resulting from the outbreak of the COVID-19 pandemic (Survey 2).

This study provided statistically significant and practically relevant evidence that, during a period of imposed or voluntary confinement, windows are increasingly favoured for their view out and for their affordances to connect, physically and socially, with the outside. Many participants moved their desk closer to the window during the period of confinement. Participants who sat near the window or moved their desk closer to it during the lockdown, particularly enjoyed the daylight that was brought in and the ability to look out, keeping their blinds and curtains open more often.

These results might have important implications on design practice and research, although further investigations are needed considering that this was among the very first studies analysing the differences in the perception of windows within a period of lockdown. Nevertheless, these findings help capture the psychological impacts of confinement on people and may be relevant also to other domains, such as the design of prisons, hospitals, or care homes, where occupants could strongly benefit from the restorative effects of window views.

8.4. Implications

This research has intended to make a contribution to studies investigating view preference. Our findings demonstrate that (gaze)

behavioural responses may reveal what participants notice in views, while preference (liking) for a view engenders characteristic patterns of eye movements. This research has provided supportive evidence to previous literature positing that gaze behaviour may differ based on view types, that is whether the observed view is natural or urban (Valtchanov and Ellard, 2015, Berto et al., 2008). The two modalities, perceived naturalness of the view and how much one likes or prefers a view, may interact with one's gaze behaviour. A feature in the view that holds a person's attention for longer may be either natural and/or a disliked or incongruent object.

Individual differences such as a person's inclinations and pre-dispositions – e.g., how one relates with nature – may also affect their gaze behaviour. It is, therefore, important that research on view preference takes into account human-centric indicators, including physiological measures such as gaze behaviour, and personal predispositions, for example nature relatedness. Instead of uniquely relying on external reviewers for aesthetic assessment of views to be used as stimuli in studies, it would be beneficial if observers' own views could be taken into account.

The existing scientific literature, and also most guidelines on window view design, are still divided along the distinction between urban and natural views. However, such distinction is neither clearly defined nor actually relevant to the real world window views in most modern cities, where the presence of natural contents is becoming more common and, likely, an actual necessity in the future.

In this research, a triangulation of three types of data (Study 1) revealed that even the slightest perception of naturalness in a view can cause the gaze behaviour to differ. Study 2 confirmed this finding, showing that attention and gaze are correlated with preference and naturalness in different ways, and that personality attributes and expectations could play a mediatory role in gaze behavioural response. This notion was first posited in the findings of Aries et al. (Aries et al., 2010), who suggested that natural views and attractive views had different paths to predict wellbeing outcomes in people. Brain activation studies have also revealed that there might be specific cerebral areas devoted to aesthetic assessment and naturalness perception (Jacobs et al., 2012). However, research has shown that not all natural views lead to satisfaction and have a positive impact on people (Gilchrist et al., 2015), while greenery is not consistently a predictor of window view preference when there is already abundant greenery in a city (Matusiak and Klöckner, 2016). On these bases, this research has sought to emphasise the aesthetic elements of views that drive interest and subsequent gaze behaviour, instead of dividing the views along natural-urban types.

This research has made a methodological contribution towards our understanding of window view preference. Empirical research on subjective preferences have conventionally adopted either a *reductionist* (Aries et al., 2010) (Hellinga and Hordijk, 2014) or a *qualitative* approach (Al-Akl et al., 2018, Mirza, 2015), yet offering only a partial understanding of the complex

underlying principles driving view preference (Holmes and Zanker, 2012). A multi-method approach, as embraced by this research, is needed and essential to meaningfully interpret gaze behaviour, particularly when visualised using heatmaps. Although this multi-method approach might take longer and require more sophisticated analyses of the resultant data sets, it offers deeper, better, insights into the constructs under investigation.

8.5. Limitations of the Study

This research has been based on studies conducted using two different data collection methods – a controlled laboratory setting using eye-tracking, and an online survey – to explore the relationship between gaze behaviour and window view preference. Qualitative open-ended responses were used to assess people's self-reported perception and better contextualise their behaviour.

Before our findings can be transferred to other contexts (e.g., building occupants observing real window views), it should be acknowledged that our results from Study 1 and Study 2 were based on a laboratory experiment, where participants viewed photographic scenes for 15 seconds while keeping a static head position. The images used in these studies were obtained from an open-source database in order to use pre-calibrated stimuli within the experimental procedure and avoid (as much as possible) researcher's bias in image selection. Utilising an open-source image repository allows for reproduction of the experimental protocol and enabled the choice of a wide

variety of visual stimuli – from close-up images to long distance views. However, this methodological choice also implied the short-coming that images could not be fully representative of the variety of views from an actual window. It is suggested that future studies could potentially utilise the database of real window views collected in the Study 3 for image selection. In addition, in a real building, both the position of the viewer and the content of the window view may change continuously. The dynamic quality of light, the content of the view (i.e., including but not limited to the seasonality, time of the day, and other personal and contextual factors such as the presence of an attention attractor), or people attending to another visual task, may influence people's preference of the view, the time spent attending it, or evoke different gaze behaviour. The effect of long-term exposure to a view, when participants might become increasingly familiar with the environment, are additional questions raised by this study that require further research.

According to the Attention Restoration Theory (ART), restoration takes place when depleted attentional resources are replenished through exposure to unthreatening natural environments. Since, the studies in this research did not intentionally deplete participant's attentional resources (Joye et al., 2013), the restorative effects were not measured. The perceived restoration scale (PRS), one of the most frequently used scales to measure the restorative potential of environments, is inclusive of preference rating, suggesting that preference is a construct that contributes towards restoration. The results from this research could contribute towards an

understanding of restorative effects of window views, nonetheless. Amongst other measures, the PRS measures how much a person can feel 'being away', which could potentially be a biased representation of restorativeness, as it is not a representation of the general encounters of a person with their window view. Although differences in gaze behaviour due to view types have been attributed to perceived restorativeness (Valtchanov and Ellard, 2015, Berto et al., 2008), in this research participants did not rate the scenes on this scale for the reasons above.

In a recent study on natural landscape perception, Huang (Huang and Lin, 2020) found that people's preferences and gaze behaviour differed a lot, and that within natural scenes, colour of the landscapes plays an important role to attract attention. Yellow-magenta-green variations were found to be an important factor in mountain landscapes, yellow-blue in aquatic landscapes, complexity was considered an important factor in open landscapes, and hue variation in forest landscapes to draw attention. In our research, it was found that people also liked the changing colour of the landscapes.

Online surveys, such as those used for Study 3 and Study 4, can capture the perceptions that participants express for their window, *in situ*, without any possibility of experimental control. This, unavoidably, adds variability to the data. The data in the two surveys (Survey 1 and Survey 2) were gathered at different times of the year and some of the differences detected may possibly be ascribed to an effect of seasonality. In the absence

of any previous global studies on window perception and window views, a robust validation of findings cannot be drawn. Nonetheless, this research found a significant and substantive difference between perception of windows and the value of the view out, in the first survey and during the lockdown, demonstrating the importance of windows during a period of confinement. The data in Survey 2 were collected for only one month to retain the answers limited to the period of lockdown in the different parts of the world. In comparison, Survey 1 was run for over 3 months with almost double the number of participants. Finally, Survey 2 was not purposely designed to investigate differences in window perception in a period of lockdown, but the same questions used in Survey 1 had to be employed to allow comparability of data.

Since a pandemic and the subsequent lockdown could not be anticipated, some potential confounding variables in Study 4 could not be addressed within the framework of this study. These include, but are not limited to, contextual factors (for example, working from home, sense of control, ability to position the desk as desired, etc.), as well as other aspects of organisational productivity that are known to have a significant impact on the mental and physical wellbeing of building occupants, e.g., work-life balance and parameters of indoor environmental quality (thermal comfort, air quality, ventilation, lighting, etc.) (Newsham et al., 2019).

8.6. Further Work

8.6.1. *Dynamism in View*

The findings from this research suggest that the dynamism and variation in the view outside may attract gaze and increase view preference. As part of this research, a necessity analysis revealed that knowledge of weather and connection with people and activities outside lead to a positive rating of preferences. Recent research work in VR has suggested that preferences for the view are higher when the view has a dynamic lighting condition (Rodriguez, 2021). Since the dynamism of view outside is difficult to recreate across many participants in experimental settings, and considering that there may be several intra- and inter-architectural features and personal predispositions towards different environments, further research would need to test for the effect of view preference in a dynamic view setting. An issue with experimental settings is that, unlike a person's real window view, the participant is unfamiliar with the view and therefore 'novelty' may be playing a role in both gaze behaviour and preferential appraisal. Therefore, for a long-term understanding of dynamism on window view preference and gaze behaviour, a setting would have to be designed to compensate for these effects.

8.6.2. *Task at Hand*

The association between the task being performed and the eye movements made while performing the task is well established. In picture viewing (Buswell, 1935, Yarbus, 1967), music and word reading (Anderson et al., 1997), visual search (Connor et al., 2004), complex real-world scene perception (Henderson, 2003), and motor tasks (Land, 2007), consistent patterns of eye movements have been detected across participants, pointing to the crucial role that the task plays in the direction of overt attention.

Research has shown that visual comfort ratings of diverse window types are not significantly different when participants perform tasks over long periods of time (Abboushi et al., 2020), even when differences were previously detected for perception of space over a short duration (Abboushi and Elzeyadi, 2018). Conversely, Abboushi et al. (2020) found that the perception and appraisal of view out of a window was significantly affected by the direction facing while performing the task. In VR, Abd-Alhamid et al. (2020) found that the farther the participant was located from the window, the more the distance adversely affected view perception and appraisal. Therefore, amongst the various intra-architectural features identified in this research, the task a person is performing is likely to impact their gaze allocation. The type of attentional demands of the task will also determine how someone will shift their gaze away from their visual focus (Marius 't Hart et al., 2009) and on the window, and how – and if – they could benefit from this. Neurophysiological studies suggest that attention can be considered as a

'race' among "*firing rates of different neuronal populations*", selectively tuned/set up for different characteristics of a person's physical environment (Hodgson and Golding, 2003:p.60). Different levels of demands of cognitive control may be placed upon us to coordinate and allocate attention and gaze for the task at hand.

Some tasks require a person to look out of the window as their daily job, or there might be settings where it is important to keep an eye on the outside while attending to a task inside, such as looking over children (Littlefair, 2011:p.25). In some groups, such as in school children, there is curiosity to learn everything about the world and, therefore, a view out of the window can provide the necessary stimulation in the environment. However, other tasks require acute attentional focus within the space, for example, an operating theatre in a medical facility could not afford a distraction with environmental stimulation. Between the two extremes – where one is required to look out for work or survival, and one where too much is at stake to break your attention – there are numerous possibilities of demands for view out and effects of view on the person and the task to be performed. It is important, therefore, to know the purpose for designing a view out of the window in the context of the task at hand; this is an aspect of design that requires continuous research.

8.6.3. *Multiple Features of Windows*

Sustainable building guidelines on window design emphasize the importance of providing a view out. This research has offered evidence that people are attracted to the view out of windows but, when this attraction is in conflict with other senses (e.g., glare or thermal sensations), it is avoided or closed off with blinds and curtains. Participants in this survey study complained about the thermal discomfort or glare that is, at times, associated with the windows. The behavioural response to this discomfort, e.g., drawing a blind, is a problem from the perspective of seeking a view out although it reveals the intrinsic links between all the senses through which we humans perceive, navigate, and respond to the environment. Recent research has shown that, in the presence of a window, thermal perceptions might be modified (Ko et al., 2020b). Tuaycharoen and Tregenza (2006) also found that visual comfort ratings are affected by interest in a view. It may, therefore, be worth investigating the role of cross-stimulation of multiple senses in window view preference.

8.6.4. *Preference and Familiarity*

Our research showed an association between familiarity with the view out of a window and the preference rating given by observers. These findings were derived from an online survey of participants' own windows. Performing eye-tracking studies in real world settings may be a considerable challenge, mostly because of the quality of portable eye-tracking equipment,

the noise in mobile eye-tracking data, and issues of reproducibility. In laboratory conditions, however, where eye-tracking is relatively easier to conduct, repeated presentations of the view stimuli have shown a difference in gaze behaviour for the same images (Kaspar and König, 2011). Multiple presentations of stimuli might lead to more liking, but the risk of boredom in familiar views should also be considered. This poses a new challenge, that is, how a view that varies on the scale of familiarity and dynamism may affect preference ratings. This may even be more relevant due to the recent trends of flexible working arrangements and hot-desking, whereas permanent desk jobs may be less and less frequent.

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Appendices

Appendix A

Experimental measures and instruments used in Study 1 and Study 2

Appendix A - 1

Participant Information Sheet

Project Title: Visual Scene Preference

What is the purpose of the study?

This study aims to analyse preferences in visual environments with specific reference to outdoor scenes.

Why have I been invited?

You have been invited to take part because your age is between 18 and 67 years and have a normal (or corrected to normal) vision.

What will I be asked to do?

This experiment is laid out in 4 stages:

1. You will obtain a detailed explanation of the study from the experimenter, and you will be asked to complete an informed consent form.
2. You will be required to fill in a short questionnaire in order to collect (anonymous) information about yourself, your visual perception and sensitivity. After this, the experimentation procedure will start. At any stage, you will have the possibility to ask as many questions as needed.
3. The experimentation procedure will require you to sit in front of a screen, where you will perform a short (3-min) calibration of the experimental apparatus. You will then be asked to give your own preference rating to a number of visual scenes. During this task, your eye movement will be recorded using an eye-tracking device.
4. You will then be asked to categorise a set of printed photographs according to two different criteria, which will be shared with you at the beginning of the test. Once this is completed, you will be asked a few

questions regarding this task in the form of an audio-recorded interview. Audio recording will later be transcribed for analysis purposes only and the number of photograph identification will be noted down.

The whole procedure will last around 45 minutes.

Expenses and payments

Participants will not be paid an allowance to participate in the study.

What are the possible disadvantages and risks of taking part?

There are no known risks or adverse effects associated with this experiment.

What are the possible benefits of taking part?

This research will strengthen our understanding of visual scene preferences. This could help us plan and design more meaningful environments for people.

What if there is a problem?

If you have a concern about any aspect of this study, you should speak to the experimenter who will do their best to answer your questions. If you wish to obtain further information, you can do this by contacting the researcher's Supervisors. All contact details are given at the end of this information sheet.

Will my taking part in the study be kept confidential?

We will follow ethical and legal practice and all information about you will be handled in confidence. Your anonymity in this project will be protected. You are not required to provide your name nor personal contact information on any form that you will fill. Paper and electronic records will be securely stored according to University of Nottingham procedures. In order to maintain anonymity, the consent form collected during the study will be kept in a separate box from the rest of the data.

All data will be stored for a minimum of seven years post-publication in line with University of Nottingham's data policy. After this time, electronic files will be deleted and any hard copies of data will be destroyed.

What will happen if I do not want to carry on with the study?

Your participation is voluntary and you are free to withdraw at any time, without giving any reason, and without your legal rights being affected.

What will happen to the results of the research study?

Data from the rating task and sorting task will be analysed and reported. All reported findings will be made anonymous so that you will not be identifiable in any form of dissemination of this research. These findings will be released in the form of a written report and will be disseminated in academic publications. Fully anonymised data might be used for secondary analysis purposes, and anonymised dataset might be included in the publication of results.

Who is organising and funding the research?

This research is being organised and funded by the University of Nottingham.

Who has reviewed the study?

This study has been reviewed and approved by the Faculty of Engineering Research Ethics Committee.

If you have any questions or concerns please do not hesitate to ask. We can also be contacted through the contact information below.

Further information and contact details

Experimenter: Ayesha Batool laxab20@nottingham.ac.uk

Supervisor:

Dr. Peter Rutherford lazrut@nottingham.ac.uk

Prof. Sergio Altomonte sergio.altomonte1@nottingham.ac.uk

Prof. Timothy Ledgeway lpztl@exmail.nottingham.ac.uk

Prof. Paul McGraw lpzpvm@exmail.nottingham.ac.uk

Appendix A – 2

PARTICIPANT CONSENT FORM

Project title: Visual Scene Preference

Researcher: Ayesha Batool
Supervisors: Dr. Peter Rutherford, Dr. Sergio Altomonte, Dr. Timothy Ledgeway and Dr. Paul McGraw

Please initial box

1. I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, and without my legal rights being affected. I understand that should I withdraw then any information collected may still be used in the project analysis. ☐

3. I understand that data from this experiment will be stored in a secure location in accordance with University of Nottingham regulations. All hardcopy data will be stored in a locked file cabinet with the researcher, in the Human Factors Research Group office, University of Nottingham. Electronic copies of transcripts of audio recording and digital data collected during the experiment will be stored securely on the University of Nottingham's password protected office 365 server. Only the researcher and supervisors listed above and the individual subjects will have access, upon written request to this data. ☐

4. I understand that an interview will be recorded and that anonymous direct quotes from the interview may be used in the study reports. ☐

5. I understand that anonymised data collected from this study may be used for secondary analysis and may be provided with the studies and publications. ☐

6. I give permission to collect, store, analyse and publish information obtained
from my participation in this study. I understand that the data collected will be fully anonymised and I will not be identified in anyway. ☐

7. I agree to take part in the above study. ☐

Participant ID: ……

Signed ……**Date** ……

Researcher: **Print name** ……

Signed ……**Date** ……

Contact Details:
Researcher: laxab20@nottingham.ac.uk
Primary Supervisor: lazrut@exmail.nottingham.ac.uk

Human Factors Research Group Research Ethics Coordinator:
robert.houghton@nottingham.ac.uk

Appendix A - 3

Pre-Test 'About you' Questionnaire

Participant ID _____ (provided by researcher)

Your answers to the following questions will help us analyse the test results.

From the multiple choice answers, choose one option unless otherwise specified.

1. How old are you?
   - ☐ Under 18
   - ☐ 18-24
   - ☐ 25-34
   - ☐ 35-44
   - ☐ 45-54
   - ☐ 55-64
   - ☐ 65-70
   - ☐ 71 and over
2. Sex
   - ☐ Male
   - ☐ Female
   - ☐ Prefer not to say

3. What is your Nationality?

_____(Please type in)

4. How often do you use a computer?
   - ☐ Never
   - ☐ Occasionally
   - ☐ Monthly
   - ☐ Weekly
   - ☐ Daily

Household and living arrangements

5. How long have you lived in Nottingham?
   - ☐ Under a month
   - ☐ 1 – 6 months
   - ☐ Over six months
   - ☐ Over year

6. How long have you lived in the United Kingdom?

- ☐ Under a month
- ☐ 1 – 6 months
- ☐ Over six months
- ☐ Over year

7. Do you consider yourself a city person or a countryside person?

Please mark a cross along the horizontal line indicating your position on the scale.

City ---------- Countryside

Education and Profession

8. What is the highest degree or level of school you have completed? If currently enrolled, highest degree received.
   - ☐ College
   - ☐ Undergraduate
   - ☐ Master
   - ☐ Post-graduate
   - ☐ Other_____
9. What is your role and department?

Role _____
Department _____

Health and Eyesight

10. Do you have a normal colour vision?
    - ☐ Yes
    - ☐ No
11. Do you wear glasses/spectacles while you are working?
    - ☐ Yes, always
    - ☐ Yes, sometimes
    - ☐ No, prescribed but I don't bother
    - ☐ No
12. Do you wear contact lenses while you are working?
    - ☐ Yes, always
    - ☐ Yes, sometimes
    - ☐ No, prescribed but I don't bother
    - ☐ No
13. Is your sight limited by an eye disease or eye disorder, even when you wear glasses or contact lenses? (e.g. colour blindness)
    - ☐ Yes
    - ☐ No
14. Are your eyes sensitive to intense light?
    - ☐ Yes, very sensitive
    - ☐ Yes, somewhere sensitive

- ☐ No

15. Do you wear sunglasses outdoors during sunny weathers?
    - ☐ Always
    - ☐ Often
    - ☐ Regularly
    - ☐ Sometimes
    - ☐ Never
16. What is the state of your current health?
    - ☐ Good
    - ☐ Not too bad
    - ☐ Feeling ill

Thank you for filling out the questionnaire. Your responses will remain anonymous and confidential. Please rest your eyes by looking away from the screen for a few seconds before proceeding on to the next screen.

Appendix A – 4

Psychomotor Vigilance Test (Evans et al., 2019)

REACTION TIME TEST

You are going to be shown a black screen. At the centre of the screen, you will be shown a red circle for between 2 – 10 seconds followed by a timer.

Please TAP on the screen as soon as the timer starts counting.

There will be 5 trials in total, which will take approximately 30 seconds to complete.

Please respond as quickly as possible.

Thank you.

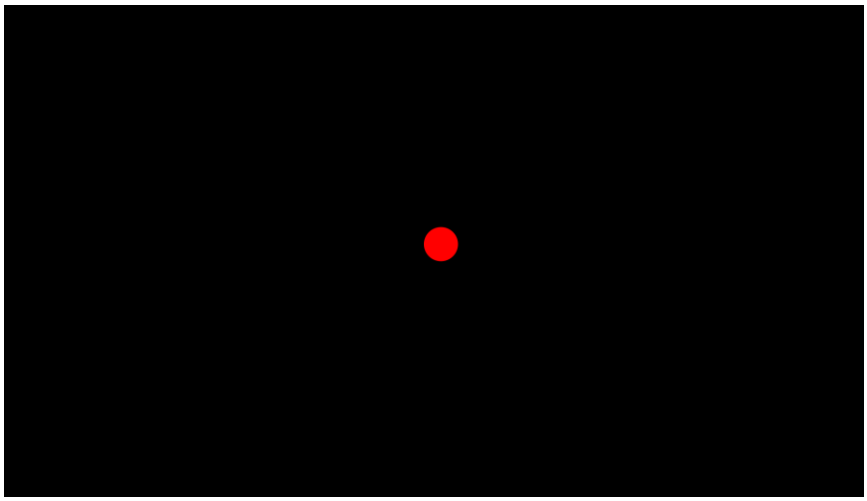


Figure A1 Sample screen during the reaction time test

Appendix A – 5

NRS Questionnaire (Nisbet et al., 2009)

For each of the following, please rate the extent to which you agree with each statement, using the scale from 1 to 5 as shown below.

1	2	3	4	5
Disagree strongly	Disagree a little	Neither Agree or disagree	Agree a little	Agree strongly

Please respond as you really feel, rather than how you think "most people" feel.

1. I enjoy being outdoors, even in unpleasant weather. ____
2. Some species are just meant to die out or become extinct. ____
3. Humans have the right to use natural resources any way they want. ____
4. My ideal vacation spot would be a remote, wilderness area. ____
5. I always think about how my actions affect the environment. ____
6. I enjoy digging in the earth and getting dirt on my hands. ____
7. My connection to nature and the environment is a part of my spirituality. __
8. I am very aware of environmental issues. ____
9. I take notice of wildlife wherever I am. ____
10. I don't often go out in nature. ____
11. Nothing I do will change problems in other places on the planet. ____
12. I am not separate from nature, but a part of nature. ____
13. The thought of being deep in the woods, away from civilization, is frightening. ___
14. My feelings about nature do not affect how I live my life. ____
15. Animals, birds and plants should have fewer rights than humans. ____
16. Even in the middle of the city, I notice nature around me. ____
17. My relationship to nature is an important part of who I am. ____
18. Conservation is unnecessary because nature is strong enough to recover from any human impact. ____
19. The state of non-human species is an indicator of the future for humans. __
20. I think a lot about the suffering of animals. ____
21. I feel very connected to all living things and the earth. ____

Thank you for filling out the questionnaire. Your responses will remain anonymous and confidential.

Appendix A – 5B

Nature Relatedness Scale (NRS) reordered by sub-themes, Experience items, Self items, and Perspective items (Nisbet et al., 2009).

Sub-Theme	Question	Item Description
NR-experience items	1	I enjoy being outdoors, even in unpleasant weather.
	4	My ideal vacation spot would be a remote, wilderness area.
	6	I enjoy digging in the earth and getting dirt on my hands.
	9	I take notice of wildlife wherever I am.
	10	I don't often go out in nature.
	13	The thought of being deep in the woods, away from civilization, is frightening.
NR - self items	5	I always think about how my actions affect the environment.
	7	My connection to nature and the environment is a part of my spirituality.
	8	I am very aware of environmental issues.
	12	I am not separate from nature, but a part of nature.
	14	My feelings about nature do not affect how I live my life.
	16	Even in the middle of the city, I notice nature around me.
	17	My relationship to nature is an important part of who I am.
	21	I feel very connected to all living things and the earth.
NR - perspective items	2	Some species are just meant to die out or become extinct.
	3	Humans have the right to use natural resources any way they want.
	11	Nothing I do will change problems in other places on the planet.
	15	Animals, birds and plants should have fewer rights than humans.
	18	Conservation is unnecessary because nature is strong enough to recover from any human impact.
	19	The state of non-human species is an indicator of the future for humans.
	20	I think a lot about the suffering of animals.

Appendix A – 6

Eye-tracker Calibration Procedure

The experiment apparatus included a desktop mount EyeLink 1000, that allows the camera to operate so that no apparatus needed to be attached to the participant's head. The eye-tracking equipment is based on a camera tracking the eye, by taking a series of images of the eye at a specific frequency, that in this experiment was fixed at 500 Hz. The camera figures out where on the screen the participant is looking, by recording two pieces of information, the centre of the pupil and the centre of the corneal reflection. The corneal reflection is the reflection of the fixed light source (the infrared illuminator) built into the eye-tracker (SR-Research, 2021). With the stabilized head position, the corneal reflection remains relatively steady, but the location of centre of pupil changes when the eye rotates (due to a saccadic eye movement).

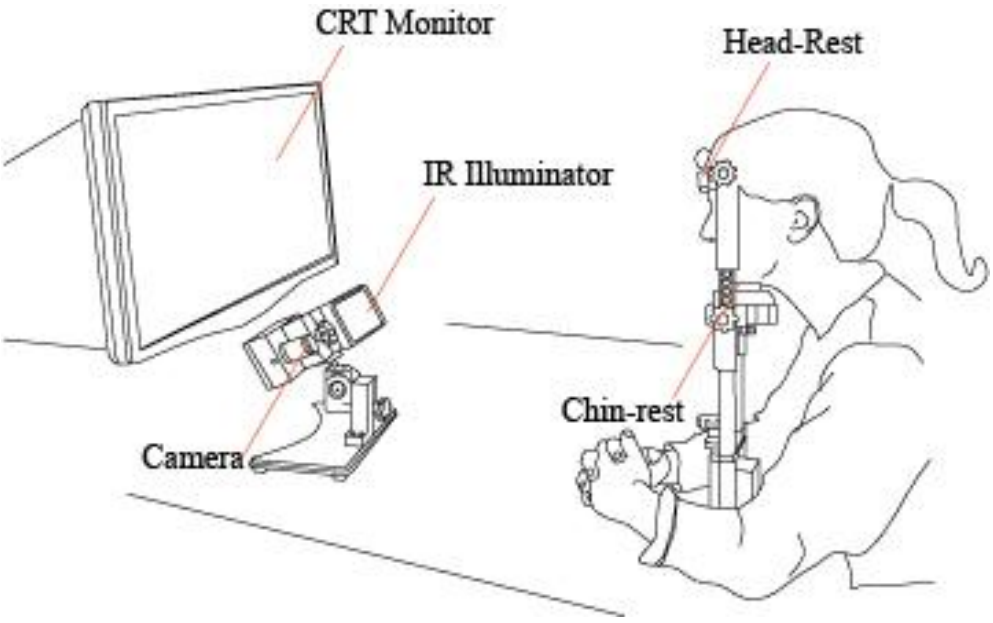


Figure A2 Eye-tracker set-up. Adapted from EyeLink 1000 Introduction and Training Session by SR Research Ltd.

The recording of eye-gaze therefore requires a calibration process. The calibration process is composed of three steps. There are two computer screens. One screen on which the participants is viewing (CRT Monitor). The second computer screen (R-computer) away from the view of the participant is used by the researcher to make sure that the eye-tracker is working, following these steps.

1. Participant rests their head against the chin and head rest in a comfortable position. The participant is asked to look at the four corners on the CRT Monitor screen. The researcher checks that the position of the pupil, that of participant's dominant eye, is in centre of the viewing window on R-computer (Figure 9.1). Adjust the position of the chinrest and seat heat of participant to make sure that the pupil is in the centre of the camera window. Manually focus the lens of the camera on the eye-tracker until the image of the pupil is crisp.
2. Inform participant that there will be a dot on the screen that will move around, and their task is to follow the dot as accurately as possible. Initiate the calibrate process using the R-computer. Calibration starts using a 9-point step on CRT-Monitor, by mapping raw eye data to gaze position coordinates (Figure 9.2 a).
3. At the end of this process, researcher confirms the status of calibration through a validation process. The validation screen shows the researcher the accuracy of the calibration points and at this point

the researcher has the choice to accept the calibration and proceed with the experiment or repeat the calibration process or return to camera setup (Figure 9.2 b). Researcher checks for warning signs generated by the eye-tracking software regarding pupil or corneal reflections. Some participants may need practice before calibration can be accepted.

The process of calibration is repeated at the start of every block of trials to prevent the drift in eye movement data. After a calibration is performed, participants are asked to keep their head in a steady position with the head and chin rest. Therefore, after each block, participants are requested to rest their eyes and neck (that is when their eyes are not calibrated). For further issues related to eye-tracking and participants wearing mascara, lenses and eyeglasses refer to Holmqvist et al. (2011:pp.116-128).



Figure A3 Research Computer showing participant setup (Source: Author)

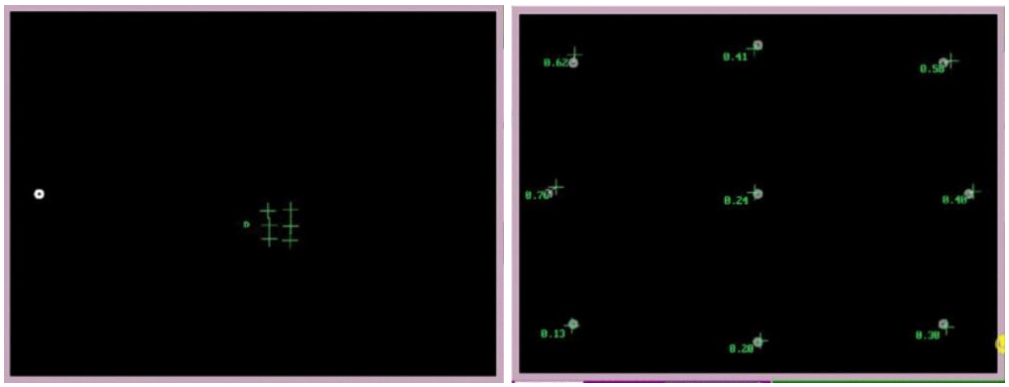


Figure A4 Calibration (left) and Validation (right) process shown in two screens on the Research Computer (Source: Author)

Appendix A – 7

Stimuli used in Practice Block- Study 1

1



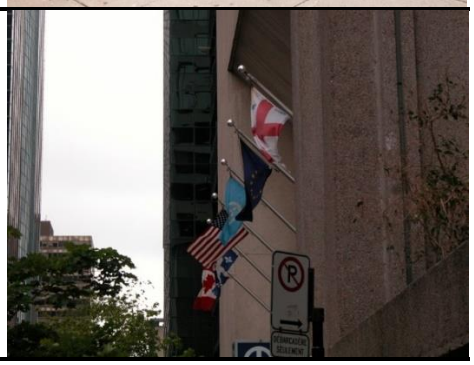
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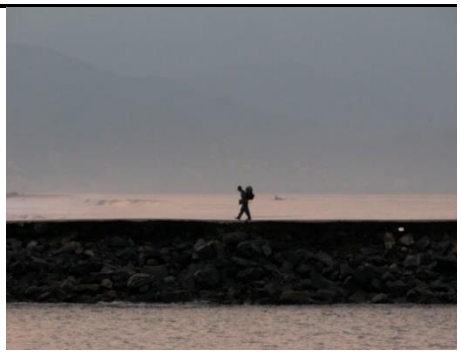


Stimuli used in Practice Block - Study 2

1



2



3



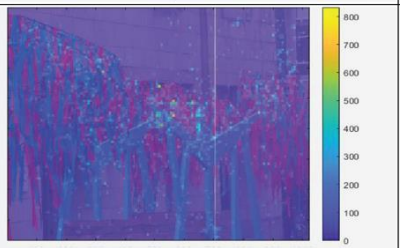
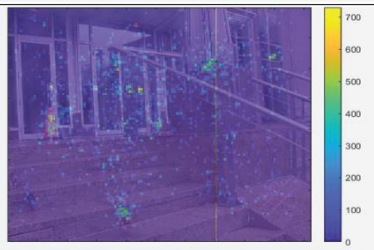
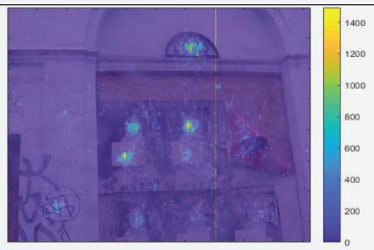
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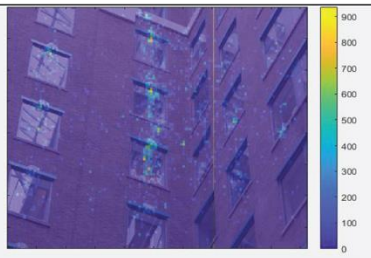
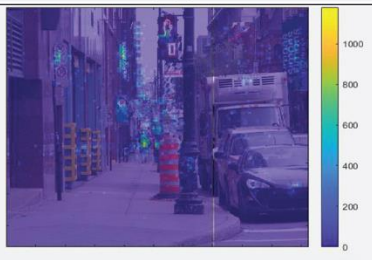
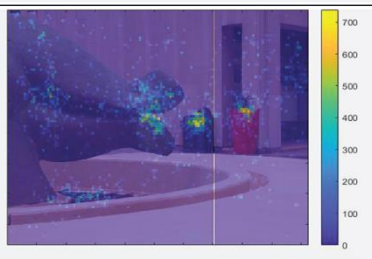


Appendix B – 1

Heat Maps: Study 1

The study uses 40 images extracted from the McGill Calibrated Colour Image Database (Olmos and Kingdom, 2004). In order to identify the foci of attention via eye-tracking, heat maps (HM) were plotted for each view. In the table, the yellow, green, and blue colours represent, in descending order of occurrence, the number of gaze points directed towards specific parts of the image. The absolute values that each of these colours characterises (i.e., the scale used for the heat maps) differ from image to image so as to better adapt to the whole range of gaze behaviours to be represented. Image size is 1024 x 768 pixels.

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i3		i4	
i5		i6	
i7		i8	
i9		i10	

ID	Image Heat Map	ID	Image Heat Map
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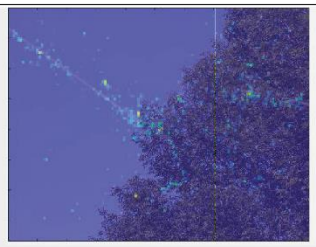
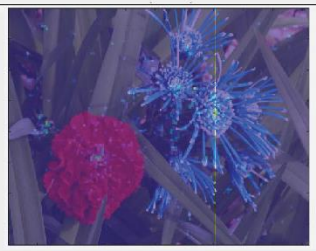
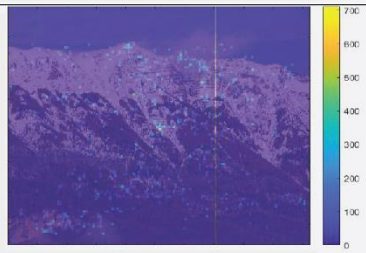
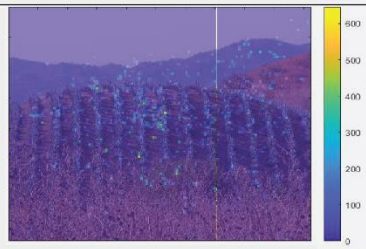
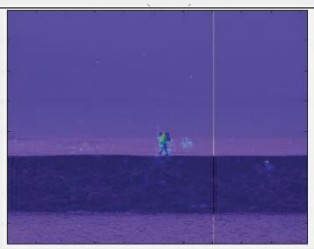
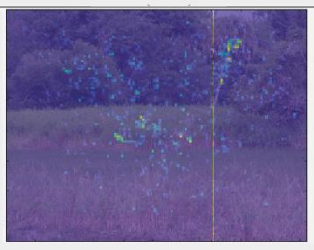
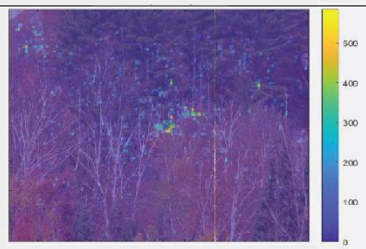
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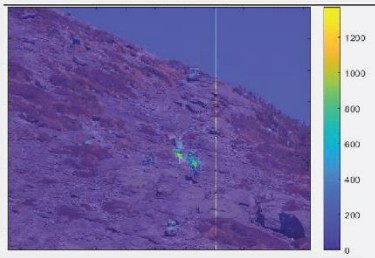
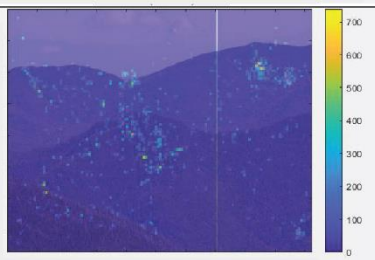
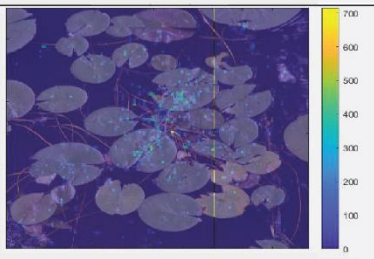
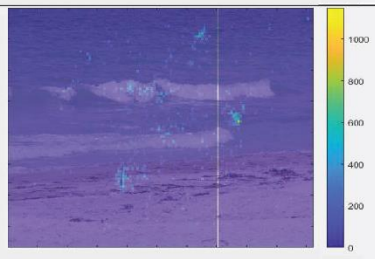
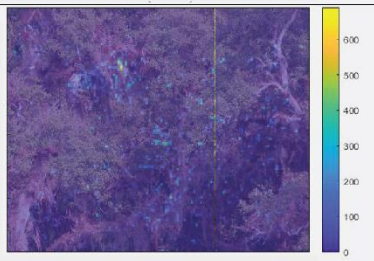
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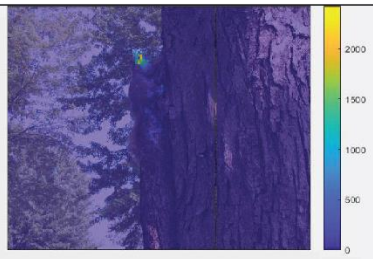
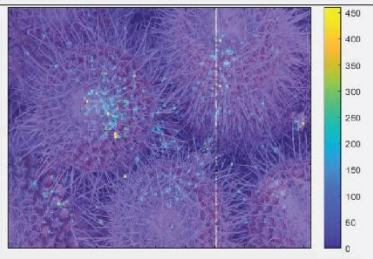
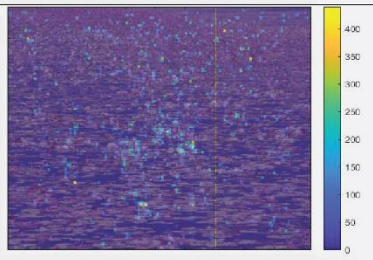
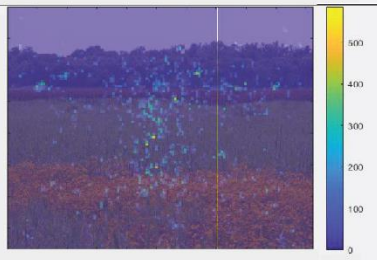
Appendix B – 2

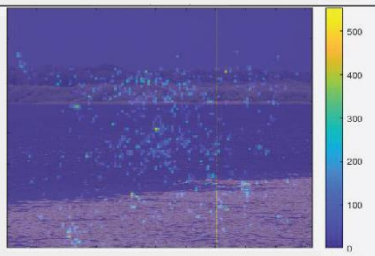
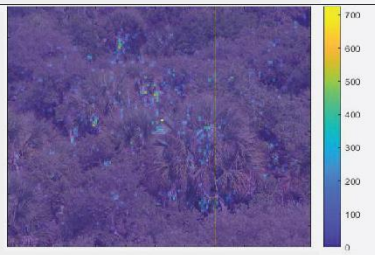
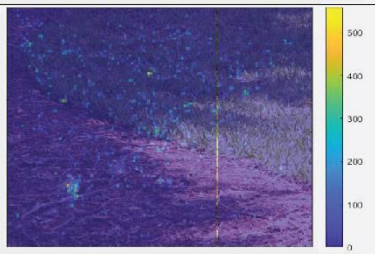
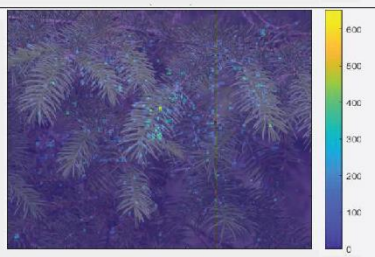
Heat Maps: Study 2

The study uses 40 images extracted from the McGill Calibrated Colour Image Database (Olmos and Kingdom, 2004). In order to identify the foci of attention via eye-tracking, heat maps (HM) were plotted for each view. In the table, the yellow, green, and blue colours represent, in descending order of occurrence, the number of gaze points directed towards specific parts of the image. The absolute values that each of these colours characterises (i.e., the scale used for the heat maps) differ from image to image so as to better adapt to the whole range of gaze behaviours to be represented. Image size is 1024 x 768 pixels.

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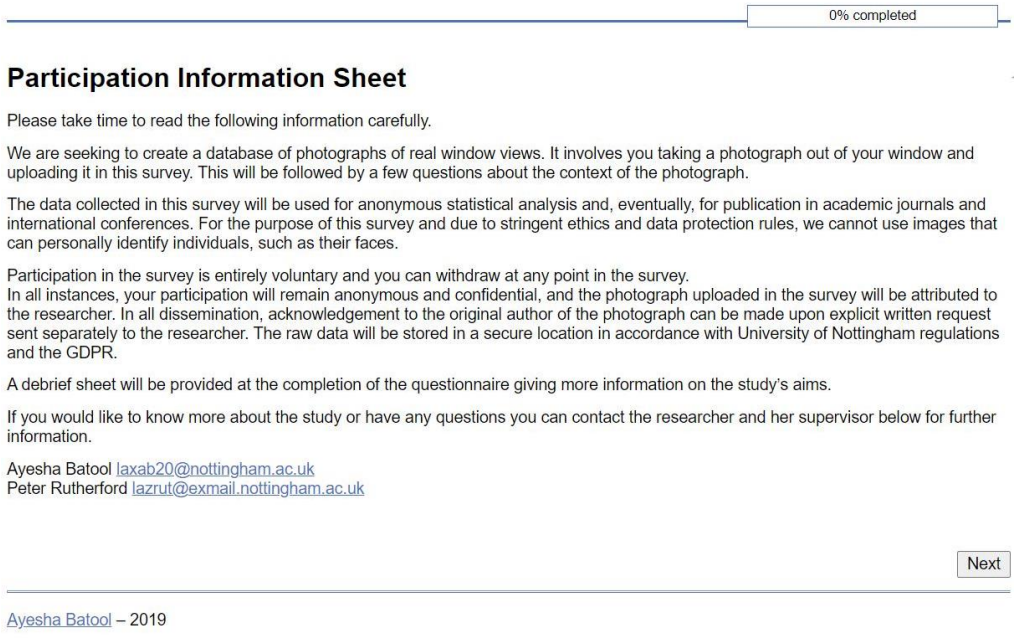
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i29		i30	

ID	Image Heat Map	ID	Image Heat Map
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i33		i34	
i35		i36	
i37		i38	
i39		i40	

Appendix C

Window View Survey

Screenshots of window view survey are presented below.



0% completed

Participation Information Sheet

Please take time to read the following information carefully.

We are seeking to create a database of photographs of real window views. It involves you taking a photograph out of your window and uploading it in this survey. This will be followed by a few questions about the context of the photograph.

The data collected in this survey will be used for anonymous statistical analysis and, eventually, for publication in academic journals and international conferences. For the purpose of this survey and due to stringent ethics and data protection rules, we cannot use images that can personally identify individuals, such as their faces.

Participation in the survey is entirely voluntary and you can withdraw at any point in the survey.
In all instances, your participation will remain anonymous and confidential, and the photograph uploaded in the survey will be attributed to the researcher. In all dissemination, acknowledgement to the original author of the photograph can be made upon explicit written request sent separately to the researcher. The raw data will be stored in a secure location in accordance with University of Nottingham regulations and the GDPR.

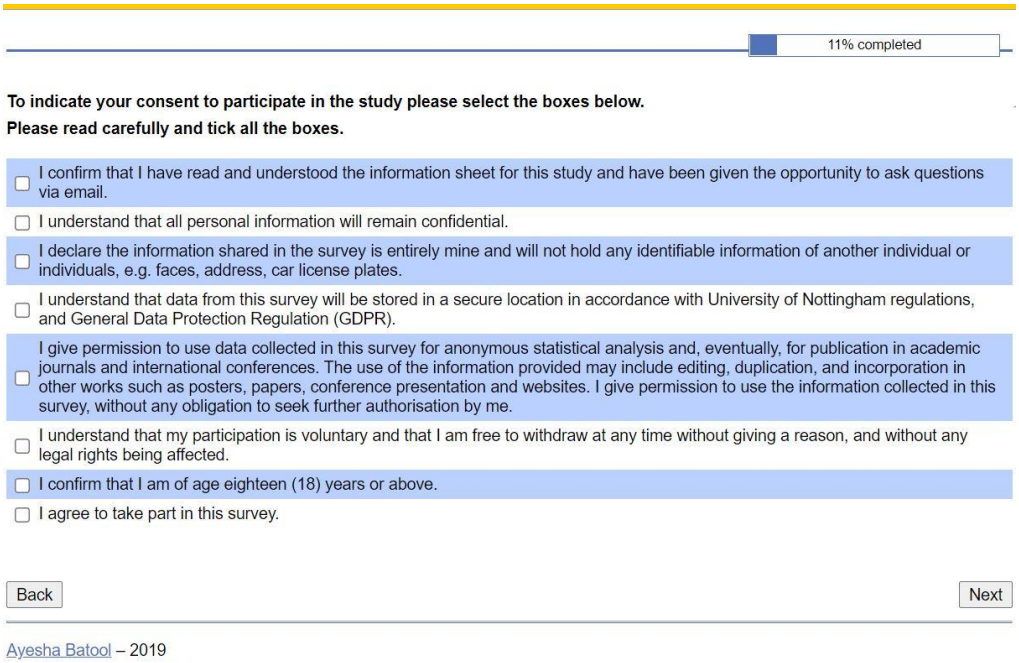
A debrief sheet will be provided at the completion of the questionnaire giving more information on the study's aims.

If you would like to know more about the study or have any questions you can contact the researcher and her supervisor below for further information.

Ayesha Batool laxab20@nottingham.ac.uk
Peter Rutherford lazrut@exmail.nottingham.ac.uk

Next

Ayesha Batool – 2019



11% completed

To indicate your consent to participate in the study please select the boxes below.
Please read carefully and tick all the boxes.

- ☐ I confirm that I have read and understood the information sheet for this study and have been given the opportunity to ask questions via email.
- ☐ I understand that all personal information will remain confidential.
- ☐ I declare the information shared in the survey is entirely mine and will not hold any identifiable information of another individual or individuals, e.g. faces, address, car license plates.
- ☐ I understand that data from this survey will be stored in a secure location in accordance with University of Nottingham regulations, and General Data Protection Regulation (GDPR).
- ☐ I give permission to use data collected in this survey for anonymous statistical analysis and, eventually, for publication in academic journals and international conferences. The use of the information provided may include editing, duplication, and incorporation in other works such as posters, papers, conference presentation and websites. I give permission to use the information collected in this survey, without any obligation to seek further authorisation by me.
- ☐ I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason, and without any legal rights being affected.
- ☐ I confirm that I am of age eighteen (18) years or above.
- ☐ I agree to take part in this survey.

Back Next

Ayesha Batool – 2019

11% completed

Please choose at least 8 option(s)!

Please also answer this question – Your answer to this question is of importance to this study.

To indicate your consent to participate in the study please select the boxes below.

Please read carefully and tick all the boxes.

- [ ] I confirm that I have read and understood the information sheet for this study and have been given the opportunity to ask questions via email.
- [ ] I understand that all personal information will remain confidential.
- [ ] I declare the information shared in the survey is entirely mine and will not hold any identifiable information of another individual or individuals, e.g. faces, address, car license plates.
- [ ] I understand that data from this survey will be stored in a secure location in accordance with University of Nottingham regulations, and General Data Protection Regulation (GDPR).
- [ ] I give permission to use data collected in this survey for anonymous statistical analysis and, eventually, for publication in academic journals and international conferences. The use of the information provided may include editing, duplication, and incorporation in other works such as posters, papers, conference presentation and websites. I give permission to use the information collected in this survey, without any obligation to seek further authorisation by me.
- [ ] I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason, and without any legal rights being affected.
- [ ] I confirm that I am of age eighteen (18) years or above.
- [ ] I agree to take part in this survey.

Back Next

22% completed

What is your first language?

- ○ English
- ○ Other – Please State

Back Next

Ayesha Batool – 2019

33% completed

Could you please take a photograph of the view out of your window and upload it here?

Please take a clear photograph of the view outside of your window.

The Photograph must:

1. be clear
2. exclude any identifiable information of an individual (e.g. face)
3. be focused
4. if possible include as little internal environment of the room and just focus on the view while looking out of the window
5. if possible, the photograph should be taken from a position perpendicular to the window

You may use your digital camera, smartphone, or tablet to take this photograph.

Max file size 4MB Choose File No file chosen

Back Next

Ayesha Batool – 2019

44% completed

Where was the photograph taken?

Please type the location of the photograph.

Country

Nearest town or city

Which floor are you on?

- [ ] Underground – below ground
- [ ] Ground
- [ ] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [ ] 5
- [ ] Other

How long have you occupied the place (e.g., desk) from where the photograph was taken?

Please select from the following options.

- ○ Less than 3 months
- ○ 3 – 6 months
- ○ Between 6 months and 1 year
- ○ 1-3 years
- ○ More than 3 years

Which type of device was used to take the photograph of the window view?

[Please choose]

Can you identify the model or make of the device that was used to take the photograph of the window view?

Please enter the full name and model of the device.

Model

Back Next

Ayesha Batool – 2019

44% completed

Please also answer this question – Your answer to this question is of importance to this study.

Please choose at least 1 option(s)!

Where was the photograph taken?

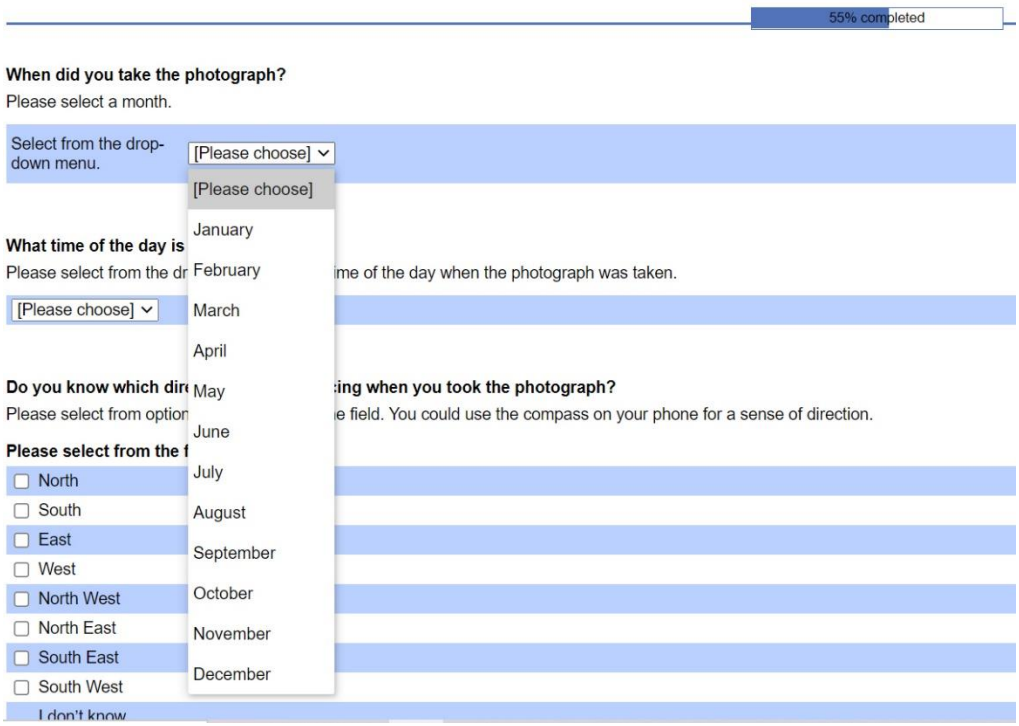
Please type the location of the photograph.

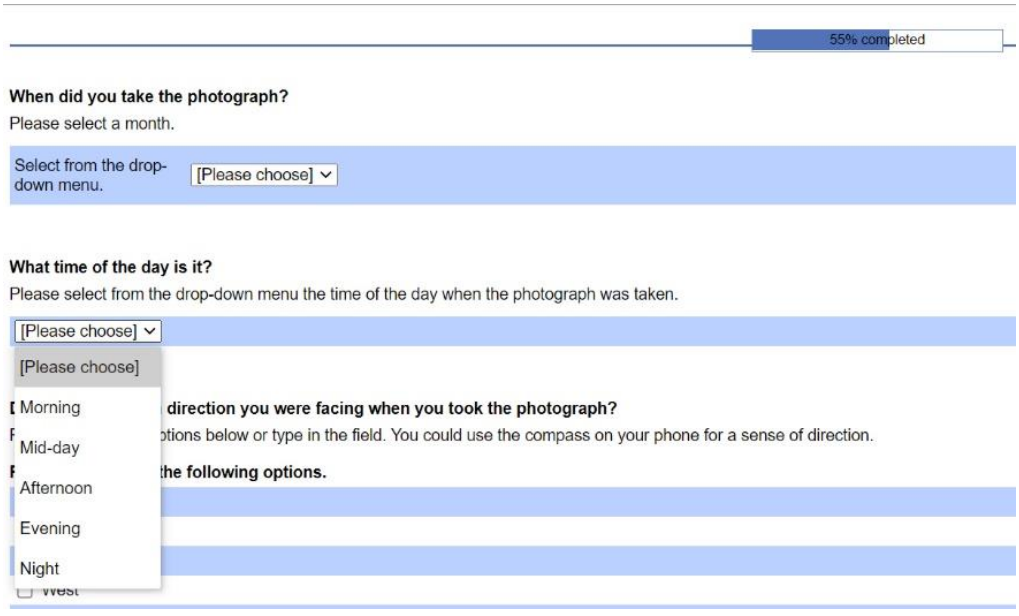
Country

Nearest town or city

Which floor are you on?

- ☐ Underground – below ground
- ☐ Ground
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ Other


55% completed
When did you take the photograph?
Please select a month.
Select from the drop-down menu.
[Please choose]
[Please choose]
January
February
March
April
May
June
July
August
September
October
November
December
What time of the day is
Please select from the dr
me of the day when the photograph was taken.
[Please choose]
Do you know which dir
ing when you took the photograph?
Please select from option
e field. You could use the compass on your phone for a sense of direction.
Please select from the f
North
South
East
West
North West
North East
South East
South West
I don't know


55% completed
When did you take the photograph?
Please select a month.
Select from the drop-down menu.
[Please choose]
What time of the day is it?
Please select from the drop-down menu the time of the day when the photograph was taken.
[Please choose]
[Please choose]
Morning
Mid-day
Afternoon
Evening
Night
direction you were facing when you took the photograph?
tions below or type in the field. You could use the compass on your phone for a sense of direction.
he following options.

Do you know which direction you were facing when you took the photograph?

Please select from options below or type in the field. You could use the compass on your phone for a sense of direction.

Please select from the following options.

- ☐ North
- ☐ South
- ☐ East
- ☐ West
- ☐ North West
- ☐ North East
- ☐ South East
- ☐ South West
- ☐ I don't know

Do you know which window elements are present in this photograph?

Sometimes window elements may be present when we are looking out of a window. These include window glass if the window is shut, wire mesh, blinds, etc.

Please select from options below.	Yes	No	Maybe
Glass	○	○	○
Wire mesh	○	○	○
External Shading, (e.g., louvers, overhangs, etc.)	○	○	○
Internal Shading, (e.g., blinds, curtains, etc.)	○	○	○
Any other shading device	○	○	○

If the window was closed when the photograph was taken, do you know if the glass is tinted (e.g., coloured, darkened, etc.)? Ignore this question if the window was open at the time of the photograph.

Tinted Glass	○	○	○

In your space, are you able to control the shading (e.g., blind, curtain, etc.)?

- ○ Yes
- ○ No
- ○ Does not apply

If the blind/curtain on your window is shut, why would you open it?

(Please read all options before checking maximum 3 answers)

- ☐ Let daylight in
- ☐ Tell me how the weather is outside
- ☐ Tell me the time of day
- ☐ Increase or decrease the ventilation
- ☐ Provide light to plants
- ☐ Let me observe other people and activities outside
- ☐ Provide good lighting in the space
- ☐ Provide a view out
- ☐ Allows me to look away from my task (e.g., computer screen)
- ☐ Let me interact with something/someone on the other side of the window
- ☐ Other

Can you estimate the distance to the window from your usual location in this space?

For example, if you were in an office the distance in meters (feet) between your location and the nearest window.

- ○ Adjacent to Window
- ○ 1 meter (1- 3 feet)
- ○ 1-2 meters (4- 6 feet) away
- ○ More than 3 meters (7 feet+) away
- ○ Other

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Ayesha Batool – 2019

67% completed

How much do you prefer this window view?

Preference is also known as how much you like the window view, for whatever reasons you may have.

Drag the slider below to give your response on the line on how much you prefer the image from left (least preferred) to right (most preferred).

Least Preferred — Most Preferred

Preference

How familiar or known is this window view to you?

Familiarity means how much the window view is known to you or how acquainted you are to it.

Drag the slider below to give your response on the line on how familiar this window view is to you: left (not at all familiar) to right (extremely familiar).

Not at all Familiar — Extremely Familiar

Familiarity

Please indicate how satisfied you are with the following regarding the window.

Drag the slider below to give your response on the line on how satisfied from least (left) to most (right).

The size of the window



View out of the window



Your usual location relative to the window (s)



The size of the room with respect to the window



Which of the following statements do you find the most positive about the window?

(Please read all options before checking maximum 3 answers)

No more than 3 answers

- [ ] None
- [ ] Tells me the time of day
- [ ] Lets daylight in
- [ ] Tells me how the weather is outside
- [ ] Provides light to plants
- [ ] Allows me to look away from my task (e.g., computer screen)
- [ ] Allows fresh air into the space
- [ ] Provides good lighting in the space
- [ ] Provides a view out
- [ ] Lets me observe other people and activities outside
- [ ] Lets me interact with something/someone on the other side of the window
- [ ] Other

Which of the following statements do you find the most negative about the window?

(Please read all options before checking maximum 3 answers)

No more than 3 answers

- [ ] None
- [ ] Allows too much heat
- [ ] Allows too much sunlight
- [ ] Provides too much cold draft in winter
- [ ] Activities outside distract me
- [ ] Allows too much noise from the street
- [ ] Causes annoying glare
- [ ] Can't see the ground
- [ ] Can't see the sky
- [ ] Reduces the ability to freely furnish the space
- [ ] Provides poor working light
- [ ] Allows others to see inside
- [ ] Other

What is it that you like about this view through the window?

What do you especially notice when you look?

Type here

What is it that you dislike about this view through the window?

Type here

What day is it today?

Select from the drop-down menu. [Please choose]

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Ayesha Batool – 2019

Additional Questions in SURVEY 2

78% completed

Has your workspace arrangement or location been affected by the current COVID-19 lock-down?

- [ ] Yes
- [ ] No

If you answered yes to the above question, could you please add some details on your interaction with your window?

For example: Did you set up your new workspace close to your window, and why? Do you open your window or your blinds more often? Do you spend more or less time looking out of the window? Is there something of your view that you appreciate more or less now?

Type here

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Appendix D

Composite Features of Windows – Sun Burst Charts

This section presents the sunburst charts created to illustrate the relationships between the selected features of windows in Study 3. The detailed explanation on reading a sunburst chart is presented in Section 3.2.7. The following section present the sunburst charts along with the key presented at the beginning of each section, positive and negative window features.

Positive window features

Participants were presented with 11 choices of positive window features out of which they were offered to choose up to three. These are:

A None
B Tells me the time of day
C Lets daylight in
D Tells me how the weather is outside
E Provides light to plants
F Allows me to look away from my task (e.g., computer screen)
G Allows fresh air into the space
H Provides good lighting in the space
I Provides a view out
J Lets me observe other people and activities outside
K Lets me interact with something/someone on the other side of the window

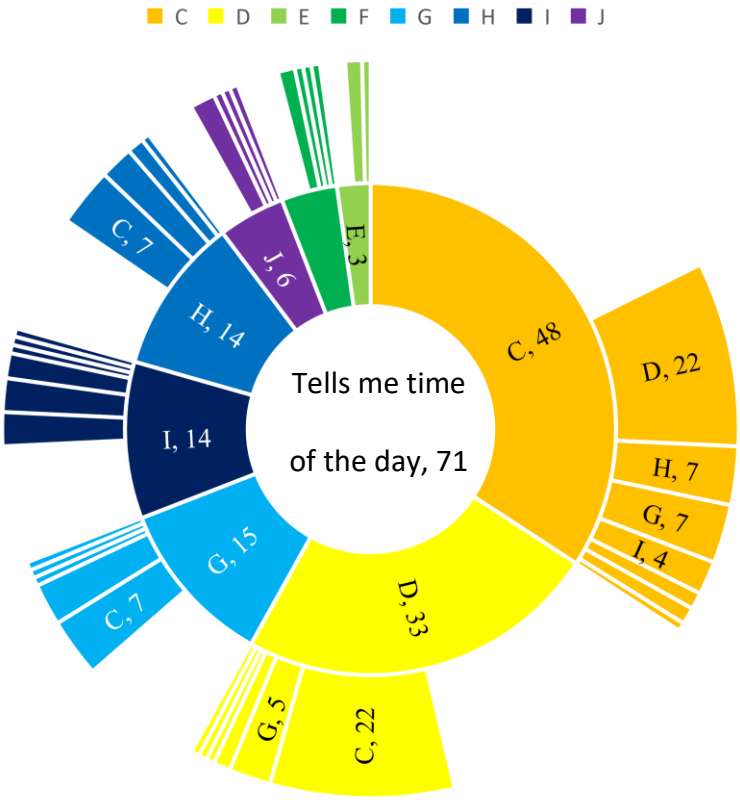
A detailed account of the most frequently selected features is presented in Section 5.2.4. The following sections present the sunburst charts corresponding to all variables, with each variable held at the centre of the sunburst chart.

A. None

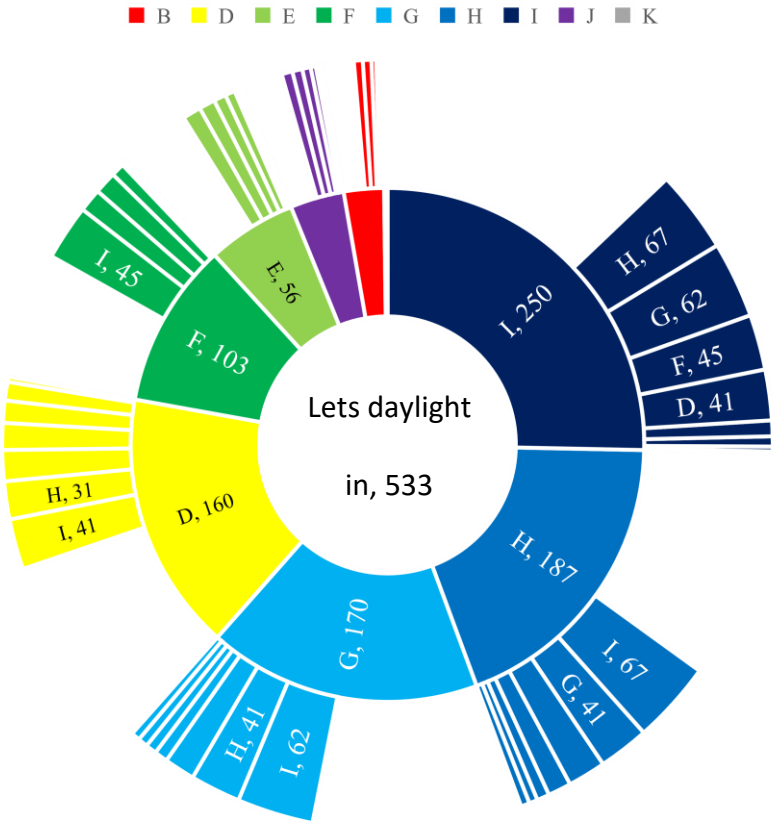
A	3

None was selected only by three participants and in isolation from other features, therefore a sunburst chart could not be generated.

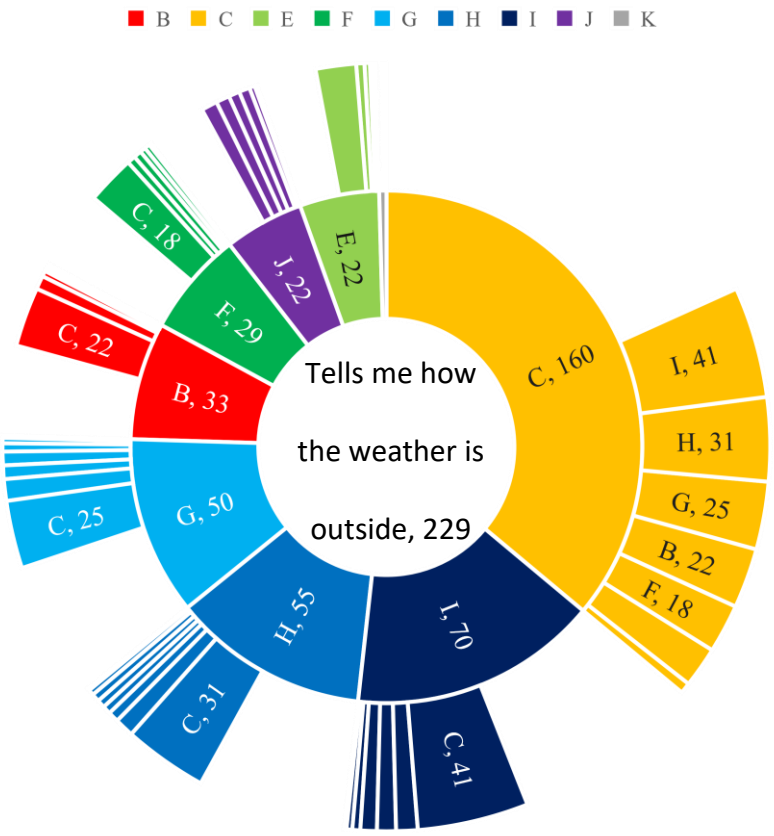
B. Tells me time of the day



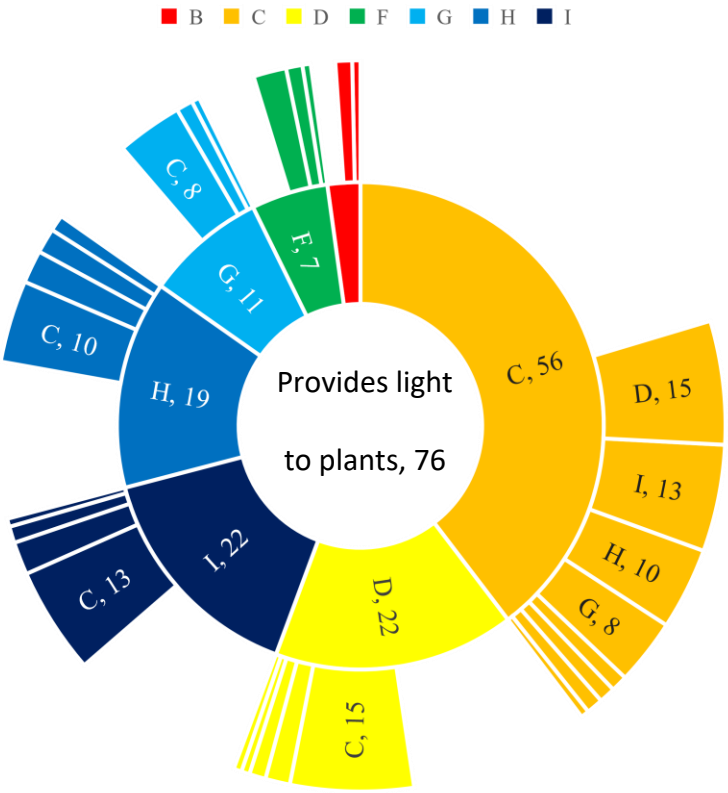
C. Lets daylight in



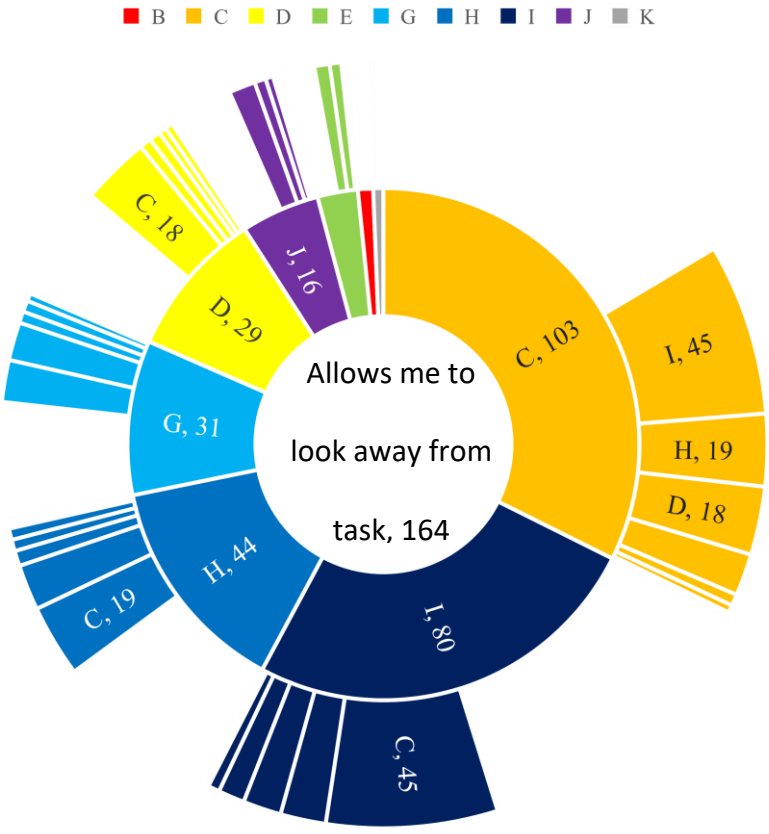
D. Tells me how the weather is outside



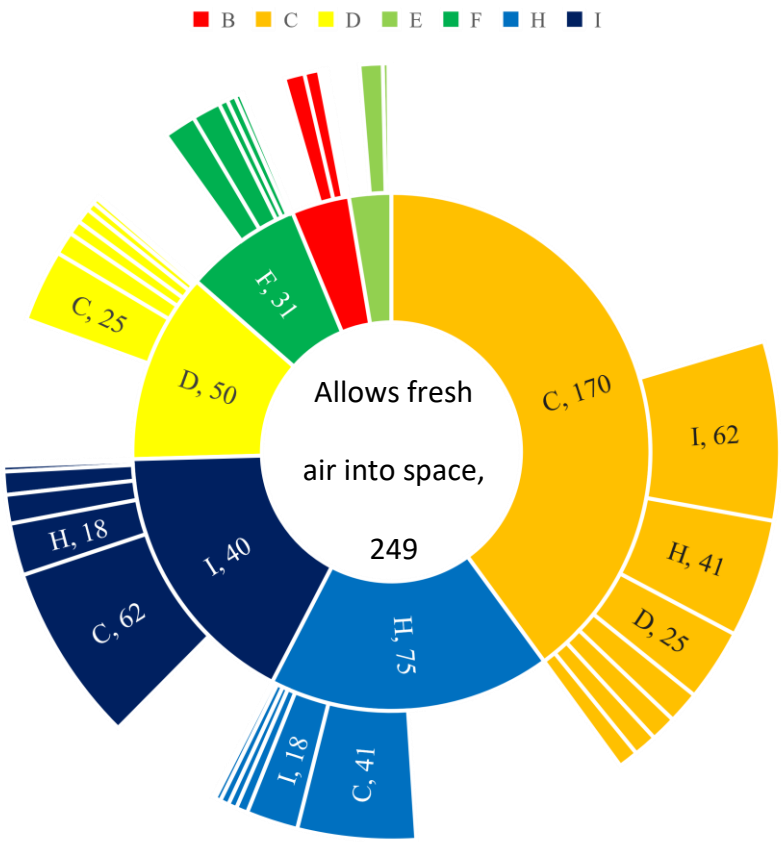
E. Provides light to plants



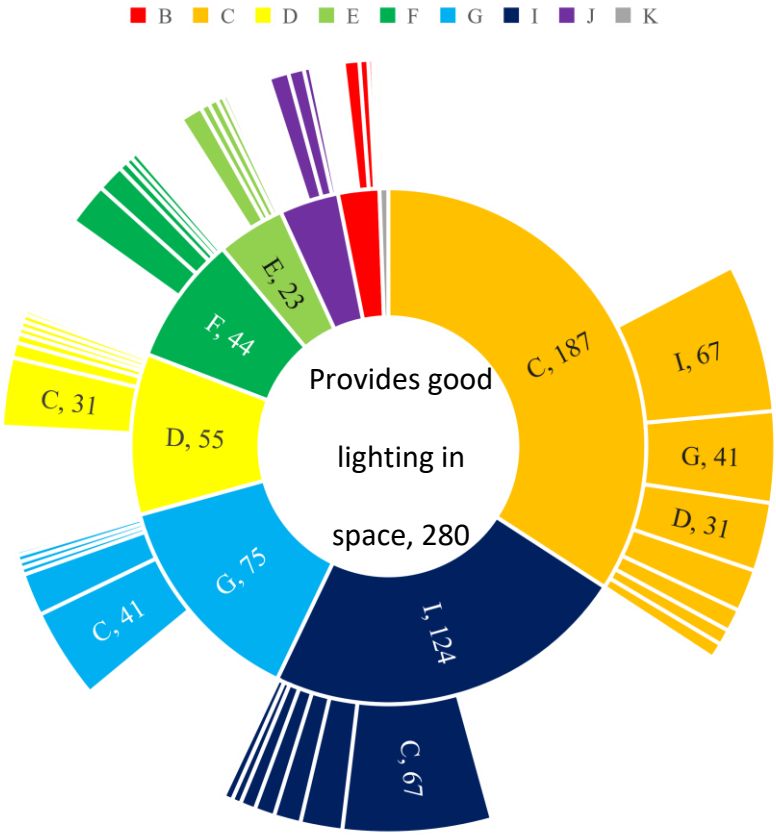
F. Allows me to look away from the task (e.g. computer screen)



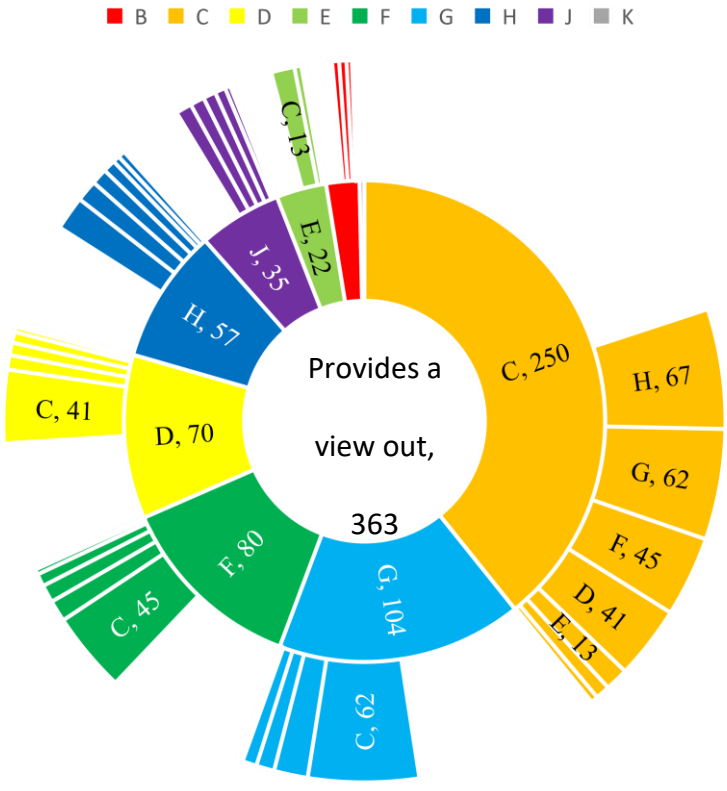
G. Allows fresh air into the space



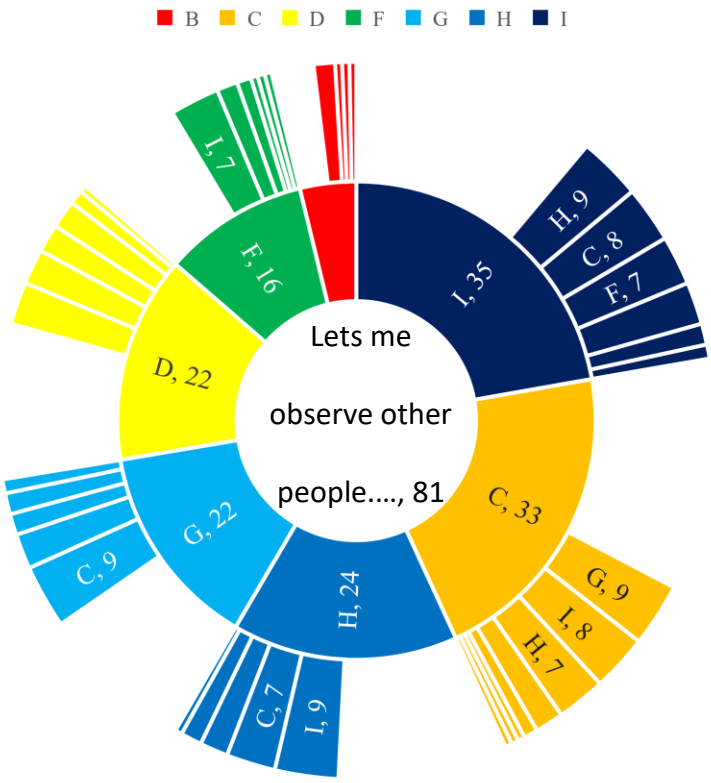
H. Provides good lighting in space



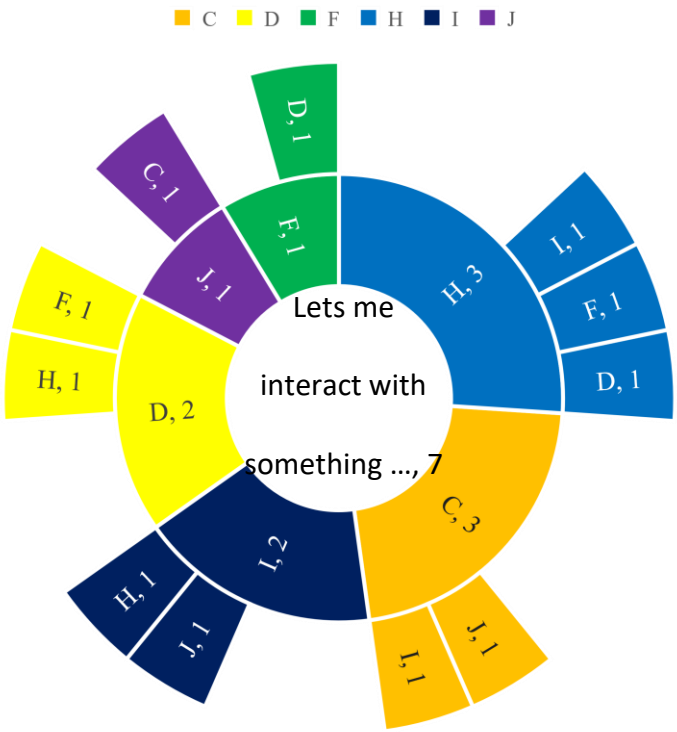
I. Provides a view out



J. Lets me observe other people and activities outside



K. Lets me interact with something/someone on the other side of the window



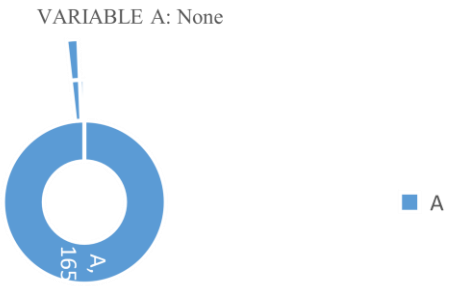
Negative Window Variables

As explained in Section 3.2.7, participants in Study 3 were presented with 12 choices of negative window features out of which they were offered to choose up to three. These are:

A	None
B	Allows too much heat
C	Allows too much sunlight
D	Provides too much cold draft in winter
E	Activities outside distract me
F	Allows too much noise from the street
G	Causes annoying glare
H	Can't see the ground
I	Can't see the sky
J	Reduces the ability to freely furnish the space
K	Provides poor working light
L	Allows others to see inside

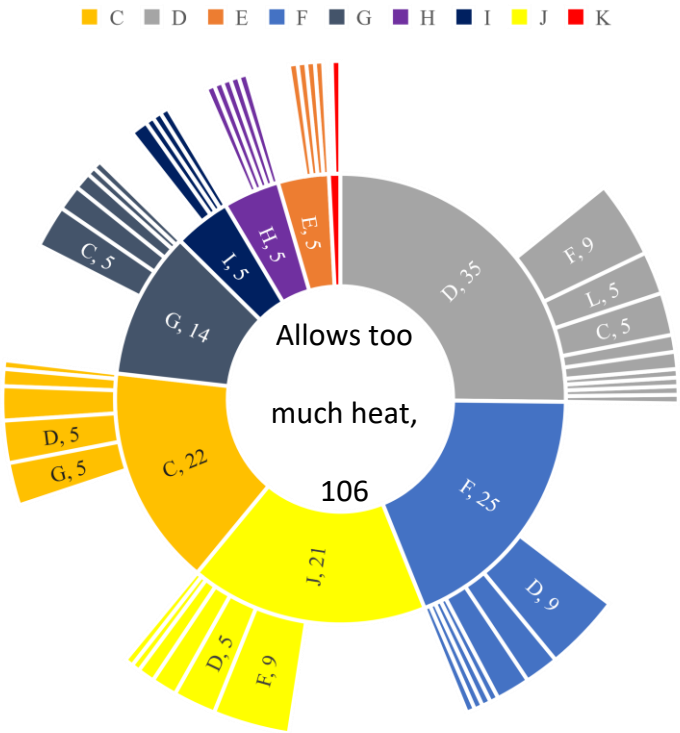
A detailed account of the sunburst chart corresponding to most frequently selected negative features is presented in Section 5.2.4. Sunburst charts of all features held as anchors are presented here.

A. None

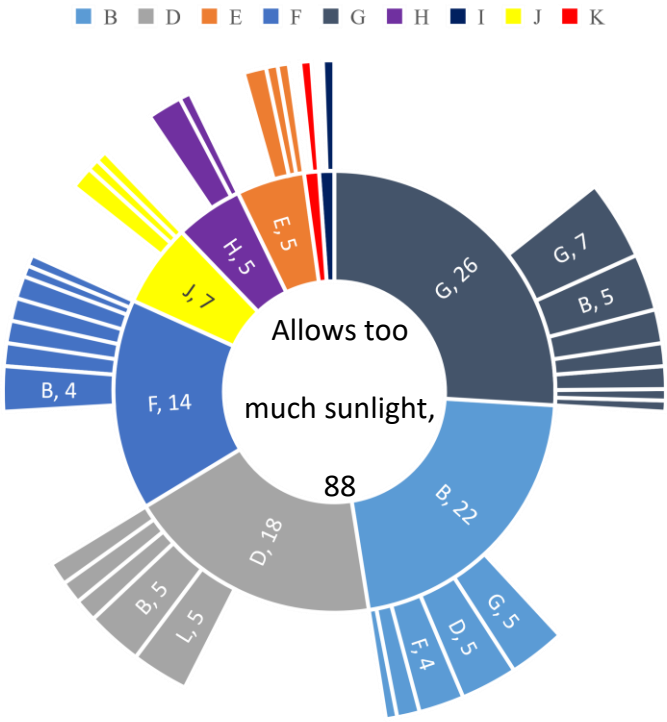


None was most often selected on its own, therefore the sunburst chart is presented in this way.

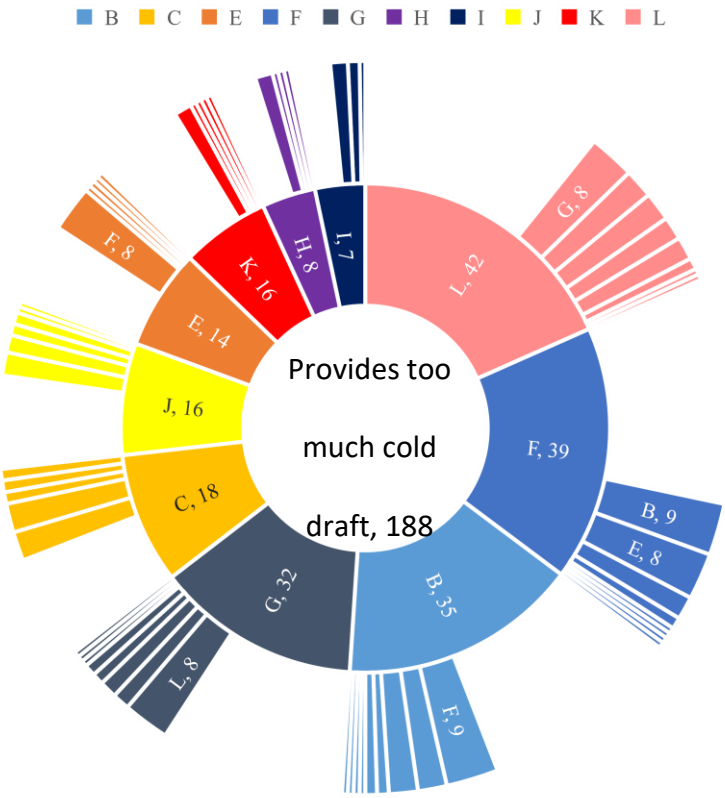
B. Allows too much heat



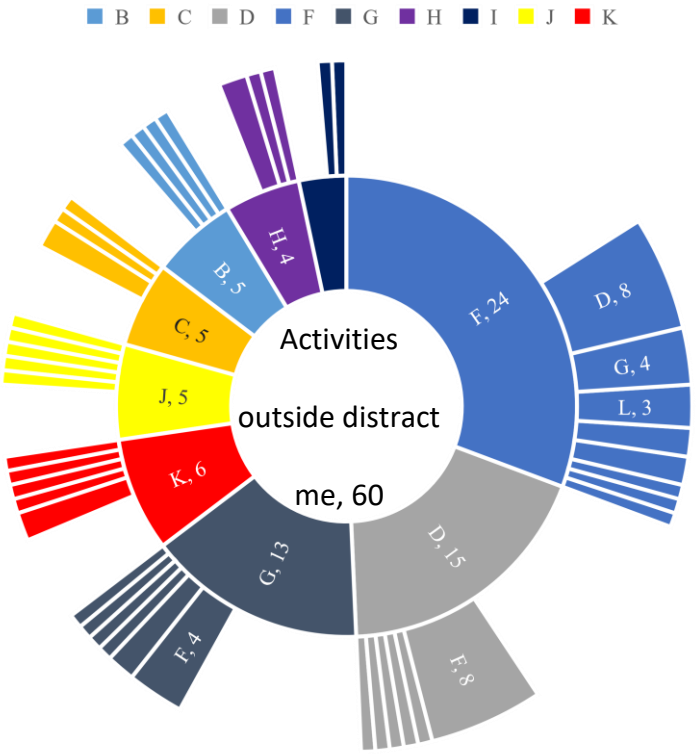
C. Allows too much sunlight



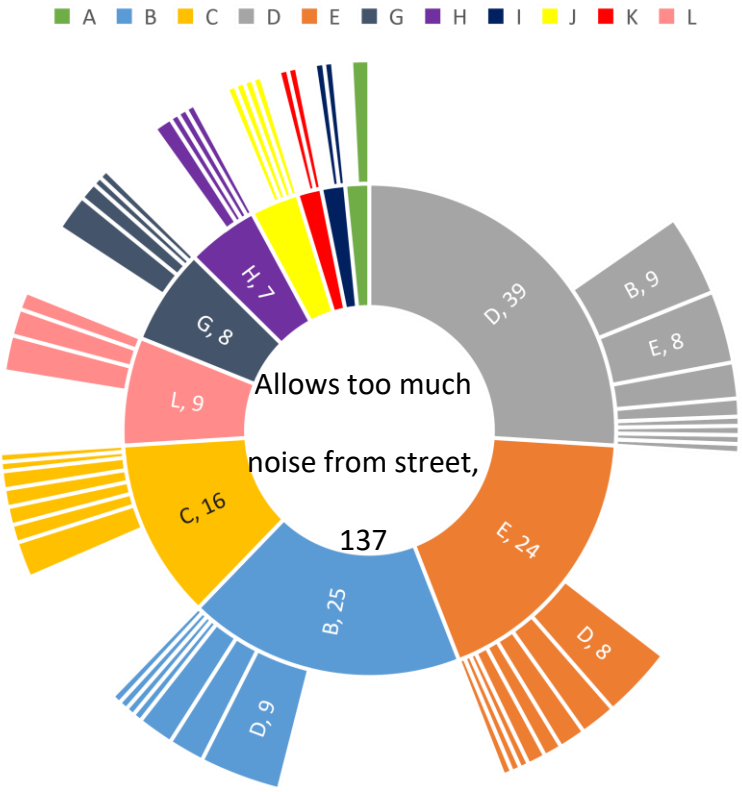
D. Provides too much cold draft in winter



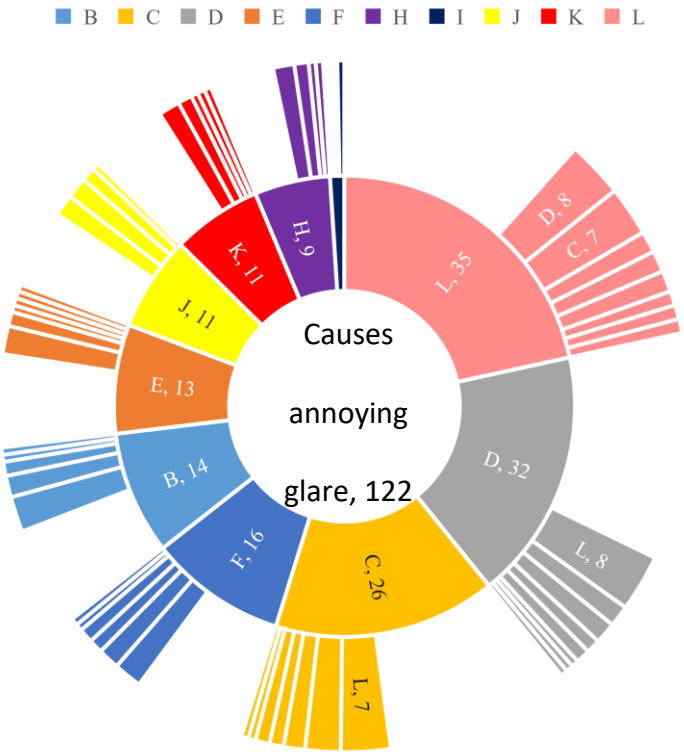
E. Activities outside distract me



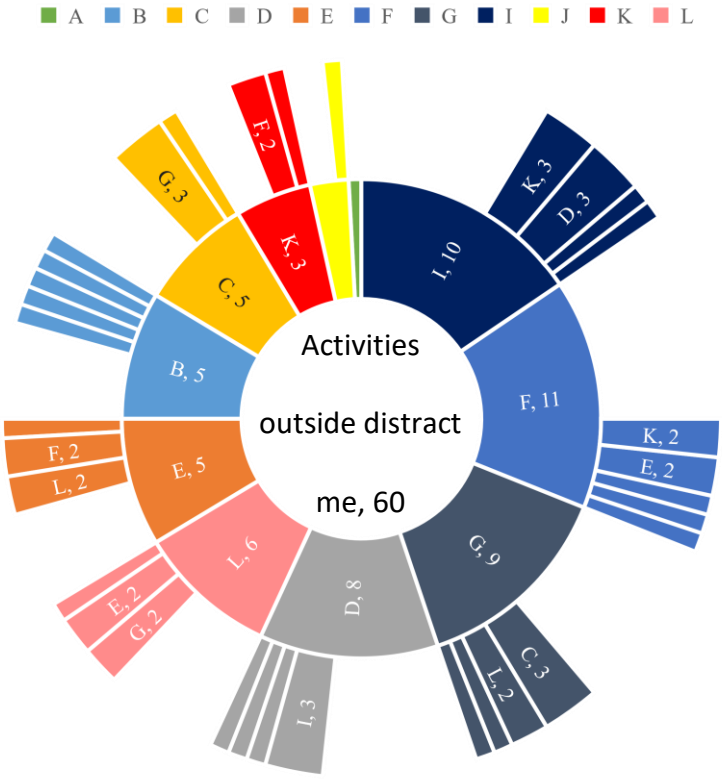
F. Allows too much noise from the street



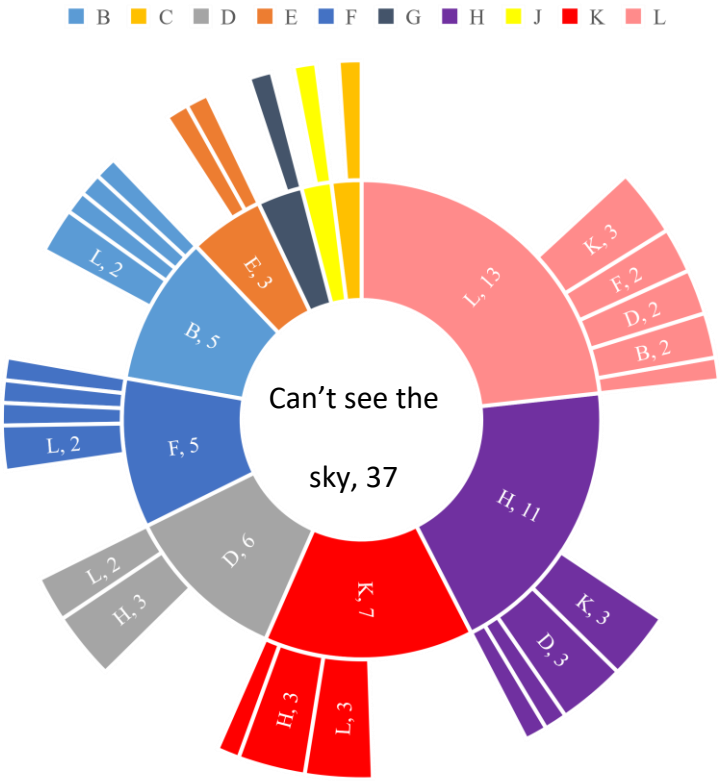
G. Causes annoying glare



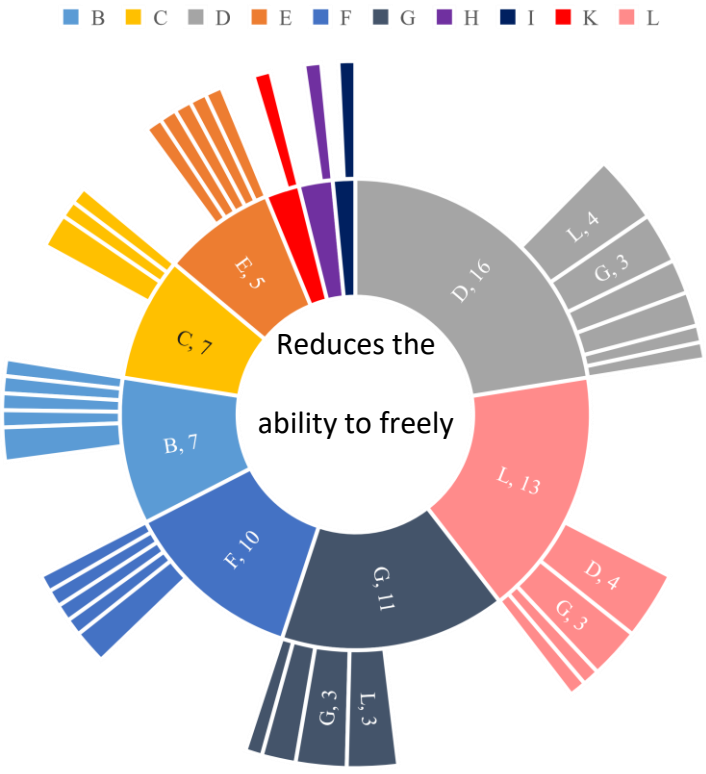
H. Can't see the ground



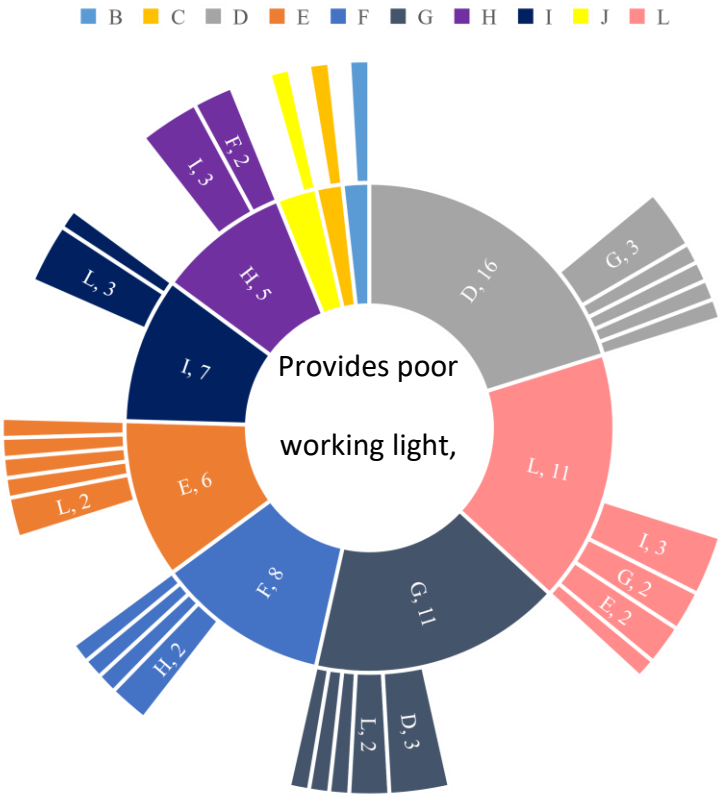
I. Can't see the sky



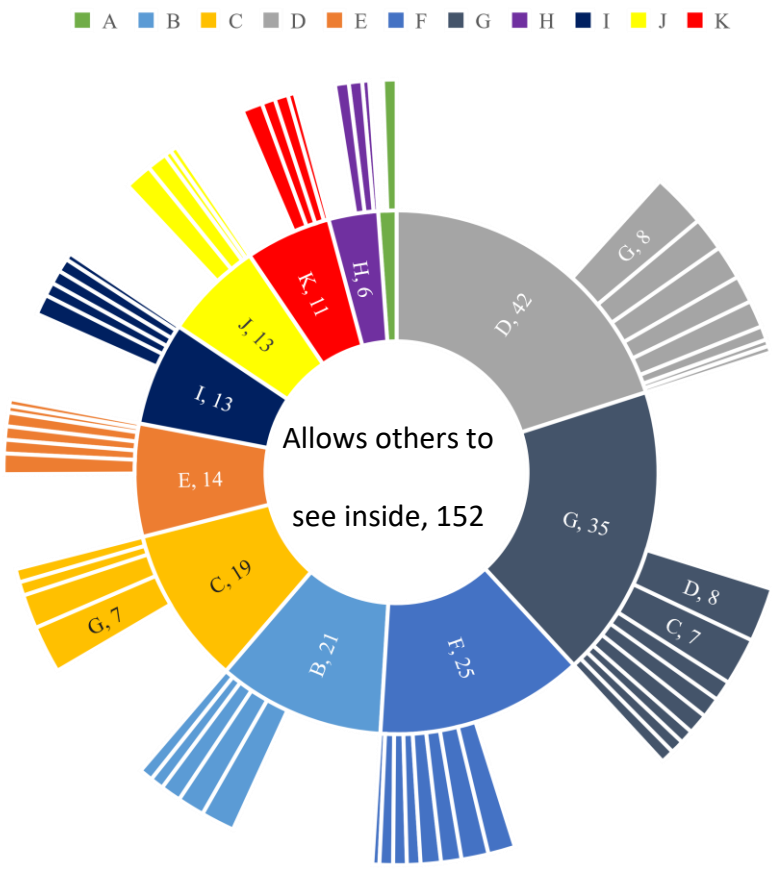
J. Reduces the ability to freely furnish the space



K. **Provides poor working light**



I. Allows others to see inside



Appendix E

Stages of Conducting a Necessary Condition Analysis (Dul 2015, 2020)

There are six recommended steps in the analysis process.

1. Making a graphical representation of the X-Y relationship, that is, to create two-dimensional X-Y scatter plots, for all independent variables (positive window attributes and negative window attributes) and window view preference as the dependent variable. This was done using the scatter plot feature in SPSS (version 25.0).
2. Identifying the empty space in the top left corner - involves visual inspection of the plots, in order to identify which variables are fit for further analysis. In this data, two variables 'Tells me how the weather is outside' and 'Lets me observe other people and activities outside' had an empty space in the top left corner.
3. Drawing a ceiling line: involves the use of the software package in R (RStudio, 2020) to be implemented (Dul, 2015). This was carried out by importing the two independent variables along with the dependent variable, window view preference, dataset in R and running NCA R package.
4. Quantify the NCA parameters: calculating the necessity effect size: The NCA R package calculates both the *d* effect size and the *p* value associated with this effect.
5. Evaluation of the results: Since the axis and order of variables makes the interpretation of results especially important. In our analysis,

using and testing two independent variables against window view preference, the Y axis of the latter if flipped, i.e., it decreases along the axis. This was done since the R package can identify only the results output for the empty space in the top left corner. Therefore, data was laid out in a way that the space could be interpreted. This means that the interpretation of the ceiling is this: The presence of the variable enables a minimum threshold of view preference, such that view preference below this value will not occur. In other words, the presence of X, is a necessary-but-not sufficient-condition for a high window view preference and guarantees a high view preference, above the threshold identified through the ceiling line, and presented as the effect size.

6. Formulation of a conclusion: Since the *p* values for both the variables were statistically significant ($p < 0.05$), and the values of *d* was found to greater than 0.00, the two variables, 'Tells me how the weather is outside' and 'Lets me observe other people and activities outside') are necessary-but-not-sufficient conditions for view preference.

Appendix F

Stringency Index as a measure of confinement measures during the time period in which Survey 2 was conducted.

Table F1 Stringency Index during Survey 2 for all countries except USA

Country	Number of Responses	Stringency Index$_{(Max)}$*	Stringency Index$_{(Average)}$**
Australia	2	73.15	67.32
Austria	2	87.96	82.20
Belgium	35	87.96	66.25
Bulgaria	1	96.30	82.08
Cambodia	1	93.52	75.36
Canada	2	79.63	75.93
Croatia	2	96.30	86.30
Cyprus	1	94.44	88.20
Czech Republic	1	85.19	73.51
Denmark	4	90.74	79.18
Egypt	2	94.44	89.12
Estonia	1	93.52	84.82
France	4	93.52	91.54
Germany	2	77.78	77.09
Greece	1	85.65	83.57
Hungary	1	76.85	72.10
India	1	100	84.96
Indonesia	1	86.11	77.16
Ireland	2	90.74	86.53
Israel	1	94.44	77.23
Italy	11	93.52	83.06
Lebanon	1	93.52	87.54
Malaysia	2	75.93	73.20
Netherlands	2	79.63	79.18
Nigeria	1	85.65	83.91
Norway	1	79.63	74.31
Pakistan	9	96.30	85.84
Poland	3	83.33	81.48
Portugal	5	87.96	84.30
Saudi Arabia	1	94.44	88.23

Country	Number of Responses	Stringency Index$_{(Max)}$*	Stringency Index$_{(Average)}$**
Slovenia	2	89.81	77.80
Spain	11	87.96	84.03
Switzerland	2	86.11	77.56
Turkey	1	96.30	86.47
United Kingdom	91	92.59	83.06

Note. 1
Sourced from Hale, et al. (2020a)

* Maximum stringency index achieved during the administration of Survey 2

** An average value of stringency index over the 30-day duration

Table F2 Stringency Index in selected USA states during Survey 2

State (USA)	Number of Responses	Stringency $Index_{(Max)}$*	Stringency $Index_{(Average)}$**
California	4	75.00	75.00
Colorado	1	75.93	73.51
Florida	1	73.15	72.85
Illinois	2	70.37	68.94
Indiana	1	73.15	62.19
Kansas	1	76.85	71.90
Massachusetts	5	55.56	54.48
Michigan	1	75.93	75.09
Montana	1	76.85	75.12
New York	4	74.07	73.53
Ohio	1	68.52	67.09
Oregon	1	70.37	70.19
Pennsylvania	2	65.74	63.83
Tennessee	1	62.96	61.23
Texas	1	72.69	70.96
Virginia	1	71.30	69.33

Note.

Sourced from Hale, et al. (2020b)

* Maximum stringency index achieved during the administration of Survey 2

** An average value of stringency index over the 30-day duration