Façade colour and aesthetic response: Examining patterns of response within the context of urban design and planning policy in Sydney

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Statement of originality

This thesis is my original work, and has not been submitted, in whole or in part, for a degree at this or any other university.   Nor does it contain, to the best of my knowledge and belief, any material published or written by another person, except as acknowledged in the text.

Zena O'Connor

Approval of the Human Ethics Committee

The Human Ethics Committee of the University of Sydney granted approval for the survey component of this research – Reference number 7289 April 2004.

Abstract

The overall aim of this research was to examine aesthetic response to façade colour. Drawing on a range of theories and studies from environment-behaviour studies (EBS), Nasar's (1994) probabilistic model of aesthetic response to building attributes provided a theoretical framework within which to examine patterns of response. Prompted by the Development Control Plan for Sydney Regional Environmental Plan: Sydney Harbour Catchment (NSWDOP, 2005), this research also linked its aims and methods to planning policy in Sydney.

The main research questions focussed on whether changes in aesthetic response are associated with variations in façade colour; and whether changes in judgements about building size, congruity and preference are associated with differences in façade colour. A quasi-experimental research design was used to examine patterns of aesthetic response. The independent variable was represented by four façade colours in two classifications. An existing process, environmental colour mapping, was augmented with digital technology and used to isolate, identify and manipulate the independent variable and for preparation of visual stimuli (Foote, 1983; Iijima, 1995; Lenclos, 1977; Porter, 1997). Façade colour classifications were created from extant colour theories (including those of Albers, 1963; Hard & Sivik, 2001 and Itten, 1961). The façade colour classifications were further developed using F-sort and Q-sort methodology (Amin, 2000; Miller, Wiley & Wolfe, 1986; Stephenson, 1953). Ten dependent variables, linked to overall aesthetic response, were drawn from studies relating to environmental evaluation, building congruity and preference (Groat, 1992; Janssens, 2001; Russell, 1988; Russell, 2003; Russell, Ward & Pratt, 1981; Wohlwill & Harris, 1980). The dependent variables were presented in the form of a semantic differential rating scale and a sample group of 288 evaluated the visual stimuli. The Latin-square technique was used for the controlled presentation of visual stimuli. Factor analysis, correlation analysis and analysis of variance were applied to the data.

The findings indicate that variations in aesthetic response are associated with differences in façade colour. Judgements about building size varied by up to 5% and buildings featuring contrasting façade colours were judged to be larger and more dominant. Judgements about a building's congruity varied by up to 13% and buildings that featured harmonious colours were considered to be more congruous. Preference varied and harmonious façade colours were not necessarily preferred over contrasting façade colours.

The outcomes from this research suggest that a new approach to façade colour within the context of planning policy may be appropriate. A model of façade colour evaluation is presented and, unlike current planning guidelines, the model allows for a participatory approach to façade colour evaluation and specification. The model allows for factors that may influence aesthetic response to façade colour (such as contextual, perceptual and idiographic factors) as well as variation in architectural expression with respect to façade colour.

Acknowledgements

TABLE OF CONTENTS

List of Figures and Tables

List of Figures and Tables (continued)

List of Figures and Tables (continued)

Note: The images on the first page of each key section feature an apartment building in Kirribilli, Sydney. Each image is identical but digitally manipulated so that the façade colour of the apartment building matches the colour characteristics of an element from its surroundings. The image on the first page of the Methods section depicts the apartment building's current colour (Original photograph and images by Z O'Connor).

INTRODUCTION

This research examines the relationship between façade colour and aesthetic response within the context of urban design and planning policy in Sydney, Australia. The introductory chapter comprises seven sections as follows:

- Façade colour and planning policy: An urban design dilemma?
- Summary of the research aims and questions;
- Overview of the main theories relevant to this research;
- Outline of the research methodologies;
- Scope of the research;
- Summary of the key research findings and outcomes;
- Organisational structure of the thesis;

Façade colour and planning policy: An urban design dilemma?

This research was prompted by front page headlines in *The Sydney Morning Herald,* Sydney's leading daily broadsheet newspaper, on 3 July 2004 (see Figure 1). The main headline ("Strict new rules to save the harbour") referred to a draft Development Control Plan for Sydney Harbour foreshores. One sub-headline ("Colour-coded") drew attention to a requirement for building facades to "complement the harbour" (*SMH*, 2004, p1). A second sub-headline ("No eyesores") highlighted a requirement under the Plan whereby "all new structures must fit in with the landscape" (*SMH,* 2004, p1). In short, implementation of the Plan would result in Harbour foreshores scattered with buildings that would be effectively colour-camouflaged to match the colours of the natural surroundings and obscure their existence.

Figure 1. Facsimile of the front page of the Sydney Morning Herald of 3 July 2004.

Released in its final form in 2005, the Plan (NSWDOP, 2005) contends that façade colour impacts on visual quality, and more specifically, the Plan suggests that façade colour characteristics that contrast with the colour characteristics of the natural surroundings impact negatively on the unique visual qualities of Sydney Harbour.[1] On reflection, I was unable to understand the logic and implications of this contention and it occurred to me that the opposite seemed to hold true for buildings by architects such as Luis Barragán and locations such as Positano and Santorini – locations noted for their visual quality and scenic appeal and whose buildings are not only not colour-camouflaged but often vibrantly contrasting.

The Plan was touted as a sorely needed response to the existing state of urban affairs on Sydney Harbour and prompted the Mayor of North Sydney, Genia McCaffery, to declare: "This is the strategic direction that Sydney wants for the Harbour" (*SMH*, 2004, p1). To explain, while successive Governments protected many sections of Sydney Harbour foreshores, urban development in most areas around Sydney Harbour has occurred in an *ad hoc* manner that didn't always realise the "opportunities worthy of her setting" (Uren, 2005, p59). Sydney has been described as a "work in progress" and successive development and redevelopment has resulted in a "vileness of our built responses" wherein "butt-locked red-brickery" sit side by side with contemporary *pieds a terre*, buildings of heritage value and high-rise Modernist apartment buildings with the occasional marina, boatshed, wharf and harbour-side restaurant (Farrelly, 2005, p109). As a result, development around Sydney Harbour foreshores is thought by some to be somewhat of a mish-mash of architectural styles.

One of the key aims of the Plan, released in its final form in 2005, was "to maintain, protect and enhance the unique visual qualities of Sydney Harbour" (NSWDOP, 2005, p2). In addition, the Plan included performance criteria for all development applications aimed at "ensuring the scenic quality of the area is protected or enhanced" (NSWDOP, 2005, p2). The Plan noted that the "height, width, siting, scale, colour, reflectivity and function" of developments influenced visual quality, and a clear implication within the Plan was an assumption that contrasting façade colour has a negative impact on visual quality (NSWDOP, 2005, p17). The guidelines relating to façade colour within the Plan were narrow and prescriptive. For example,

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[1] The Plan's full title is *Development Control Plan for Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005* but it is also referred to *as Sydney Harbour Foreshores and Waterways Area Development Control Plan 2005*.

"Landscape character type 1: Developments…overall colours should match the natural vegetation" (NSWDOP, 2005, p19).

"Colours should be sympathetic with their surrounds and consistent with the colour criteria where specified for particular landscape character types" (NSWDOP, 2005, p49).

"Exterior colours should be compatible with the overall landscape character type…olive and mangrove greens are preferred" (NSWDOP, 2005, p52).

The nature of these façade colour guidelines prompted a series of questions in regard to the relationship between façade colour and aesthetic response: What exactly are 'sympathetic', 'compatible' or 'contrasting' façade colours? Are responses to façade colour universal and predictable as the Plan seems to imply; or, are responses linked to individual differences? Turning to the issues of visual quality and visual impact: How does façade colour influence the visual impact of a building? Does façade colour influence judgements of congruity or size? Does façade colour contrast impact in a positive or negative way on visual quality? Do colour-camouflaged buildings impact positively or negatively on visual quality? What are façade colour preferences? Finally, the Plan also provoked a series of questions about the nature of the planning instrument itself: Why are the guidelines so narrow and prescriptive? Why are the guidelines seemingly undemocratic and inflexible? Where was the opportunity for a participatory approach to decision-making with regard to façade colour selection? Furthermore, how did the plan allow for architectural expression in regard to façade colour? Finally, do similar planning guidelines relating to façade colour guidelines exist in places like Positano or Santorini?

These questions formed the overall context within which this research was conducted. While the breadth and range of these questions were beyond the scope of this research, the main research aims and questions were narrowed as follows.

Summary of the research aims and questions

The main aim of this research was to examine patterns of aesthetic response to façade colour, and an underlying aim was to link the research to planning policy in Sydney, Australia, by using terminology frequently found in planning guidelines relating to façade colour. The research topic is summarised in Figure 2 and the specific research questions are as follows:

- Research question 1: Are variations in overall aesthetic response associated with differences in façade colour treatment?

- Research question 2: Are variations in judgements relating to building congruity associated with differences in façade colour treatment?

- Research question 3: Are variations in judgements relating to building size associated with differences in façade colour treatment?

- Research question 4 comprised two parts: Are preferences for a building stable irrespective of differences in façade colour treatment? Is preference for a façade colour treatment consistent across different building?

- Research question 5: Are variations in overall aesthetic response associated with differences in individual characteristics?

- Research question 6: Are variations in overall aesthetic response associated with differences among sub-groups indicating a possible educational bias?
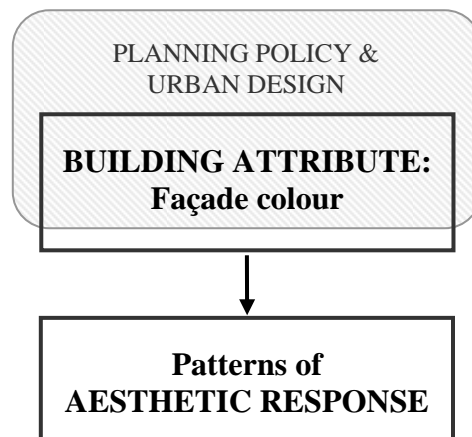
Figure 2. A simplified model of the research topic.

An underlying aim was to link the research findings and outcomes with planning policy current at the onset of this research project by using terminology and concepts frequently found in planning policy.

Overview of the main theories relevant to this research

Façade colour is just one of a number of physical characteristics that comprise the external elements of a building. However, while façade colour is used and manipulated in a variety of ways by architects, an "uneasy relationship to colour" never-the-less exists among many architects due to the ongoing influence of Modernist ideas about surface and ornamentation (Koolhaas, Foster & Mendini, 2001, p8). Despite this, façade colour is often used a form of

architectural expression (as evidenced in the architectural work of Barragán, Rogers and Piano, Foster and Partners); as a communication device (see Foote, 1983; Foster, 1982); or to link buildings to their surroundings and reduce visual contrast or bulk (see Iijima, 1995; Unver & Ozturk, 2002).   In addition, façade colour has also been used to create a sense of 'place' and is considered to contribute to Lynch's (1960) notion of 'imageability' (see Lenclos, 1976; Marcus & Matell, 1979).

However, the nature of the relationship between façade colour and aesthetic response is unclear and few studies exist that focus on this relationship in particular.   In general, aesthetic response to building attributes such as façade colour is considered a complex interface involving affective appraisal and cognitive judgements (Nasar, 1994; Stamps, 2000).   Furthermore, the personality, affective state and cultural experience of the observer are considered to be factors that may influence aesthetic response to building attributes (Nasar, 1994).   Nasar (1994) has proposed a probabilistic model of aesthetic response to building attributes in response to the complexity of the relationship between building attributes and aesthetic response, and this model served as the theoretical framework for this research.

In terms of the relationship between colour and aesthetic response, this is also considered to be a complex and unpredictable interface (Hard & Sivik, 2001).   While a plethora of theories exist that attempt to explain and predict the nature of the interface between colour and aesthetic response, these are often conflicting and lack consensus (for example, see Albers, 1963; Chevreul, 1839; Itten, 1961; Munsell, 1921; Ostwald, 1916).   From an ontological point of view, many of these theories are based on an underlying assumption that the interface between colour and aesthetic response is universal, deterministic and therefore predictable.   However, more recently, theorists have acknowledged that the relationship between colour and aesthetic response may be open to the influences of contextual, cultural, temporal and idiosyncratic factors; and may therefore be more idiographic and less predictable in nature (for example, see Anter, 1996; Hard and Sivik, 2001; Janssens, 2001; and Svedmyr, 1996).

Planning policy in Sydney tends to reflect the underlying ontological assumption that responses to façade colour are universal, deterministic and therefore predictable (for example, see NSWDOP, 2005; COSC, 2001; COSC, 2005).   In addition, the narrow and prescriptive nature of many planning recommendations and guidelines relating to façade

colour do not appear to allow for the influence of cultural, temporal and contextual factors or individual differences (for example, see NSWDOP, 2005). Furthermore, these planning recommendations and guidelines relating to façade colour frequently use terms such as 'harmonious', 'contrasting' and 'sympathetic'; terms that remain undefined within the context of planning policy and which have been sharply criticised for their vague and ambiguous nature (Stamps, 2000).

As discussed in greater detail below, this research was conducted under the aegis of the environment-behaviour studies (EBS) research group, Faculty of Architecture, University of Sydney and drew heavily on theories, studies and methodologies common within EBS.

Outline of the research methodologies

This research comprised two preliminary studies and a main study, and used a mix of qualitative and quantitative methods. The first preliminary study focussed on developing a tool for identifying and quantifying environmental colour characteristics generally and façade colour characteristics in particular. The tool (environmental colour mapping using digital technology) was applied in the second preliminary study and the main study. The second preliminary study focussed on developing a simple taxonomy of façade colour based on terminology frequently found in planning policy in Sydney. The outcome of this second preliminary study was a set of simple façade colour classifications based on the terms 'harmonious' and 'contrasting'.

The main study investigated the research questions listed above. The tool developed in the first preliminary study (environmental colour mapping using digital technology) as well as the simple classifications of façade colour developed in the second preliminary study were used to develop the visual stimuli used in the main study. A measurement instrument comprising ten variables representing aesthetic response was used to quantify overall aesthetic response including judgements relating to building size and congruity. A Latin-square, quasi-experimental research design was applied wherein a sample group of 288 participants evaluated four treatments each resulting in 1,152 evaluations. Data analysis techniques included factor analysis, correlation analysis, analysis of variance and multivariate analysis of variance.

Finally, this research relied used an extended version of environmental colour mapping, a methodology pioneered by Lenclos (1976) that enables the isolation and identification of environmental colour characteristics (Foote, 1983; Iijima, 1995, Porter, 1997). The environmental colour mapping process was adopted and extended for the purposes of this research to enable the isolation, identification and the manipulation of environmental colour characteristics.

Scope of the research

While this research was concerned with aesthetic response to façade colour within the context of urban design and planning policy, it drew mainly on theories from Environment-Behaviour Studies and theories relating to colour. Beyond the narrow confines of this topic and, where relevant, the scope of this research was limited to 20th and 21st century Western architecture and planning policy.

Variables representing aesthetic response

As the topic focussed on the nature of the relationship between aesthetic response and façade colour, theories and studies relating to this relationship were highly relevant. However, aesthetic response has a broad range of meanings within a number of domains from art and design to psychology. In addition, aesthetic response may vary over time, in different situations, at different life stages, and so on.   For the purpose of this research, aesthetic response is limited to patterns of response in terms of a range of variables, detailed within the body of this dissertation. As such, this research is not concerned with how people perceive and evaluate façade colour in a broader sense; or, in the symbolic, connotative or associational meanings of façade colour.   Instead, this research focussed on identifying patterns of aesthetic response without delving into the reasons for such responses. While this represents a limitation of the research, it also stands as an opportunity for further research.   Initially, a range of ten variables were identified from the literature and used to represent aesthetic response. However, factor analysis of the research data indicated that eight of these variables formed one key factor and the remaining two variables formed a secondary factor. The eight variables were used thereafter to represent the construct of aesthetic response within the context of this research. The remaining two variables (large-small and dominating-insignificant), which formed the secondary factor, related to judgements about size. Thereafter, these two variables were retained and formed

the basis of examining patterns of response relative to façade colour and judgements about a building's size – Research question 3.

Defining façade colour

Similarly, the concept of colour has a broad range of meanings and definitions across the fields of physics, perception and psychology. This research limits the construct of colour to that category of general effect or appearance by which a façade may be categorised in terms of hue, saturation and luminance. While façade colour may appear to alter due to changes over time, surface character or weathering, these alterations in the perception of façade colour and their subsequent effect on aesthetic response are beyond the scope of this research. Studies that deal with the differences between perceived and inherent façade colour such as those by Anter (1996 & 2001) are referred to as relevant within the body of this dissertation. A detailed definition of façade colour and how it has been applied in this research is to be found in the section: Research methodology.

Façade colour and planning policy in Sydney

Planning policy with respect to façade colour varies in Sydney depending on region and government control and involvement. As in many countries, planning policy in Sydney is introduced and subsequently adjusted or modified on an ongoing basis. It is beyond the scope of this research to link the methodology and findings to planning policy that may continue to evolve and change. Therefore, this research was linked specifically to the above-mentioned Development Control Plan for Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005 (NSWDOP, 2005).[2]

External building colour: The exclusion of roof colour

The Development Control Plan for Sydney Regional Environmental Plan (Sydney Harbour Catchment) includes many clauses that focus on external building colour, with some distinguishing specifically between façade colour and roof colour. The Plan includes sixteen sections representing sixteen 'Landscape Character Types' (NSWDOP, 2005, p19-34). Each of these sections describes each landscape character type and provides supporting aerial photographs of each area. Of the 32 photographs included in the Plan, 23 photographs include images of buildings displaying red terracotta roofs – a common

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[2] Also referred to as the Sydney Harbour Foreshores and Waterways Development Control Plan 2005.

feature of the Sydney landscape. Given the preponderance of red roofs as a feature of the Sydney landscape and as illustrated within the Plan, it was decided that this research would focus on façade colour but exclude roof colour. This decision was taken because incorporating buildings with red roofs may have distracted or diverted the course of the research and confounded the evaluations and resultant findings.

The use of photographs as visual stimuli

The strengths, weaknesses and limitations of this research are detailed throughout this thesis. However, a key limitation is the decision to use static simulations of environmental scenes rather than assessing evaluations of environmental settings in situ. The validity of Gibson's (1966) ecological approach to environmental perception and its relevance to this research is fully acknowledged. It is also noted that extant research literature in the EBS field often utilise static environmental representations evaluating a range of façade colours (discussed more fully below). In addition, a number of studies have pointed to the influence of confounding factors that may impinge on evaluations of in situ studies (see for example, Hull & Stewart, 1992). Furthermore, the logistics of evaluating a range of façade colours in situ was beyond the capacity of this research. Therefore, the generalisability of the findings from this research is limited.

Summary of the key research findings and outcomes

The key findings of this research are briefly detailed below. These findings are discussed in greater depth in Part D of this thesis.

Environmental colour mapping using digital technology

Preliminary Study #1 found that environmental colour mapping using digital technology provided a reliable process for isolating, identifying and manipulating environmental colour characteristics.

Harmonious and contrasting façade colours

Preliminary Study #2 found that façade colours could be classified using the terms harmonious and contrasting. Harmonious façade colours were generally those that exhibited hue similarity between façade colour and the colour characteristics of the surroundings. Contrasting façade colours were found to be those that exhibited hue

contrast with the colour characteristics of the surroundings. However, these classifications were not found to be watertight and some façade colours classified initially as contrasting were subsequently evaluated as harmonious.

Responses to façade colour: Less universal and more idiographic and stochastic
The main study found that variations in façade colour are associated with changes in overall aesthetic response. In examining patterns of response, it was found that responses are not predictable and universal, as suggested by the prescriptive and narrow nature of guidelines relating to façade colour within the context of planning policy, but may be somewhat more idiographic and stochastic. In addition, preference for a building was not found to be consistent across different façade colours and preference for a façade colour was not consistent across the four buildings that featured in the main study.

Façade colour: The influence on judgements about size and congruity
This research indicated that judgements about building size may vary by as much as 5% depending of façade colour. Buildings that featured contrasting façade colours were judged to be larger and more dominant than buildings that featured harmonious façade colours. In regards to judgements about congruity, judgements varied by up to 13% depending on façade colour. Buildings that featured harmonious façade colours were judged as more congruous and sympathetic to surroundings than the same building when it exhibited contrasting façade colour.

Implications for planning policy
The implications of these findings suggest that planning guidelines relating to façade colour in Sydney may be inappropriate. In response to the findings, a new approach to façade colour is proposed as an alternative to façade colour guidelines contained within existing planning policy. Influenced by Arnstein (1969), Fincher (2003) and Webler and Tuler (2001), this new approach is somewhat more transparent and democratic: it encourages consensus from among a broader range of interested parties by employing a participatory methodology.

Organisational structure of the thesis

In addition to this introduction, the thesis is organised into four main parts: context, methods, results of the main study and discussion.

Part A discusses the context within which this research was conducted in terms of the key theories, studies and findings in a number of areas including environmental evaluation and aesthetics; colour theories relating to aesthetic response; façade colour and architecture and planning policy relating to Sydney Harbour foreshores.

Part B provides details of the overall methodological approach plus the aims, methodologies and outcomes of the two preliminary studies. This section also discusses the main study in depth and provides details in respect to the research questions, hypotheses, research design (including dependent and independent variables), visual stimuli, measurement instrument, pilot studies and data collection.

Part C focuses on the results of the data analysis arising from the main study. This section also details the assumptions made in regard to the data analysis of the main study and discusses and interprets the data analysis results in relation to each of the research questions and hypotheses.

Part D is a discussion of the key outcomes of this research in terms of implications, relevance and significance of the findings in regard to the literature as well as planning policy. In this section provides recommendations based on the findings of this research.

PART A: CONTEXT OF RESEARCH

This section is sub-divided into five key topic areas as follows:

- Overview of context and literature review

- Environment-behaviour studies (EBS):
    - Environmental perception and evaluation;
    - Environmental aesthetics;
    - Aesthetic response to building attributes;

- Colour and aesthetic response:
    - The concept of colour; colour theories and models;
    - Competing paradigms in the domain of colour;
    - Colour harmony: an elusive concept;
    - Factors that may influence aesthetic response to colour

- Urban design, planning policy and façade colour
    - The aesthetic qualities of urban design;
    - The use and manipulation of façade colour in architecture;
    - Planning policy, visual quality and façade colour;
    - Planning policy relating to façade colour in Sydney, Australia;

- Rationale for this research.

Overview of context and literature review

Conducted under the aegis of the EBS Research Group at the University of Sydney, this research drew heavily on EBS theories relating to environmental perception and evaluation, environmental aesthetics and aesthetic response to building attributes. Literature relating to colour theory revealed that colour is not a straightforward subject and a plethora of theories and studies relating to both colour as well as the nature of the relationship between colour and aesthetic response were found to exist. The literature from the EBS domain and literature relating to colour were the two strands that formed the main source of knowledge for this research.

The areas of urban design and planning policy formed the context within which this research was conducted. Of specific focus were the aesthetic qualities of urban design as well as the many ways in which façade colour can be used and manipulated in the built environment by architects. In addition, the research was prompted and therefore linked to planning policy in Sydney, Australia. Figure 3 illustrates the research topic and the main and secondary components of the literature review and context. These components tend to exist as independent, semi-related or unrelated areas of literature with little or no overlap in terms of findings and knowledge.
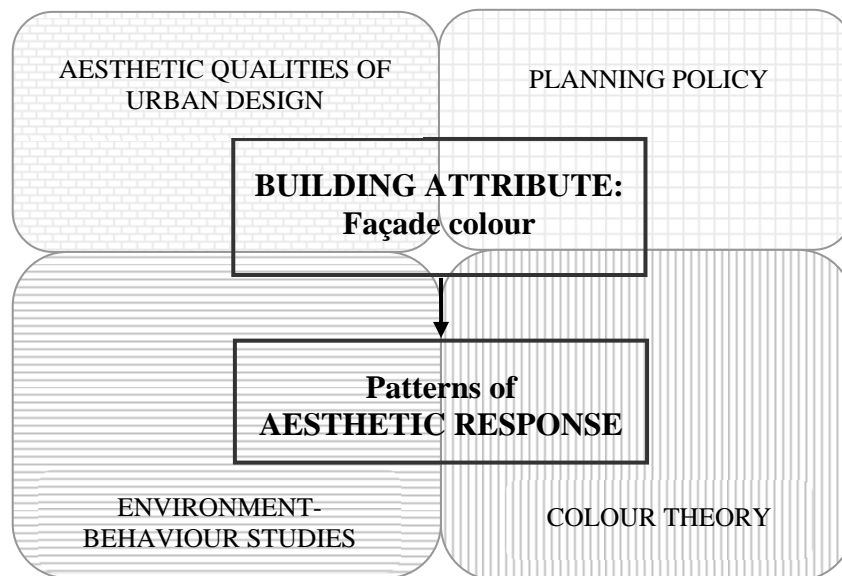
Figure 3. The main components of the literature review.

ENVIRONMENT-BEHAVIOUR STUDIES

Lewin (1967) conceptualised the environment-behaviour interface as follows wherein behaviour (B) is considered to be a function of the interactions between personal factors (P) and the environment (E).

$$B = f(P, E)$$

However, the simplicity of Lewin's equation belies the complexity of the interface between humans and environmental settings, an interface that is generally the subject of EBS research. Moore (1987) suggests that EBS research tends to focus on the "mutual relations between the socio-physical environment at all scales and human behaviour at all levels of analysis, and the utilization of knowledge thus gained in improving the quality of life through better informed environmental policy, planning and design" (Moore, 1987, p1360). Moore (1987) also suggests that there are nine different types of EBS theory categorised according to the unit under analysis, as follows.

– Person-based theories generally focus on the individual and individual traits such as privacy act as regulators of behaviour;

– Social group theories tend to assume that the social group takes precedence over the individual whereby the individual takes on the characteristics of the group and that it is the group which acts to regulate behaviour;

– Cultural theories consider that behaviour is, to a certain extent, regulated by the variables and characteristics of a particular cultural group;

– Empiricist theories tend to focus on aspects of the physical environment and these are considered to act as factors that regulate or influence behaviour. Underlying Empiricist theories is the assumption of a deterministic link between the environment and behaviour;

– Mediational theories suggest that variables such as stress, expectations, perception, cognition and meaning may intervene and influence the relationship between environment and behaviour;

– Phenomenological theories do not assume a deterministic relationship between environment and behaviour and tend to focus is on understanding the holistic and unpredictable phenomenon in a more qualitative manner;

– Structuralistic theories tend to assume that systematic patterns of behaviour exist and that these patterns of behaviour frame a structure, as distinguished from function or phenomenon. Some Structuralistic theorists suggest that it is the structures inherent in an environment that dominate; while other Structuralistic theorists suggest that it is the structures of the mind – as found in Gestalt theories – that dominate;

– Interactional theories adopted the Kantian distinction between the properties or characteristics of reality as they appear to us visually, aurally or physically (that is, phenomenon) and reality as perceived by the mind in the form of mental constructs

(noumena). Interactional theorists suggest that behaviour occurs as an interaction between the phenomena of the physical world and the noumena of the mind.

- Transactional theorists suggest that the interface between humans and the environment is complex and influenced by the interaction between external, environmental factors and internal, cognitive and affective factors requiring holistic analysis.

It is acknowledged that the interface between aesthetic response and façade colour would benefit from a transactional approach to the study of this interface and its related patterns of association. However, an holistic, transactional study of this interface was beyond the scope of this research and an interactional approach was adopted instead to simplify what could have been a complex study. The rational being that the outcomes from this research would contribute to the "building block approach" to knowledge about what is essentially a complex interface between aesthetic response and façade colour (Altman, Werner, Oxley & Haggard, 1987, p502).

Environmental perception and evaluation

Environmental perception and evaluation involves the visual, auditory, olfactory and tactile human senses (Rapoport, 1977; Ulrich, 1983). Humans tend to make evaluative judgements about an environment and these judgements may be conscious or unconscious (Kaplan & Kaplan, 1982). Ittelson (1973) suggests that environmental perception involves five inter-related levels of response and analysis: affect, orientation, categorisation, systematisation and manipulation. This suggests a complex process involving emotional responses coupled with cognitive judgements relating to the identification and analysis of environmental features as well as an acknowledgement of the interactive nature of the interface between observer and environment. Ittelson further purports that these five levels of response and analysis continuously inter-act and change over time, and are also a function of how an observer chooses to conceptualise the environment under observation.

Appleton (1975) suggests that the way in which an observer chooses to evaluate and conceptualise an environment is linked to two key theories that he has defined as 'Habitat theory' and 'Prospect-refuge theory'. Habitat theory hypothesises that "aesthetic satisfaction, experienced in the contemplation of landscape, stems from the spontaneous perception of landscape features which, in their shapes, colours, spatial arrangements and other visual attributes, act as sign-stimuli indicative of environmental conditions favourable to survival, whether they really are favourable or not" (Appleton, 1975, p69). Prospect-refuge theory relates to the notion that we tend to evaluate an environment in

terms of the opportunities to see (prospects) and the opportunities to hide (refuge). Appleton suggests that these two theories underpin our understanding of the aesthetic properties of an environment. Certain aspects within an environment have the power to attract attention and therefore act as magnets due to dominant features or visual focal points. Buildings, under Appleton's theory, can provide effective symbolic substitutes for natural environmental features and can therefore also serve as magnets or places of prospect-refuge. Appleton cautions that "we must accept the existence of a wide variation in the aesthetic potential of particular places" and that there are bound to be variations in preference in this regard (Appleton, 1975, p246).

Similarly, Gibson (1979) posits that environmental evaluation is a process of information pick-up beyond the simple mechanics of visual perception. That is, environmental information is picked-up and processed in terms of importance relative to human meaning, values and needs in a process of ongoing data input and evaluation. Gibson's ecological understanding of environmental perception suggests that what we perceive when we look at an environment is the qualities and characteristics of the environment as well as the 'affordances' that are offered by the environment. Gibson suggests that affordances represent the value and meaning that the qualities and characteristics may hold for the observer in terms of possible benefits or dangers. Gibson suggests that affordances are perceived as quickly as the colour characteristics of an environment.

Ulrich (1983) suggests that, due to the influence of survival instincts on the process of environmental perception, the process involves affective responses that are pre-cognitive. These instincts trigger rapid non-cognitive responses to environmental stimuli which occur when the environment is scanned for the existence of what Ulrich has termed *preferenda*. It is highly likely that this scanning process takes place during the eye's saccades and the properties and elements within an environmental setting that Ulrich linked to *preferenda* include,[1]

- *Structural properties:* the level of order or structural configuration within a scene. That is, the presence or absence of hills, valleys, cliffs, fields, and so on;

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[1] Saccades are rapid eye movements that occur at the rate of about three per second when a scene is scanned or an activity performed. Saccades occur very rapidly during normal human vision and involve distributed attention until an object or event catches the eye during a saccade, thereby drawing focal attention to the object or event (O'Regan, 1992).

- *Complexity*: the level of detail within a scene in terms of features and elements from few to a multitude. The level of complexity with a scene may influence the apparent opportunities for exploration and refuge with a scene;

- *Focality*: the presence or absence of a focal point that is apparent due to the structural organisation of a scene or the level of complexity apparent with a scene;

- *Depth*: the sense of perspective and distance between foreground and background visually afforded by a scene. This notion also links in with apparent opportunities for exploration and refuge within a scene;

- *Ground surface texture*: the textural characteristics of the scene under observation and includes textural elements that are considered to be easily negotiable or textural elements that may impede movement;

- *Threat*: the presence or absence of hazards or threats perceived within a scene. Possibly underpinned by the *fight or flight* response identified by Cannon (1915), this preferendum is considered to elicit an immediate affective response;

- *Deflected vistas*: the existence of an extended or deflected line of sight through to a landscape beyond the foreground, a landscape offering the promise of further information or opportunities;

- *Water*: the presence or absence of water within a landscape in the form of rivers, pools, lakes, and so on. The presence or absence of water in a variety of forms may present feelings of danger or otherwise;

The presence of natural elements and water (in terms of rivers, lakes and the like) within an environment are considered to positively influence environmental evaluation and Wohlwill (1977) considers this represents a "seemingly pervasive pro-nature bias in people's affective and evaluative responses to their environments" (Wohlwill, 1977, p22). Wohlwill further suggests that may therefore explain a high correlation between nature-dominant scenes and ratings of congruity.

Turning to the perception and evaluation of urban environments, Lynch (1960) suggests that this is a two-way process. Environmental images arise as a result of this two-way process and these images, Lynch asserts, comprise three components: identity, structure and meaning. The first of these components, identity, has to do with the notion that each environmental image is a separate entity and distinct from other environmental images; structure relates to the spatial and relational patterns inherent in an environmental image; and, meaning relates to the practical or emotional meaning that the environmental image holds for the observer. Lynch (1960) identified five key elements that contributed to a particular city's identity: landmarks, paths, districts, edges and nodes.

Imageability is the term Lynch coined to refer to the qualities inherent in an environment "that gives it a high probability of evoking a strong image in any given observer" (Lynch, 1960, p9). Lynch suggests that shape, colour and arrangement of the key elements that contribute to the 'imageability' of a particular environment and, while imageability tends to arise mainly due to the overtly perceptible components of identity and structure, environmental meaning arises due to the subjective nature of the interface between humans and the physical characteristics of environments.

During environmental perception and evaluation, Rapoport (1977) suggests, perceptual inputs pass through a series of filters that involve cognitive judgements and affective responses. Rapoport proposes that "the built environment is partly the organisation of meaning and communication…and the environment can be conceptualised as a form of communication" (Rapoport, 1977, p325). As a form of communication, the built environment may therefore convey both symbolic information and non-verbal messages. Previously, Rapoport considered this communication to be of a somewhat universal nature which "can be read and understood and, if congruent…can elicit appropriate behaviours" (Rapoport, 1977, p326). However, Rapoport (2005) considers that the level of congruence between the built environment and users or observers is influenced by cultural factors. Furthermore, he asserts that judgements relevant to the notion of 'quality' in regard to environmental evaluation are not only open to the influence of cultural factors but may also hinge on an emics versus etics issue: what may be valued emically (that is, by the members of a particular cultural group) may be quite different to what is valued etically by those who are not members of the same cultural group.[2] Therefore, given that environmental perception and evaluation passes through a series of filters and that it may be open to the influence of cultural factors, it stands to reason that "the construct of environmental quality is itself multidimensional and complex" (Craik & Feimer, 1987, p894). The construct of environmental quality is generally the focus of research in environmental aesthetics, and Nasar (1992) considers that environmental aesthetics now stands as a unique and independent field of inquiry.

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[2] The terms emic and etic were coined by Pike in 1954 to distinguish between the members and non-members of a particular cultural group (http://dictionary.oed.com).

Environmental aesthetics

Environmental aesthetics has to do with appreciation of the environment as it affects our senses in a pleasing way (Carlson, 2000). More specifically, Nasar (1992) suggests that environmental aesthetics is concerned with the interface between the objective, physical characteristics of human habitat and the subjective responses by humans to such environmental characteristics; and that environmental aesthetics "represents the merging of two areas of inquiry: empirical aesthetics and environmental psychology" (Nasar, 1992, pxxi). Empirical aesthetics in this context refers to the systematic study of aesthetics using experimental methodologies with a focus on issues such as pattern perception, experience of settings and vistas, and definitions of constructs such as complexity, simplicity and congruity (Nasar, 1992). Nasar (1992) notes the distinction that has been identified between sensory aesthetics, formal aesthetics and symbolic aesthetics in which sensory aesthetics has to do with the "pleasurableness of the sensations received from the environment" (Nasar, 1992, p11). Formal aesthetics relates to the perception and appreciation of the somewhat more quantifiable characteristics of an environment such as shapes, complexities and so on. While symbolic aesthetics focuses on the associational meanings that an environment may convey.

A number of architectural variables or qualities may convey symbolic meaning and these include building configuration, spatial configuration, materials, illumination and pigmentation (Lang, 1992). In addition, Lang suggests that there are a number of non-physical variables that may also carry architectural symbolism and these include the names of places due to the meaning inherent in the name; places where specific events took place (such as Anne Frank's house) or places designed by particular architects or developers whose body of work and reputation convey a degree of meaning.

Response to the environment is considered to involve numerous and complex perceptual, cognitive and affective responses which in turn prompt behavioural responses (Ward & Russell, 1981). At this point, it may be appropriate to provide further explanation and discussion of the roles of cognition and affective appraisal in relation to environmental perception and evaluation.

The roles of cognition and affective appraisal

Environmental responses include a complex interaction of affective and cognitive responses to environmental stimuli (Kaplan, 1987; Nasar, 1994; Rapoport, 1977; Ulrich, 1983; Zajonc & Markus, 1982). However, affective and cognitive responses may be of a non-linguistic nature and therefore difficult to quantify (Osgood, Suci & Tannenbaum, 1957).

Cognitive responses are considered to involve the processing of visual information along with a level of categorisation and inferential processing that may or may not be conscious (Kaplan, 1992; Ulrich, 1983). Cognitive responses are considered to be learned to a certain extent and may therefore be open to influence from factors such as values, attitudes, culture, age, educational level, gender, past experiences and so on (Ulrich, 1983). Cognitive responses may result in cognitive judgements as a consequence of cognitive processes that recognize, categorize, predict and evaluate environmental stimuli (Kaplan, 1992).

In attempting to measure meaning in terms of affective appraisal and cognitive judgements, Osgood, Suci and Tannenbaum (1957) found three key factors: evaluative, potency and activity. The evaluative factor was linked to measurement variables such as good-bad, beautiful-ugly, and pleasant-unpleasant; the potency factor was linked to variables such as large-small, strong-weak, and rugged-delicate; while the activity factor was linked to variables such as fast-slow, tense-relaxed, active-passive, and so on. Osgood *et al* (1957) assert that while meanings may vary multidimensionally, the evaluative, potency and activity factors are stable. In addition, they suggest that the "pervasive evaluative factor in human judgement regularly appears first and accounts for half to three-quarters of the extractable variance" (Osgood *et al*, 1957, p72).

Russell, Ward and Pratt (1981) suggest that the affective and cognitive components of environmental responses are highly inter-related and therefore difficult to separate, they also suggest that the affective component comprises three dimensions: pleasure, arousal and potency/dominance (Russell, 1988; Russell *et al*, 1981; Ward & Russell, 1981). These three dimensions are considered to "summarise the emotion-eliciting qualities of environments" (Mehrabian & Russell, 1974, p8). "Far from being independent, these (responses) are highly inter-related in complex ways" (Ward & Russell, 1981, p122). However, more recently it has been suggested that responses to affective qualities are linked to only two dimensions: hedonic (pleasure-displeasure) and arousal (inactive-active)

and the potency dimension is now considered to represent more of a cognitive judgement than a dimension of affective quality (Russell, 2003).

A range of descriptors has been linked to the hedonic and arousal dimensions and these have been found to be useful in quantitative studies relating to perception of affective qualities.[3]   A sample set of these descriptors are detailed in Figure 4 wherein I and II represent the pleasure and arousal components respectively.
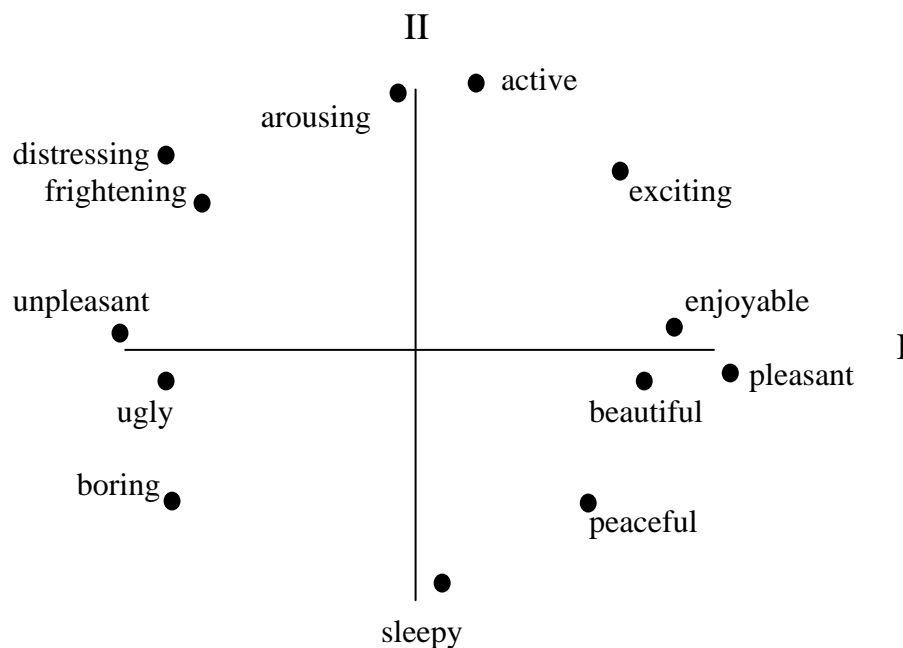
Figure 4. Affective descriptors of environments (Russell, Ward & Pratt, 1981).[4]

Aesthetic response to building attributes

Overall aesthetic response to the built environment involves cognitive judgements about building attributes, affect (that is, emotional reactions), and affective appraisal in terms of the connotative meanings that particular building attributes may convey (Nasar, 1994; Stamps, 2000). Hershberger (1992) suggests that it is the forms, colours and spatial configuration of the built environment that may influence overall aesthetic response; and,

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[3] Russell (1988) suggests that the descriptors used to describe the affective qualities of environments mentioned in earlier studies are not the only descriptors and provides forty additional descriptors for eliciting affective appraisals. Each of these descriptors is a variation of the two dimensions of pleasure and arousal and is located at different points within the spatial representation featured in Figure 4.

[4] These affective descriptors of environments provided a basis for developing pairs of semantic differential rating scales used in the main study of this research and discussed in greater detail below.

due to the variation among such elements, that the relationship between aesthetic response and the built environment may be difficult to describe and predict. From a factor analysis of a range of building attributes that impacted on evaluation, a four dimensional factor structure was found: the first factor had a positive loading on ornamentation, surface and curves and the second factor included functional expression, angles and vertical dimensions; while the fourth factor included composition and colour (Oostendorp & Berlyne, 1992). While this study found a "large degree of consistency in judgements of the buildings", the study also acknowledged the complexity that a range of building attributes brings to the evaluative process (Oostendorp & Berlyne, 1992, p225).

More specifically, Nasar (1994) considers overall aesthetic response to building attributes to be a complex process involving perception, cognitive judgements, affect and affective appraisals. In addition, the Observer's personality, affective state, intentions and cultural experiences, and so on, also impact on the process of perception, cognition and affective appraisal. In response to the complexity of this entire process, Nasar (1994) proposed a probabilistic model of aesthetic response as detailed in Figure 5.
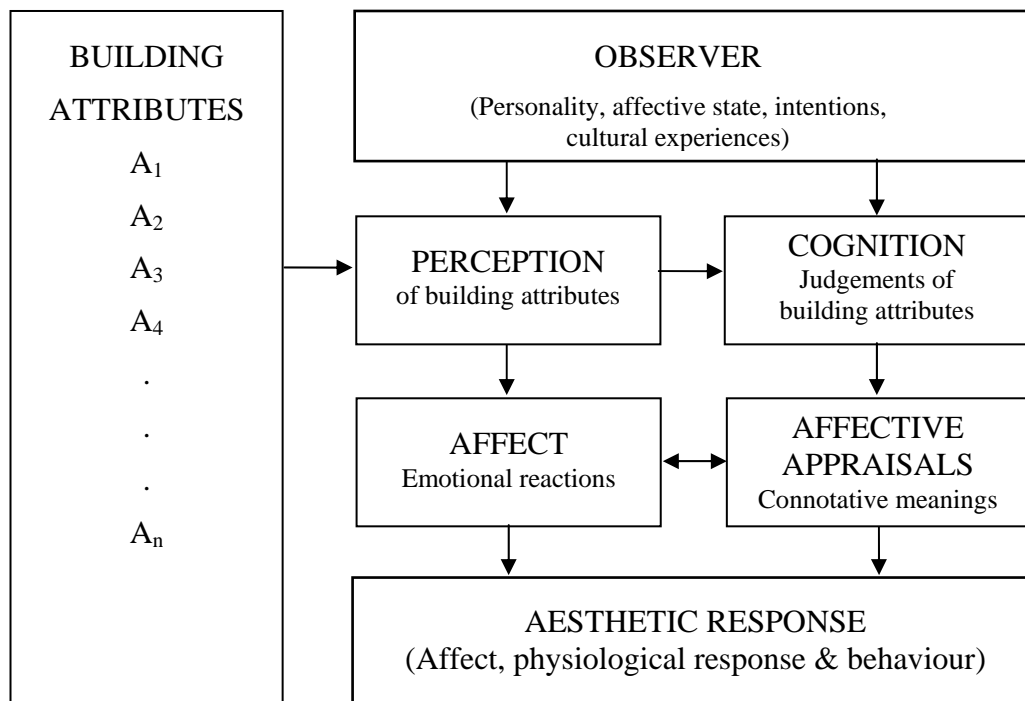
Figure 5. Probabilistic model of aesthetic response to building attributes (Nasar, 1994).

Nasar's model acknowledges that affect, cognitive judgements and affective appraisals of building attributes may be complex and highly inter-related. Furthermore, the model acknowledges that overall aesthetic response may be influenced by personality, affective state and cultural experience. While Nasar's model suggests a level of causality between building attributes and aesthetic response and given the complexity and unpredictable nature of this interface, Nasar's model is probabilistic rather than predictive. The influence of contextual factors and their possible effect on the relationship between building attributes and aesthetic response is not specifically acknowledged within the model; however, buildings do not exist in a vacuum and Nasar's research thoroughly acknowledges this notion (Nasar, 1994 & 1998).

Preference, as distinct from aesthetic response, is considered to involve cognitive judgements about whether the building is liked or not. As with environmental preference, this type of cognitive judgement may be conscious or not and generally involves an assessment of the potential and capacity of an environment to meet human needs (Kaplan & Kaplan, 1982; Zube *et al*, 1982). In studies that focus on preference for objects or environments, the construct is generally represented by the variable like-dislike (Caivano & Rimoldi, 1997; Herzog, 1992; Kaplan & Herbert, 1992; Tannenbaum & Osgood, 1952).

In terms of judgements about a building's congruity relative to its surroundings, façade colour is just one of a number of attributes considered to influence cognitive judgements relating to the 'fit' between a building and its surroundings; or whether it is considered sympathetic with, or in harmony with, its context (Groat, 1992; Janssens, 2001; Unver & Ozturk, 2002; Urland, 1997; Wohlwill, 1977; Wohlwill & Harris, 1980). The dimensions of texture, shape, colour and size have been found to influence judgements about the congruity and appropriateness of artificial structures in natural settings (Wohlwill & Harris, 1980). This study found correlations of .72, .87, .61 and .81 for the dimensions of colour contrast, texture contrast, size obtrusiveness and shape congruity respectively with the dimension of "overall fittingness" (Wohlwill & Harris, 1980, p359).

In terms of judgements about a building's apparent size, mass or bulk, façade colour is considered to be one of a number of factors that may influence judgements of this nature (Unver & Ozturk, 2002). Similarly, in relation to interior architecture, colour has been

found to influence perception and cognitive judgements regarding the size of interiors (Guthrie, 1995; Inui & Miyata, 1973; Porter & Mikellides, 1976; Smith, 1989).

Individual characteristics such as personality, affective state and cultural experience are considered factors that may influence aesthetic response to building attributes (Nasar, 1994). Stamps and Nasar (1997) found that environmental preference did not generally vary according to differences in demographic factors such as age and cultural background; but they suggest that the issue of the influence of demographic factors remains "ripe for empirical enquiry" (Stamps & Nasar, 1997, p14).[5] A meta-analysis conducted by Stamps (1999b) found a high degree of consensus in terms of environmental aesthetics across all demographic groups. Although a level of dissensus was found when adults were compared with children; when members of special interest groups were compared with other people; and when designers were compared with non-designers in respect to assessing avant-garde architecture.[6] Familiarity is not considered to play a major role or act as a predictor in terms of environmental assessment or preference (Kaplan & Herbert, 1992; Purcell, Peron & Berto, 2001). However, familiarity was considered to influence aesthetic response in terms of the evaluation and assessment of colour (Svedmyr, 1997). Finally, differences in aesthetic response to the built environment are considered to exist between architects and non-architects (Hershberger & Cass, 1992).

To summarise, the literature suggests that façade colour may be one of a number of building attributes that influences aesthetic response to a building. This notion, discussed in more detail below, is often reflected in planning policy in Sydney. However, little is known about the relationship between colour and aesthetic response. The following section discusses the concept of colour as well as notions such as colour harmony, along with various theories relating to the relationship between colour and aesthetic response.

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[5] Stamps and Nasar (1997) further suggest that a possible lack of consensus in relation to environmental evaluation review may lead to dissensus thereby stripping planning policy and review of its fundamental justification.

[6] These findings have not been replicated in studies relating to consumer behaviour where differences in individuals in terms of age, gender, cultural background and so on has been well recognised for some time and applied in marketing strategy (Kotler, 1994; Kotler, Adam, Brown & Armstrong, 2003). Marketing segmentation strategy is often conducted on the basis of demographical differences (individual characteristics such as age, gender, familiarity, education), geographical/cultural differences (region of birth, cultural differences), psycho-graphical differences (attitudes and aspirations), and lifestyle preferences (Wilkie, 1990).

COLOUR AND AESTHETIC RESPONSE

The literature includes a large plethora of theories and studies relating to the relationship between colour and aesthetic response, many of which are diverse and often contradictory (Burchett, 2002; Hard & Sivik, 2001; Wise & Wise, 1988). This section provides a review of selected theories and studies relating to the relationship between colour and aesthetic response, and includes references to the constructs of colour contrast and colour harmony, where appropriate.

The variations and apparent contradictions within the theories and studies may be explained by different understandings of the constructs of colour, colour contrast and colour harmony; as well as differences in epistemological approach and ontological assumptions embedded within these theories and studies. Therefore, this section includes a discussion of epistemologies and ontological assumptions found within the selected theories and studies.

However, a brief review of the mechanics of visual perception is also provided because colour and colour contrast play key roles in visual perception and these, in turn, are considered to influence environmental perception and evaluation, environmental aesthetics and urban design aesthetics.

Visual perception

Visual perception is a complex process that is only partly understood (Livingstone, 1988). Incoming visual information, in the form of light-waves, is received by rod and cone receptors in the retina and these have different sensitivities: cone receptors are colour sensitive and rod receptors are light sensitive but not colour sensitive. There are about six million cone receptors in the retina and these are found in the fovea and peripheral areas of the retina; and about 120 million rod receptors located in the peripheral area of the retina, out-numbering cone receptors by a ratio of about 20-to-1. The fovea, located directly in the line of sight in the retina, is cone-rich and does not contain rod receptors (Goldstein, 1996).

Visual information, which is passed through to the brain via the optic nerve, continues along different pathways and through different areas of the brain (Goldstein, 1996; Livingstone, 1988). The parvocellular pathway, which distinguishes between varying brightness levels of different hues thereby allowing for perception of shapes and borders, has a slower processing

time but higher acuity or resolution. The magnocellular pathway reduces all visual information to tones of black, grey and white, is sensitive to contrast (in terms of tonal level contrast between hues and luminance contrast) as well as movement, and has a faster response time but lower acuity (Livingstone, 1988). Some signals from both pathways are also processed in a third area, which is sensitive to colour and luminance, but not to movement, depth or shape. A coloured image on a coloured background can be easily perceived by the parvocellular system, but very difficult to perceive by the magnocellular system if the colours are equiluminant (Livingstone, 1988).

During visual perception, the human eye typically makes many movements when scanning a scene or performing any activity. Known as saccades, it is estimated that the eye makes about three scanning movements per second and these tend to occur unhindered during both focal and distributed attention (O'Regan, 1992, cited in McPeek, Maljkovic & Nakayama, 1999). But what catches the attention of a saccade? A study that focussed on visual thresholds for visual detection, recognition and impact found that contrast was a key predictor variable for visual detection (Shang & Bishop, 2000). Shang and Bishop also found that visual contrast was of greater influence in visual detection than size, object type and landscape type. While contrast can refer to different levels in any one of the three dimensions of colour: hue, saturation and luminance; it is contrast in terms of luminance level that is referred to in Shang and Bishop's study.[7] Their study lends support to an earlier study which found a tendency for the human eye to notice, and focus on an object, that is bright relative to its surroundings (Boynton, 1979). Called a 'fixational reflex', Boynton suggests that this occurs because the object attracting attention is not only bright relative to its surroundings but is deemed significant, indicating a level of cognitive processing that occurs almost in tandem with visual perception.[8]

To summarise, colour and colour contrast play important roles in visual perception. It is colour contrast in terms of luminance, rather than contrast in terms of hue or saturation, that plays a greater role in terms of visual detection thresholds and fixational reflex.

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[7] The dimensions of colour (hue, saturation and luminance) are discussed in greater detail below.

[8] The complexity of the processes and mechanisms that comprise visual perception are also relevant to a later section of this thesis that deals with the perceptual effects that may influence aesthetic response to façade colour.

The concept of colour

Colour is the perceptual sensation that begins in the retina in response to the light-waves reflected from objects and substances, and which is commonly assigned names such as *red*, *blue* or *yellow* (Goldstein, 1996). However, the concept of colour is considered to have a number of dimensions and also tends to fall into different categories, as discussed below.

The dimensions of colour: Hue, saturation and luminance

Colour is widely considered to have, or referred to as having, three dimensions: hue, saturation and luminance (Albers, 1963; Gage, 1995; Itten, 1961; Munsell, 1912; Ostwald, 1916; Wise & Wise, 1988). Hue is the attribute of colour by which a sample is recognized as 'red' or 'green'. Saturation (also referred to as chroma and chromaticity) is the level of colour intensity or purity, and luminance (also referred to a tone and tonal value) is the level of lightness or darkness of a hue (Gage, 1995). Figure 6 illustrates hue, saturation and luminance.
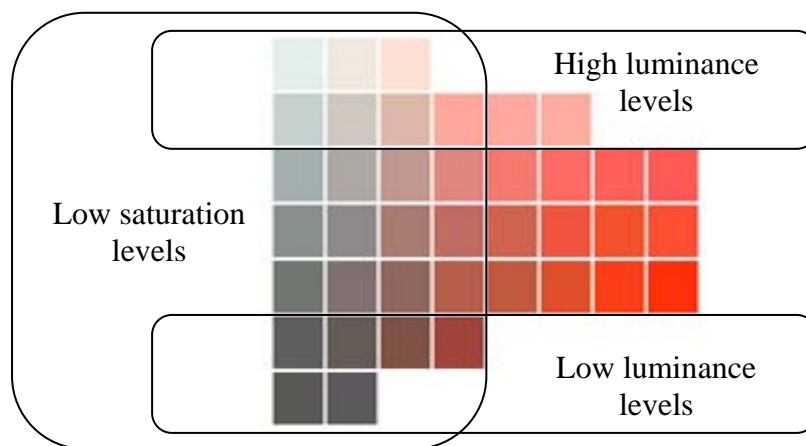
Figure 6. The hue *red* with examples of different levels of saturation and luminance.
(Image adapted from http://www.cis.rit.edu/)

Green-Armytage (2006) suggests that colour can be understood in a number of different ways and has identified four categories of these as: conventional colour, substance colour, formula colour and spectral profile colour. Colours within these categories can generally be identified using the dimensions of colour and also using commonly available colour notation systems. [9]

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[9] A range of colour notation systems exist and these are mainly concerned with identifying colour in its various manifestations (that is, in the form of light-waves, pigments, paints and so on). Colour notation systems include the CIE/CIELAB system, NCS system, the Pantone, system, the Munsell system, the sRGB system and the HSL system. Selected colour notation systems are briefly described in the Appendix.

Conventional colour

Conventional colour refers to the basic appearance that is associated with an object or substance such as blue sky or green foliage. Similar to the term hue, conventional colour indicates only broad classifications under which an assortment of colours, tints and shades are categorised under terms such as red, blue, green and so on. Figure 7 illustrates an assortment of green hues. As is clear from Figure 7, a hue can have many different variants (such variants are often referred to as tints, tones and shades).[10]

Figure 7. Conventional colour: Ten samples of green.

Substance colour

Substance colour refers to the colour of specific pigments or dyes (such as carmine, azure, vermilion, indigo, etc) that are unique and often recognisable and familiar. Frequently derived from natural sources, substance colours can be identified via chemical analysis and colour notation systems. For example, the substance colour vermilion, derived from a sulphide of mercury, can be identified via chemical analysis and indigo is derived from the plant *Indigofera tinctorial*. Both vermilion and indigo can be identified using the sRGB and CMYK colour notation systems (Delamare & Guineau, 2000).[11] Vermilion and indigo are illustrated in Figure 8.

Figure 8. Substance colours: Vermillion and indigo.
(Images: *Madonna* by Raphael and a pair of jeans –http://www.ibiblio.org/wm/paint/)

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[10] Tints are considered hues lightened with the addition of white or a lighter hue; tones are hues darkened with the addition of grey or black, and shades are hues darkened by the addition of another hue (Feisner, 2000).

[11] sRGB and CMYK colour notations for vermillion and indigo sourced from *Wikipedia.* Retrieved November 14, 2006, from http://en.wikipedia.org/wiki/Vermillion & http://en.wikipedia.org/wiki/Indigo

Formula colour

Formula colour represents the myriad colours that may arise from mixing, to a specific or *ad hoc* formula, various samples of substance colour derived from pigments, paints, dyes or printing inks. Numerous theories, models and formulae for creating formula colours exist in the literature (including, but not limited to, Albers, 1963; Hard & Sivik, 2001; Itten, 1961; Munsell, 1912; and Ostwald, 1916). Colour models (such as Itten, 1961; Munsell, 1912) and notation systems like the CMYK model, the sRGB colour space and the NCS colour model are commonly used both to identify formula colour and as a basis for colour mixing and combination.

Spectral profile colour

Spectral profile colours are colours that are visible in the form of light-waves (Green-Armytage, 2006). Spectral profile colour, illustrated in Figure 9, can be transmitted by radiation and reflection, is visible in rainbows and is used in computer and television monitors. Spectral profile colour can be identified using some colour notation systems.
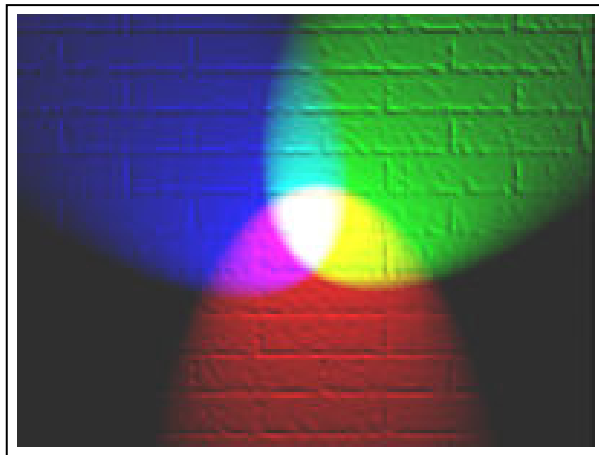
Figure 9.
Spectral profile colours.
(Image: http://www.answers.com/main/content/)

Different interpretations of the concept of colour (that is, conventional colour, substance colour and so on) within a range of fields of research from physics and psychology to art and design have prompted the development of a range of theories that focus on describing colour, and the attempts to explain the relationship between colour and aesthetic response. The following section discusses a selection of some of the key colour theories.

Colour theories and models

A diverse range of theories exist that attempt to describe and explain the phenomenon of colour as well as the relationship between colour and aesthetic response. Many of these, which often

make use of models and colour notation systems, exist across a number of domains: physics, psychology, art and design. This section provides a summary of selected theories and models. This summary is not intended as an exhaustive review; rather as an illustrative examination of key theories and models. Also included are references to 'primary colours', 'complementary colours' and 'contrasting colours.' Primary colours, considered to be key colours, are integral colour components for colour combination Primary colours are occasionally referred to as 'opponent,' 'complementary' or contrasting colours (Gage, 1995, p169 & 254; see also Burchett, 2002; Chuang & Ou, 2001; Gao & Xin, 2006; Ou & Luo, 2006).[12]

Albers colour theory

Albers (1963), a teacher at the Bauhaus who became the Head of Design at Yale University, developed a colour combination theory based on his colour triangle model, illustrated in Figure 10. For Albers, the three primary colours are red, yellow and blue. Secondary and tertiary colours can be created from these three primary colours. Albers asserted that selected groups of colours derived from his colour triangle can be associated with meaning such as *sad, serene, melancholic* and so on, and provided colour combination models that represented these particular meanings, as illustrated in Figure 10.
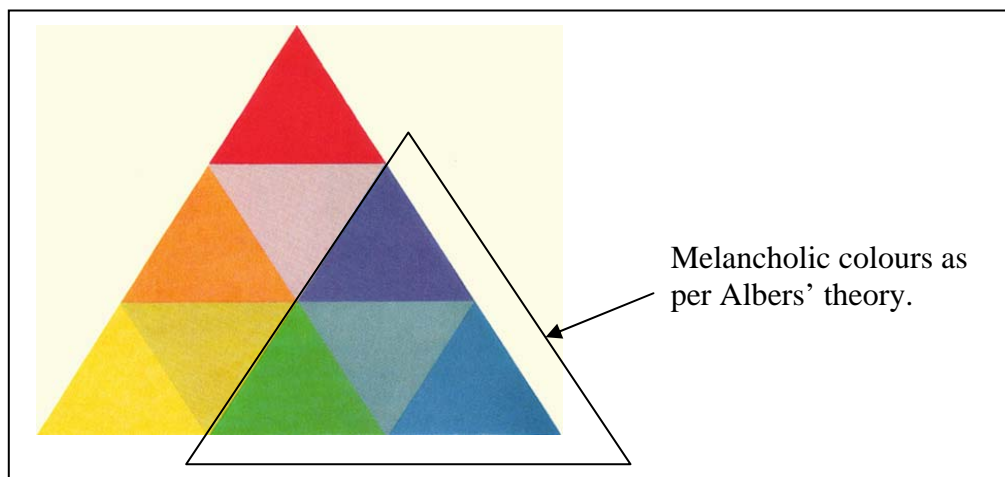
Figure 10. Albers (1963) colour triangle.
(Image: Josef Albers and Sewell Sillman, Yale University Art Gallery, New Haven, http://www.all-art.org).

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[12] A convention exists among some theorists whereby complementary colours are considered to equate with colour harmony (see Itten, 1961; Ostwald, 1916). A link between complementary colour and colour harmony was strongly championed by Chevreul (1839).

Albers considered that combinations of colour samples were always open to the influence of contextual and perceptual effects such as simultaneous contrast, the Craik-O'Brien effect and the Bezold effect.[13] Albers advised that combinations of colour samples that may be considered harmonious in one context may not be considered as such in different contexts due to these perceptual effects. Albers considered that previous published formulaic approaches to combining colour samples aimed at achieving colour harmony were "worn out" and that "no mechanical colour system is flexible enough to pre-calculate the manifold changing factors in a single prescribed recipe" (Albers, 1963, p42).

Hard and Sivik's descriptive model of colour combination

Hard and Sivik (2001) proposed a descriptive model for use as a guide for colour combination. The model is not predictive in terms of aesthetic response as Hard and Sivik suggest that the "almost infinite" number of possible colour combinations inhibits any kind of predictive capacity (Hard & Sivik, 2001, p4). The model relies on the NCS colour wheel model wherein the primary colours are red, green, blue, yellow, black and white; and is underpinned by the notion of a 'colour gestalt' that represents the totality of the combined colour samples within any given context. A complex concept, colour gestalt all aspects of any given colour combination including context as well as the details and specifics of 'colour interval' (that is, the interval between colour samples as determined by their location on the NCS colour wheel model), the concordance of colour samples within a 'colour chord' in terms of hue, saturation and luminance; and 'colour tuning' in terms of the relative proportions and rhythms among a group of colour samples. While Hard and Sivik's model is complex, it represents perhaps more faithfully the complex nature of the phenomenon of colour as well as the relationship between colour and aesthetic response. The model acknowledges that colours constantly interact and that the overall form and character of any particular colour combination represents a phenomenon that changes whenever there is a change or variation in colour combination or context. In addition, Hard and Sivik's model is not predictive due to the belief that aesthetic response to colour is always open to the influence of individual, cultural and contextual factors. As such, Hard and Sivik's colour combination model fits the description of normative design theory – "a doctrine or ideology, a largely programmatic idea of how things ought to be done" (Moore, 1997a, p24).

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[13] Contextual and perceptual effects such as simultaneous contrast, the Craik-O'Brien effect and the Bezold effect are defined and discussed in greater detail below.

While Hard and Sivik (2001) are quick to caution that the model provides a basis for combining colour samples only and is not predictive, they do report that earlier studies indicated that that groups of colour samples that exhibited similarity of hue were judged as more beautiful that those without similarity of hue. Furthermore, Hard and Sivik suggest that constancy in regard to one of the attributes of colour (that is, hue, saturation or luminance) across a group of colour samples may be judged as aesthetically pleasing and they report on a study in which colour combinations containing similarity of hue and saturation were judged more harmonious than other colour combinations.

Itten colour theory

Itten (1961), who taught colour theory at the Bauhaus and his theories have been influential in art and design education studies since, developed a 12-hue colour wheel model and determined that the three key primary colours are red, yellow and blue as illustrated in Figure 11 (Feisner, 2000; Gage, 1995). From these three colours, secondary and tertiary colours could be derived. Itten also asserted that seven kinds of colour contrast exist as follows,

1. Contrast of hue;
2. Light-dark contrast: that is, contrast in terms of opposing levels of luminance;
3. Cold-warm contrast: that is, in terms of the notions of *warm colours* and *cool colours*;[14]
4. Complementary contrast (colours that occur opposite each other on the colour wheel);
5. Simultaneous contrast (a perceptual effect that occurs and is described in full below);
6. Contrast of saturation (that is, contrast in terms of opposing levels of saturation);
7. Contrast of extension (that is, contrast in terms of proportions among colour areas).

Figure 11.
Itten (1961) colour wheel model.
(Image: Malte Ahrens,
http://commons.wikimedia.org/wiki/Image%3AFarbkreis_Itten_1961.png)

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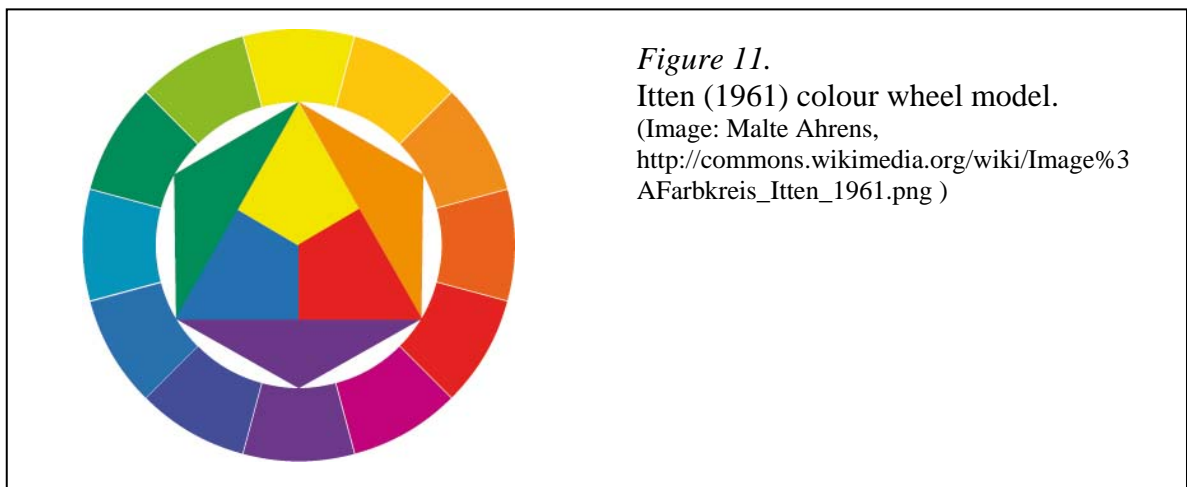
[14] Warm colours are considered to be red, orange and yellow; while cool colours are considered to be blue, green and purple (Itten, 1961).

Itten presented somewhat conflicting theories about colour harmony. One approach is based on the use of contrasting or complementary colours: "Harmony implies balance (of complementary colours); a symmetry of forces" (Itten, 1961, p21). Furthermore, Itten suggested that any combination of colour samples that achieved neutral grey or equilibrium in the human retina equates with colour harmony.

> (Colour) harmony in our visual apparatus then would signify a psychophysical state of equilibrium in which dissimilation and assimilation of optic substances are equal. Neutral grey produces this state. I can mix such a grey from black and white; or from two complementary colours and white; or from several colours provided they contain the three primary colours: yellow, red and blue in suitable proportions (Itten, 1961, p22).

However, Itten concedes that "colour combinations called harmonious in common speech usually are composed of closely similar chromas or else different colours in the same shades. They are combinations of colours that meet without sharp contrast" (Itten, 1961, p21).

Munsell colour theory and system

Under the Munsell (1912) system, contrasting colours are colours that appear opposite each other on the Munsell colour wheel model as illustrated in Figure 12.

Figure 12.
Munsell (1912) colour wheel model.
(Image: PlusMinus,
http://commons.wikimedia.org/
wiki/Image%3AMunsellColorWheel.png)
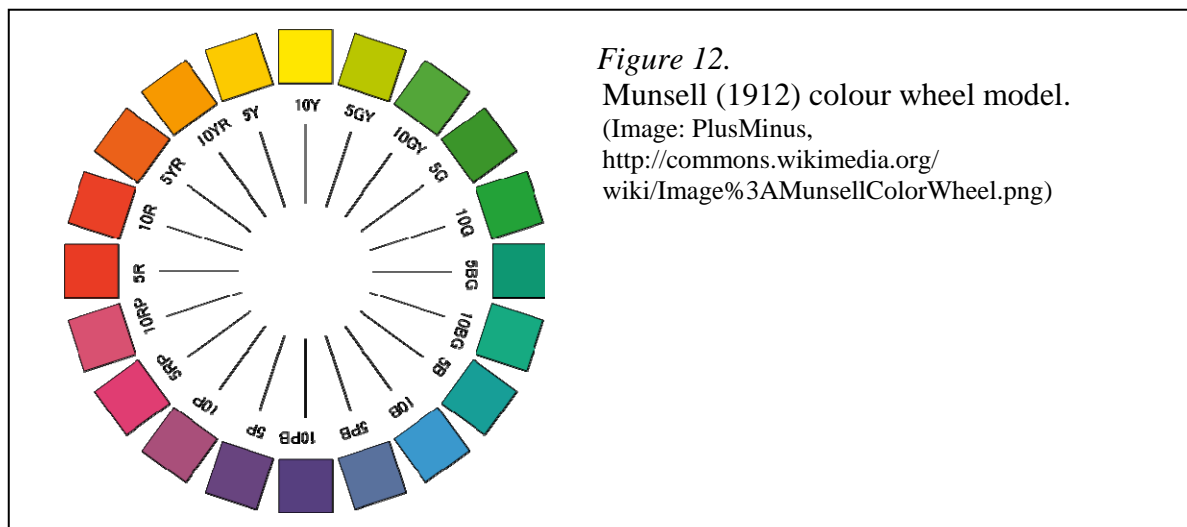
Munsell's (1912) colour theory, which evolved at around the same time as the CIE system, suggests that the gamut of distinguishable colours form a solid colour sphere that features five primary colours: red, yellow, green, blue and purple as well as numerous secondary and

tertiary colours (Feisner, 2000; Landa & Fairchild, 2005). The solid colour sphere includes white at the top of the sphere and black at the bottom of the sphere as per Figure 13.

Figure 13.
The Munsell colour system.
(Image: Creative Commons;
http://en.wikipedia.org/wiki/Image%3AMu
nsell-system.svg#file)

Munsell pioneered the concept of a colour atlas and published *A Color Notation* in 1905 within which each colour sample is described by hue; 0 to 15 different levels of chroma (saturation); and 0 to 10 levels of tonal value (luminance). [15]   Also referred to as 'complementary' colours, the Munsell contrasting colours are: red-blue/green; yellow-blue-purple; green-red/purple; blue-yellow/red; purple- yellow/green (Cleland, 1937). Munsell considered that colour harmony rests on two key notions: similarity of hue; and a degree 'balance' among colour samples that are opposite in terms of value (luminance) and chroma (saturation) wherein balance is achieved be applying a strict proportional use of colour.

Ostwald colour theory

Ostwald (1916), who won the Nobel Prize for Chemistry in 1909, detailed his colour theory in *Die Farbenfibel* ('The Colour Primer') (Gage, 1995).[16] Ostwald developed a double cone-shaped colour space with four primary colours: red, yellow, green and blue and suggested that the colour space included all possible colour including white and black, which featured at the top and bottom of the sphere. Under Ostwald's theory, contrasting colours revolve around the

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[15] The Munsell Color Science Laboratory continues to conduct research and provides education up to PhD level at the Rochester Institute of Technology, New York. The Munsell system is still used across a number of fields including imaging system calibration and soil-profile categorisation (Landa & Fairchild, 2005).

[16] Ostwald's colour theories drew on the earlier theories of Ewald Hering, whose work also influenced the development of the NCS colour notation system (Feisner, 2000; Gage, 1995).

opponent colours of red-green and blue-yellow (Gage, 1995). Ostwald's approach to colour harmony was strict and prescriptive: "Colour is order" and colour harmony is achieved through a proportional combination of complementary colours (Feisner, 2000). Ostwald's approach to colour combination and colour harmony had wide appeal and influence in art and design and specifically with the De Stijl art movement and the Russian Constructivists (Ostwald, 1916, cited in Gage, 1995, p258).

In conclusion, while the above is a limited summary of selected colour theories and models, it never-the-less reveals that variations exist in the description of colour as well as definitions of the relationship between colour and aesthetic response and notions such as colour harmony. To a certain extent, these variations can be explained by differences in epistemology as well as ontological assumptions embedded within the theories and the following section provides an in-depth discussion of these on theories relating to colour, colour harmony and the relationship between colour and aesthetic response.

'Competing' paradigms in the domain of colour

It has been suggested that there are four "competing" paradigms that currently guide research: Positivism, Postpositivism, Critical Theory and Constructivism (Guba & Lincoln, 1994, p105). Of these, all but Critical Theory are evident in theories relating to the relationship between colour and aesthetic response. It is the fundamental differences in the patterns of knowledge within each paradigm that has, to a certain extent, contributed to the conflicting descriptions and predictive models regarding notions such as colour contrast and colour harmony.

However, it is an earlier paradigm, rationalism, which is evident in the writings of theorists considered influential in the domain of colour: Newton and Goethe (Feisner, 2000; Gage, 1995 & 1999). Newton, for example, who drew an analogy between colour and music to explain the phenomenon of colour and provided a colour wheel model based on mathematical proportion.[17] In regard to the relationship between colour and aesthetic response, Newton proposed that colour harmony relied upon the proportional arrangement of colours similar to the mathematical basis of musical composition:

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[17] Gage (1995) considers that Newton's approach to colour and colour harmony can be traced back to the Pythagorean aesthetico-mathematical understanding about the nature of reality.

> …not only because it agrees with the phenomena very well, but also perhaps because it involves something about the harmonies of colours (which is) perhaps analogous to the concordance of sounds (Newton, 1669, cited in Gage, 1995, p232).

Goethe suggested that harmonious colour combinations were those that represented the totality of his colour wheel model (Crone, 1999; Gage, 1995). Goethe's approach to colour harmony is based on the notion of balance in terms of the polarity of opposing forces.[18] As discussed above, the notion of balance and equilibrium among opposing or complementary colour recurs in the theories of Itten, Munsell and Ostwald.

Under the positivist paradigm, reality is considered to be apprehendable, quantifiable and reduce-able atomistically. As such, positivists tended to embrace the doctrines of reductionism and determinism, and considered that aspects of reality could be studied in time- and context-free isolation. Experimental and quantitative methods are hallmarks of positivism, as is the verification rather than the falsification of hypotheses (Guba & Lincoln, 1994; Magee, 2001).

The doctrines of reductionism and determinism bring inherent weaknesses that may undermine the veracity of theories that adopt the positivist paradigm (Guba & Lincoln, 1994). This is particularly evident in some theories relating to the phenomenon of colour. For example, colour is a complex phenomenon: it is estimated that humans can distinguish between 1.8 million to ten million different colours (Gouras, 1991; Judd & Wyszecki, 1975; Pointer & Attridge, 1998). However, reductionism under the positivist paradigm provided some theorists with the impetus to reduce the phenomenon of colour to simplistic colour wheel models featuring a tiny proportion of the gamut of distinguishable colours (for example, see Itten, 1961; Munsell, 1912; Ostwald, 1916). The weakness of these colour wheel models is their inability to represent or accommodate a larger array of colours or atypical colours such as brown, khaki green, fluorescent colours and so on. In addition, Heraclitus' assertion: 'Everything is flux' is nowhere more evident than in regard to colour which is constantly open to the influence of manifestations of flux such as time, ambient light conditions and so on.

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[18] This concept harks back to the ancient Greeks: Heraclitus, for example, considered that the world was subject to opposing forces and harmony within any aspect of reality involved the balancing of these forces (Magee, 2001). Pythagoras shared this view and considered that equilibrium occurs when opposing forces neutralise each other (Eco, 2004).

Reductionism provided an opportunity for some theorists to put "fixity on the flux"[19] thereby enabling theorists to simplify the study of colour in context-free isolation (for example, see Munsell, 1912; Ostwald, 1916). Finally, it has been calculated that the number of possible combinations of colour samples "is almost infinite" (Hard & Sivik, 2001, p4). However, theorists in the domain of colour adopted a reductionist approach and applied Ockham's razor[20] with gay abandon in attempts to provide simplistic one-size-fits-all principles or formulae aimed at predicting the relationship between colour and aesthetic response (for example, see Chevreul, 1839; Itten, 1961; Munsell, 1921; Ostwald, 1916). Given the limitless number of possible colour combinations, it seems folly to attempt to explain let alone predict aesthetic response to multiple colour combinations and yet some studies have attempted this (see also Chuang & Ou, 2001; Ou, Luo, Woodcock & Wright, 2004; Rapoport & Rapoport, 1984). These theories also reveal an underlying deterministic approach wherein a strong and irrefutable causal relationship existed between colour and aesthetic response (see Itten, 1961; Munsell, 1921 and Ostwald, 1916).

Under the post-positivism paradigm, a paradigm that evolved from positivism, it is considered unsound to suggest transferring the findings of one study to other situations or contexts, and Popper (1959) advises against putting forward conjectures as explanations without any "ingenious and severe attempts to refute them" (Popper, 1959, cited in Ackerman, 1976, p109). The aims of enquiry under Post-positivism are explanation, prediction and control, and aspects of reality are assumed to be only "imperfectly and probabilistically apprehendable" (Guba & Lincoln, 1994, p109). The Postpositivist paradigm emerged in response to the criticisms made in regard to Positivism: that is, the stripping of contextual factors or influences through experimental control; the diminishing or minimising of human meaning and subjectivity; the problem of induction, and the lack of objectivity and value-free inquiry. Reliance on the falsification of hypotheses as well as the use of qualitative methods transpired as improvements of the Positivist paradigm. Only some of the theorists mentioned above acknowledge that groups of colour samples are considered to be always open to the influence of contextual and perceptual effects (see Albers, 1961; Hard & Sivik, 2001).

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[19] The notion of 'imposing fixity on the flux' as been borrowed from a quote by John Gage in Friedman, B.H. (1972) *Jackson Pollock: Energy made visible*. New York: McGraw-Hill.

[20] 'Ockham's razor', a doctrine attributed to William of Ockham, 13th century, suggests that where there are two explanations for the same phenomenon, the more complicated is likely to be erroneous in some way and, other things being equal, the simpler explanation is likely to be correct (http://dictionary.oed.com).

In terms of constructivism, this paradigm suggests that reality is assumed to be in "the form of multiple, intangible mental constructions…often shared among individuals and even across cultures" (Guba & Lincoln, 1994, p110). While a particular set of constructs in any one domain may achieve a level of general consensus, under constructivism, they are always open to review, revision and reinterpretation. Aspects of the constructivist paradigm are evident in most current theories as they invariably contain notions or ideas that are constructions or inventions of the human mind such 'colour gestalt', 'colour chords', 'colour intervals', 'complementary colours', and 'primary colours' (see Chevreul, 1839; Hard & Sivik, 2001; Itten, 1961; Munsell, 1921; Ostwald, 1916).

To summarise, different epistemologies have been identified in relation to a selected range of extant colour theories and these have, to a certain extent, undermined the veracity of some theories relating to the phenomenon of colour as well as the relationship between colour and aesthetic response. However, three main approaches to understanding the relationship between colour and aesthetic response emerge from the above-mentioned theories and these are summarised as follows.

Colour harmony based on contrasting (complementary) colour

A number of theorists equate colour harmony with combinations of colour samples that exhibit completely different or contrasting (complementary) colours (see Itten, 1961; Munsell, 1912; Ostwald, 1916).   This understanding of colour harmony evolved during the 18th and 19th centuries and was "a view given the greatest authority by the exhaustive experiments of a French chemist Chevreul" (Gage, 1995, p173). Chevreul (1839) championed a strong link between colour harmony and complementary colours and he extolled this view in *The Law of Harmonious Colouring*, considered to be "the most widely used colour-manual of the 19th century" (Gage, 1995, p173).

Colour harmony based on similarity of hue

This approach to colour harmony suggests that it arises from combinations of colour samples that exhibit similarity of hue or similarity of saturation level or luminance level (see Hard & Sivik, 2001; Itten, 1961; and Munsell, 1912).   Hard and Sivik (2001) suggest that empirical evidence points to a link between 'analogous' colours and positive aesthetic response. Analogous colours represent colours that are similar in hue and or luminance.   Itten (1961) also suggests that a link exists between aesthetic response and analogous colours,

The colour combinations called 'harmonious' in common speech usually are composed of closely similar hues (chromas), or else different colours in the same shades. They are combinations of colours that meet without sharp contrast (Itten, 1961, p21).
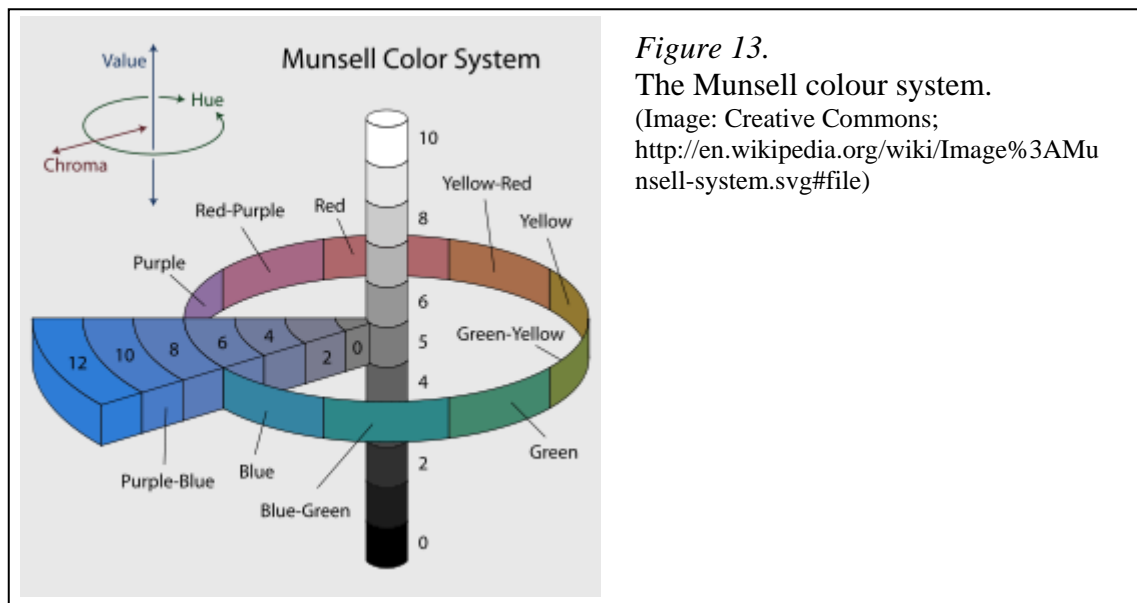
This understanding about the nature of colour harmony has become widely accepted possibly due to the influence of Itten as suggested by Feisner (2000) and Gage (1995). In school curriculum in Sydney, Australia, for example, analogous colours (or colours that exhibit similarity of hue, are referred to as harmonious colours (NSWDET, 2005).

Colour harmony: an unpredictable phenomenon

This third approach does not attempt to predict the nature of the relationship between colour and aesthetic response, or equate the notion of colour harmony with formulaic groupings of colour samples. The approach is somewhat in the minority but is evident in the work of Albers (1963) and Hard and Sivik (2001). It is hardly surprising therefore that Burchett (2002) found little consensus in regard to the notion of colour harmony after conducting a content analysis of leading texts on colour science, art and design, colour theory and psychology.

Colour harmony: An elusive concept

"Colours seen together to produce a pleasing affective response are said to be in harmony" (Burchett, 2002, p28). The simplicity of this statement belies the complexity of the interface between colour and aesthetic response and colour harmony remains an elusive concept. While a number of diverse approaches to colour harmony exist (as discussed above), aesthetic response to colour is a complex phenomenon that is not only difficult to describe, but also to predict or quantify (Hard & Sivik, 2001; Sivik, 1997). Furthermore, consensus in the literature is lacking with respect to the notion of colour harmony (Burchett, 2002; DeWitt, 1987; Hard & Sivik, 2001).

A lack of consensus in regard to the nature of the relationship between colour and aesthetic response can be partly attributable to the two opposing ontological approaches evident in the literature.[21] Moore (1997a) suggests that the ontological understanding that underpins research brings some fundamental assumptions about the nature of the

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[21] Ontology has to do with the nature of the aspect of reality under focus or that is the subject of research as opposed to the nature of our knowledge about reality (Moore, 1997a).

aspect of reality that forms the focus of the research. For example, whether reality is essentially nomothetic – that is, readily explained in terms of universals, general laws, or principles that can be assumed to apply to all – or whether reality is more idiographic and therefore can't be explained in terms of universals because of the influence of individual differences. Another assumption has to do with whether the world is fundamentally deterministic. That is, whether reality is constantly exposed to influences from some kind of force, forces or power; and that reality is a complex sequence of causes and effects. The alternative view is that the workings of reality are more randomly determined, stochastic and less predictable. A third ontological assumption has to do with whether reality is atomistic and divisible, and can be studied and explained in terms of isolated parts. The opposing view is that reality is essentially holistic and therefore more than the sum of its parts; parts which perhaps shouldn't be studied and explained in isolation (Moore, 1997a).

Colour harmony: A predictable and universal phenomenon

This ontological understanding of colour harmony suggests that it is both nomothetic and deterministic. That is, colour harmony is accorded the status of a universal phenomenon: absolute and immutable not just in abstract form but as a fixed and identifiable aspect of reality. In addition, a high degree of causality is assumed to exist between colour and aesthetic response irrespective of individual, cultural, contextual and temporal factors. This ontological assumption is evident in theories relating to the relationship between colour and aesthetic response. Chevreul, for example, "equated maximal contrast of the complementaries with maximum (colour) harmony" (Chevreul, 1839, cited in Gage, 1999, p218). Likewise, Ostwald asserted: "Harmony is order" and provided strict rules for colour combination (Ostwald, 1916, cited in Gage, 1995, p258). Similarly, Munsell provided rules aimed at predicting colour harmony and he asserted that "Colour harmony is attained when any three…rules are followed" (Munsell, 1921, cited in Cleland, 1937, p19). "Harmony implies balance (of complementary colours); a symmetry of forces" (Itten, 1961, p21).

Colour harmony: An idiographic and stochastic phenomenon

The second ontological approach suggests that the relationship between colour and aesthetic response is perhaps more idiographic, less deterministic and more holistic in nature. Under this ontological approach, colour harmony is not accorded the status of a universal phenomenon and responses to colour are not considered to be deterministic. This approach,

which tends to be the current, prevailing approach, is evident in the work of Albers (1963) and Hard and Sivik (2001) wherein aesthetic response to colour is acknowledged to be open to the influence of individual differences and cultural, contextual and temporal factors. This ontological approach is also evident in a number of recent studies wherein individual differences such as familiarity, preference and recognition as well as cultural, contextual and temporal factors have been found to influence aesthetic response to colour (see Chuang & Ou, 2001; Janssens, 2001; Svedmyr, 1997; Taft & Sivik, 1997; Urland, 1997). Under this ontological approach there is no place for prescriptive, predictive guidelines or formulae as these could not possible accommodate all of the factors that may impinge on the relationship between colour and aesthetic response.

Factors that may influence aesthetic response to colour

As mentioned above, the prevailing understanding about the nature of the relationship between colour and aesthetic response acknowledges that a number of factors may influence this relationship. These factors include, but may not be limited to, the following.

Contextual and perceptual factors

A number of perceptual effects are considered to influence perception and evaluation of colour in general as well as the relationship between colour and aesthetic response (Albers, 1973; Anter, 2000; Hard & Sivik, 2001; Itten, 1961). These perceptual effects tend to be related to the context within which a group of colour samples is perceived. Simultaneous contrast, featured in Figure 14, occurs when the visual appearance of an area of colour seems to change marginally due to the proximity of a surrounding colour (Goldstein, 1996).

Figure 14. Simultaneous contrast. The red squares are identical; however the green surround makes the red appear lighter and larger (Adapted from Goldstein, 1996).

The Craik-O'Brien effect, also known as the Cornsweet effect, is similar to simultaneous contrast and occurs when differing levels of luminance occur between two areas of colour in close-proximity gives rise to an illusion of brightness in one of the colour areas (Davey, Maddess & Srinivasan, 1998). The Craik-O'Brien-Cornsweet effect is featured in Figure 15.
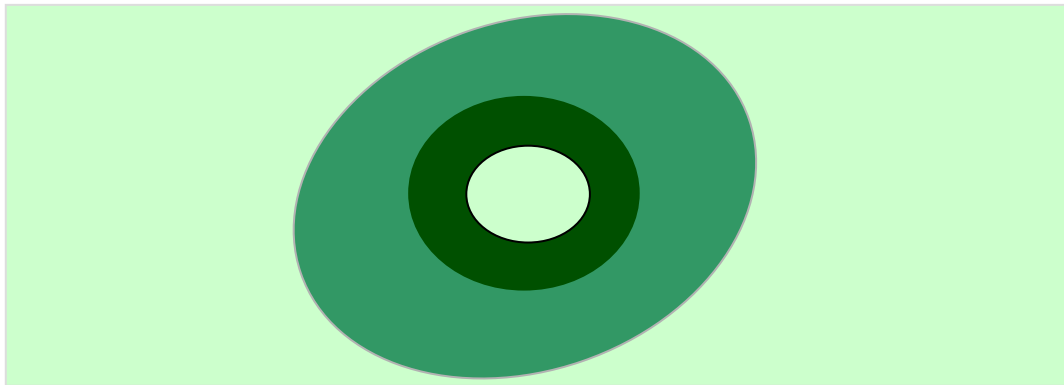
Figure 15.
The Craik-O'Brien effect. The inner circle and outer area are identical but the inner circle appears lighter due to the proximity of darker surrounding it (Adapted from Ratliff, 1972).

The Bezold effect occurs when a change in surrounding colours influences the appearance of a colour sample. The Bezold effect is illustrated in Figure 16.

Figure 16. The Bezold effect. The green bands are identical but they appear different due to the proximity of black and white bands (Adapted from Itten, 1961, and Kanizsa, 1979).

Individual and cultural differences

Some individual characteristics, such as age and gender, are considered to influence to an unspecified level, aesthetic response to colour (Manav, 2007). As mentioned above, evaluation of colour is also considered to be influenced by the associations that we may hold in relation to specific colours and it is suggested that familiarity may therefore influence aesthetic response to colour (Svedmyr, 1997). In addition, colour meanings and associations are considered to vary considered across cultures (Feisner, 2000; Gage, 1995). A cultural analysis of colour meanings and associations shows distinct differences across cultures with respect to the seven colours: white, blue, green, yellow, red, purple, and black (Aslam, 2006). The results of Aslam's (2006) cultural analysis of colour meanings are partially reproduced in Table 1.

Table 1. Cultural analysis of colour meanings and association (Aslam, 2006).

| Colour | Country-culture cluster | | | |
	Anglo-Saxon	Germanic	Chinese	Japanese
White	Purity	--	Death Mourning	Death Mourning
Blue	High quality Masculine	Warm Feminine	High quality Trustworthy	High quality Trustworthy
Green	Envy Good taste	--	Pure Reliable	Love Happy
Yellow	Happy	Envy Jealousy	Pure Good taste	Envy Good taste
Black	Mourning Fear Expensive	Fear Anger Mourning	Expensive Powerful	Expensive Powerful

Preference

Numerous colour preference studies were conducted during the 20th century, however some of these tend to suffer from a lack of experimental rigour and methodological shortcomings as highlighted by Whitfield and Wiltshire (1990). Never-the-less, Whitfield and Whiltshire (1990) suggest that colour preference is subject to "individual and cultural differences" (Whitfield & Whiltshire, 1990, p393). Svedmyr (1997) suggests that familiarity influences preference, which in turn influences aesthetic response: colours that are familiar are more likely to be colours that are preferred and to which we are more likely to exhibit positive aesthetic response. Chuang and Ou (2001) found that the inclusion of favourite or preferred

colours in a combination of colours was found to have a significant, positive influence on perceptions of colour harmony.   However, it is suggested that colour preference has less to do with the dimensions of colour (such as hue, saturation and luminance) and more to do with the totality of colour experience; that is, the 'colour gestalt' (Hard & Sivik, 2001).

In summary, literature in the domain of colour revealed diverse theories relating to the concept of colour as well as the nature of the relationship between colour and aesthetic response.   Not only do conflicting understandings of notions such as harmonious colours exist, but a number of factors are thought to influence the relationship between colour and aesthetic response.   These factors include, but may not be limited to, contextual and perceptual factors, individual and cultural differences and variations in preference.

The following section discusses the role of façade colour in relation to urban design and planning policy.   As will be discussed, the role of colour is often acknowledged within urban design and planning policy as an important element.   However, it is clear that there is often little or no overlap between current theories relating to the nature of the relationship between colour and aesthetic reponse; and the way in which façade colour is dealt with by architects and planners.

URBAN DESIGN, PLANNING POLICY AND FAÇADE COLOUR

Krieger (2004) asserts that urban design is a bridge between planning and architecture. It is urban design elements manifested within architecture that are generally subject to review in terms of a city's planning policies. This section examines the role of urban design as a bridge between planning and architecture with particular reference to the design element of façade colour.

This section begins by reviewing the aesthetic qualities of urban design and focuses on the role of façade colour as one of a number of key design elements. This is followed by a discussion of the many ways in which façade colour is used and manipulated in the field of architecture. Finally, planning policy is investigated in terms of the ways in which façade colour is treated with specific reference to planning policy in Sydney.

The aesthetic qualities of urban design

Urban design is concerned with the organisation and structure of architecture within the public urban realm as opposed to the private domain (Moughtin, Oc & Tiesdell, 1995). A multi-faceted discipline, urban design deals with a range of overlapping and inter-related dimensions that relate to the use and functioning of the public realm and include physical form, social, visual and spatial dimensions (Kozlowski, 2006). A number of design variables have been identified as being highly relevant to urban design and these include: unity, proportion, scale, harmony, rhythm, contrast, balance and symmetry (Moughtin *et al*, 1995).[22] It is suggested that these urban design elements may influence aesthetic response to urban environments and that variations within these design elements may generate positive or negative aesthetic response.

In terms of colour, it has been suggested that colour is evident at four different scales within an urban environment: at the scale of an entire city or district; at the scale of streetscapes or squares; at the scale of individual buildings; and at the scale of particular details such as doors,

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[22] In brief, the design variable of unity refers to a level of visual cohesion or relatedness among a diversity grouping of urban design elements. Proportion relates to the nature of the relationship between greater or lesser (or larger or smaller) urban design elements within a given setting. Scale relates to the nature of the relationship between overall urban design elements of a given setting and human scale as well as in relation to the function and setting of particular buildings. Harmony implies a level of similarity of proportion or ration among design elements. Balance and symmetry relate to the overall impression of axial placement of urban design elements. Rhythm has to do with the emphasis and intervals among a group of urban design elements. Finally, contrast implies a level of dissimilarity among a group of urban design elements (Moughtin *et al*, 1995).

windows, and so on: "The colour scheme of the street or square may have considerable effect upon its character and appearance" (Moughtin *et al*, 1995, p142). In addition, colour is considered to influence aesthetic response to the urban design variables of unity, harmony, rhythm and so on. The following section provides some illustrated examples of the role of façade colour in terms of specific urban design elements.

Urban design variables and the role of façade colour

Colour generally and in the form of façade colour are considered to have the capacity to influence the perception of overall urban design (Moughtin *et al*, 1995). Colour is considered to be one of three basic design elements that influence judgements about visual quality (Polakowski, 1975). In regard to the urban design variables mentioned above, façade colour has the capacity to influence the perception of these variables and two examples are provided to illustrate this point. The first example illustrates the role of façade colour in contributing a degree of unity within a streetscape. Figure 17 features the contrasting façade colours common in Burano, Italy. Façade colours are specifically selected to contrast with neighbouring buildings. However, window and door frames are traditionally painted white and the introduction of white provides a unifying element among a group of buildings.

Figure 17.
House façades in Burano, Italy.
(Image: http://www.image53.webshots.com)

Similarly, façade colour can also be used to strengthen the design concepts of harmony, rhythm and contrast. For example, the façades of buildings in Longyearbyen, Norway, exhibit the same group of colours thereby contributing to a sense of harmony and rhythm among the buildings in this particular district. The façade colours also contrast somewhat amongst themselves and with the surroundings (either with the greens and greys of the

natural surroundings in warmer months or the white of snow during the winter months), thereby adding visual diversity to the district. Figure 18 features the buildings of Longyearbyen.

Figure 18.
Buildings in Longyearbyen, Norway.
(Image: http:// www.sxc.hu/pic/m/i/is/isdngirl)

To conclude, façade colour is considered one of a number of design elements that contribute to urban design aesthetics. More away from urban design and into the domain of architecture, the following section discusses the many ways in which architects use façade colour in the built environment. In doing so, many architects specifically manipulate the urban design element of façade colour for a diverse range of reasons.

The use and manipulation of façade colour in architecture

Gerhard Mack notes "Colour has an uneasy place in architecture" and this is reflected in the wide range of ways in which façade colour is specifically and purposefully handled by architects (Koolhaas, Foster & Mendini, 2001, p13). This section includes a résumé of the ways in which façade colour is used, incorporated, manipulated or disregarded by architects in the built environment. This summary is included to highlight the many ways in which façade colour exists in the built environment and, as discussed below, to indicate that this is not generally reflected in planning policy.

From a purely practical perspective, Koolhaas *et al* (2001) suggests that colour can feature in one of two ways in terms of the exterior of a building: colour as an integral feature of the materials used in construction; and artificial colour, that is, colour that has been applied by way of painted surfaces, cladding, and the like. In addition to the functional requirements of the external elements of a building, it is suggested that the façade of a building should provide a

'pleasing exterior which relates well to its surroundings' (Gatz & Achterberg, 1967, p7). While Gatz and Achterberg (1967) do not define the notion of a 'pleasing exterior', they do suggest that this is related to the notion of environmental aesthetics.

Although the various approaches detailed here appear under categories, they may not necessarily fit neatly into strict, excusive categories due to the diverse aims and preferences of architects in respect to the use of façade colour. This summary is not intended as a comprehensive review, rather as a discussion of the broad ways in which façade colour features within the built environment.

Façade colour and crime: Ornament vs. integrity

Among some architects, there appears to be a disinclination to use or exploit façade colour and colouration in the built form exists only as a by-product of construction materials. For these architects, colour is a form or ornament that stands in opposition to the integrity of design and the built form. I have included in this group of architects those who consider white to paramount: "White is the ephemeral emblem of perpetual movement…White is the light, the medium of understanding and transformative power" (Richard Meier cited in Koolhaas, Foster & Mendini, 2001, p6). Evident in the work of architects Tadao Ando, John Pawson and Richard Meier among others, this approach to façade colour tends to adopt a minimalist approach to the design of the built environment wherein colour is considered ornamental. Reflecting the "polemic of disegno against colore" that underscored discourse relating to art, design and architecture during the Renaissance period, this approach to façade colour is championed in the work of theorists such as Owen Jones and Ruskin, as well as Loos, Le Corbusier, Gropius, Sullivan and exponents of the Modernist movement in general (Gage, 1995, p117).

Ruskin declared that 'the true colours of architecture are those of natural stone' (Ruskin, 1880, p52). Ruskin suggested that form should be completely independent of colour; an element he equated with ornament, and suggested 'Nobody wants ornaments in this world, but everybody wants integrity' (Ruskin, 1880, p54). Similarly, Owen Jones (1856) considered that colour was fundamentally ornamental and secondary to the eminence of form. Jones advised limiting the use of colour to primary colours (red, blue and yellow) and claimed that other colours, such as tertiary colours, are associated with a decline into decadence.

Loos, one of the key contributors to the theories underlying the Modernist movement, used his essay *Ornament und Verbrechen (Ornament and Crime)* to espouse his views on the role of ornament: "the evolution of culture marches with the elimination of ornament from useful objects" (Loos, 1908, cited in Banham, 1960, p94). Beauty of form was considered paramount by Loos and anything else was considered "wasted effort" (Loos, 1908, cited in Banham, 1960, p94). To design and build without ornamentation was considered right and proper in the Machine Age of the early 20th century: "Building without ornament offers the greatest possibilities for purity and architectural expression…All decoration is inessential, mere outward compensation for inner impotence" (Oud, 1921, cited in R. Banham, 1960, p159). Façade colour, Oud considered, was the least important element and open to weathering: "so that what was originally a harmony would become a discord in a week; a discord that would strike the eye all the more clearly when pure painted colours have been used than where a more neutral tint is employed" (Oud, 1921, cited in Banham, 1960, p161). Oud championed the integrity and purity of materials over the "inessentialism" of ornamental appearances (Oud, 1921, cited in Banham, 1960, p162).

Le Corbusier asserted that 'the idea of form precedes that of colour. Form is pre-eminent; colour is only one of its accessories' (Le Corbusier, 1935, cited in Braham, 2002, p6). While form and the interplay of light are central to Le Corbusier's work, as evidenced in many of his early buildings such as the Villa Savoye and Notre Dame de Haut, Le Corbusier also used colour to draw attention to particular details. Le Corbusier suggested that "Colour…is not an ornament or decoration, but an organic element of architectural expression" (Le Corbusier, 1953, cited in Wilkes & Packard, 1988, p676). Le Corbusier followed up on this assertion in a number of projects, notably the playful use of colour in the façade of the Unité d'Habitation, a Modernist apartment complex in Marseille.

Somewhat in contrast, Gropius declared: "Architecture during the last few generations has become weakly sentimental, aesthetic and decorative….this kind of architecture we disown" (Gropius, 1923, cited in Curtis, 1987, p126). Gropius was christened the 'silver prince' by Wolfe (1981) due to his preponderance for façades featuring stainless steel and glass and his buildings were predominantly austere, functional and often white. Gropius spawned a generation of "White Gods," architects who adopted a Modernist approach to the built environment and tended to favour a monochromatic approach to façade colour (Wolfe, 1981, p45). "Buildings became theories constructed in the form of concrete, steel, glass and stucco.

Inside and out, they were white or beige with the occasional contrasting detail in black or grey" (Wolfe, 1981, p22).

Sullivan's contribution is similar: "I take it as self-evident that a building, quite devoid of ornament, may convey a noble and dignified sentiment by virtue of mass and proportion" (Sullivan, 1947, p187).   Sullivan considered that 'the form exists because of the function, and this something behind the form is neither more nor less than a manifestation of what you call the infinite creative spirit, what I call God' (Sullivan, 1947, p46). This notion evolved into the 'form follows function' dictum, a guiding principle in Modernist architecture. Under Modernism, ornament was a crime; façade colour was aligned with ornament and, by default, became its partner in crime.   Modernism segued into the International Style, and Hitchcock and Johnson (1932) described this style as having a focus on the expression of volume rather than mass, and balance rather than symmetry with the concerted exclusion of ornament.

The Modernist and International styles disdained the use of façade colour as ornament and an artifact of the materials used in construction.   However, Le Corbusier did in fact use colour in some of his projects (for example, Villa Schwob and the Villa La Roche) and acknowledged that colour can be used as a form of architectural expression, as discussed below.

Façade colour and architectural expression: From the ordinary to the extraordinary

Façade colour can be used as a form of architectural expression and this approach is evident in, but not limited to, the work Lenclos, Barragán, Jarmund Vigsnaes Architects, Nouvel, Piano and Rogers, and Norman Foster.

Porter and Mikellides (1976) suggest that Lenclos is responsible for a widespread and concerted effort in endowing "the built environment with richly coloured space(s)…his colour applications range from collaboration with architects on individual buildings to the development of a comprehensive grammar of polychromy for new towns" (Porter & Mikellides, 1976, p39).   Lenclos (1976) suggests that façade colour can be used to transform an environment and create a sense of place; to camouflage unsightly buildings and to humanise industrial environments. For example, Lenclos featured bright-coloured super-graphics on the main façade of an industrial building at Port Barcares; and incorporated bright greens, blues, reds and oranges on various structures and façades of industrial buildings at Fos-sur-mer and Limay Porcheville.

Koolhaas (2001) believes that colour as a form of architectural expression became ideologically acceptable during the 1960s, a time period when "colour was crucial for the unfolding of daily life" (Koolhaas, Foster & Mendini, 2001, p11). An exuberant use of colour in the built environment among some architects continued through to the 1980s when, as Koolhaas suggests, "under the rise of post-modernism, colour suddenly became suspect" (Koolhaas, Foster & Mendini, 2001, p11).

The use of façade colour as a form of architectural expression is exemplified in the work of Luis Barragán has used façade colour to create strong visual differentiation, a sense of the extraordinary and to create a sense of place (Schindler, 2007). Figure 19 illustrates Cuadra San Cristobál, designed by Barragán in 1966-68, features vivid façade colours reflecting Barragán's desire to create a sense of the extraordinary.

Figure 19.
Cuadra San Cristobál, Los Clubes,
(Photograph: Armando Salas Portugal/Barragán Foundation, Switzerland, http://www.barragan-foundation.org)

Barragán won the Pritzker Architecture Prize in 1980, and, in recognition of his contribution to architecture, his house and studio were listed on the World Heritage List by UNESCO in 2004.[23] Barragán cites "the colourful (Mexican) streets; the humble majesty of (Mexican) village squares…" as the key sources of his inspiration (Barragan, 1980, p7). It has been suggested that Barragán specifically avoided the use of green as a façade colour as this colour was similar to the colours of the natural surroundings; and he was keen to use colours that created a dynamic contrast with the surroundings (Schindler, 2007).

Façade colour as a form of architectural expression was also used by Richard Rogers and Renzo Piano during the 1970s in the Centre Pompidou, featured in Figure 20. Rogers and

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[23] Luis Barragan House and Studio, Mexico City, listed on the United Nations Educational, Scientific and Cultural Organisation (UNESCO) World Heritage List in 2004 (Reference 1136) (see http://whc.unesco.org/en/list)

Piano sought to present the Museum as a "democratic place for all people, all ages and all creeds" and designed it as "a giant climbing frame, the antithesis of existing cultural monuments" (Rogers, Stirk, Harbour and Partners, 2007, http://www.rsh-p.com/). The mechanical services of the building, located externally, are coloured in a range of highly saturated colours. This device reflects the intention of creating an approachable and unintimidating museum and also served to help in revitalize the Marais area of Paris, an area that was experiencing a period of decline at the time.

Figure 20.
Centre Pompidou, Paris.
(Photograph: http://www.rsh-p.com/)

A desire to "allow guests to experience extraordinary moments" provided Jean Nouvel with the impetus to create a unique and colourful façade for the Hotel Puerta America built in 2005 in Spain (Nouvel, 2005, p1).   The façade of the Hotel Puerta America is featured in Figure 21 and exhibits highly saturated colours including yellow, orange, red, blue and purple.
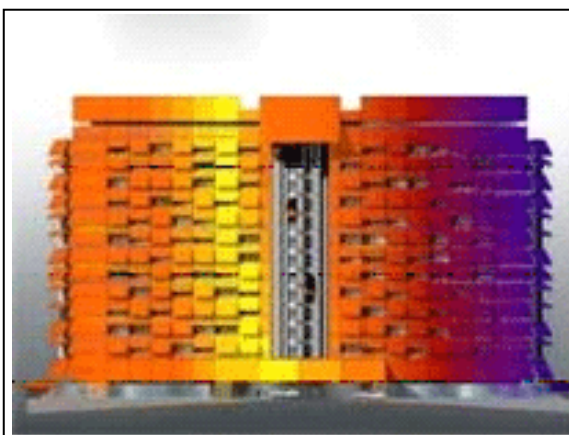
Figure 21.
Hotel Puerta América, Spain.
(Photograph: http://www.mundolujo.com/)

Jarmund Vigsnaes Architects (2007) suggest that the highly saturated red façade of the Red House, Norway, helped express the dynamism of the project and the personality of the owner (see Figure 22).   The setting provides a high level of contrast when the building is surrounded by snow as well as when the building is surrounded by natural vegetation.

Figure 22.
The Red House, Norway.
(Photograph: Nils Peter Dale,
http://www.jva.no/)

Façade colour and communication: A word from God and our sponsor

Foote (1983) proposes that façade colour constitutes a form of communication and suggests that façade colours may convey symbolic associations or meanings. However, Foote cautions: "to maintain that there is a natural and intrinsic iconography universally applicable to the interpretation of (façade) colour use stretches the argument beyond its capacity" (Foote, 1983, p7). Foote (1983) found a statistically significant relationship between organisational function and the number and type of colours featured in specific building façades. For example, churches, educational institutions and banks featured fewer façade colours and generally neutral colours such as white, off-white, beige and grey. Fast food restaurants featured a larger range of highly saturated façade colours. An example of the overt use of façade colour as a communication device is the Renault Distribution Centre by Foster and Partners, featured in Figure 23. The yellow façade serves to visually reinforce Renault's corporate identity.

Figure 23.
Renault Distribution Centre.
(Photograph: Foster and Partners,
http://www.fosterandpartners.com)

Lang (1992) suggests that façade colour may convey symbolic meaning "often by explicit social conventions. These conventions may be understood by broad segments of a population, even though the antecedents of the convention may be unknown" (Lang, 1992, p18). Places of worship such as churches provide an example here and churches in Sydney, Australia, which are not constructed of stone frequently feature white-washed façades.

The contributions of Foote (1983) and Lang (1992) echo the assertions of Rapoport, mentioned above, who proposed that 'the built environment is partly the organisation of meaning and communication…and the environment can be conceptualised as a form of communication' (Rapoport, 1977, p325). While the built environment may convey symbolic information and non-verbal messages, these are not necessarily universal and deterministic; and Rapoport (2005) considers that cultural factors may impinge on the interface between aspects of the built environment and humans.

Façade colour and its contribution to 'place' and 'imageability'

Façade colour is one of a number of elements that can contribute to a sense of 'place' (Porter, 1997, p23).[24] To some extent, this echoes Lynch's (1960) assertion that it is the form, colour and arrangement of elements of the built and natural environments that contribute to the *imageability* of a particular setting. In a way, Alexander (2007) adds weight to this contention by asserting that the rise of Modernism has been accompanied by a decline of a sense of place: "In the application of universal city-building solutions that are functional and utilitarian in nature, the urban environment became a diminished place" due to the characterless-ness of "standardized urban forms" (Alexander, 2007, p99).

It has been suggested that the colour characteristics of both the built and natural environments contribute to the uniqueness of particular locations (Porter, 1997). Environmental colour mapping studies have been used extensively as a means of identifying and differentiating environmental colour characteristics (see Foote, 1983; Iijima, 1995, 1997; Lenclos, 1982; Porter, 1997). These studies adopted a methodology pioneered by Lenclos (1976), who conducted environmental colour mapping studies across the regions of France and found that each region exhibited unique colour characteristics derived from the colours of façades,

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[24] 'Place' here is understood to be similar to Norberg-Schulz's (1980) understanding of the spirit of a particular place; and Tuan's (1977) research on 'sense of place' in relation to the positive affective ties arising from particular places.

construction materials, local stone, and so on. Similarly, Porter (1997) found that Oslo and Risør (Norway), and Harlow and Oxford (England) exhibited unique colour identities conveyed primarily via façade colour.

The following images provide illustrative support for the contention that façade colour may contribute to a sense of 'place' and the imageability of specific locations. Figure 24 features one of the distinctive red timber cabins common in rural Sweden. These cabins are typically painted red and contrast with their mostly natural surroundings.   The red façade and simple form of these cabins have come to represent a highly preferable and idyllic rural image for Swedes (Hagerhall, 1999). The esteem in which these red cabins are held in Swedish heritage is evidenced by the prominence of a red cabin on the main page of the Swedish National Heritage Board's website.[25]   A village comprising 424 red timber cottages was included on the World Heritage List by UNESCO in 1996.[26]

Figure 24.
A red timber cottage in rural Sweden.
(Photograph: C. Hagerhall)

Figure 25 features Manarola, a village located in the Cinque Terre region, Italy.   The Cinque Terre region was included on the World Heritage List in 1997 as a site of "outstanding value, representing the harmonious interaction between people and nature to produce a landscape of exceptional scenic quality" (UNESCO, 2007).[27]   Façades in Manarola are painted in a range of hues (red, terracotta, ochre, yellow and white) which contrast with the colours of the surroundings.

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[25] National Heritage Board of Sweden website (see http://www.raa.se).

[26] The church village of Gammelstad, Lulea, County of Norrbotten, Sweden listed on the UNESCO World Heritage List in 1996 (Reference 762) (see http://whc.unesco.org/en/list).

[27] Portovenere, Cinque Terre and the Islands of Palmaria, Tino and Tinetto, Province of La Spezia, Liguria Region, Italy, listed on the UNESCO World Heritage List in 1997 (Reference 826) (see http://whc.unesco.org/en/list).

Figure 25.
Manarola in the Cinque Terre region.
(Photograph: UNESCO http://whc.unesco.org)

Figure 26 features Positano where building façades exhibit a range of colours (white, red, terracotta, ochre and yellow) that contrast with the colours of the natural surroundings. The Amalfi Coast region, listed on the World Heritage List by UNESCO in 1997, is considered "an outstanding example of a Mediterranean landscape, with exceptional cultural and natural scenic values" (UNESCO, 1997).[28]

Figure 26.
Positano, Amalfi Coast.
(Photograph: www.ruf.rice.edu)

Figure 27 features the buildings of Santorini, Greece, where buildings are predominantly white or light hues with blue details. The façade colours contrast strongly with the colour characteristics of the natural surroundings in hue and luminance level.

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[28] Costeria Amalfitana, Province of Salerno, Campania, Italy listed on the UNESCO World Heritage List December 1997 (Reference 830) (see http://whc.unesco.org/en/list).

Figure 27.
Santorini, Greece.
(Photograph: D. Kartonis/G. Leonard)

Façade colour and heritage: Replication for conservation

The existence of historical urban heritage and the need for its conservation frequently underscores the use and manipulation of façade colour in urban developments (Naoumova & Lay, 2007; Porter, 1997). In Sydney, Australia, this need has been translated into planning policy wherein variation in façade colour from heritage-specified colours are considered to detract from the heritage character of selected areas (COSC, 1991; 2005). Planning policy recommends that new façade colour replicate traditional colours: "New buildings and additions are to use colour schemes that have hues and tones that relate to traditional colour schemes" (COSC, 2005, p36).

Uncoordinated use of façade colour is considered to diminish the Heritage value of streetscapes and to assist with the selection of traditional colours, guidelines are provided that specify particular façade colours. For example, *Main street heritage paint scheme for King Street, Newtown and Enmore Road, Enmore* (COSC, 1991). Figure 28 features buildings along Oxford Street, Darlinghurst, Sydney. The façade colours of these buildings are subject to the *Oxford Street Darlinghurst and Paddington Heritage and Urban Design Development Control Plan* (COSC, 2005).

Figure 28.
Oxford Street, Darlinghurst, Sydney.
(Photograph: Z. O'Connor)

This approach to façade colour tends to provide for the ongoing replication of traditional façade colours, rather than an evolution of façade colour schemes that maintain a degree of chromatic consistency with the past but allow alternative options.

Façade colour and its contribution to architectural style

Façade colour can be used as an integral design element that contributes to architectural style and this is particularly evident in buildings of the Art Deco or the De Stijl styles of the early 20th century. The highly stylised façades of Art Deco buildings often include a range of façade colours augmented with coloured neon lighting as illustrated in Figure 29.

Figure 29.
Art Deco façade.
(Image: www.lotsafunmaps.com)

In regard to De Stijl, façade colour was used somewhat less exuberantly than in Art Deco style and white, black and grey were predominant along with accents of red blue and

yellow. The Rieveld-Schröder House is considered a classic example of De Stijl style where façade colour is used as an integral façade feature, as illustrated in Figure 30 (Moughtin *et al*, 1995).

Figure 30.
The Rietveld-Schröder House
(Image: www.en wikipedia.org)

An holistic approach to façade colour

The architect Norman Foster suggests a metaphor of 'caves and temples' in regard to the use of colour in the built environment. Façade colour, Foster advises, is one of a number of elements that can reinforce the notion of the imposition of an artificial object in the landscape much the same way as a temple appears to be "deliberately and symbolically placed in the landscape"; or, alternatively the "careful integration" of a structure that blends with its surroundings (Foster, 1976, p62). This approach to façade colour suggests an holistic approach whereby the colour characteristics of the surroundings are considered in determining the colour characteristics of the built environment.

Lynch's asserts "The sensuous function (of the built environment) is as important as the demands of circulation or of use" (Lynch, 1960, p55). Buildings don't exist in a vacuum and "it is the total orchestration of these units which would knit together a dense and vivid image, and sustain it over areas of metropolitan scale" (Lynch, 1960, p108). However, this holistic approach to façade colour has been tackled in slightly different ways by Iijima (1995; 1997), Marcus and Matell (1979) and Unver and Ozturk (2002).

Marcus and Matell (1979) suggest that a holistic approach to façade colour provides a means of visually linking elements within an environment at the same time as creating a level of

visual diversity. Acknowledging Lynch as their key inspiration, Marcus and Matell (1979) developed a façade colour scheme for a large apartment building complex in Sweden that comprised 18 buildings, varying in height from 8 to 12 storeys. The visual aspects of the complex, from close-by and from a distance, were considered important and two key aims emerged: to lighten the overall heaviness of the buildings and to use colour to modulate the overall form of the complex in a sensuous and holistic manner. As a result, the northern facades were painted white and light greys as were the building façades facing each other; and the façades facing south were painted in 15 vivid colours ranging from red through to orange, yellow, green, blue and purple, all of which at maximum purity (saturation) level but at the same tonal (luminance) level.

A problem identified as the "overflow of colour in urban landscapes" prompted a number of environmental colour mapping studies (Iijima, 1995, p271). Iijima used the outcomes from these studies to develop façade colour alternatives aimed at providing a holistic level of overall colour harmony within streetscape areas. Similarly, in a mass housing apartment complex in Turkey, Unver and Ozturk (2002) used façade colour holistically to create a high degree of compatibility between and among the buildings and their surroundings. To achieve this level of compatibility, Unver and Ozturk linked a proportion of façade colour to the colours of the surroundings and also incorporated levels of contrast in terms of hue, luminance or saturation

In conclusion, "Colour has an uneasy place in architecture" (Koolhaas *et al*, 2001, p4). Façade colour is considered one of a number of building attributes that can be used and manipulated in a variety of ways in the built environment. It is clear that some architects purposefully apply colour contrast or colour harmony via façade colour for specific and often diverse reasons. Given the role of façade colour in terms of urban design aesthetic and the many ways in which façade colour is used and manipulated by architects, it is no wonder that façade colour attracts special attention in the area of planning policy. The following section discusses the notion of visual quality and planning policy with special reference to façade colour.

Façade colour and planning policy

In general, planning policy in Sydney tends to imply a strong link between a range of urban design elements and aesthetic response (for example, see COSC, 2001; NSC, 2001; NSWDOP, 2005). As a result, planning guidelines and controls aimed at managing or controlling urban design elements within the public and private realms are common; and these controls to the notion of preserving or enhancing visual quality.[29] This section discusses visual quality within the context of planning policy and with particular reference to façade colour.

The notion of visual character is generally understood to relate to the perception of overall urban design elements and natural elements with a setting (Friedman, Zimring & Zube, 1978; Nasar, 1992; Stamps, 2000). Specifically, visual quality, from a planning perspective, is an assessment of visual character in terms of the complex inter-relationships of a range of specific features and characteristics of a scene or setting (Laurie, 1975). These specific features and characteristics include the presence or absence of natural vegetation, the condition and character of buildings and structures, the presence or absence of bodies of water and so on. In reference to the character of buildings, it is here that urban design elements may contribute to visual character and therefore influence judgements relating to visual quality.

In terms of aesthetic controls in European countries, planning guidelines that proactively address environmental visual quality on an ongoing basis are becoming the norm (Nelissen, 1999). The same is occurring in Sydney wherein the aims of planning policy tend to articulate a need to maintain or enhance visual quality. A key aim of the *Sydney Harbour Foreshores and Waterways Area Development Control Plan* is "ensuring that the scenic quality if the area is protected or enhance" (NSWDOP, 2005a, p2). Similarly, one of the key planning principles contained within the *Sydney Regional Environmental Plan* recommended that "development that is visible from the waterways or foreshores is to maintain, protect and enhance the unique visual qualities of Sydney Harbour" (NSWDOP, 2005b, p10).

As discussed above, the building attribute of façade colour has been identified as a key urban design element and as an inherent quality of a range of characteristics that contribute to visual quality (Moughtin *et al*, 1995; Zube, Brush & Fabos, 1975). In terms

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[29] The term visual quality is used throughout this dissertation. However, the term is often used interchangeably with the term scenic quality, scenic amenity or scenic character in planning instruments in New South Wales (for example, see NSWDOP, 2005; COSC, 2001).

of planning policy, façade colour is often the subject of specific guidelines and controls. However, a limited review of planning policy relating specifically to façade colour found that this particular building attribute is subject to a diverse range of guidelines and controls.

Diverse approaches to façade colour within planning policy

Planning policy in respect to façade colour varies around the world and also tends to vary in different parts of Australia. In some areas planning guidelines are explicit, narrow and highly prescriptive; and in other areas, guidelines tend to be less explicit and broader. In addition, it appears that there is diversity within these two different approaches to façade colour. This section provides a limited discussion of the details of some policies and is provided for comparison purposes with planning guidelines relating to façade colour in Sydney, Australia. An exhaustive world-wide survey is beyond the scope of this research; however, some examples are provided to illustrate different approaches to façade colour in planning policy.

In some locations, vivid façade colours are acceptable and recommended in planning policy. For example, the Argyll and Bute Local Plan (A&BC, 2005) identifies the multi-coloured façades along Main Street in Tobermory (the main town of the Isle of Mull, Scotland) as a key environmental feature and as a special conservation area. In reponse to this assessment, the Local Plan states: "The Conservation (Plan) has capacity to accommodate a wide variety of vivid colour schemes for building façades, particularly within Main Street where striking reds, blues and yellows presently exist" (A&BC, 2005, p53). The building façades of Tobermory, Hull, are illustrated in Figure 31. (Anecdotal evidence suggests that planning policy either recommends or accepts vivid and contrasting colours in Burano, Italy, as per the image featured in Figure 17 above).

Figure 31. Tobermory, Hull. (Image: www.fishies.org.uk/ardnamurchan/tobermory)

In some areas, planning policy recommends that façade colours should by sympathetic with the surroundings and guidelines recommend that façade colours should be harmonious or not visually intrusive. For example, in the Shire of Augusta-Margaret River in Western Australia, the *Shire of Augusta-Margaret River Town Planning Scheme No. 11* (WAPC, 2007) suggests that "Buildings should be of a sympathetic design, material and colour to complement the surrounding landscape elements, to the satisfaction of the local authority" and "materials and exterior design of the building will be in harmony with the bushland environment" (WAPC, 2007, p62, 143). Similarly, planning policy relating to specific precincts in Shellharbour, New South Wales, recommends that "Architectural style, colour and materials are sympathetic with the surrounding buildings" (SCC, 2006, p21). The Wyong Local Environmental Plan recommends that "proposed buildings will not be visually intrusive by way of bulk, scale, design or colour" (WSC, 1991, p73).

Some areas have developed colour schemes for specific areas and planning policy recommends their use. For example, in Port Stephens Council, New South Wales, the *Port Stephens Development Control Plan* suggests that "All buildings shall use colour schemes derived from the range of colours nominated for the area" (PSC, 2007, p5). Similarly, a range of heritage-related colours are recommended for Darlinghurst and Paddington in Sydney wherein the *Draft Oxford Street Darlinghurst and Paddington Heritage and Urban Design Development Control Plan* recommends that "New buildings and additions are to use colour schemes that have hues and tones that relate to traditional colour schemes" (COSC, 2005, p36).

While this is only a very limited selection of various planning instruments, it is clear that planning policies treat façade colour in a range of different ways. The same is evident in planning instruments in Sydney as per the following discussion.

Façade colour and planning policy in Sydney

In Sydney, a number of planning instruments include specific planning guidelines in regard to façade colour including the *Sydney Harbour Foreshores and Waterways Area Development Control Plan* (NSWDOP, 2005) and the *Residential Flat Design Pattern Book* (NSWDOP and NSWDOPW&S, 2001).

The *Sydney Harbour Foreshores and Waterways Area Development Control Plan* includes extensive and specific references to façade colour (NSWDOP, 2005). One of the key aims of the plan is to ensure the scenic quality of the entire area and a guiding principle is that "development along the foreshore and waterways should maintain, protect, maintain and enhance the unique visual qualities of Sydney Harbour and its islands" (NSWDOP, 2005, p2). The visual qualities are considered to be impacted by the "height, width, siting, scale, colour, reflectivity and function" of developments (NSWDOP, 2005, p17). Colour contrast is considered to impact negatively on visual impact and "colours for buildings and structures that minimise the degree of visual contrast with adjoining development or landscapes" are strongly recommended (NSWDOP, 2005, p71). The plan categorises the areas within its jurisdiction into 16 landscape character types and includes a number of specific guidelines in regard to façade colour:

> Landscape character type 1: Developments…overall colours should match the natural vegetation (NSWDOP, 2005, p19).

> Colours should be sympathetic with their surrounds and consistent with the colour criteria, where specified, for particular landscape character types (NSWDPO, 2005, p49).

> Maritime facilities…lighter colours sympathetic to the marine setting should be used for window frames, etc. Roofs should be midtone grey or grey-green (NSWDOP, 2005, p50).

> Exterior colours should be compatible with the overall landscape character type…olive and mangrove greens are preferred (NSWDOP, 2005, p52).

Somewhat in contrast to the above plan, the *Residential Flat Design Pattern Book* applies a different approach to façade colour (NSWDOP & NSWDOPW&S, 2001). A joint initiative of the NSW Government Department of Urban Affairs and Planning's Urban Design Advisory Service and the NSW Government Architect, the *Residential Flat Design Pattern Book* aims to provide a "source of information on good design" and "a resource of ideas and precedents to guide the design process" (NSWDOP & NSWDOPW&S, 2001, p2). Building façades are identified as a key design component and prescriptive guidelines are provided for three main design types: Urban, Coastal and Garden. Façade colours suggested for the Urban design type are: mid to dark red tones; light sandy grey; charcoal; warm earthy browns and tans. Façade colours for the Coastal design type are: Light whites and greys with brown timber screens. Façade colours for the Garden design type are: Natural 'mud' colours with brown timber screens. A rationale for these particular façade colours is not provided except in a very general way such as "giving strong definition to the

corner" and "the overall appearance is of warm, earthy colours" (NSWDOP &NSWDOPW&S, 2001, p28, 31).

To conclude, façade colour is dealt with in a range of different ways in planning policy in Sydney. As detailed above, when particular façade colours are not specified, planning instruments often recommend the use of 'sympathetic' façade colours. Given the context within which these guidelines are provided, there is a strong implication that both particular colours and sympathetic colours contribute to visual quality.

However, Stamps (2000) points out, terms such as 'sympathetic', 'compatible', 'harmonious', 'enhance', 'appropriate' within the context of planning policy are not only vague and ambiguous, but confuse subjective responses to the environment with the objective aspects of an environment. Stamps points out that the vagueness and ambiguity of such terms plus a lack of accountability in terms of governmental control of issues relating to visual quality can lead to legal dispute and he cites a number of such disputes in both the UK and the US.[30] The narrow and prescriptive nature of guidelines relating to façade colour do not appear to allow for factors that may influence perception of, and aesthetic response to, façade colour. These factors are included in, but not limited to, the discussion below.

Factors that may influence aesthetic reponse to façade colour

Anter (2000) suggests that a number of factors may influence perception of façade colour and, in turn, aesthetic response to façade colour. These factors include perceptual factors, contextual factors (such as ambient viewing conditions, viewing distance, observation angle, surrounding colours and so on), and the influence of individual characteristics such as cultural references, intentions and attitudes.

Perceived façade colour tends to vary from inherent façade colour. That is, the same façade colour viewed under controlled conditions (inherent colour) tends to be perceived differently when viewed as an exterior element on a building façade in-situ. Anter (2000) found that perceived façade colours exhibit less blackness and slightly

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[30] This research stopped short of investigating and discussing extant legal disputes regarding façade colour and governmental control at the Local or State Governmental level in Sydney. While this stands as a limitation of the research, the theoretical discussion contained herein is not affected, influenced (or diminished) by this limitation. Further research in this particular area may provide additional insight into how notions such as 'harmony' and 'compatibility' are dealt with in legal practice and legal disputes.

greater chromaticeness or intensity that inherent colour. Anter (2000) suggests that the differences between inherent and perceived façade colour may be due to the influence of the simultaneous contrast effect (mentioned above) as well as individual differences. The effects of time and weathering may also influence aesthetic response to façade colour. Façade colours change over time with weathering and the breaking down of colour-fast capacities of paints and pigments; and neglected exteriors, with fading colour and decaying surfaces, were found to be factors that influenced aesthetic evaluation of building exteriors (Urland, 1997).

RATIONALE FOR THIS RESEARCH

Façade colour can be used and manipulated as an integral building attribute by architects for a diverse range of reasons. For some architects, it is considered an irrelevant attribute, a partner-in-crime to ornamentalism and anathema to the spirit and intention of Modernism and the form follows function dictum. Façade colour's uneasy place in the built environment extends to planning policy wherein it is acknowledged as a contributing factor in visual quality, but its role is often restrictively controlled.

In regard to planning policy in Sydney, the narrow and prescriptive nature of planning guidelines relating to façade colour highlights some key issues. Specifically, this type of policy inhibits the use of façade colour as a means of architectural expression and does not allow for the role of façade colour in urban design and architectural style. Furthermore, policy of this nature does not adequately acknowledge the contribution that façade colour may make in respect to 'imageability' and a sense of 'place'. In addition, while façade colour may play a role in judgements about visual quality, its role has not been examined and remains little understood. Finally, policy of this nature is underpinned by an ontological assumption that aesthetic responses to colour are universal and deterministic; and yet research in the domain of colour reveals that responses to colour may be more idiographic than universal, and less deterministic than previously thought.

Given the above issues, I contend that aesthetic response to façade colour may be of a diverse nature rather than a universal nature. In relation to planning policy, this notion may therefore echo Stamps and Nasar's (1997) suggestion that a possible lack of

consensus in relation to environmental evaluation may lead to dissensus thereby stripping such narrow and prescriptive planning policy of its fundamental justification. Furthermore, it is clear that a range of different façade colours contribute to the visual quality of various locations around the world; and it is hard to argue that façade colour doesn't contribute to the *imageability* and sense of 'place' of locations such as Manarola, Positano and Santorini.

The lack of opportunities for participation in planning policy with respect to façade colour indicates a power imbalance between planners and the general public. The decision-making process with respect to façade colour appears to be fixed and inflexible. The apparent lack of flexibility and the narrow, prescriptive nature of such planning policy essentially imply that responses to façade colour are universal and deterministic, and not open to influence from cultural and contextual factors or individual differences. This research sought to examine responses to façade colour in light of these possible influences.

Finally, colour has been used in areas other than architecture to alter perceptions about size. Colour in terms of hue and luminance has been found to influence judgements about the size of an object (Goldstein, 1996; Oyama & Nanri, 1960). Oyama and Nanri's study found that the size of an object as judged to increase as the luminance value of the object's colour increased and decreased as the luminance value of the background increased. In addition, the simultaneous contrast effect is also considered to influence judgements about the size of an object (Goldstein, 1996). In view of the possibility that colour may influence judgements about size, this research also sought investigate the relationship between façade colour and judgements about a building's size. A secondary aim of this particular line of research was to explore the notion of using façade colour to visually minimise or camouflage buildings that may impinge on the visual quality of the landscape. This particular notion appears to underpin current planning policy in Sydney with respect to buildings on Sydney Harbour however the notion is not made explicit in planning policy.

To conclude, the anomalies highlighted above, plus a lack of research particularly in regard to the relationship between aesthetic response and façade colour provided the rationale for this research. Currently, little is known about the relationship between façade colour and aesthetic response beyond anecdotal evidence, and the outcomes from this research may prove useful for architects in terms of a clearer understanding of the

role of façade colour. In terms of planning policy, the focus of much classical planning was deemed to be public interest: a notion usually defined for the public by professional planners and the design review panels. The nature of the planning policy relating to façade colour reflects this public interest approach. However, more recently the focus of policy planning has shifted towards a client orientation wherein planning policy reflects the values of a broader section of the community as suggested by Weimer and Vining (1992). This research sought to examine aesthetic response to façade colour within the broader community thereby aiming to bring a wider perspective on the issue of façade colour in relation to aesthetic response and urban design.

PART B: METHODS

Part B of this thesis is divided into four main sections: Research methodology, preliminary study #1, preliminary study #2 and main study. Each section is presented as a stand-alone chapter.

The first section of Part B, research methodology, is further divided as follows.

- Research methodology
  - Main, secondary and underlying research aims;
  - Overall theoretical framework and methodological approach;
  - Research plan;
  - Research questions and hypotheses of the main study;
  - Key constructs and associated variables;
  - Visual stimuli and the use of photographic images
  - Outline of data collection and data analysis methods;
  - Strengths and limitations of the research methodology.

Research methodology

Main and secondary research aims

Façade colour is considered to be one of a number of building attributes that may influence aesthetic response to a building (Nasar, 1994; Stamps, 2000). However, little is known about the relationship between aesthetic response and façade colour, and the main aim of this research was to examine patterns of aesthetic response to a set of façade colour treatments as per the model featured in Figure 32.

```
┌─────────────────────────────┐
│    BUILDING ATTRIBUTE:      │
│    Façade colour (1, 2, 3...n) │
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│        Patterns of          │
│     AESTHETIC RESPONSE       │
└─────────────────────────────┘
```
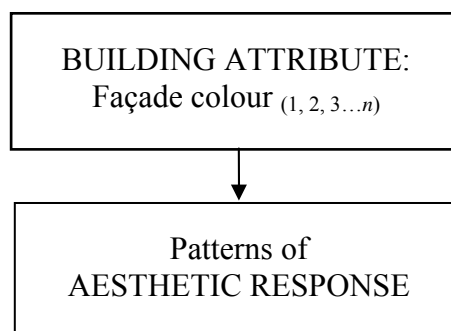
Figure 32. Model of the main research aim.

In terms of the secondary aims of this research, the relationship between façade colour and judgements about a building's size and congruity were examined. In addition, the relationship between façade colour and preference was investigated to determine whether variations in preference were associated with differences in façade colour; and whether changes in preference for a building were associated with differences in façade colour. Finally, the relationship between aesthetic response and variations in individual differences and sample group sub-set were investigated.

The overall aims of this study were limited and kept specifically focussed and narrow. As a result, the limitations of the research are numerous and these are detailed in the sections below: Strengths and limitations of the research methodology.

Underlying research aim

An 'implementation gap' is said to exist between research findings and the implementation of research findings by practicing professionals (Appleyard, 1973; Sommer, 1997). Sommer

(1997) suggests that the extent of this gap can be linked to one of three models of research: the academic model, the applied research model and the action research model. While most academic research provides valuable and relevant findings, weaknesses of this type of research are the extensive review process and long lead-times that delay publication and the use of academic language – that can create a comprehension barrier for non-academics. Research that fits the applied research model is often conducted using scientific methods in applied-research situations, but the implementation of the findings hinges on the willingness and commitment of the research funding providers to disseminate the findings. Finally, action research tends to be problem-centred and aims to specifically bridge the gap between theory and practice.[1] Research priorities, Appleyard (1973) suggests, should focus on studies that demonstrate a better fit between existing environmental variables and particular needs and values.

In view of the above, the underlying aim of this research was to adopt a quasi-action model and the research aims, questions and outcomes were specifically linked to existing planning policy in Sydney: specifically, the draft Sydney Harbour Foreshores and Waterways Development Control Plan which was released in its final format in 2005 (NSWDOP, 2005). In partial performance of this underlying aim, several papers have been published in urban design journals and presented at local and international conferences. In each case, these papers have had a practical focus and the findings were presented in simple language and style without compromising academic standards.

Epistemological framework & methodological approach

In addition to the nine types of theory identified by Moore (1987) within the EBS domain, it has been suggested that a number of paradigms exist which offer fundamentally different approaches to research and these paradigms include but are not limited to post-positivism/logical-positivism, interpretivism/constructivism and critical enquiry (Crotty, 1998; Groat & Wang, 2002; Guba & Lincoln, 1994; Patton, 1980). Guba and Lincoln (1994) suggest that the post-positivism paradigm is underpinned by the understanding that reality can only ever be "imperfectly and probabilistically apprehendable" as opposed to the tenet embedded within positivism wherein "real reality can be apprehendable" and the goal of research is to verify rather than falsify hypotheses (Guba & Lincoln, 1994, p109). Under

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[1] The action research model described here is akin to *action research* in the field of psychology which has been described as a practical intervention in everyday situations that uses applied psychology methods to effect change coupled with the monitoring of results (Coolican, 2004).

the interpretivism/constructivism paradigm, reality is considered to be relative and open to local and/or specific constructed realities; while the critical paradigm tends to shape reality according to any one of a number of influences: social, political, economic, ethnic and gender-specific (Guba & Lincoln, 1994).

As discussed earlier, the unit of study in this research (that is, the interface between aesthetic response and façade colour) was studied from an interactional perspective and the underlying paradigm was essentially post-positivist. Nasar's (1994) probabilistic model of aesthetic response to building attributes provided a practical model upon which to base this research. Nasar's model is reproduced in Figure 33.
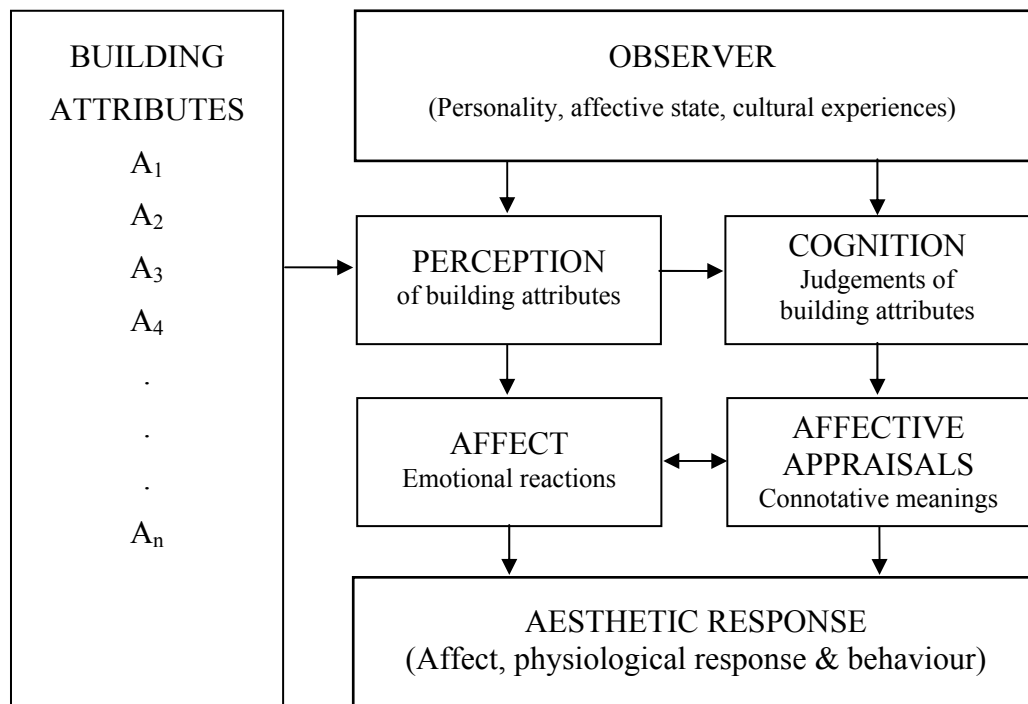
Figure 33. Probabilistic model of aesthetic response to building attributes (Nasar, 1994).

While the model suggests a level of determinism between building attributes and aesthetic response, it is probabilistic in that aesthetic response may vary and may be influenced by a range of factors such as personality, affective state and cultural differences. The influence of contextual factors and their possible effect on the relationship between building attributes and aesthetic response is not specifically detailed or included within the model. However,

buildings do not exist in a vacuum and Nasar's research thoroughly acknowledges this notion (Nasar, 1994 & 1998).

In terms of methodology, some argue that different epistemologies tend to be associated with either qualitative or quantitative methods: for example, quantitative methods tend to be associated with post-positivist inquiry while qualitative methods tend to be associated with approaches that are more interpretative/constructivist (Crotty, 1998; Groat & Wang, 2002; Guba & Lincoln, 1994; Patton, 1980). Sale, Lohfield and Brazil (2002) suggest that a clear distinction occurs between quantitative research methods and qualitative research methods based on the differing ontological assumptions of these two methods. Specifically, it is suggested that the qualitative approach is based on an ontological assumption of "multiple realities or multiple truths based on one's construction of reality" while the quantitative approach is based on positivism and assumes a more universal understanding of reality (Sale *et al*, 2002, p45). Qualitative research is therefore characterised by a focus on interpretation and meaning and seeks to understand how or why people make sense of a phenomenon, situation or setting (Coolican, 2004; Groat & Wang, 2002). Conversely, some suggest that quantitative research seeks to identify patterns within relationships between variables or within a situation or setting without necessarily seeking to understand how or why (Coolican, 2004; Groat & Wang, 2002).

This research used a mixed methods approach. Firstly, qualitative methods were employed to identify what types of façade colour are classified under the terms 'harmonious' and 'contrasting'. Secondly, quantitative methods were used to identify patterns of response to a set of façade colour treatments. Guided to a large degree by Alreck and Settle (1995), Argyrous (2001), Campbell and Stanley (1966), Coolican (2001), Groat and Wang (2002) and Zeisel (2006), this research involved four main phases and these are discussed in the following section.

Research plan

The initial exploratory phase of the research comprised a literature survey across a number of areas: environmental evaluation and assessment, and environmental aesthetics; theories relating to colour and the relationship between colour and aesthetic response; approaches to the use and manipulation of façade colour in architecture; and finally the area of planning policy. From this exploratory phase, two sub-problems arose that led to two preliminary studies. The main phases of the research are detailed in Table 2.

Table 2. Research plan: Main phases and methodological approach.

Phases of research	Methodological approach
1) Preliminary study #1 (Sub-problem #2)	Quantitative data collection via a case study
2) Preliminary study #2 (Sub-problem #1)	Qualitative data collection
3) Main study (experimental study)	Quantitative data collection

Sub-problem #1

This research was linked to current planning policy in Sydney wherein planning guidelines frequently recommend that façade colours should be 'compatible', 'sympathetic', 'harmonious' and 'contrasting' (NSWDOP, 2005). However, these terms imply an assumption that responses to colour are of a universal, deterministic nature. While many early studies and theories relating to colour tend to share this view, more recent studies indicate that aesthetic response to colour may be more idiographic and less deterministic thereby rendering terms like 'harmonious' hard to define and possibly inappropriate (Hard & Sivik, 2001).

Perhaps more importantly, Stamps (2000) has noted that planning policy commonly uses vague and ambiguous terms such as 'harmonious' and 'sympathetic' without providing definitions. A literature search did not reveal definitions for these terms either in regard to colour in general or façade colour in particular. Furthermore, a taxonomy or classification system of façade colour did not appear to exist. Therefore, the first preliminary study set about to develop simple classifications of façade colour and qualitative methods were used to identify classifications based on the terms 'harmonious' and 'contrasting'. This first sub-problem constituted Preliminary Study #2 as discussed below.

Sub-problem #2

However, before addressing Sub-problem #1 it was necessary to find a process that could isolate, identify and manipulate façade colour. Earlier studies indicated that environmental colour mapping was a process that enabled the isolation and identification of environmental colour characteristics (see Foote, 1983; Iijima, 1995, 1997; Lenclos, 1982; Porter, 1997). The investigation and extension of this process formed the main aim of Preliminary Study #1.

Summary of Preliminary Study #1

The aim of Preliminary Study #1 was to extend environmental colour mapping to provide a means for the isolation, identification and manipulation of environmental colour characteristics generally and façade colour characteristics in particular. Preliminary Study #1 involved applying digital technology to the existing process of environmental colour mapping. A case study was used as the basis for this study wherein quantitative data collection methods captured environmental colour characteristics. These environmental colour characteristics were digitally isolated and identified using existing colour notation systems resulting in a database of key colour characteristics of the case study environment. Preliminary Study #1 also found that this extended version (environmental colour mapping using digital technology) provided a means of isolating and identifying as well as manipulating environmental colour characteristics. The process was subsequently applied in Preliminary Study #2 and the Main Study of this research.

Summary of Preliminary Study #2

Preliminary Study #2 aimed to develop simple classifications of façade colour based on terms frequently used in planning guidelines: 'harmonious' and 'contrasting'. Qualitative methods were used, specifically F-sort and Q-sort techniques, to investigate and classify responses to a range of façade colour treatments. The main outcome from Preliminary Study #2 was two classifications of façade colour based on terms *harmonious* and *contrasting*. A secondary outcome was an indication that responses to façade colour treatments were not necessarily of a universal nature. These façade colour classifications were subsequently applied in the Main Study of this research.

Outline of the main study

The main study comprised a quasi-experimental study in which quantitative data collection methods were used to identify and examine patterns of response. Four façade colour treatments comprised the independent variable and the measurement instrument

featured a semantic differential rating scale with ten dependent variables linked to components of the construct, aesthetic response, and to judgements about a building's relative size and congruity. The Latin-square technique was applied and 288 participants evaluated four façade colour treatments each, resulting in a total of 1,152 evaluations. Factor analysis, analysis of variance and multivariate analysis of variance were applied to the resulting data. Figure 34 details the relationship of the preliminary studies and the main study to the topic of this research.
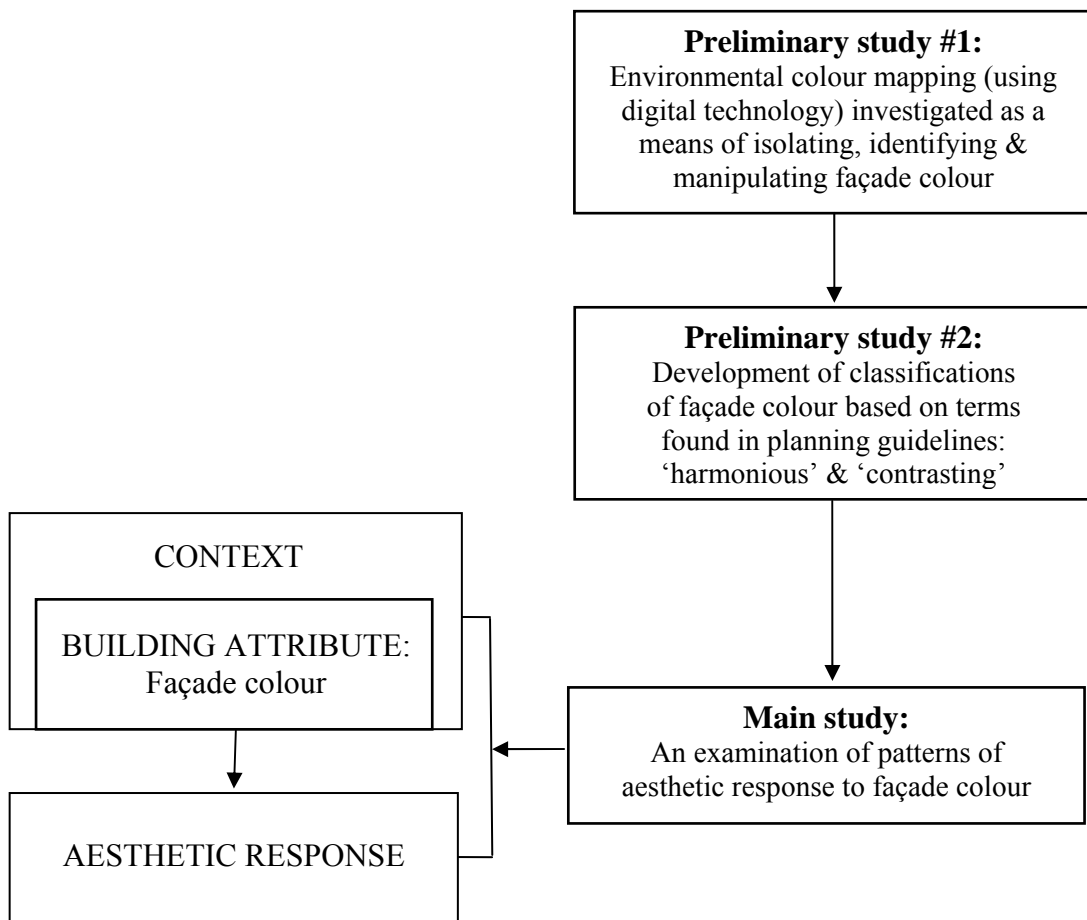
Figure 34. Model of the research.

Research questions and hypotheses of the main study

The six research questions and related hypotheses of the main study are as follows.

Research question 1: Façade colour and aesthetic response

Façade colour is considered to influence aesthetic response to a building (Nasar, 1994; Stamps, 2000). This notion is reflected in planning policies in Sydney (for example, NSWDOP, 2005). However, little is known about the relationship between façade colour and aesthetic response. The first research question sought to explore whether changes in façade colour treatment are associated with differences in overall aesthetic response. It was anticipated that some change in aesthetic response would occur in response to different façade colour treatments, however, the extent or strength of this change was not known. The null and alternative hypotheses are as follows.

$$H_0: \quad \mu AR_{T1} = \mu AR_{T2} = \mu AR_{T3} = \mu AR_{T4}$$

$$H_1: \quad \mu AR_{T1} \neq \mu AR_{T2} \neq \mu AR_{T3} \neq \mu AR_{T4}$$

where μ refers to population mean; 'AR' is aesthetic response, and 'T1-4' represents four façade colour treatments.[2]

Research question 2: Façade colour and judgements about congruity

Façade colour is considered a factor that may influence whether a building is considered to 'fit' or be congruous in relation to its surroundings (Janssen, 2001). This notion is also reflected in planning policies wherein guidelines frequently suggest that façade colours should be harmonious or sympathetic relative to the surroundings (see NSWDOP, 2005). This research question sought to investigate whether changes in façade colour treatment are associated with differences in judgements about the congruity of a building relative to its surroundings. It was anticipated that an effect may occur, but the extent of this effect was not predicted. The null and alternative hypotheses are as follows.

$$H_0: \quad \mu CON_{T1} = \mu CON_{T2} = \mu CON_{T3} = \mu CON_{T4}$$

$$H_2: \quad \mu CON_{T1} \neq \mu CON_{T2} \neq \mu CON_{T3} \neq \mu CON_{T4}$$

where μ is the population mean, 'CON' refers to judgements about congruity and 'T1-4' represents four façade colour treatments.

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[2] Notational style for null and alternate hypotheses adapted from Argyrous (2001) and Shaughnessy & Zechmeister (1997).

Research question 3: Façade colour and judgements about size

Just as colour is considered to influence judgements about the size of a room, this notion was explored in relation to façade colour and judgements about a building's size. This research question investigated whether changes in façade colour treatment are associated with differences in judgements about the size and apparent visual significance or dominance of a building. It was anticipated that differences in façade colour treatment would be associated with changes in judgements about the size of a building may occur by as much as +/- 5%. The null and alternative hypotheses for this research question are as follows.

H_0: $\mu SIZE_{T1} = \mu SIZE_{T2} = \mu SIZE_{T3} = \mu SIZE_{T4}$

H_3: $\mu SIZE_{T1} \neq \mu SIZE_{T2} \neq \mu SIZE_{T3} \neq \mu SIZE_{T4}$

where μ is the population mean; 'SIZE' refers to judgements about a buildings size, and 'T1-4' represents the four façade colour treatments.

Research questions 4a & 4b – Façade colour and preference

Research questions 4a and 4b sought to investigate the relationship between façade colour treatment and preference. This research question comprised two parts: firstly, whether preference for a building may change due to different façade colour treatments. Secondly, whether preference for a façade colour treatment is consistent across different a range of buildings – in this case, the four buildings featured in the visual stimuli. The null and alternative hypotheses for these research questions are as follows.

H_0: $\mu PREFER_{B1(T1-4)} = \mu PREFER_{B2(T1-4)} = \mu PREFER_{B3(T1-4)} = \mu PREFER_{B4(T1-4)}$

H_{4a}: $\mu PREFER_{B1(T1-4)} \neq \mu PREFER_{B2(T1-4)} \neq \mu PREFER_{B3(T1-4)} \neq \mu PREFER_{B4(T1-4)}$

H_0: $\mu PREFER_{T1(B1-4)} = \mu PREFER_{T2(B1-4)} = \mu PREFER_{T3(B1-4)} = \mu PREFER_{T4(B1-4)}$

H_{4b}: $\mu PREFER_{T1(B1-4)} \neq \mu PREFER_{T2(B1-4)} \neq \mu PREFER_{T3(B1-4)} \neq \mu PREFER_{T4(B1-4)}$

where μ is the population mean; 'PREFER' refers to preference rating, 'T1-4' represents four façade colour treatments & 'B1-4' refers to four building.

Research question 5 – Façade colour and individual differences

The fifth research question sought to explore whether variations in overall aesthetic response to façade colour are associated with differences in individual characteristics. As discussed below, the operational definition of individual characteristics for the purposes of this study was limited to gender, age, region of birth and familiarity. It was hypothesised that variations in aesthetic response may be associated with differences in individual characteristics however the extent of this association was not predicted. The null and alternative hypotheses are as follows.

$$H_0: \quad \mu AR_{(T1*IND)} = \mu AR_{(T2*IND)} = \mu AR_{(T3*IND)} = \mu AR_{(T4*IND)}$$

$$H_5: \quad \mu AR_{(T1*IND)} \neq \mu AR_{(T2*IND)} \neq \mu AR_{(T3*IND)} \neq \mu AR_{(T4*IND)}$$

where μ is the population mean; 'AR' refers to *aesthetic response[r]*, and 'IND' refers to the individual characteristics: gender, age, region of birth & familiarity.

Research question 6 – Façade colour and group differences

It has been suggested that architects' education may influence how architects experience architecture in terms of affective and evaluative responses (Hershberger, 1992). The sixth research question sought to determine whether this held true in respect to responses among subsets of the sample group. The sample group comprised graduate students from the Faculty of Architecture; graduate students from non-Architecture Faculties and members of the general population. It was anticipated that overall *aesthetic response* may vary between the subsets but the extent of this variation was not predicted. The null and alternative hypotheses are as follows.

$$H_0: \quad \mu AR_{T1\text{-}4 \, (Subset \, 1)} = \mu AR_{T1\text{-}4 \, (Subset \, 2)} = \mu AR_{T1\text{-}4 \, (Subset \, 3)}$$

$$H6: \quad \mu AR_{T1\text{-}4 \, (Subset \, 1)} \neq \mu AR_{T1\text{-}4 \, (Subset \, 2)} \neq \mu AR_{T1\text{-}4 \, (Subset \, 3)}$$

where μ is population mean; 'AR' refers to *aesthetic response[r]*; T1-4 represent four façade colour treatments and Subsets 1-3 represent 3 subsets of the sample population.

The relationship of the research hypotheses to Nasar's (1994) probabilistic model of aesthetic response to building attributes is illustrated in Figure 35.

Key constructs and associated variables

This section discusses the main constructs of this study: façade colour, aesthetic response, preference, congruity, size, individual differences and group differences. Table 4 itemises the research questions and the constructs and dependent variables linked to each individual research question.

Façade colour

The independent variable of this research, façade colour, is generally considered to be a two-dimensional silhouette with surface markings, details and projections that may be independent of the silhouette (Stamps, 2000). Surface colour can occur across all areas of a façade and Figure 36 illustrates the various markings, details, projections and areas of surface colour evident in the eastern façade of a building.

The colour characteristics of a building's façade are inherent in the materials used in construction (cladding, brick, glass, and so on) or as painted surfaces (Gatz & Achterberg, 1967; Guthrie, 1995). These colour characteristics are open to influence from temporal factors (time of day, etc); perceptual factors as well as the distribution of light (cesia), the ageing process, and the influence of textural effects and contextual factors (Anter, 1996; Caivano, Menghi & Iadisernia, 2004). These factors may change the visual appearance of the colour characteristics of various areas of a building's façade.
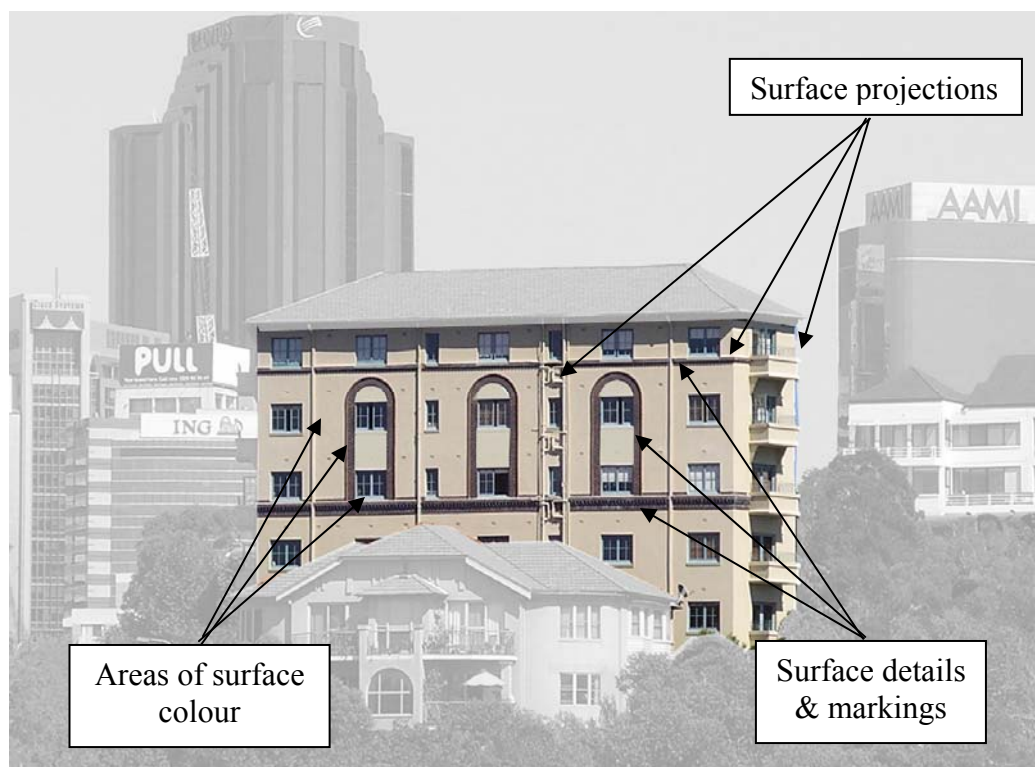
Figure 36. Façade of a building (with façade details, projections and façade colour). (Photograph: Z O'Connor)

The operational definition of façade colour for the purpose of this research is the major colour characteristic of a single two-dimensional façade of a building. As the number of colour characteristics may vary per façade for any given building, and to simplify what could have been a complex investigation, façade colour for the purpose of this study was limited to one homogenous façade colour characteristic per façade. To achieve this, the stimulus sampling process sought buildings that featured minimal façade markings, details and projections.[3] Figure 37 depicts a building whose façade exhibits minimal markings, detail and projections; and presents one homogenous façade colour characteristic.

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[3] The stimulus sampling process, discussed in full in the section: Main Study, acknowledges the various effects discussed above and applied measures to address or minimise these. For example, all digital images of buildings were taken in the same season and at the same time of day. Furthermore, images were taken of buildings that appeared to be recently painted; and that were surrounded by typical Australian natural vegetation in an attempt to maintain consistency in terms of context.

Figure 37.
Image of a building with one homogenous façade colour.
(Photograph: Z O'Connor)

(NOTE: Due to the degradation of colour data that occurs when transferring digital images from computer to printed copy, the quality of full-colour digital images in this thesis is not optimum. For more detail, see page 101).

Aesthetic response

The operational definition of the construct aesthetic response for the purpose of this research is considered to comprise a bundle of responses that include emotional reactions, affective appraisals and cognitive judgements as per Nasar's (1994) probabilistic model of aesthetic response. These responses are considered to include two dimensions of affective appraisal discussed earlier: the hedonic dimension (pleasure-displeasure) and the arousal dimension (inactive-active); and cognitive judgements relating to preference, size and congruity (Mehrabian & Russell, 1974; Osgood, Suci & Tannenbaum, 1957; Russell, 1988; Russell, Ward & Pratt, 1981; Ward & Russell, 1981). The components and semantic differential rating scale variables linked to the construct aesthetic response are detailed in Table 3.

Table 3. Components and dependent variables of the construct: aesthetic response.

Component	Dependent variables
Affective appraisal (Evaluative dimension)	Beautiful-ugly Pleasant-unpleasant
Affective appraisal (Arousal dimension)	Stimulating-boring Exciting-dull
Preference	Like-dislike
Cognitive judgement: Size	Large-small Dominating-insignificant
Cognitive judgement: Congruity	Harmonious-inharmonious Fits/Contrasts with surroundings Sympathetic-unsympathetic

Preference

Evaluating an environment generally involves making a judgement about whether the environment is liked or not. This type of judgement may be conscious or not and the cognitive process generally involves perception of the visual aspects of an environment and an affective appraisal of the environment (Kaplan & Kaplan, 1982; Nasar, 1994; Zube *et al*, 1982). In environmental evaluation and environmental aesthetics studies, preference is generally represented by the variable like-dislike. The operational definition of preference for the purpose of this study was the degree to which a participant liked or disliked each façade colour treatment and the dependent variable linked to preference is like-dislike.

Congruity

Various building attributes, including façade colour, are considered to exert some influence on judgements relating to the 'fit' of a building and whether it is considered appropriate in relation to, or sympathetic with, or in harmony with, its context (Groat, 1992; Janssens, 2001; Urland, 1996; Wohlwill, 1977; Wohlwill & Harris, 1980). In addition, as discussed above, the notion of congruity is mentioned in planning policy in Sydney (NSWDIPNR, 2004; NSWDOP, 2005). The operational definition of congruity for the purpose of this study is a cognitive judgement as to whether a building is considered *harmonious* or *sympathetic* relative to its surroundings; and whether or not it is considered to 'fit' with its surroundings. The dependent variables linked to congruity are harmonious-inharmonious, fits with surroundings-contrasts with surroundings, and sympathetic-unsympathetic.

Size

Façade colour is considered to influence perceptions about the size and bulk of a building (Unver & Ozturk, 2002). Colour is frequently used to alter perceptions or judgements regarding the size of an interior (Guthrie, 1995; Inui & Miyata, 1973; Porter & Mikellides, 1976; Smith, 1989). Size was therefore included as a construct in this study to determine whether differences in judgements about the size of a building are associated with differences in façade colour. In addition, cognitive judgements about size and dominance have been considered a component of affective appraisal in earlier studies by Mehrabian and Russell (1974) and Osgood *et al* (1957). These earlier studies referred to a potency dimension of affective appraisal linked to variable such as large-small and strong-weak. For the purpose of this research, the operational definition of size is considered a cognitive judgement relating to whether a building is considered large or small, and

visually dominant or insignificant. The dependent variables linked to size are large-small and dominating-insignificant.

Individual differences

Responses to colour are often considered to be universal and many early theories of colour were underpinned by the idea this assumption. Predictive colour theory models and colour harmony formulae are common in the literature, all of which are presented as colour combination solutions that will always elicit specific responses irrespective of age, gender, culture or context (for example, see Albers, 1963; Munsell, 1912; Ostwald, 1916). These predictive colour theory models and colour harmony formulae do not appear to allow for a more idiographic, stochastic approach in regard to responses to colour.

This study sought to determine whether differences in overall aesthetic response were associated with individual differences in a generalised way and the four characteristics used to represent individual differences were gender, age, country of birth and familiarity.

The individual characteristics of gender and age were self-reported by participants using the variables: male, female; as well as the following age sub-categories:

a)   18 to 24;   d) 45 to 54
b)   25 to 34;   e) 55 to 64
c)   35 to 44;   f) 65 plus

Individual differences with respect to country of birth were identified using the same categories as the Australian Bureau of Statistics (ABS, 2005) as follows.

a)   Australia, New Zealand and Oceania
b)   Europe and the United Kingdom
c)   The Middle East and Northern Africa
d)   North-eastern Asia
e)   South-east and Southern Asia
f)   North America and Canada
g)   South America
h)   Africa.

Finally, familiarity was self-reported by participants when viewing each one of the four visual stimuli and was identified by the variable yes-no on the measurement instrument.

Group differences

Finally, architects' education is considered to exert some influence on architects' affective and evaluative responses to architecture (Hershberger, 1992). The main study sought to determine whether differences in aesthetic response may be statistically linked with differences among the three sample group subsets. The subsets comprised participants drawn from the general public, participants with an educational link to the field of architecture and participants with an educational link to fields other than architecture. The membership of sample group subsets was identified prior to participation in the study and the measurement instruments were duly noted as to the sample group subset membership of each participant.

The dependent variables of the main study linked to the research questions and constructs are detailed in Table 4 as follows.

Table 4. Research questions, constructs and dependent variables.

Research question	Construct	Dependent variables
Research question 1	Aesthetic response	Beautiful-ugly Pleasant-unpleasant Stimulating-boring Exciting-dull Like-dislike Large-small Dominating-insignificant Harmonious-inharmonious Fits/Contrasts with surroundings Sympathetic-unsympathetic
Research question 2	Congruity	Harmonious-inharmonious Fits/Contrasts with surroundings Sympathetic-unsympathetic
Research question 3	Size	Large-small Dominating-insignificant
Research question 4	Preference	Like-dislike
Research question 5	Individual differences	Gender (Male/female) Age (6 x age categories) Country of birth (8 x categories) Familiarity (Yes/no)
Research question 6	Group differences	Three sample group subsets

Data collection and data analysis methods

In Preliminary Study #1, digital technology was used to isolate and identify data using a case study approach. Data occurred in the form of environmental colour characteristics and these were isolated and identified using digital technology, Photoshop 7.0 software and existing colour notation systems. This is discussed in greater detail below.

In Preliminary Study #2, qualitative data collection methods, specifically F-sort and Q-sort techniques, were used in tandem with nominal group consensus technique to develop basic classifications of façade colour. This preliminary study is discussed in greater detail in the section: Preliminary Study # 2.

In the main study, quasi-experimental research methods were employed to identify and examine patterns of reponse in terms of ten dependent variables to the independent variable, represented by four façade colour treatments. A variety of quantitative data analysis methods were used including factor analysis, correlation analysis, analysis of variance (ANOVA) and analysis of covariance (ANCOVA). The main study is discussed in greater detail in the section *Main Study*. Key assumptions relating to the data and data analysis methods are to be found in the section: Results of the main study.

Strengths and limitations of the research methods

This research used a mixed methods approach; however, quantitative methods were used primarily in the main study. Therefore, the findings arising from the main study focus on the quantifiable nature of aesthetic response to façade colour rather than delving deeper into the underlying subjective reasons for such responses. While one of the key strengths of the main study is the summarisation of a substantial amount of data, and, while, quantitative methods can provide a summary of subjective responses, they cannot provide an indication of the qualitative nature of the responses. In partial defence of this, it has been suggested that "environmental meaning cannot appropriately be represented by a single set of orthogonal dimensions. Instead, it should be viewed as involving numerous environmental attributes related to perceptual, cognitive, affective and behavioural responses to places….far from being independent, these are highly inter-related in complex ways including empirical associations, cause and effect relationships and conceptual relationships" (Ward and Russell, 1981, p122). The complexity of responses to façade

colour is acknowledged and one of the key limitations of this research is the inability to provide an understanding of the complexity of the relationship between aesthetic response and façade colour. This stands as a key limitation of the research methodology but also provides an opportunity for further research in this area.

Visual stimuli and the use of photographic images

The independent variable of this research (façade colour) was investigated using static, two dimensional digital photographic images as representations of real buildings. Digital photographic images, manipulated using computer software, were used in each preliminary study and the Main Study of this research.

It is acknowledged that static photographic simulations are a poor substitute for reality because of the impossibility of replicating the huge amount of information present in a multimodal environment. A major weakness in using photographs, digital or otherwise, is this loss of multimodal information. While digital photographic images can capture a substantial amount of visual information, they cannot capture 100% of this information. Environments are constantly open to changes of a temporal and ever-changing nature, and the effects of seasonal and diurnal cycles have an impact on the visual characteristics of an environment. These various impacts cannot be adequately captured or represented by digital photographs.

Colour or black and white photographs or slides have been extensively as surrogates for real settings in studies in the EBS domain (for example, see Brown & Gifford, 2001; Hershberger, 1988; Imamoglu, 2000; Groat, 1988; Heft & Nasar, 2000; Nasar, 1988; Stamps, 2000; Stamps & Nasar, 1997). However, Heft and Nasar (2000) report differences in terms of perceiver's reactions between static and dynamic displays of landscape and recommend exercising caution when extrapolating findings from studies that use static representations of environmental settings. Similarly, Daniel and Meitner (2001) question the representational validity of digital photographic images in landscape evaluation and assessment. Hull and Stewart (1992) report differences between on-site and photographic image-based evaluations. However, they also suggest that differences may arise, or be explained by, the influence of mood, meaning and novelty between on-site and photo-based contexts. Participant fatigue and social interaction in relation to on-site assessments

may also influence evaluations. In addition, Scott and Canter (1997) suggest that "people conceptualise the content of a photograph in a different way to how they conceptualise the places represented in the same photographs" (Scott & Canter, 1997, p275).

Despite the disadvantages of using photographic simulations of environmental settings, the key advantage in terms of this research focussed on the capacity of digital photographic images to be manipulated to enable the creation of multiple façade colour treatments. To be able to examine evaluations of the same building in the same setting in terms of a range of façade colour treatments would be impossible in any other format than digital photographs. Therefore, digitally manipulated photographic representations of environmental settings were used as visual stimuli throughout this research.   This research fully acknowledges the validity of using such environmental representations and recommends caution in interpreting the findings and results of the preliminary studies and the Main Study.

The relativity of the terms: harmonious and contrasting

The development of façade colour treatments in the main study was linked to terms frequently used in planning guidelines relating to façade colour – that is, the terms 'harmonious' and 'contrasting'. As implied in planning policy, façade colours are considered to be either harmonious or contrasting relative to the colour characteristics of the surroundings. Therefore, the labels 'harmonious' and 'contrasting' have an arbitrary and relative nature, dependent upon the link with the colours of the surroundings.

Further complicating the relativity of the terms harmonious and contrasting is the issue of how to define colour characteristics of the surroundings. If a building is completely surrounded by natural vegetation, the issue is reasonably straightforward. However, in the case of buildings surrounded by a mix of natural and artificial elements, the issue is somewhat more complicated. Figure 38 illustrates a building surrounded by natural vegetation as well as apartment and office buildings.

Figure 38. Apartment building with three different façade colours[4].

The colour characteristics of the surroundings include a range of colours: greens, white/beiges, blues, greys and reds. Determining a harmonious façade colour for this particular building is problematical. The illustration features the building with a green façade to harmonise with the natural vegetation; an off-white façade to harmonise with the façades of neighbouring buildings and a blue façade to harmonise with both neighbouring buildings and the colour of the sky.

Range of façade colour treatments

As discussed in greater detail below, the independent variable of the main study was represented with a relatively small range of façade colour treatments. As discussed earlier, the human eye can distinguish between 1.8 million and 10 million different colours (Gouras, 1991; Judd & Wyszecki, 1975; Pointer & Attridge, 1998). In addition, the number of possible colour combinations is considered to be "almost infinite" (Hard & Sivik, 2001, p4). However, the visual stimuli used in *Preliminary study #2* and the *Main study* featured a limited range of façade colour treatments: twelve and four respectively. It was beyond the scope of this research to extend the investigation and include a larger range of façade colour treatments mainly due to budget and timing constraints.

Measurement instrument

The measurement instrument used in the main study had not been previously used and had not been standardised. Therefore, while a large number of evaluations formed the focus of quantitative analysis in the main study, it was not possible to determine whether data

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[4] Note: Due to the degradation of colour data that occurs when transferring digital images from computer to printed copy, the quality of full-colour digital images in this thesis is not optimum. This issue is discussed in greater detail in the section title *Possible degradation of colour data*, page 101

arising from this study is truly representative of the stated population of this study. Therefore it is statistically unsound to derive anything other than general conclusions about the probabilistic behaviour of the population from which the sample was drawn.

Control and quasi-experiment research design

In relation to the quasi-experimental method used in the main study, a draw back is the deficiency in control mechanisms characteristic that may always occur when applying such a method. Any number of influences – psychological, physical or emotional – may impinge on participants in an experimental study thereby affecting their responses. While action was taken to allow for, and control for, some of these influences; it was not possible to control for all possible influences. For example, in regard to ambient lighting levels, all surveys were conducted in rooms with both natural lighting and artificial lighting during the day. However, the level of ambient lighting may have varied marginally from room to room. Similarly, time of day, survey room size, interior design of survey room and so on may also have varied marginally from survey session to survey session, and it was not possible to ensure that these factors were identical in every survey session. Some factors – such as the emotional state of participants – were beyond the control of this research. While Stamps (1992) and Stamps and Nasar (1997) suggest that results may be reproducible without controlling for presentation effects and influences, the sample size was increased to 288 in an attempt to partially address the lack of control in this respect. The initial sample of 96 was based on one rotation of the Latin-square format.

Individual differences and group differences

This research stopped short of investigating a broader range of individual differences in respect to responses to façade colour and this also stands as a limitation of the research. Furthermore, the research was limited in terms of investigating a larger range of sample group subsets than the three sample group subsets discussed above. As such the limitations mentioned here provide opportunities for further research.

PRELIMINARY STUDY #1

Isolating, identifying and manipulating environmental colour characteristics using digital technology[1]

Preliminary study #1 constitutes a sub-section of Part B (Methods) of this thesis and is further divided as follows.

- Preliminary study #1
    - Main aims of Preliminary Study #1;
    - Environmental colour mapping;
    - Environmental colour mapping using digital technology: A case study;
    - Strengths and limitations of the process
    - Discussion of the key outcomes of Preliminary Study #1.

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[1] An earlier version of this chapter was published in *Urban Design International (2006) 11*, 21-28.

Main aims of Preliminary Study #1

The main aims of Preliminary Study #1 was to apply digital technology to the process of environmental colour mapping process and evaluate its effectiveness as a means of isolating, identifying and manipulating environmental colour characteristics including façade colour.

As mentioned above, a key sub-problem that arose when planning this research focussed on the issue of isolating façade colour in such a way as to examine responses to a range of different façade colour treatments. Two main approaches were considered in response to this sub-problem and the first of these considered the possibility of isolating and manipulating façade colour in a real-world setting. Conducting an investigation in this manner would involve repeated measures of the dependent variables relative to the various treatments of the independent variable (façade colour) in-situ. While this approach is considered acceptable, Hershberger and Cass (1988) point to three main drawbacks: time and expense as well as control problems in terms of factors that may impinge on the measurement of variables using this approach. These drawbacks seemed highly relevant in terms of this research. Firstly, conducting repeated measures of the dependent variable in relation to the independent variable in-situ may leave relationship between the two variables open to influence from a large number of factors, such as the effects of time, weather, ambient lighting, visual and aural distractions and so on. These factors would be difficult to control and may impact on the reliability and validity of the study's findings. Secondly, conducting the research using this approach was beyond the budget for this research. For these reasons, this approach was discarded in favour of an alternative approach.

The alternative approach focussed on investigating an existing process (environmental colour mapping) and applying digital technology to different stages within this process, where possible. In doing so, digital photographic representations of real settings would be used to isolate, identify and manipulate environmental colour characteristics. A case study approach was used as a means of investigating the process and assessing its effectiveness as a means of isolating, identifying and manipulating environmental colour characteristics in general and façade colour characteristics in particular.

Environmental colour mapping

Environmental colour mapping studies has been found to be a reliable process for identifying and isolating environmental colour characteristics in both natural and built environments (Lenclos, 1976; Porter, 1997). The process has also been found to be reliable in studies that focus on façade colour in particular (Foote, 1983; Iijima, 1995).

Environmental colour mapping, a process pioneered by Lenclos (1976), first emerged during an extensive colour audit conducted by Lenclos in regional France. This audit found that environmental colour characteristics varied considerably, with each region reflecting a unique chromatic palette. This occurred, Lenclos concluded, mainly because the colour characteristics of the built environment reflected those of the construction materials, generally sourced locally.   The four stage process is detailed in Figure 39.

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│                             │
│        Environment          │
│                             │
└─────────────────────────────┘
              │
              ▼
┌─────────────────────────────┐
│    Isolation of samples of  │
│    natural and artificial   │
│          elements           │
└─────────────────────────────┘
              │
              ▼
┌─────────────────────────────┐
│      Identification of      │
│    elements using a colour  │
│       notation system       │
└─────────────────────────────┘
              │
              ▼
┌─────────────────────────────┐
│        Database of          │
│    environmental colour     │
│      characteristics        │
└─────────────────────────────┘
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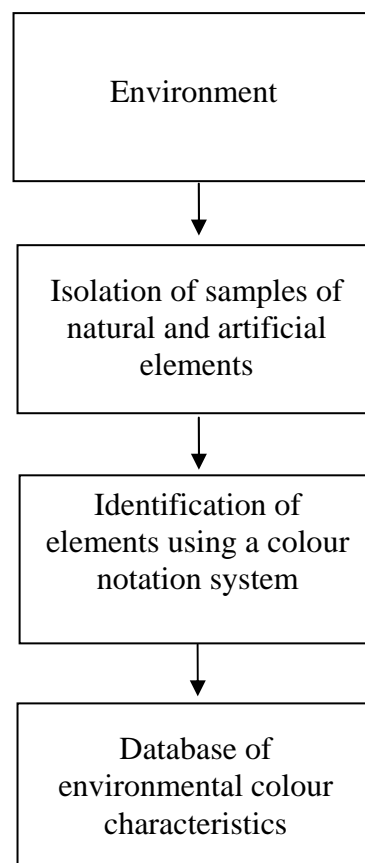
Figure 39. Environmental colour mapping (Lenclos, 1976; Porter, 1997).

Porter (1997), using a similar process, conducted colour mapping studies of Oslo, Norway, and Harlow, England, in which colour characteristics of each environment were

identified and classified. Other researchers, whose studies focussed on urban areas, used a similar process to produce databases of environmental colour characteristics that focussed on façade colour (Foote, 1983; Iijima, 1995, 1997).

Environmental colour mapping studies in a number of Japanese towns and cities have been used to address the issue of the 'overflow' of building façade colour and to assist in maintaining a sense of colour harmony among local buildings (Iijima, 1995 and 1997). Porter's (1997) studies were aimed at identifying the environmental colour identity of existing urban settlements and to identify compatible colour alternatives for future, adjacent settlements. The outcome from an extensive colour mapping study of the greater Chicago area has been used to suggest that façade colour plays a role in the corporate communication strategy of organisations (Foote, 1983). Each of these studies used manual methods for isolating and identifying environmental colour characteristics. This manual method for colour matching to existing colour notation systems was considered reliable.

Environmental colour mapping using digital technology: A case study

Digital technology was applied to the environmental colour mapping process and a single unit case study (single unit of analysis) research design was applied. Case studies allow for intensive investigation and in-depth data collection, and can be applied to individuals or societies, buildings or locations; events, programs or processes (Groat & Wang, 2002; Yin, 1994; Zeisel, 1981). The case study method as described by Yin (1994) is considered to include four major types: single case study or multiple case studies each with either single or multiple units of analysis.[2] A single case study (single unit of analysis) design is considered appropriate to test, confirm, challenge or extend an existing theory or rationale (Yin, 1994). In relating the case study approach to architectural settings, Groat and Wang (2002) extended Yin's (1994) earlier definition of case study research design to: "an empirical inquiry that investigates a phenomenon or setting" (Groat & Wang, 2002, p346).

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[2] Single units of analysis may include a country's economy, an industry, a policy or aspect of trade, an event, a process, the behaviour of an individual or group or a geographic area; while multiple units of analysis may include multiples of said single units of analysis or similar. Multiple case studies comprise a group of single case studies for comparison purposes (Yin, 1994).

Preliminary study #2 set out to apply digital technology to this process, and in doing so, the aim was to confirm whether the process provided a means of isolating, identifying and manipulating façade colour in particular. Digital technology was therefore applied to the four main tasks of the process, as detailed in Figure 40.
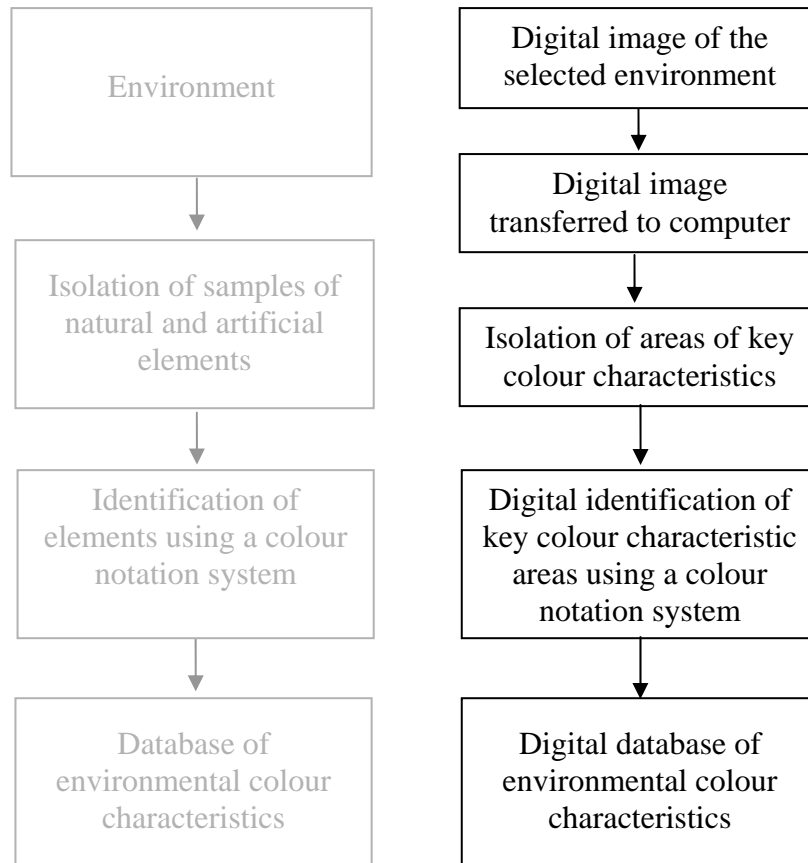
Figure 40. Environmental colour mapping using digital technology.

A digital image was captured of a small apartment building on Berry's Bay, Sydney Harbour using a Pentax Optio 550 camera (the same camera was used for all digital photographs of this research). This camera has a 5 mega pixel capacity and the image was captured on the highest setting: JPEG[3] at 2592x1944 pixels per image. The Optio 550 uses a 12 bit CCD (charge couple device), 3 colour RGB filter[4] to capture image and colour data, and the image was stored and downloaded to computer via the camera's memory card as a JPEG file. The

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[3] JPEG, an acronym for Joint Photographic Expert Group, represents a standard file format for compressed digital photographic images. JPEG formats correspond to ISO (International Organisation for Standardisation) and IEC (International Electrotechnical Commission) standards.

[4] RGB filters are sensors within a digital camera that capture the light signals transmitted from the image being photographed in terms of the key red (R), green (G) and blue (B) light waves (Morovic & Morovic, 2003).

image file was transferred into Photoshop 7.0 computer software and stored as a JPEG file. Figure 41 features the digital photograph used in this case study.

Figure 41. Digital image of an apartment building.

The second stage involved isolating the key façade colour areas within the digital image using the *Polygonal Lasso tool* of Photoshop 7.0.   In carrying out this task, two assumptions were applied. Firstly, areas of façade colour that appeared similar in the digital image were deemed to be identical. Secondly, areas of natural elements like trees and shrubbery that were similar were also treated as identical.   In this way fourteen areas were identified as being 'major' areas of colour. Without applying these assumptions, the resulting colour map would consist of an exhaustive number of colour samples in highly similar hues. Figure 42 illustrates samples of 'major' façade colour areas.
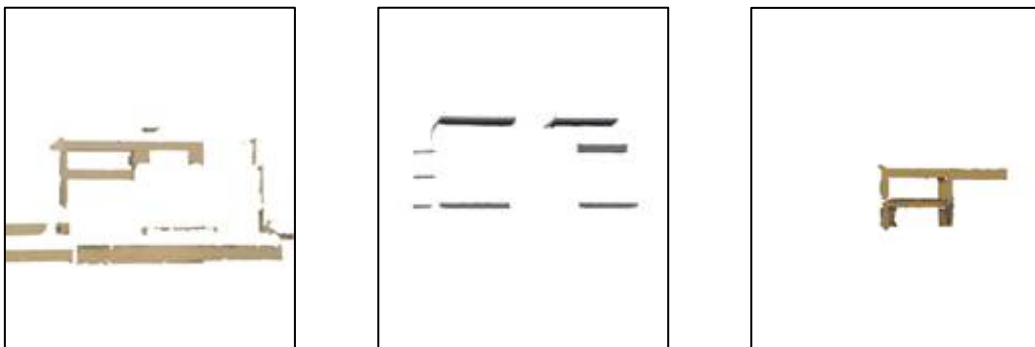
Figure 42. Samples of 'major' façade colour areas.

The next stage involved identification of the major colour areas and this was carried out using the Colour Picker tool of Photoshop 7.0. This tool identifies the colour within a specified pixel or group of pixels and can identify colour using a variety of existing colour notation systems including the sRGB system, the Pantone system, the HSB system, the CMYK system, the Lab system and the Toyo system. To conduct identification of the major colour areas, a grid was placed over the master image and the entire image was reduced in size by 75%. By reducing the image in size, the colour data within each grid segment are reduced via compression algorithms whereby the colour data are mathematically averaged. However, the compression process does not average colours that are different and share a border – these colours are processed individually.

Figure 43 features the digital image used in this case study with a grid superimposed over the image. Two colour notation systems were used to identify the colour characteristics: the sRGB system and the Pantone system. The sRGB system is the standard default colour space of Microsoft applications and has extensive multimedia applications. As such, colour data can be easily transferred across different software applications. The Pantone system was chosen as it is frequently used in colour specification for external house paints. Photoshop 7.0 has the capacity to translate colour data from one colour notation system to another. Issues regarding the reliability of this method of colour identification are discussed below.

Figure 43.
Digital image of building plus grid.

Shown significantly smaller than it would appear on a computer screen, this image was used to perform the colour matching function using the colour picker tool in Photoshop 7.0.

Each individual colour area with each segment was identified and tallied thereby building a database of colour characteristics. The details of this database are featured in Table 5.

Table 5.
Database of environmental colour characteristics of apartment building.

	Major colour characteristics		sRGB value	Pantone reference	% of total area
1		Grey: awnings, etc	104-103-109	Cool grey 11C	1.8%
2		Dark red: window, column trim	124-62-57	499C	2.0%
3		Mid yellow/beige: façade	168-138-84	4505C	3.0%
4		Light yellow/beige: façade	197-178-146	7502C	8.8%
5		Landscaping plants	72-78-41	7498C	4.2%
6		Doors & windows (glass)	92-113-103	5615C	13.6%
7		Foundations	109-99-89	Warm grey 11C	5.6%
8		Adjacent building at right	130-140-163	7544C	0.6%
9		Adjacent building at right	192-187-194	435C	0.3%
10		Roof of building at right	168-100-85	7523C	0.4%
11		Adjacent building on left	197-170-160	4735C	1.1%
12		Water	97-92-77	405C	19.0%
13		Sky	229-227-241	663C	6.0%
14		Surrounding trees & shrubbery	90-95-65	5753C	33.6%
					100.0%

Strengths and limitations of the process

Environmental colour mapping using digital technology was found to provide a reliable means of isolating, identifying and manipulating environmental colour characteristics. In assessing the reliability of this enhanced version of environmental colour mapping, recourse was made to studies that focus on key aspects of digital technology such as the isolation and identification of colour characteristics, digital colour matching and digital colour reproduction. This method of assessing reliability reflects Yin's (1994) suggestion that single case studies (single unit of analysis) can be used to test, confirm, challenge or extend an existing theory or rationale. In conducting this case study, a number of benefits as well as limitations of the process became apparent and these are discussed below.

Photographs as simulations of reality

As discussed earlier, static photographic simulations are a poor substitute for reality. In using photographic images as surrogates for real settings, the huge amount of information usually present in a multimodal environment is reduced to a static, two-dimensional representation. A major weakness in using photographs, digital or otherwise, is the loss of multimodal information. While digital photographic images can capture a substantial amount of visual information, they cannot capture 100% of this information. In addition, environments are constantly open to changes of a temporal and ever-changing nature. The effects of seasonal and diurnal cycles have an impact on the visual characteristics of an environment and therefore on the colour characteristics of an environment. These various impacts cannot be adequately captured or represented by digital photographs. However, full-colour or black and white photographs or slides have been extensively as surrogates for real settings in studies in the EBS domain (for example, see Brown & Gifford, 2001; Hershberger, 1988; Imamoglu, 2000; Groat, 1988; Nasar, 1988; Stamps, 2000; Stamps & Nasar, 1997). To compensate for the loss of multimodal information a number of measures can be taken such as increasing the image size, increasing the number of pixels per image and selecting a large image capture and storage file format. These measures were applied in this case study as well as in Preliminary Study #2 and the Main Study.

Environmental definition limitations imposed by the digital capture process

Defining the environment to be digitally represented is problematical. Various proportions of elements are possible within a digital image frame, and if the setting to be digitally represented features a structure and its surroundings, a proportion of 50:50 (structure to surroundings) may seem logical. Figure 44 features an image of a building in which the proportion of structure to surroundings (including sky) is 50:50.

Figure 44.
Proportion of structure to surroundings: 50:50.
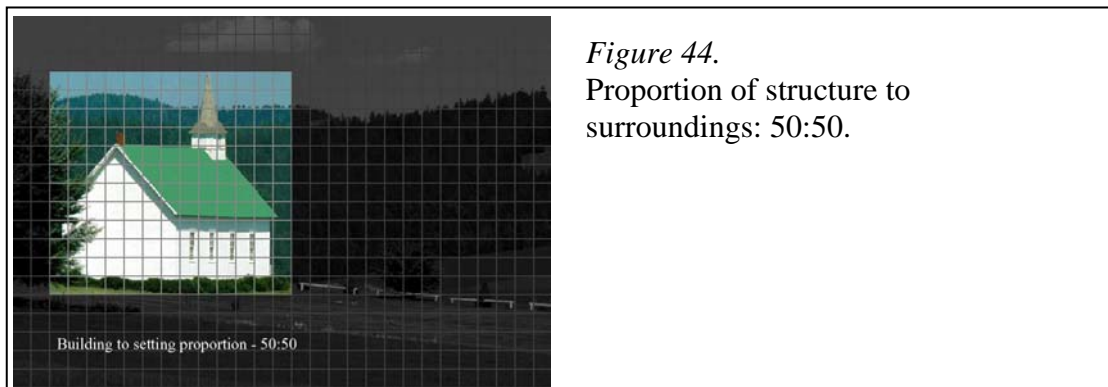
However, a 50:50 proportion limits the amount of surrounding detail visible in an image and the proportions of 25:75 or 40:60 allows for greater surrounding detail to be visible. Figures 45 and 46 features images of the same building with these proportions.
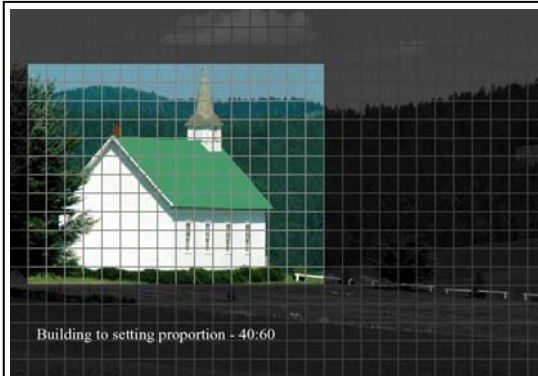
Figure 45.
Proportion of structure to surroundings: 40:60.
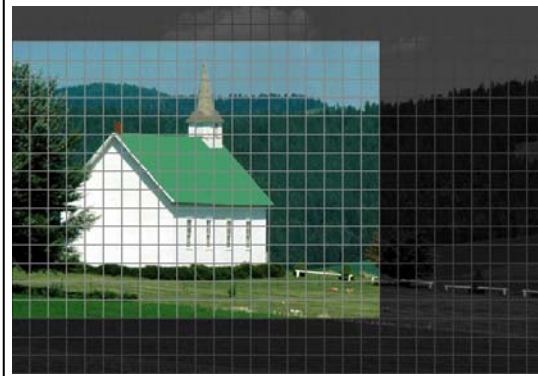
Figure 46.
Proportion of structure to surroundings: 25:75.

As one of the aims of the main study focussed on assessing façade colour within the context of surroundings, the proportion of surrounding detail was set at a maximum of 25: 75; structure to surroundings with minimal sky detail included. This setting enabled a sufficient proportion of surroundings to be included in each digital image, thereby enabling investigation into judgements of congruity and overall aesthetic response.

Possible degradation of colour data
The possible degradation of colour and other visual data contained within digital images and digital files is another weakness that may impinge on the reliability of the process. Degradation may occur due to the variety of distortions that can impact on the image during digital image processing and file storage (Wang, Bovik, Sheikh & Simoncelli, 2004).

There are a couple of ways to minimise this degradation of visual quality including increasing the number of pixels per image, selecting an appropriate file storage format;

calibrating Photoshop to meet ICC standards; and minimising image file processing procedures.

Most digital cameras, when photographing an object or environment, capture photons of light using CCDs – charge couple devices[5]. A CCD has light receiving photo-pixel elements that generate electrons in proportion to the amount of light received by each element at a rate that varies from 8 bits per pixel up to 24 bits per pixel (Miura, 2001; Vrhel, 2000). The resulting image data is then translated into binary code and compressed for storage and subsequent processing, often as a JPEG file – a common and widely used image file format (Dipert, 1998). Jointly developed by the International Telecommunications Union (ITU) and the International Organisation for Standardisation (ISO), the JPEG evolved as an international standard for compressing image data (Skodras, Christopoulos & Ebrahimi, 2001). The image data is weight-averaged using a discrete cosine transform function, usually in blocks of 8x8 photo-pixels, thereby compressing the data (Dipert, 1998; Schroeder, 1997). As some image data is lost as a result of this process, JPEGs are referred to as 'lossy' unlike an alternative method of processing image data, TIFF[6]. It is widely known that the more pixels captured per image, the greater detail and clarity per image; and the current convention therefore is to capture images at the highest possible pixel per image rate as JPEG files and ensure adequate provisions for file storage (Janesick & Putnam, 2003; Skodras *et al*, 2001). While images of 120 pixels per centimetre provide images of very high quality, Pentax – the manufacturer of the camera used in this research – consider that pixel counts greater than this are beyond the detection threshold of human vision (http://www.pentax.com/, 2003).

To minimise loss of colour data due to low pixel count per image, the images captured for this and subsequent studies were taken at the highest pixel count possible with the camera used – the Pentax Optio 550. In addition, JPEG file format was selected over TIFF file format due to the problem of excessive storage space (in both the camera and computer file storage) required for TIFF files. To offset the loss of detail, JPEG images at the highest pixel count were used in this and subsequent studies of this research.

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[5] A new imaging technology, complementary metal oxide semiconductor (CMOS) technology is emerging as a competing technology to CCDs. However, CMOS technology does not yet deliver the same image quality as CCDs – considered to be the more mature technology (Janesick & Putnam, 2003).

[6] TIFF is an image file format that does not compress image data. It is known as a 'lossless' file format however, TIFF image files require much larger storage space than JPEG files.

Digital images are also subject to degradation during processing. A main reason for this is that digital cameras usually capture colour data using the RGB colour imaging system. As part of the compression process, the colour data is converted to another colour space – frequently the YUV colour system. Compression as well as transferring the image data to another application – such as a computer software program – usually induces another conversion of the colour data resulting in possible degradation of the colour data. Serial conversions lead to a digital form of 'Chinese whispers' – gradual degradation of image data over time. To avoid this type of data degradation, the current convention is to avoid multiple file transfers and editing of digital images (Hong, Luo & Rhodes, 2001; Morovic & Morovic, 2003).

To minimise degradation of colour data in relation to the digital images used in this preliminary study and subsequent studies, all digital images were captured at the highest pixel rate possible.

Possible variations in colour data arising from different input/output devices

Different input devices – such as digital cameras and scanners – use different colour imaging systems and these colour imaging systems differ from the ones used in output devices – such as computer monitors, projectors and printers. Therefore variations in digital image data, and specifically colour data, will arise when images are transferred between input and output devices (Morovic & Morovic, 2003; Vrhel, 2000). The flow of digital image data via input and output devices in detailed in Figure 47.
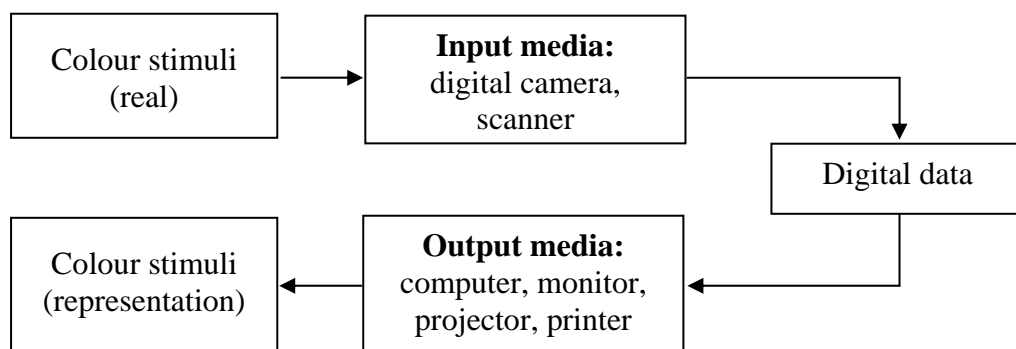
Figure 47. Digital data flow though input and output devices (Morovic & Morovic, 2003).

To minimise colour variations arising from different input and output devices, the current convention is to limit the times the digital image is processed by different digital devices and

to limit the number of times the colour data is translated from one colour imaging system to another (Morovic & Morovic, 2003).   This action was taken with regard to the digital image files used in this and subsequent studies of this research.

Colour matching function

In earlier colour mapping studies, the colour matching function relied on the manual/visual colour matching ability of the researcher (for example: Foote, 1983; Iijima, 1995, 1997; Lenclos, 1976). Foote (1983) found no significant difference between on-site colour matching and colour identification using photographic transparencies.

Photoshop 7.0 software incorporates a *Colour Picker* tool and this tool allows an area of colour to be isolated and identified using a variety of colour systems including sRGB, HSB, Lab and CMYK. The colour matching function occurs immediately, thereby considerably reducing the time spent on this task. In Photoshop 7.0, colour data is converted from sRGB into the Lab system before conversion to other colour system because the Lab mode provides a greater gamut of colours and loss of colour data is minimised (http://www.adobe.com/, 2003). The sRGB colour system, a standard colour system used across all Microsoft Windows applications, is ICC compliant and is based on the IEC 61966-21 standard (Stokes, Anderson, Chandrasekar & Motta, 1996; Susstrunk, Buckley & Swen, 1999). This ensures that colour data remains stable and reliable across a number of different computer applications including Photoshop 7.0, Microsoft Word and PowerPoint, and over the Internet (Stokes *et al,* 1996).

This preliminary study and the subsequent studies of this research used the colour matching function embedded in Photoshop 7.0 software. As is discussed above, the way that colour data is stored and processed using the sRGB colour system is considered reliable across various software platforms (Stokes *et al*, 1996).

In-situ colour comparison

An in-situ visual comparison was made of the resulting colour database and the building featured in the digital image. This followed the protocol of earlier environmental colour mapping studies whereby the researcher visually compared and checked colour samples with

colours from an existing colour notation system.[7] The colours characteristics detailed in the database were found to be comparable with the colour characteristics of the building in-situ. This supports an earlier study by Foote (1983) who found no significant difference between on-site colour matching and colour identification using photographic transparencies.

Digital colour manipulation capacity of the process

In applying digital technology to the environmental colour mapping process a benefit of environmental colour mapping using digital technology was the capacity of the process to manipulate environmental colour characteristics within a digital image. This capacity is one of a number of capabilities of Photoshop 7.0 and occurs when the *Select* tool is combined with the *Brush* tool and the *Colour Picker* tool. In using these tools, the colour characteristics of a selected area can be manipulated and changed to any other specified colour available from the various colour notation systems within Photoshop 7.0. The manipulation occurs quickly and allows the colour characteristics of all other areas within the digital image to remain unchanged.

Key outcomes and discussion

Environmental colour mapping studies were found to provide a reliable process for isolating and identifying environmental colour characteristics (Foote, 1983; Iijima. 1995, 1997; Porter, 1997). Preliminary Study #1 applied digital technology to this process and investigated it as a means of isolating, identifying and manipulating environmental colour characteristics.   In doing so, the process followed step-wise the earlier process and can be therefore deemed analytically, but not necessarily statistically, reliable. This follows a protocol considered acceptable for checking the reliability of case studies by Yin (1994).

The application of digital technology to environmental colour mapping brought some benefits as well as some weaknesses. These weaknesses included the loss of multimodal information arising from the use of digital images; environmental definition limitations imposed by the digital capture process; the possible degradation of colour data; and possible variations in colour data. In response to these weaknesses, measures aimed at minimising the effect of these were applied to this case study as discussed above.

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[7] An alternative method for in-situ colour comparison (as suggested by an anonymous reviewer) would have been to ask other raters to conduct the colour comparison. This method could have been used during the course of the research by taking one or a group of raters out onto Sydney Harbour by boat to conduct the in-situ colour comparison from the same location that the original photograph was taken.

Two key benefits were identified: digital colour matching and the ability to use digital technology to manipulate environmental colour characteristics. By using digital colour matching, the process does not rely on the colour-matching ability of the researcher but on the reliability of computer software (in this case Photoshop 7.0). Digital technology and the sRGB colour system within Photoshop 7.0 software is considered to be reliable in respect to colour matching (Stokes *et al*, 1996; Wang *et al*, 2004).

However, the main benefit is the capacity of Photoshop 7.0 to allow for the manipulation of environmental colour characteristics within a digital image. This capacity allowed for the development of a range of façade colour treatments suitable for use in Preliminary Study #2 and the Main Study of this research. Previously, the development of different façade colour treatments (either via painting or some other manual method) would have been cumbersome, time-consuming and costly. Digital technology therefore provides a means of creating a range of façade colour treatments quickly, cost-effectively and reliably using colour notation systems and JPEG file formats.

PRELIMINARY STUDY #2

Developing a basic taxonomy of façade colour[1]

Preliminary Study #2 constitutes a sub-section of Part B (Methods) of this thesis and is further divided as follows.

- Preliminary Study #2

    o Background to Preliminary Study #2;
    o Main aim of Preliminary Study #2;
    o Development of façade colour treatments;
    o Discussion of the key outcomes;
    o Strengths and limitations of Preliminary Study #2.

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[1] An earlier version of this chapter was published in the *Journal of Urban Design (2006) 11*, 335-345.

Background to Preliminary Study #2

Planning guidelines in Sydney often recommend that façade colours should be 'harmonious', 'sympathetic' or 'compatible' and should not contrast with the colours of the surroundings (for example, NSWDOP, 2005). However, as Stamps (2000) notes terms such as 'harmonious' and 'sympathetic' are often used but rarely defined within the context of such guidelines. Beyond planning policy, there exists very little research relating to aesthetic response and façade colour in general, an oversight that has already been noted (Svedmyr, 1997). Svedmyr (1997) suggests that, in view of the absence of research in this area, a starting point for investigating responses to colour are the colour theories in the field of art, studies of colour responses in psychology and colour combination theories based linked to colour notation systems.

Relatively comprehensive reviews of research relating specifically to colour theory, harmonious colour and the construct of colour harmony can be found in Gage (1995 and 1999). In addition, research findings are also discussed in the publications of the Association Internationale de la Couleur (AIC), the Commission Internationale de l'Eclairage (CIE) and journals such as *Color Research and Application*. However, consensus regarding both *harmonious* colour and the construct 'colour harmony' is lacking in the literature (Burchett, 2002). The literature reveals a multitude of prescriptive colour combination methods all of which aim to achieve either 'harmonious' colour or colour harmony. These methods tend to fall into three main groups:

1) Colour harmony based on similarity of hue (Chuang & Ou, 2001; Hard & Sivik, 2001; Ostwald, 1916);

2) Colour harmony based on contrasting or 'complementary' hues (Chevreul, 1839; Itten, 1973; Munsell, 1929);

3) Colour harmony based on colour symbolism, the connotative meanings of colour, or the notion of a colour *gestalt* (Albers, 1963; Hard & Sivik, 2001).

Various sub-groups exist in addition to the three main groups listed above – such as colour harmony based on similarity of tonal value and colour harmony based on the proportional use of colour (Itten, 1973; Munsell, 1929; Ostwald, 1916). In all, these various methods belie the simplicity of Burchett's suggestion that "Colours seen together to produce a pleasing affective response are said to be in harmony" (Burchett, 2002, p28).

However, achieving harmonious colour or colour harmony is more than simply combining a range of colours and factors such as context, congruity and familiarity may all impinge on human response to colour. For example, the context within which the colours are to be viewed or evaluated is considered an important factor in achieving *harmonious* colour and colour harmony (Hard & Sivik, 2001). Context is also considered relevant in the field of architecture and Norman Foster, using a metaphor of caves and temples, suggests that façade colour is one of a number of elements that can be used to reinforce the contextual relationship between a building and its surroundings (Foster, 1976). In applying this metaphor, Foster suggests that façade colour based on similarity of hue relative to the colours of the surroundings reinforce the 'cave' approach; while façade colours that are vivid or contrast with the colours of the environment reinforce the 'temple' approach.

Façade colour is considered to have an impact on whether a building appears to enjoy a level of congruity with its surroundings (Janssens, 2001; Unver & Ozturk, 2002). Unver and Ozturk (2002) suggest that façade colours should be linked to the colours of the surroundings, via similarity of hue, to enable a building to 'fit' with its surroundings. However, façade colour and its influence in regard to the notion of 'fit' between a building and its environment is not simply a matter of neatly matching façade colour to the colour characteristics of the surroundings via hue. Janssens (2001) suggests that "A (façade) colour has to fit in to its surrounding, not disappearing all together and becoming indifferent, nor becoming too conspicuous, which might make it appear badly chosen" (Janssens, 2001, p20). This suggestion implies that a gentle level of contrast, either in terms of hue, tonal value or saturation, is appropriate.

Familiarity is another factor that is considered to influence notions of *harmonious* colour and colour harmony with respect to façade colour (Svedmyr, 1997). The limited range of pigments, paints and dyes in previous times inadvertently created a kind of colour conditioning whereby specific colours came to be associated with certain objects or settings such as the blue of denim jeans, the black of ironwork and the yellow plaster facades of typical in Stockholm. Svedmyr (1997) suggests that it may be the contextual familiarity of these colours that influences positive aesthetic response. For example, the red façades of cottages that are a characteristic feature of the Swedish countryside – while

contrasting sharply hue-wise with their green surroundings – are considered to be particularly aesthetically pleasing and idyllic in Sweden (Hagerhall, 1999).

Main aim of Preliminary study #2

The main aim of preliminary study #2 was to develop basic classifications of façade colour based on the terms: 'harmonious' and 'contrasting'. It was not the aim of this study to provide a definitive, broad-ranging classification system of façade colour based on these terms but rather to develop simple classifications of façade colour that could be applied in the main study of this research.

Method

Preliminary study #2 comprised two iterative studies wherein the nominal group consensus technique was applied in conjunction with F-sort and Q-sort techniques, as described below. The nominal group consensus technique is one of a number of techniques used to gain consensus among participants in respect to selected research questions. Unlike the Delphi technique (which uses a panel of experts) the nominal group technique employs participants that are considered to have relevant knowledge or experience to the aims of the study (Campbell & Cantrill, 2001; Keeney, Hasson & McKenna, 2001).

The Q-sort technique, developed by Stephenson (1953), seeks to elicit perceptions and judgments that are of a subjective nature by directing participants to sort visual stimuli using categories defined by the researcher (Amin, 2000; Stephenson, 1953). The F-sort technique is a modification of the Q-sort technique and allows participants to define their own categories without direction from the researcher when sorting visual stimuli (Miller, Wiley & Wolfe, 1986). Both the F-sort and Q-sort techniques are considered an effective qualitative approach for capturing patterns of subjective responses to a set of stimuli that feature objective physical characteristics while allowing quantitative data collection and analysis (Amin, 2000; Brown, 1986).

A series of two iterative studies were conducted. The aims of the first iterative study were twofold. Firstly, to determine whether participants categorised façade colour in a way that linked or referred to the colours of the surroundings as featured in the visual

stimuli. Secondly, to determine which façade colour treatments are considered to be 'harmonious' or 'contrasting'. This second aim was replicated in the second iterative study as a means of testing the reliability of the first round of responses. The research questions and methods of Preliminary Study #2 are detailed in Table 6.

Table 6.
Research questions and methods of Preliminary Study #2.

Components of Preliminary Study #2	Method	Research questions
1st iteration	F-sort	Are façade colour categories linked in any way to the colours of the natural surroundings?
	Q-sort	What façade colour treatments are considered 'harmonious' and 'contrasting' relative to the colours of the natural surroundings?
2nd iteration	Q-sort	What façade colour treatments are considered 'harmonious' and 'contrasting' relative to the colours of the natural surroundings?

Participant group

The participant group of both iterative studies of Preliminary Study #2 comprised a cohort of academic staff and graduate students of the Environment-Behaviour Studies research group, Faculty of Architecture, the University of Sydney: eight in the first study and ten in the second study.

Given their education and experience within the domain of architecture, the participants were considered to have a relatively higher level of knowledge about the built environment in general. By possessing this relevant knowledge, the members of the cohort met the conditions for participating in nominal group consensus technique as mentioned above and defined by Campbell & Cantrill (2001) and Keeney *et al* (2001).

Development of façade colour treatments

Digital technology and Photoshop 7.0 software were used to create a range of different façade colour treatments based on the terms 'harmonious' and 'contrasting'. In developing the range of façade colour treatments, guidance was sought from the literature relating to colour theory. This literature suggests that colours generally considered harmonious are those that feature similar hues or exhibit similar tonal value or saturation levels (Chuang & Ou, 2001; Hard & Sivik, 2001; Itten, 1973; Ostwald, 1916). The literature also suggests that colours generally considered contrasting or 'complementary' are those that exhibit opposing hues, tonal value and saturation as per the colour opposite each other on simple colour wheel models (Chevreul, 1839; Itten, 1973; Munsell, 1929). A simple colour wheel models is featured in Figure 48.

Figure 48.
Simple colour wheel model.

Colours considered similar in hue are considered to be adjacent on a colour wheel model. Colours considered contrasting or 'complementary' are those located on opposite sides of a colour wheel model. (Image: http://www.colormatters.com/colortheory.html)
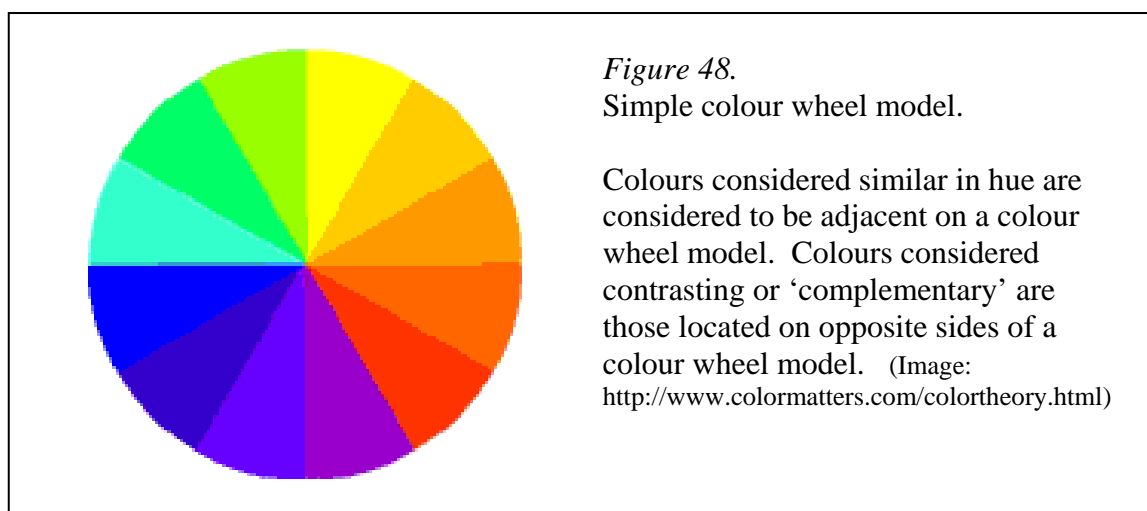
The number of possible façade colours is extensive.[2] Therefore the range of possible façade colour treatments that could be used in this research is also large and it was beyond the capacity of this research to investigate responses to a large range of façade colour treatments. As a result, the range of façade colour treatments used in this study was kept specifically narrow and limited, and were developed based either on hue similarity or contrast of hue. In addition, roof colours were varied and matched to façade colours to avoid confounding effects that may have arisen due to simultaneous contrast between the roof and façade colours. These issues represent limitations of the study as discussed in the chapter Research methodology.

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[2] As mentioned in an earlier chapter, it is estimated that the human eye can distinguish between 1.8 million and ten million different colours (Gouras, 1991; Judd & Wyszecki, 1975; Pointer & Attridge, 1998). In addition, the number of possible colour combinations is considered "almost infinite" (Hard & Sivik, 2001, p4).

Façade colour treatments based on hue similarity

Five treatments were created based on hue similarity between façade colour and the colours of the natural surroundings. The five treatments are detailed using the sRGB colour notation system[3] in Table 7. Featuring predominantly tones of shades of green, the façade colour treatments are illustrated in Figure 49. Roof colours have been adjusted to match the hue of the façade colour. This adjustment was made to focus attention on the façade colour and also to minimise the possibility that simultaneous contrast may impinge on the interaction of roof and façade colour.

Table 7.
Five façade colour treatments based on similarity of hue.

Code	Façade colour treatment description	sRGB value
CC1	Façade: Green – similar in hue to surrounding vegetation	140-140-100
CC2	Façade: Green – similar in hue to surrounding vegetation	165-165-140
GC1	Façade: Green – similar in hue to surrounding vegetation	183-187-165
DK1	Façade: Green – similar in hue to surrounding vegetation	177-167-158
MC1	Façade: Green – similar in hue to surrounding vegetation	165-176-157

Figure 49. Five façade colour treatments featuring hue similarity.

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[3] The sRGB system was used as it is compliant with ICC International standards and is common across Photoshop and Microsoft software applications. It is also considered stable and reliable across these applications (Stokes, Anderson, Chandrasekar & Motta, 1996; Susskind, Buckley & Swen, 1999).

Façade colour treatments based on contrasting colour

The unlimited range of possible contrasting façade colours was narrowed to a range of seven: yellow, orange, orange-red, red, blue, purple and off-white as detailed in Table 8 and illustrated in Figure 50. As mentioned above, the roof colours have been adjusted to match the hue of the façade colour. This adjustment was made to focus attention on the façade colour and also to minimise the possibility that simultaneous contrast may impinge on the interaction of roof and façade colour.

Table 8.
Seven façade colour treatments based on contrasting hue.

Code	Façade colour treatment description	sRGB value
OC1	White – original façade colour	255-255-255
CH1	Desaturated orange/red – contrasting hue	230-195-180
CH2	Desaturated orange/red – contrasting hue	255-223-208
RC1	Desaturated red – contrasting hue	246-204-223
BC1	Blue	204-210-236
PC1	Purple	202-166-208
YC1	Yellow	246-241-177

Figure 50. Seven façade colour treatments featuring hue contrast.

A set of A5 digital images were produced that featured the range of façade colour treatments and these comprised the visual stimuli. This set of visual stimuli was used in both iterations of Preliminary Study #2 (twelve in the first and nine in the second iteration). Each digital image featured a harbour-side boatshed and was identical except that the boatshed displayed a different façade colour treatment.

Procedure

Participants were provided with a set of visual stimuli and a questionnaire sheet that provided written instructions and enabled them to record their responses. The first task was an F-sort task and participants were asked to sort the visual stimuli into groups according to their own criteria without direction from the researcher. The first Q-sort task required participants to sort the visual stimuli according to whether they considered the façade colours to be harmonious or contrasting relative to the colours of the surroundings to a lesser or greater degree. Participants were not provided with definitions of the terms harmonious and contrasting. The second Q-sort task required participants to sort the visual stimuli into categories of harmonious façade colour or contrasting façade colour.

Data collection and analysis

Responses for all tasks were recorded by participants using the questionnaire sheets. The pattern of responses arising from the F-sort task were examined and grouped according to categories created by the participants and tallies were made of these groupings. Participants' responses from the subsequent Q-sort tasks were tallied and examined for patterns in response.

Results

The tally from the F-sort task indicated that 62% of participants created categories that were possibly linked to the colour characteristics of the building but which were not overtly linked, or made specific reference to, the colours of the surroundings. For example, "kitsch" and "warm graduated." The remaining 38% created categories that were interpreted as indicating a link between the colour characteristics of the building and the colour characteristics of the surroundings. For example, "contrasts with environment" and "muted, fitting into context."

The tally from the first Q-sort task indicated that 100% of participants' categorised façade colour treatments that featured contrasting hues to be 'contrasting to a greater degree.' In

addition, 100% of participants' categorised façade colour treatments that featured similarity of hue as 'harmonious to a greater degree.' The tally also indicates that some façade colour treatments that exhibited hue contrast were also categorised as 'harmonious to a greater degree' by 50% of the participants as depicted pictorially in Figure 51.
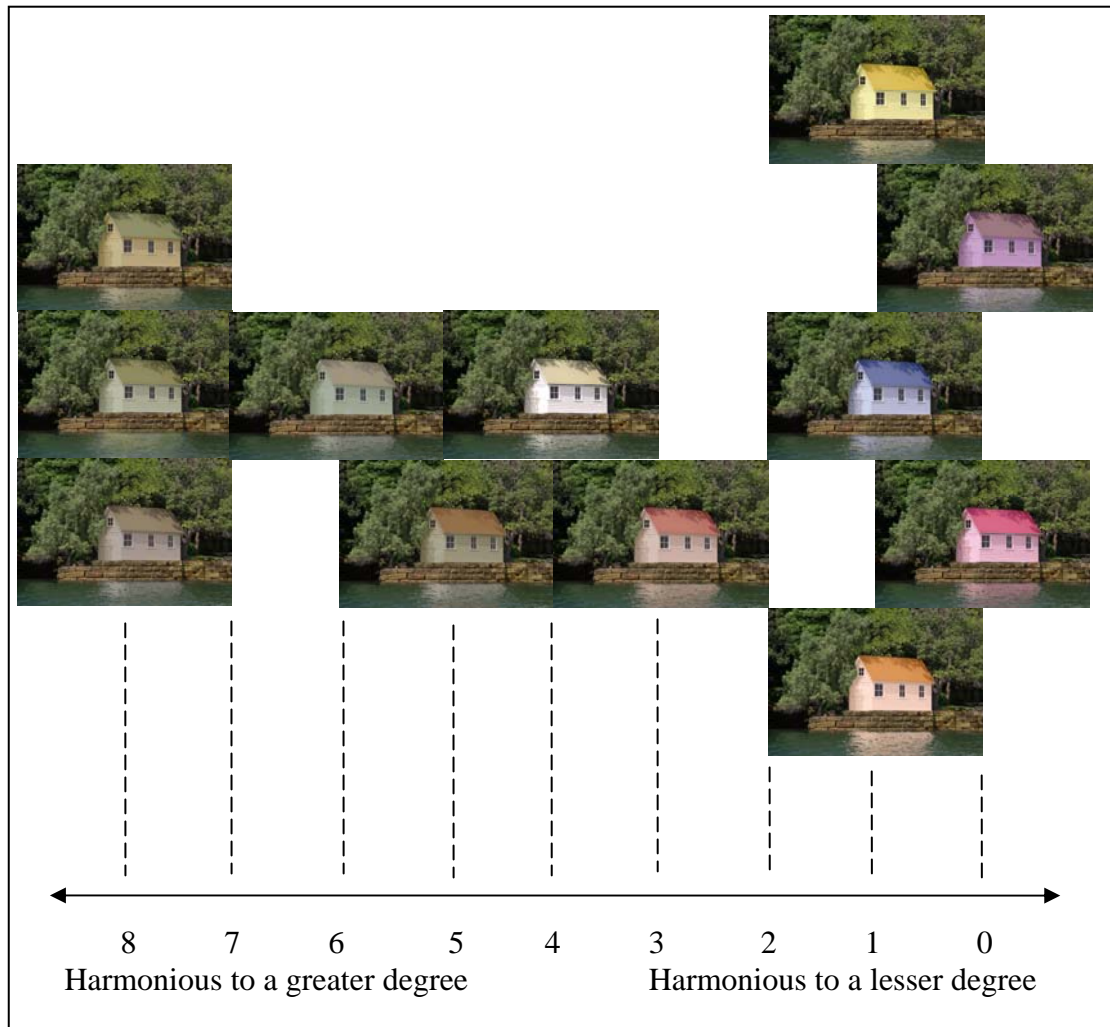
Figure 51. Façade colour treatment evaluations.

The results of the second Q-sort task indicated that façade colour treatments that feature hue similarity are generally considered to be harmonious and façade colour treatments that feature hue contrast are generally considered contrasting. However, 30% of participants also considered harmonious some façade colour treatments that featured contrasting hues as indicated by the circled responses in Table 9. The façade colour treatments featuring hue contrast that were considered harmonious are off-white and desaturated. Figure 52 features images depicting façade colour treatments.

Table 9.
Tally of responses to Q-sort task number 2.

Façade colours that exhibit hue similarity relative to the colours of the natural surroundings								Façade colours that exhibit hue contrast relative to the colours of the natural surroundings									
CC1		CC2		DK1		GC1		OC1		BC1		CH2		CH1		RC1	
H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C
✓		✓		✓		✓			✓		✓		✓		✓		✓
✓		✓		✓		✓			✓		✓		✓	✓			✓
✓		✓		✓		✓			✓		✓		✓		✓		✓
✓		✓		✓		✓			✓		✓		✓	✓			✓
✓		✓		✓		✓		✓			✓		✓		✓		✓
✓		✓		✓		✓			✓		✓		✓		✓		✓
✓		✓		✓		✓			✓		✓		✓		✓		✓
✓		✓		✓		✓			✓		✓		✓		✓		✓
✓		✓		✓		✓			✓		✓		✓		✓		✓
✓		✓		✓		✓			✓		✓		✓		✓		✓
10	0	10	0	10	0	10	0	1	9	0	10	0	10	2	8	0	10

Note: Responses circled in red indicate individual variations.
     Key: H – Harmonious colour; C – Contrasting colour.

CC1   CC2   DK1   GC1   OC1   BC1   CH2   CH1   RC1
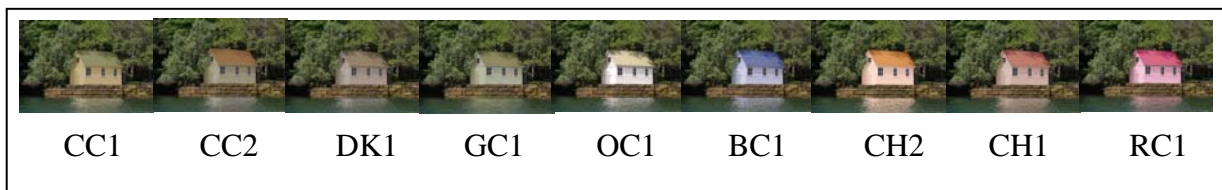
Figure 52. Nine façade colour treatments.

Strengths and limitations of Preliminary study #2

F-sort and Q-sort procedures were applied in Preliminary study #2 and these are considered an effective and reliable method for capturing patterns of subjective responses to a set of visual stimuli that feature objective physical characteristics (Amin, 2000; Brown, 1986).   However, a key limitation of Preliminary study #2 is the small number of façade colour treatments used to develop basic classifications of façade colour. The visual stimuli used in Preliminary study #2 featured a range of twelve façade colour treatments and, as discussed, this represents a limited number of façade colour treatments in respect to the gamut of possible façade colour treatments. In addition, the F- and Q-sorting tasks

were carried out with a small group of participants and with limited but not stringent controls in terms of ambient lighting. These issues highlight further limitations of Preliminary study #2.

The results indicate that some contrasting façade colour treatments were also considered harmonious. These results reflect the different approaches to colour harmony found in the literature discussed above. However, these findings do not reflect the intent of planning guidelines regarding façade colour and, for the purpose of the main study of this research, these findings will be set aside, providing an opportunity for future research.

A limitation in respect to the development of a taxonomy of façade colour that became obvious during this preliminary study, and which was noted by an anonymous reviewer of this thesis, was the effect of simultaneous contrast between the façade colours of the boatshed and the colours of the surroundings. As discussed above, simultaneous contrast occurs when the visual appearance of an area of colour seems to change marginally due to the proximity of a surrounding colour (Goldstein, 1996). Simultaneous contrast, which may make a colour appear different in terms of hue, lightness and saturation, caused the contrasting colours (specifically, OC1, CH1, CH2 and RC1) to appear not just different in terms of hue but brighter due to the simultaneous contrast effect arising from the darker green surroundings. Simultaneous contrast is an effect that occurs automatically and, in this preliminary study, the effect could not be avoided or controlled unless the colours of the surroundings were altered.

Finally, the limitations mentioned in Preliminary Study #1 with respect to the use of photographs as simulations of reality, the issue of definition of 'environment', the degradation of colour data and the occurrence of variations in colour data arising from different input/output devices also apply to the outcomes of Preliminary Study #2.

Key outcomes and discussion

Preliminary study #2 sought to develop basic classifications of façade colour based on terminology frequently found in planning guidelines, specifically the terms harmonious and contrasting. A series of iterative studies was conducted using F-sort and Q-sort technique coupled with nominal group consensus. The visual stimuli featured a range of façade colour

treatments.   While the responses were not unanimous, the results provide a general basis for classifying façade colour treatment based on the terms harmonious and contrasting.

Harmonious and contrasting façade colours

Façade colour treatments generally considered *harmonious* are those that feature similarity of hue between façade colour and the colours of the surroundings – in this case the colours of the natural surroundings.   Façade colour treatments considered *contrasting* are those that feature façade colours that contrast with the colours of the surroundings.   However, some overlap between these categories occurred and two contrasting façade colour treatments were also considered to be harmonious: off-white (OC1) and terracotta (desaturated red-orange, CH1).   However, the findings suggest that façade colour classifications are not completely watertight. The implication being that responses to façade colour may not be universal and deterministic.

MAIN STUDY

This section constitutes a sub-section of Part B (Methods) of this thesis and is further divided as follows.

- Main study
  - Research questions and hypotheses[1]
  - Quasi-experimental research design
  - Applying the Latin-square technique
  - Population and sample
  - Independent variable: Façade colour
  - Visual stimuli
  - Measuring aesthetic response
  - Pilot Study #1
  - Pilot Study #2
  - Data collection
  - Assumptions relating to the data and data analysis
  - Data analysis methods
  - Research quality assurance
  - Strengths and limitations of the main study

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[1] The research questions and hypotheses as well as the constructs underlying the dependent variables are discussed in greater detail in the section: Research methodology. The data analysis methods and results arising from the Main Study are fully described and discussed in the section: Results of the main study.

Research questions and hypotheses

Six research question and hypotheses formed the focus of the main study, and these sought to examine patterns of response in ten dependent variables in respect to four treatments of the independent variable: façade colour. The dependent variables represented the construct aesthetic response and judgements about a building's congruity and size relative to its surroundings. In addition, aesthetic response to façade colour was investigated in terms of individual differences among members of the sample group and three subsets of the sample group.

Research question 1: Façade colour and aesthetic response

It is suggested that façade colour may influence aesthetic response to a building (Nasar, 1994; Stamps, 2000). This suggestion is reflected in planning policy in Sydney, Australia, which contains specific, prescriptive guidelines relating to façade colour (NSWDOP, 2005). However, little is known about the relationship between façade colour and aesthetic response and this became the focus of the first research question. For the purpose of this study, overall aesthetic response was considered to comprise affective appraisals, cognitive judgements and preference.[2]

The first research question sought to explore whether changes in façade colour treatment are associated with differences in overall aesthetic response. It was anticipated that some change in aesthetic response would occur in response to different façade colour treatments, however, the extent or strength of this change was not known. The null and alternative hypotheses for this first research question are as follows.

$$H_0: \quad \mu AR_{T1} = \mu AR_{T2} = \mu AR_{T3} = \mu AR_{T4}$$

$$H_1: \quad \mu AR_{T1} \neq \mu AR_{T2} \neq \mu AR_{T3} \neq \mu AR_{T4}$$

where μ refers to population mean; 'AR' is aesthetic response, and 'T1-4' represents four façade colour treatments.[3]

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[2] Please see the section: *Research methodology* for a more detailed discussion of this construct.

[3] Notational style for null and alternate hypotheses adapted from Argyrous (2001) and Shaughnessy & Zechmeister (1997).

Research question 2: Façade colour and judgements about congruity

It is suggested that façade colour plays a role in whether a building is considered to 'fit' or be congruous and sympathetic in relation to its surroundings (Janssen, 2001). This notion is also reflected in planning policies wherein guidelines frequently recommend that façade colours should be harmonious or sympathetic relative to the surroundings. The second research question sought to investigate whether changes in façade colour are associated with differences in judgements about the congruity of a building relative to its surroundings. It was anticipated that an effect may occur, but the extent of this effect was not predicted. The null and alternative hypotheses are as follows.

H_0: $\quad \mu CON_{T1} = \mu CON_{T2} = \mu CON_{T3} = \mu CON_{T4}$

H_2: $\quad \mu CON_{T1} \neq \mu CON_{T2} \neq \mu CON_{T3} \neq \mu CON_{T4}$

where μ is the population mean, 'CON' refers to judgements about congruity and 'T1-4' represents four façade colour treatments.

Research question 3: Façade colour and judgements about size

It has been suggested that façade colour may influence perceptions of visual bulk in regard to large buildings (Unver & Ozturk, 2002). Colour is frequently used in interior design to make rooms appear larger or smaller, and is considered to influence judgments or perceptions of size (Guthrie, 1995). The second research question sought to explore whether changes in façade colour are associated with differences in judgements about the size and apparent visual significance or dominance of a building. It was anticipated that differences in façade colour treatment may be associated with changes in judgements about the size of a building and that these differences may be as much as +/- 5%. The null and alternative hypotheses for this research question are as follows.

H_0: $\quad \mu SIZE_{T1} = \mu SIZE_{T2} = \mu SIZE_{T3} = \mu SIZE_{T4}$

H_3: $\quad \mu SIZE_{T1} \neq \mu SIZE_{T2} \neq \mu SIZE_{T3} \neq \mu SIZE_{T4}$

where μ is the population mean; 'SIZE' refers to judgements about a buildings size, and 'T1-4' represents the four façade colour treatments.

Research questions 4a & 4b: Façade colour and preference

Research questions 4a and 4b sought to investigate the relationship between façade colour treatment and preference. This research question comprised two parts: firstly, whether preference for a building is altered by changes in façade colour treatment. Secondly, whether preference for a façade colour treatment is consistent across different a range of buildings – in this case, the four buildings featured in the visual stimuli. The null and alternative hypotheses for these research questions are as follows.

H_0: $\mu PREFER_{B1(T1-4)} = \mu PREFER_{B2(T1-4)} = \mu PREFER_{B3(T1-4)} = \mu PREFER_{B4(T1-4)}$

H_{4a}: $\mu PREFER_{B1(T1-4)} \neq \mu PREFER_{B2(T1-4)} \neq \mu PREFER_{B3(T1-4)} \neq \mu PREFER_{B4(T1-4)}$

H_0: $\mu PREFER_{T1(B1-4)} = \mu PREFER_{T2(B1-4)} = \mu PREFER_{T3(B1-4)} = \mu PREFER_{T4(B1-4)}$

H_{4b}: $\mu PREFER_{T1(B1-4)} \neq \mu PREFER_{T2(B1-4)} \neq \mu PREFER_{T3(B1-4)} \neq \mu PREFER_{T4(B1-4)}$

where μ is the population mean; 'PREFER' refers to preference rating, 'T1-4' represents four façade colour treatments & 'B1-4' refers to four building.

Research question 5: Aesthetic response and individual differences

The fifth research question sought to explore whether variations in *aesthetic response* to façade colour are associated with differences in individual characteristics. The operational definition of individual characteristics for the purposes of this study was limited to gender, age, region of birth and familiarity. It was hypothesised that variations in *aesthetic response* may be associated with differences in individual characteristics however the extent of this association was not predicted. The null and alternative hypotheses are as follows.

H_0: $\mu AR_{(T1*IND)} = \mu AR_{(T2*IND)} = \mu AR_{(T3*IND)} = \mu AR_{(T4*IND)}$

H_5: $\mu AR_{(T1*IND)} \neq \mu AR_{(T2*IND)} \neq \mu AR_{(T3*IND)} \neq \mu AR_{(T4*IND)}$

where μ is the population mean; 'AR' refers to *aesthetic response*[r], and 'IND' refers to the individual characteristics: gender, age, region of birth & familiarity.

Research question 6: Aesthetic response and sample group subset

The education of architects has been found to have some influence on how architects experience architecture in terms of affective and evaluative responses (Hershberger, 1992). The sixth sought to determine whether this held true in respect to responses to the environmental variable of façade colour. That is, whether patterns of overall *aesthetic response* were associated with one or more of three sample group subsets: graduate students from the Faculty of Architecture; graduate students from non-Architecture Faculties and members of the general population. It was anticipated that overall *aesthetic response* may vary between the subsets but the extent of this variation was not predicted. The null and alternative hypotheses are as follows.

H_0: $\mu AR_{\text{T1-4 (Subset 1)}} = \mu AR_{\text{T1-4 (Subset 2)}} = \mu AR_{\text{T1-4 (Subset 3}}$

H6: $\mu AR_{\text{T1-4 (Subset 1)}} \neq \mu AR_{\text{T1-4 (Subset 2)}} \neq \mu AR_{\text{T1-4 (Subset 3}}$

where μ is population mean; 'AR' refers to *aesthetic response*; T1-4 represent four façade colour treatments and Subsets 1-3 represent 3 subsets of the sample population.

Quasi-experimental research design

The main study sought to examine patterns of response to façade colour treatments as opposed to investigating the underlying reasons for such responses. A post-test repeated measures quasi-experimental research design was used to address the research questions.[4]

Two issues arose during the course of Preliminary Study #2 and, more markedly, during the course of Pilot Study #1 that impacted on the selection of an appropriate research design. These issues related to the method of presentation of the visual stimuli to participants in the studies. Specifically, the visual stimuli comprised digital photographs featuring the same building in a range of different façade colour treatments. During the

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[4] The research design used in the main study may be considered *experimental* as defined by some theorists in the fields of architectural research and psychology (Groat & Wang, 2002; Shaughnessy & Zechmeister, 1997). However, it would fall into the category of *quasi-experimental* under the definitions of other theorists in psychology and social research (Campbell & Stanley, 1966; Neuman, 1997). The use of the term *quasi* is often applied primarily because of a perceived lack of adequate control and a lack of random assignment (Shaughnessy & Zechmeister, 1997, p352). However, as discussed below, the Latin-square technique brings an acceptable level of random assignment and replication and hence qualifies the main study as *experimental* (Groat & Wang; 2002; Shaughnessy & Zechmeister, 1997). While the main aim of the main study was to examine patterns of response in terms of two or more dependent variables, the manipulation of the key independent variable (façade colour) precludes the study from being categorised as *correlational research* (Groat & Wang, 2002). This research does not attempt to enter the debate regarding definitions of experimental and quasi-experimental research designs and has opted to define the main study as a quasi-experimental research design.

course of these studies, some participants were observed to verbally compare different façade colours as well as express their opinions about the nature of the study. While such opinions and judgements may be relevant to investigations relating solely to preference; they were not appropriate for the main study as they indicated the existence of order-interaction and reactivity effects that may confound the results.[5]

The effects identified during the course of Preliminary Study #2 and Pilot Study #1 prompted further investigation of the literature relating to methodology to find a means of minimising these effects in the Main Study. The Latin-square technique was identified as a means of minimising order-interaction and reactivity effects, and was subsequently applied in the main study.

The Latin-square technique

Before discussing how the Latin-square technique was applied in the main study, a brief description is appropriate. The Latin-square technique allows for multiple treatments of one independent variable to be tested with a sample or a number of groups representing sample subsets (Campbell & Stanley, 1966; Fisher, 1935; Neuman, 1997; Shaughnessy & Zechmeister, 1997; Tabachnick & Fidell, 2001). Latin-squares are commonly applied to post-test or repeated measures research designs and are used to "remove potential confounding between position effects (that is, order-interaction effects) and treatment effects by giving cases treatments in different orders" (Tabachnick & Fidell, 2001, p481).

Fisher (1935) asserts that the Latin-square technique is the most efficient and statistically sound method for evaluating a number of treatments as it maintains random assignment and replication is built into the research design. Both random assignment and replication are techniques that are considered to decrease the probability of error within an experiment (Campbell & Stanley, 1966; Cochran & Cox, 1957; Coolican, 2004). It is also suggested that any level of diversity or lack of homogeneity within the sample group, and the subsequent

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[5] Order-interaction effect arises from the actual testing process whereby participants who are required to evaluate a series of visual stimuli may behave differently in respect to each subsequent evaluation due to their experience of the earlier visual stimuli. As such, the *testing* process itself may pose a threat to the internal validity of a study (Campbell & Stanley, 1966; Coolican, 2004). As discussed below, reactivity effects may arise when participants become aware of the main aims of an experimental study during the course of the study. It is suggested that by knowing or guessing the aims of a study, participants may behave differently than they would under normal circumstances thereby confounding the results (Campbell & Stanley, 1966; Coolican, 2004). Single blind, double blind or expectancy control measures can be taken to avoid or diminish reactivity effects (Coolican, 2004).

effects that this may cause, are diminished with the Latin-square technique (Campbell & Stanley, 1966; Fisher, 1935). Due to the restrictively randomised nature of the Latin-square technique, each set of variables (that is, dependent and independent variables) are considered to be orthogonal to the other sets of variables and can therefore be treated as statistically independent (Campbell & Stanley, 1966; Fisher 1935; Tabachnick & Fidell, 2001). The number of squares within a Latin-square design depends on the number of treatments of the independent variable under examination, and the standard Latin-square design typically has four level of treatment (Tabachnick & Fidell, 2001). Latin-square design can accommodate a larger number of treatment levels, but this usually involves much a correspondingly larger sample group (Tabachnick & Fidell, 2001).

While the Latin-square technique was initially developed to measure the effectiveness of fertilisers across different segments of a field by Fisher (1935), the technique has been applied in studies that involve aesthetic or visual response in general and responses to colour in particular (see Stamps, 2005; Stamps & Krishnan, 2006 plus the earlier study by Tannenbaum & Osgood, 1952). In addition, the technique has been used to investigate aesthetic response to product design (Hutchinson, Kamakura & Lynch, 2000); visual perception of paintings (Avital & Cupchik, 1998); evaluation and appreciation of paintings (Leder, Carbon & Ripsas, 2006); and aesthetic response to, and preference for, music (Hugh, 2004). In addition, the Latin-square technique has been applied in conjunction with the semantic differential measurement technique (see Dean, Engel and Talarzyk, 1972).

The Latin-square technique applied in the main study of this research allows for four treatments to be evaluated in a randomised manner diagrammed in Figure 53 as follows.

$$
R \begin{cases}
X_1O & X_2O & X_3O & X_4O \\
X_3O & X_1O & X_4O & X_2O \\
X_2O & X_4O & X_1O & X_3O \\
X_4O & X_3O & X_2O & X_1O
\end{cases}
$$
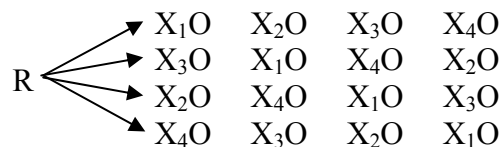
R represents random assignment; X_{1-4} represent four experimental treatments and O represents measurement of dependent variable/s (adapted from Campbell & Stanley, 1966).

Figure 53. Latin-square technique for four treatments.

In addition, to minimising order-interaction effects (as discussed above), Campbell and Stanley (1966) advise that the Latin-square technique helps to minimise possible sources of

internal invalidity such as history, maturation, testing, instrumentation, regression, selection, mortality, plus interactions of any of these effects.[6]   Finally, the Latin-square technique is a single blind procedure thereby diminishing the possibility that participants can guess the nature of the study (Coolican, 2004).

Applying the Latin-square technique in the Main study

In the main study of this research, participants were asked to evaluate four façade colour treatments provided to them in a set of visual stimuli in a pre-set presentation format that was constantly rotated as per Figure 54. The visual stimuli comprised digital images of four façade colour treatments exhibited on four different buildings.

$$
\begin{array}{lllll}
R & Xt_{1(Ba,b,c,d)}O & Xt_{2(Ba,b,c,d)}O & Xt_{3(Ba,b,c,d)}O & Xt_{4(Ba,b,c,d)}O \\
R & Xt_{3(Ba,b,c,d)}O & Xt_{1(Ba,b,c,d)}O & Xt_{4(Ba,b,c,d)}O & Xt_{2(Ba,b,c,d)}O \\
R & Xt_{2(Ba,b,c,d)}O & Xt_{4(Ba,b,c,d)}O & Xt_{1(Ba,b,c,d)}O & Xt_{3(Ba,b,c,d)}O \\
R & Xt_{4(Ba,b,c,d)}O & Xt_{3(Ba,b,c,d)}O & Xt_{2(Ba,b,c,d)}O & Xt_{1(Ba,b,c,d)}O
\end{array}
$$

Xt_{1-4} represent four façade colour treatments; B_{a-d} represent four different buildings; and O represents observation or measurement of dependent variable/s (adapted from Campbell & Stanley, 1966).

Figure 54. Applying the Latin-square technique in the Main study.

By applying the Latin-square technique, the rotational nature of the technique resulted in sixteen possible façade colour treatment/building combinations as per Table 10.

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[6] History relates to the influence on the experimental situation and particularly on participants' responses of events that occur between observations or measurements in a research design that has pre- and post-test observations or measurements. In a Latin-square research design, there are no pre- or post-test observations or measurements that may influence participants' responses. Maturation refers to processes (biological or psychological) that may vary over time and which may influence observations or measurements. In a Latin-square design, evaluations are not conducted over time and therefore processes or changes that may occur over a period of time do not impact on observations or measurements. Testing refers to the effect that a pre-test may have on a later test, observation or measurement. In a Latin-square design, all observations and measurements are conducted without pre-tests and are therefore not influenced by these. Reactivity refers to the possibility that the process of conducting an observation or measurement may influence or change that which is being measured. Reactivity effects may therefore arise when participants become aware of the main aims of an experimental study during the course of the study. It is suggested that by knowing or guessing the aims of a study, participants may behave differently than they would under normal circumstances thereby confounding the results. The counter-balanced nature of Latin-square design works to inhibit this effect. Instrumentation is also referred to instrument decay and relates to changes that may occur within the measurement instrument and may include instrument fatigue or changes in measurement or grading standards. Again, the counter-balanced inhibits this effect. In addition, in the Main study of this research, 288 sets of visual stimuli were produced to minimize instrument decay. Statistical regression occurs as a confounding effect in pre-test post-test design. This effect is negated by the counter-balanced nature of the Latin-square design. Selection relates to the notion that sample groups are not completely homogenous and this lack of homogeneity may influence or confound the resulting data. Again, the counter-balanced nature of the Latin-square design inhibits the possibility of selection acting as a confounding effect. Mortality relates to the effect that a drop-out rate among participants may confound the results. Both the counter-balanced nature of the Latin-square design and the one-shot method of testing stymie the confounding effect of mortality. The definitions of the confounding effects discussed here are from Campbell and Stanley (1966) and Coolican (2004).

Table 10.
Sixteen façade colour treatment/building combinations.

Building	Façade colour treatments			
	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Building *a*	1*a*	2*a*	3a	4a
Building *b*	1*b*	2b	3b	4b
Building *c*	1*c*	2c	3c	4c
Building *d*	1*d*	2d	3d	4d

Given sixteen façade colour treatment/building combinations, the number of possible presentation formats that included one particular façade colour treatment/building combination was six. For example, a presentation format that featured 1*a* needed to include façade colour treatment 2 (2*b*, 2*c* or 2*d*), treatment 3 (3*b*, 3*c* or 3*d*) and treatment 4 (4*b*, 4*c* or 4*d*). The number of possible presentation formats that included 1*a* is as per Table 11.

Table 11.
Six presentation formats for façade colour treatment/building combination 1*a*.

Presentation format	Treatment/building combinations in format			
Presentation format 1	1*a*	2*b*	3*c*	4*d*
Presentation format 2	1*a*	2*b*	3*d*	4*c*
Presentation format 3	1*a*	2*c*	3*b*	4*d*
Presentation format 4	1*a*	2*c*	3*d*	4*b*
Presentation format 5	1*a*	2*d*	3*b*	4*c*
Presentation format 6	1*a*	2*d*	3*c*	4*d*

Coding of the visual stimuli

The visual stimuli comprised sixteen digital images and these were coded using a system that was kept deliberately simple as participants were required to transcribe the code numbers of the visual stimuli onto the questionnaire. The code numbers are detailed in Table 12.

Table 12.
Coding of visual stimuli.

Treatment/building	Code no.	Treatment/building	Code no.
1a	B21	3a	B41
1b	B22	3b	B42
1c	B23	3c	B43
1d	B24	3d	B44
2a	B31	4a	B51
2b	B32	4b	B52
2c	B33	4c	B53
3d	B34	4d	B54

Presentation format protocol

The Latin-square technique required that the order of presentation of visual stimuli was constantly rotated, resulting in 96 different presentation formats for the main study. That is, four treatments illustrated on four buildings and presented in six different presentation formats as diagrammed in Tables 42, 43, 44 and 45 in the Appendix.[7]

As a result of the Latin-square presentation format protocol, each individual treatment/building combination was tested 24 times within one sample group subset and 72 times in total.

Population and sample

Aesthetic response to building attributes in general and façade colour in particular occurs irrespective of age, gender, culture, occupation, socio-economic group and so on. While it may be architects and planners who determine or select façade colour, this study was interested in the evaluation of façade colour treatments by ordinary people. Given that the research was conducted within the context of urban design and planning policy in Sydney, Australia, the population as defined for this research was limited to people currently residing or visiting Sydney.

It is acknowledged that both the sample group and the population of the main study may include people with colour vision deficiency or colour blindness. However, people with colour vision deficiencies were not specifically identified or excluded from research for the following reasons. Firstly, people with total colour blindness represent less than 0.0001%

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[7] The 96 different treatment/building rotated formats featured in the Tables in the Appendix have been grouped into four groups only to break up what would have been a very large table.

of the population and people with colour vision deficiency account for less than 5% of Australia's total population (Sharpe & Jagle, 2001).[8]   In addition, people with colour vision deficiency generally perceive façade colour irrespective of their vision deficiency except that their perceptual experience is somewhat different from those with normal vision.   Therefore, while colour vision deficiency may affect a small proportion of the population, this proportion was not considered large enough to warrant specific attention in terms of the population and sample of this research.   As discussed below, this stands as a limitation of this research but also as an opportunity for further research.

Sampling process and sampling frame

Environmental preference and evaluation studies often use sample groups comprised of university students.   However, because university students may not necessarily be representative of the general population, this sampling strategy has its drawbacks.   To partially offset this, the sampling process aimed to draw a sample group that more closely represented the population. As a result, the final sample group was comprised of one third members of the general population of Sydney and two thirds part-time graduate, rather than undergraduate, students. A statistical breakdown of the sample group can be found in the Appendix.[9]

Two main issues placed some constraints on the sampling process.   Firstly, some of the terms used in the measurement instrument may be considered somewhat technical and possibly difficult to understand for those whose English language skills are limited. These terms were adapted from earlier studies as well as current Sydney planning guidelines, and included terms such as *harmonious, sympathetic* and *stimulating.*   Therefore it was considered essential that members of the sample group had good English language skills.   The second consideration had to do with the limited time and budget for this research.   Therefore, the main study had to be conducted in close proximity to the University of Sydney to minimise travel time and costs.

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[8] There are three main forms of colour vision deficiency: monochromatism, dichromatism and protanopia (Goldstein, 1996).   Monochromats, who account for around 0.001% of the population, experience total colour blindness as their retinas do not have functioning cone receptors and everything is perceived in shades of white through greys to black.   Dichromats, who account for approximately 6% of males and 0.5% of females, experience partial colour blindness as their retinas process incoming colour information via two wavelengths rather than the usual three, thereby accounting for their red-green colour deficiency or blue-yellow colour deficiency; Anomalous Trichomats, who account for between 1% and 6% - depending on the type of anomalous trichomacy condition – experience colour slightly differently than normal: some colours may bee seen with greater intensity and others with less intensity (Goldstein, 1996; Sharpe & Jagle, 2001).

[9] To reiterate, all participants in the main study evaluated each of the four façade colour treatments that represented the independent variable of this study.

A logistical issue that also had an impact on the sampling process was the requirement for data collection to occur in locations that had both good natural and artificial light to ensure that evaluations were not hindered or effected by poor lighting. Given this requirement, university lecture rooms and a hired conference room were selected for data collection as both of these types of rooms met this lighting requirement. Therefore, the selection of suitable survey session rooms also influenced, in an oblique way, the sampling process.

Equal probability random sampling methods such as a stratified sample or a collection of cluster samples may provide a relatively representative sample of the population of Sydney. However, these sampling procedures may result in sample group members whose language skills are inadequate for this study. Convenience sampling was therefore used for the main study; a method considered to be a non-probability based sampling method (Coolican, 2004). The sample group was therefore multidimensional and consisted of three equal subsets as follows:

- o Graduate, part-time students and lecturers, Faculty of Architecture (USYD[10]);
- o Graduate, part-time students and lecturers, non-Architecture Faculty (USYD);
- o Members of the general public.

In terms of the two sample group subsets comprising part-time graduate students, the sampling process was as follows. Classes at various faculties within the University of Sydney were selected from the University's website and permission was sought from Faculty Deans and lecturers to conduct the survey via email. Participation was entirely dependent on lecturers granting approval for the survey to be conducted during class time. A total of 44 lecturers from various faculties including Architecture, Chemical Engineering, Dentistry, Economics, Education, Law and the Institute of Teaching and Learning, University of Sydney, were approached. Of these, fifteen granted approval for the study to proceed in their class, resulting in thirteen data collection survey sessions conducted over a period of six weeks from 13 September 2005. In relation to the sample group subset comprising members of the general public, individuals were approached on the sidewalk at Bondi Junction on 15 September 2005 and asked to participate in the survey. All of the participants who formed this subset participated during the course of one day. Table 13 provides details of the sample group subsets.

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[10] USYD is an acronym for the University of Sydney.

Table 13.
Three sample group subsets.

Subset	No.	Total
(1) Graduate students		
Architecture faculty (Argumentation/Discourse)	8	
Architecture (Urban design studio)	22	
Architecture (Conservation of finishes)	19	
Architecture (Theatre performance and lighting)	14	
Architecture (Aesthetic assessment)	3	
Architecture (Contemporary architectural theories)	6	
Architecture (Architectural acoustics practice)	24	96
(2) Graduate students		
Chemical Engineering (Various subjects)	19	
Economics (Accounting principles)	34	
Dentistry (Paediatric dentistry)	9	
Education (Research methods in language learning)	12	
Education (Language in the elementary classroom)	22	96
(3) Members of the general public		96
Total		288

Sample size

A sample size of 96 was initially considered as this represented 96 presentation formats arising from application of the Latin-square technique as discussed above and which allowed each individual treatment/building combination to be tested 24 times. However, large sample sizes are less likely to exhibit sampling bias and are considered 'efficient estimators' of a population (Argyrous, 2001; Coolican, 2004). Therefore, in light of this and due to research quality issues (specifically external validity), the sample size for this study was tripled to 288.

Strategies to minimise sampling bias

A number of strategies were implemented to address the possibility of sampling bias which may occur if the weighting of a sample contains an under-representation or over-representation of one particular category of participant (Coolican, 2004). Firstly, the target sample size for this study was increased to 288. In addition, graduate students were selected from as many different faculties within the University of Sydney as possible to broaden the sample base. There is some debate as to the reliability of university students as participants in research due to the possibility of sampling bias (Coolican, 2004). In addition, Stamps and Miller (1993) have indicated that results obtained from student participants tend to vary from results obtained

from the general population. In an attempt to address this issue, graduate part-time students were selected as it was assumed that these students may represent a broader range of ages, work-experience, country of birth, and so, and may therefore be somewhat more representative of the greater population at large.
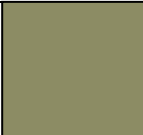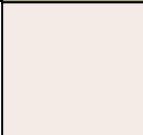
Independent variable: Façade colour

The independent variable, façade colour, was represented by four façade colour treatments.

Four façade colour treatments

Four façade colour treatments were developed based on the findings and outcomes of Preliminary Study #1 and Preliminary Study #2. Preliminary Study #1 found that environmental colour characteristics can be isolated, identified and manipulated using digital technology and Photoshop software. Preliminary Study #2 found basic classifications of façade colour based on the terms harmonious and contrasting. Four of these façade colour classifications were used in the main study: two based on harmonious façade colour and two based on contrasting façade colour. The treatments are detailed in Table 14.

Table 14.
Four façade colour treatments.

Treatment type and description	sRGB value	Sample
1) *Harmonious* façade colour: Dark green (adapted from CC1 – Preliminary Study #2)	140-140-100	
2) *Harmonious* façade colour: Greenish grey (adapted from CC2 – Preliminary Study #2)	165-165-140	
3) *Contrasting* façade colour: Off-white[11] (adapted from OC1 – Preliminary Study #2)	240-235-230	
4) *Contrasting* façade colour: Terracotta pink (adapted from CH1 – Preliminary Study #2)	230-195-180	

[11] Off-white (sRGB 240-235-230) differs marginally from the hue used in Preliminary Study #2 (White sRGB 255-255-255) as the latter white was stark, bright white. The off-white used in the Main Study was marginally reduced in brightness and whiteness to reduce its starkness against the dark background of the natural surroundings.

Two façade colour treatments per the classifications: harmonious and contrasting were used in the visual stimuli. While earlier studies found in the literature have used only one colour per category or classification – for example, see Tannenbaum and Osgood (1952) – two treatments per classification provided an opportunity for assessing replicability of results. In addition, four façade colour treatments were used rather than a greater number of façade colour treatments for two main reasons. Firstly, a greater number of façade colour treatments would have required a much larger sample group due to the application of the Latin-square technique as discussed above. This would have resulted in a much larger and possibly more unwieldy study that would have been beyond the scope of this research. Secondly, a larger number of façade colour treatments evaluated by the same number of participants may have tested their time and patience, possibly impacting negatively on the subsequent evaluations and possibly rendering the results unreliable. The four façade colour treatments are illustrated in Figure 54.

Treatment 1

Treatment 3

Treatment 2
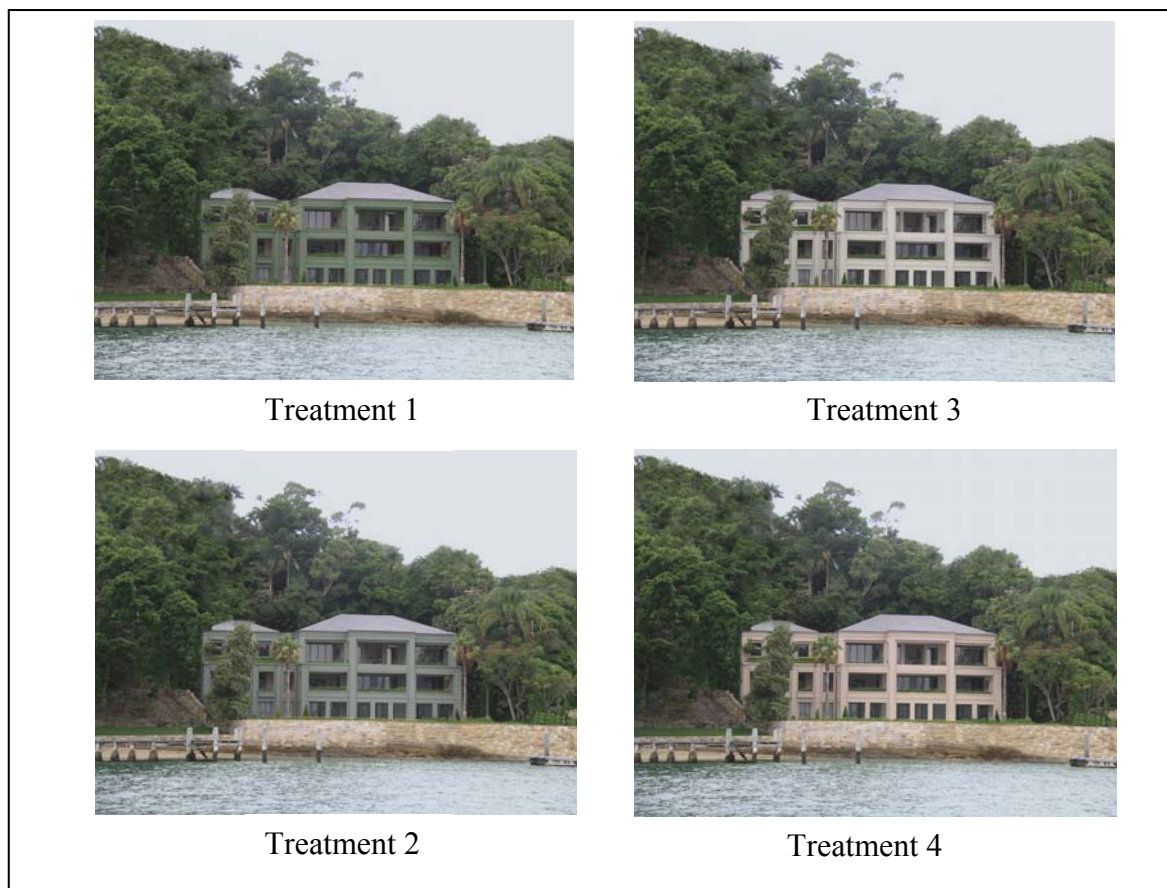
Treatment 4

Figure 55. Four façade colour treatments (as featured on Building 3).

Visual stimuli

A set of 16 full-colour A4-size digital images were used as the visual stimuli in the Main Study. Each of the sixteen images featured one of four façade colour treatments exhibited on one of four buildings. The full set of visual stimuli used in the main study can be found in the Appendix.

Stimulus sampling process

The four façade colour treatments used in the Main Study were exhibited on four buildings. The approach to the sampling of stimulus for this study, adopted from Schroeder (1988) and Wohlwill (1977), involved four field studies that involved travelling around Sydney Harbour by boat and photographing buildings located on the foreshores of the Harbour. Buildings situated on Sydney Harbour vary considerably in a number of ways other than architectural style and size. Some buildings are designed so that their main aspect faces the Harbour, while others are not. Some are heavily obscured by natural vegetation or other buildings, or partially conceal other buildings themselves. A search of free-standing buildings that presented a main aspect to the Harbour and that were not concealed by other buildings or vegetation guided the stimulus sampling process. This process resulted in 87 digital images of buildings that were transferred into Photoshop 7.0 and evaluated for suitability according to the following criteria.

- The building image leant itself to manipulation by Photoshop 7.0 computer software for the purpose of identifying and manipulating façade colour.
- The building was surrounded by natural elements with little or no other visual distractions; or, if artificial elements were present, these could be digitally removed and substituted with natural elements using Photoshop7.0.
- The building was an example of one of the following categories: non-residential public buildings, commercial buildings, single housing, and multiple housing[12].

After evaluating the 87 digital images using the above criteria, the set of images was reduced to 13. Of these 13 images, some images proved difficult in terms of digital manipulation in Photoshop 7.0 owing to highly detailed facades or difficulties experienced in removing or obscuring extraneous background details. The result of this testing procedure was a final set of four images and these represented buildings from two of the

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[12] These categories represent the same categories used by the Royal Australian Institute of Architects (NSW Chapter) in the Annual Architecture Awards (http://www.architecture.com.au accessed 14 March 2005).

categories listed above: non-residential public buildings and single housing buildings. The buildings featured in the visual stimuli appear in Figure 56.

| Building 1 | Building 2 | Building 3 | Building 4 |
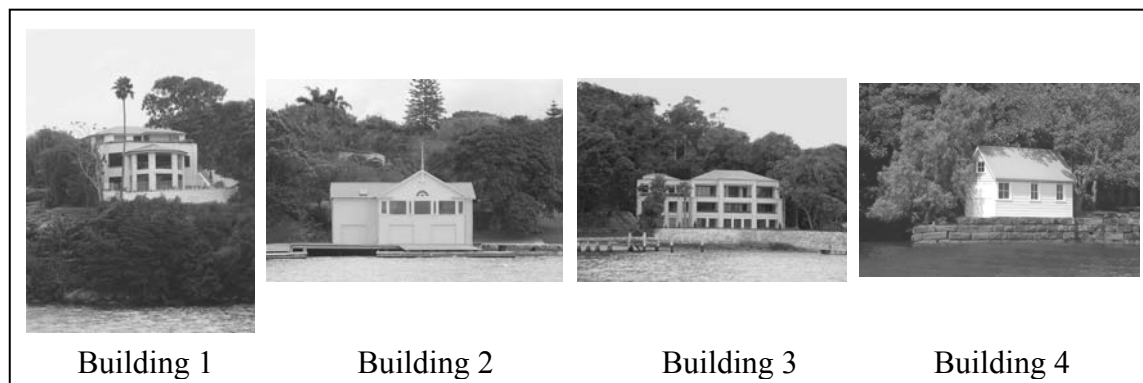
Figure 56. Four buildings featured in the visual stimuli.

Digital camera

The camera used to photograph images for this study was a Pentax Optio 550 digital camera. This camera was selected as it provided a large number of pixels per image as well as five different zoom levels and was within the allocated budget for this study. All photographs were taken as JPEG images at a rate of 2592x1944 pixels per image, the highest rate of pixels per image provided by the Pentax Optio 550, thereby providing as much visual detail as possible within each image.

Proportional content of digital images

Difficulties in visual comparison arising from variations in building size and proportion have occurred in previous environmental colour mapping studies (Foote, 1983; Schroeder, 1988). To overcome these difficulties, photographs of each building were taken at varying distances to ensure that each photograph could be cropped in such a way so as to maintain consistency of proportion of artificial to natural element within each image. The alternative – that is, to photograph each building at a consistent distance – would have led to variations in the proportion of artificial to natural elements with some photographs displaying more artificial elements and others, more natural elements. These variations may have in turn impacted on measurement of aesthetic response to the images. The methodology used to maintain proportional consistency between the building and natural elements within the surroundings were adopted from Foote (1983) and Schroeder (1988).

Measuring aesthetic response

Ten dependent variables represented components of aesthetic response as well as judgements about a building's size and congruity relative to the surroundings. The measurement instrument used to investigate patterns of response in respect to these dependent variables comprised semantic differential rating scale items linked to these variables.

Emotional reactions, cognitive judgements and connotative meanings, especially in response to the environment, may be non-linguistic and therefore difficult to quantify (Osgood, Suci & Tannenbaum, 1957). However, semantic differential rating scales have been used widely and found to be an effective tool for measuring and describing meaning in relation to environments (see Osgood et al, 1957; Russell, 1988; Russell, Ward & Pratt, 1981), and in relation to colour (Janssens, 2001; Kuller, 1972; Taft, 1997; Taft & Sivik, 1996; Tannenbaum & Osgood, 1952; Urland, 1996). In addition, semantic differential rating scales have been found to be an effective measurement tool for people of across various age groups and cultures (Heise, 1970). Finally, Stamps (2000) conducted a review of studies that used various methods of measurement including sematic differential rating scales, rankings and Q sorts, and found that the findings correlated at $r = 0.99$, implying strong reliability.

Alternative methodologies were considered, including multidimensional scaling – a methodology that involves constructing a matrix of dissimilarities usually using two dimensions. However, Ward and Russell (1981) assessed seven methods for measuring responses to the environment, including semantic differential and multidimensional scaling, and found that, despite differences in methodology, all seven methods shared some level of variance but were all found to be relevant and relatively reliable.

Semantic differential rating scales

There is no standard semantic differential rating scale or set of rating scale items; instead it is usual for researchers to use rating scale items that are considered relevant, meaningful or familiar to the construct or stimulus about which judgements are to be made (Heise, 1970; Ward & Russell, 1981). The measurement instrument used in this study incorporated ten bipolar semantic differential rating scale items adapted from earlier studies.

An initial set of 35 semantic differential rating scale items relating to *aesthetic response*, as well as judgements about a building's size and congruity was sourced from the literature. Specifically, individual rating scale items were adopted from similar studies by Janssens (2001), Osgood *et al* (1957), Ou *et al* (2004a); Russell *et al* (1981), Russell (1988), Taft (1997), Urland (1997), Wohlwill (1977), and Wohlwill and Harris (1980). These were ranked in terms of relevance to the stimulus set and, after duplications were removed, the set was reduced to twenty rating scale items. This set of rating scale items was tested in the first pilot study conducted in May 2005 (see below). As a result of this pilot study, the set of semantic differential rating scale items was reduced to ten as follows.

1) Pleasant-unpleasant
2) Beautiful-ugly
3) Exciting-gloomy
4) Stimulating-dull
5) Harmonious-disharmonious
6) Sympathetic-unsympathetic
7) Fits with surroundings-contrasts with surroundings
8) Large-small
9) Dominating-insignificant
10) Like-dislike

In considering the number of semantic differential rating scale items to include in a measurement instrument, Heise (1970) suggests that more than one rating scale item per dimension is necessary and four rating scale items per dimension is desirable. However, Heise (1970) also suggests that the maximum number of judgements or evaluations in a measurement instrument should be around fifty, and any more than this may impact negatively on participants' patience and the overall reliability of the study. Given that this study was assessing responses to four treatments, the number of rating scale items was limited to ten for each treatment bringing the total number of scales per participant to forty.

Format of semantic differential rating scales

There are basically two formats of semantic differential rating scale as per Figure 57. The first is bi-polar with opposing rating scale items placed on either end of a continuum; and the second, referred to as the semantic distance scale, is unidirectional (Alreck & Settle, 1995). The format used in the measurement instrument of this study followed similar studies in the EBS area and used the bi-polar format (for example, Janssens, 2001, and Urland, 1997).

pleasant ☐ ☐ ☐ ☐ ☐ ☐ ☐ unpleasant

- -

PLEASANT

slightly ☐ ☐ ☐ ☐ ☐ ☐ ☐ very

Figure 57. Bi-polar format (top) & unidirectional rating scales.

Number of anchor points on rating scales

Semantic differential rating scales often measure subjective responses and therefore the resulting data is classified as continuous (Alreck & Settle, 1995; Argyrous, 2001). However, anchor points or labels can be placed along or above each rating scale item and, in doing so, the data is manipulated to create interval data from data that is actually continuous (Alreck & Settle, 1995). There is some debate as to the ideal or suitable number of anchor points along a rating scale. Jacoby & Mattel (1971) suggest that three points are sufficient; while others such as Friedman and Friedman (1986) suggest that an 11 anchor point scale may produce more reliable results than 3, 5 or 7 anchor point scales. Seven is considered to provide "good reliability values and correlates well with other attitude scales thus producing high concurrent validity" (Coolican, 2004, p176). In view of the above, seven anchor points were used in the semantic differential rating scale items that featured in the measurement instrument of this study.

Labelling of anchor points on rating scales

Bartram and Yielding (1973) suggest that there is a tendency for participants to use positive descriptors more frequently than negative descriptors. While numeric values as labels coupled with subjective rating scale adjectives have been found to influence the way participants complete a semantic differential rating scale (Schwarz, Knauper, Hipler, Noelle-Neumann & Clark, 1991). In addition, labelling of anchor points may not lead to a scale that is perceived to contain equally balanced positions between each point. For example, the distance between 'very' and 'fairly' may be a perceptually larger distance between the next anchor points of 'fairly' and 'slightly' (Friedman & Amoo, 1999). The anchor points were labelled in the semantic differential rating scale used in this study primarily to reduce confusion among participants and avoid the possibility that participants may misinterpret the meaning behind each response level.

Pilot studies #1 and #2

The first pilot study was conducted in May 2005 in Sydney. The aims of this pilot study were to evaluate the questionnaire, visual stimuli and the duration of evaluations. Two participant sub-groups were involved in this pilot study. The first was a group of nine members of the general public. The second group was a peer review conducted during an Environment-Behaviour Studies research group seminar. The EBS group that participated in Pilot Study #1 comprised nine graduate students and academic staff from the Faculty of Architecture, University of Sydney.

All participants in Pilot Study #1 were asked to complete a questionnaire while examining a set of visual stimuli that featured four façade colour treatments depicted on the same building image. Participants were also asked for feedback about the questionnaire in terms of the semantic differential rating scale items, layout and format (both the questionnaire and set of visual stimuli used in this Pilot Study are included in the Appendix). Specifically,

1) Assessment of the semantic differential rating scale items in terms of quantity, content, validity and reliability.

2) Assessment of the personal characteristics questions.

3) Evaluation of the format and layout of the questionnaire and whether it was easy to understand and use.

4) Feedback with respect to the visual stimuli in terms of size, photographic quality and content.

5) Assessment of the viability of testing four façade colour treatments using visual stimuli featuring the same building.

6) An evaluation of the survey session in terms of timing.

7) Any other feedback or comments that participants considered relevant.

While non-peer review participants did not express any problems or issues regarding the measurement instrument, a number of recommendations arose from the peer review of the questionnaire. Firstly, participants considered that nineteen rating scale items were too many and it was suggested that participants may lose interest or become impatient to complete the survey session. The peer review session indicated that the rating scale items appear to be appropriate in terms of content and validity. However, some rating scale items were considered too technical or difficult to understand (for example, *congruous, discreet* and *conspicuous*). In addition, it was considered that some of the rating scale

items were duplications and could be deleted in the interests of shortening the questionnaire – for example, *prefer-don't prefer* and *like-dislike*). The measurement instrument was refined in response to the peer review.

In terms of general format, layout, anchor points, and so on, these were found to be acceptable. However, some members of the non-peer review participant group expressed unease with the lack of anchor point labels. On the basis of this feedback, anchor labels were included in the final format of the measurement instrument.

The size and quality of the photographs used as visual stimuli were considered by the majority of participants as appropriate. However, the building featured in the visual stimuli of this pilot study contained architectural features that were considered distracting and therefore inappropriate. This feedback prompted a review of the building images for the main study to ensure that the buildings featured in the visual stimuli were free of distracting features and architectural details.

In this pilot study, the four visual stimuli featured the same building with four different façade colour treatments. From observation of participants during this pilot study, it became clear that presenting the four façade colour treatments in this manner created a source of internal invalidity due to order-interaction effects – some participants began verbally making comparisons between the different façade colour treatments as featured in the visual stimuli and basing their responses on these comparisons. In addition, the validity of the test was compromised as participants soon guessed the purpose of the study. In view of this, the Latin-square technique was investigated and subsequently applied as a means of presenting the four treatments in a counter-balanced manner to avoid order-interaction effects.

In relation to the timing and duration of evaluations, these took fifteen to twenty minutes per participant and some participants expressed the opinion that the timing should be shortened to prevent boredom and declining interest impinging negatively on responses.

To conclude, a number of changes were made to the measurement instrument and visual stimuli as a result of this pilot study. In addition, the Latin-square technique was investigated and subsequently applied to minimise possible order-interaction effects and maintain randomisation in the main study.

Pilot study #2

The second pilot study was conducted in September 2005. The main aims of this pilot study were to test the amended measurement instrument for face validity; the timing of the session; and to ascertain whether there were any unforeseen issues or problems arising from the procedure. Participants comprised 13 graduate students from the Faculty of Architecture, USYD, none of whom were familiar with aims of the research study.

In this pilot study, participants were given a set of visual stimuli (four full-colour, A4 images) and a questionnaire. The procedure involved asking participants to assess the visual stimuli and complete the questionnaire. Prior to commencing the survey session, participants were verbally reminded of the instructions written on the front page of the questionnaire. On completion of the questionnaire, participants were asked for feedback and comment about the study and procedure. A version of the questionnaire that had been refined according to feedback from the first pilot study was used in the second pilot study. The visual stimuli depicted four different façade colour treatments featured on the images of four different buildings. The visual stimuli were presented to participants using the Latin-square technique described above.

The main outcomes from Pilot Study #2 were an estimate of timing and confirmation that participants appeared to be unaware of the underlying reason and purpose of the study. Participants did not report any problems or issues relating to the questionnaire, the visual stimuli or procedure, apart from reporting a small typographical error – the placement of two anchor point labels: the words 'very' and 'fairly' were incorrectly located. This typographical error was corrected in the final questionnaire used in the main study.

Data collection

This section provides details of the data collection procedure and data input sessions of the Main study. In addition, the action taken to address missing data is discussed along with data transformation and data storage procedures.

Data collection procedure

Thirteen data collection sessions were conducted over a period of six weeks as per Table 15. Twelve of the data collection sessions were conducted in class at the start of each day-time lecture or in a meeting room at various Faculties within the University of

Sydney (USYD). Each session was conducted by the researcher and the scheduling and timing of these sessions were dictated by the consenting lecturers. In the session involving members of the general public, the researcher supervised the data collection session and participation was garnered with the help of assistants.

Table 15.
Schedule of data collection sessions.

Date	Location	No. of participants
13-Sep-05	Chemical Engineering Faculty, USYD[13]	19
14-Sep-05	School of Accounting, USYD	34
15-Sep-05	Conference/church hall, Bondi Junction	96
22-Sep-05	School of Paediatric Dentistry, USYD	9
22-Sep-05	Faculty of Architecture, USYD	8
4-Oct-05	Faculty of Education, USYD	12
8-Oct-05	Faculty of Education, USYD	22
11-Oct-05	Faculty of Architecture, USYD	22
17-Oct-05	Faculty of Architecture, USYD	19
21-Oct-05	Faculty of Architecture, USYD	14
21-Oct-05	Faculty of Architecture, USYD	3
24-Oct-05	Faculty of Architecture, USYD	6
24-Oct-05	Faculty of Architecture, USYD	24
Total:		288

Each data collection session was conducted during daylight hours in lecture rooms and a conference rooms that had both natural and artificial lighting. All participants completed the questionnaire sitting at desks or desk-like tables in office style chairs. Each session took between 15 to 20 minutes. No issues or problems about the study itself or the duration of the study were reported during the course of data collection. No participants refused to participate in the study or left the data collection session without completing the study.

The same procedure was followed for each data collection session as detailed below.

1. Participants were asked to participate and, upon agreement, each participant was given the next available participant pack containing the Participant Information sheet, Consent form, questionnaire and set of visual stimuli.

2. Participants were asked to read the Information sheet and sign the Consent form.

3. Participants were verbally instructed to view each image from the set of visual stimuli one-at-a-time in the order provided, and complete the questionnaire accordingly.

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[13] An acronym for the University of Sydney

In addition, participants were advised that there were no right or wrong answers and asked not to discuss the survey with others during or after the survey session.

4. Participants self-administered the questionnaire.

5. Questionnaires, sets of visual stimuli, Participant, Information Sheets and Consent Forms were collected at the end of each session.

Missing data

Missing data is problematical for Latin-square research designs as it can impact negatively on subsequent data analysis and the insertion of an averaged score is recommended in the case of small occurrences of missing data (Tabachnick & Fidell, 2001).

During data collection, there were minimal occurrences of missing data due to the manner in which the data collection sessions were conducted. After each data collection session, questionnaires were checked for missing data and questionnaires found to contain missing data were identified and set aside. A replica set of questionnaires and visual stimuli was then included in the next data collection session and this set served as a replacement set for the set containing missing data. In this way, missing data on questionnaires was minimised and substitute sets were only required twice during the data collection sessions.

Of the final 288 questionnaires, three occurrences of missing data were found in #100, #256 and #263. In questionnaire #100, the participant failed to enter his/her personal details and these details were left blank during data input. In questionnaires #256 and #263 scores were omitted for the scale: unsympathetic-sympathetic (3rd evaluation; B41) and dominating-insignificant (2nd evaluation; B52), respectively. A rating at the mid point was entered for these scales during data input.

Data input and data checking

As the statistical software SPSS 12.0 was to be used for data analysis, an SPSS 12.0 file was created for data input and analysis for this study. The data recorded on the questionnaires was input manually by the researcher into the SPSS data file in numbered batches over a period of four weeks. After the data input was completed, a check of the data input was conducted to scrutinise for accuracy of data input. This check was conducted by the researcher with an assistant and involved checking the source documents – that is, participant's questionnaires – response variable by response variable against 10%

of inputted data. Errors that were found in data input were corrected at this stage. A second check of data occurred when the means and frequencies of each variable were computed and subsequently checked to ascertain the total numbers per variable category as a variance in total numbers provides an indication of errors in data input. No variations in total numbers were found at this stage of data checking.

Data transformation

Only one data transformation procedure was conducted in relation to the data of the main study. This transformation involved reversing the order of four of the semantic differential rating scale items (dependent variables) after data input. These semantic differential rating items were included on the measurement instrument in reverse order to minimise the possibility of response bias and it was necessary to reverse their order prior to data analysis. This data transformation task was performed using the transform tool of SPSS 12.0 (Menu: Transform/Recode/Into same variables).

Data storage

The completed questionnaires were kept in strict order from participant #1 through to participant #288. Clearly marked boxes containing the questionnaires and related visual stimuli were kept in a locked room for the duration of the study.

Assumptions relating to the data and data analysis

This section discusses the assumptions applied to the data and data analysis as well as the construct *aesthetic response*. In addition, transformations made to the data prior to data analysis are also discussed.

Continuous data and interval data

The measurement instrument in the main study featured semantic differential rating scale items. Each of these rating scale items comprised two opposing notions, such as Beautiful-Ugly, arranged at either end of a continuum. The continuum incorporated seven category value labels at equidistant intervals and these included labels such as 'Extremely', 'Very' and 'Fairly.' However, human responses to notions such as Beautiful and Ugly are subjective and involve affective appraisals and cognitive judgements that may vary imperceptibly. As a result, responses may not necessarily fall into the categories imposed on the continuum as suggested by the measurement instrument. While the underlying data

145

arising from the measurement instrument is therefore actually continuous, the imposition of intervals (via the value labels) creates interval data. A key assumption about the data arising from the main study is that it is interval data even though the underlying variable is actually continuous. It is considered acceptable to treat continuous data as though it has discrete intervals (interval data) or rankings (ordinal data) to enable measurement and subsequent statistical analysis (Alreck & Settle, 1995; Argyrous, 2001; Tabachnick & Fidell, 1996). As such, the data arising from the main study is continuous data treated as interval data.

Quasi-interval data and parametric data analysis

The measurement instrument used in this study had not been adjusted or standardised prior to being used, so it was not known whether the resulting scores matched normal distribution with standard deviation.[14] In addition, as discusses above, the data arising from the main study was continuous data treated as interval data. Coolican (2004) suggests that in the case of an invented scale that has not been previously tested for reliability or standardised to approximate normal distribution, it is statistically safer to treat the data as ordinal scale data rather than interval scale data, and apply non-parametric data analysis methods. However, it has been suggested that some types of data, such as the data arising from this study, can be considered 'plastic' interval or quasi-interval data and can be analysed using parametric analysis techniques (Coolican, 2004, p252; Tabachnick & Fidell, 1996). Therefore, a second key assumption about the data arising from the main study is that it is quasi-interval data to which parametric data analysis methods can be applied. To further support applying this assumption, the literature relating to Environment-Behaviour Studies suggests that a pattern appears to have emerged whereby ordinal data arising from similar studies that use Likert-type scales or semantic differential scale items have been treated as quasi-interval data and parametric statistical analysis methods have been applied (Heft & Nasar, 2000; Herzog, 1992; Nasar *et al*, 1992; Stamps and Nasar, 1997; Stamps, 1999a).

A key assumption of parametric data analysis methods is that responses to variables are normally distributed. That is, the results of data analysis from the data arising from the sample group can be generalised to apply to, or make inferences about, the population from

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[14] Standard deviation is a measure of deviation from the mean of a data set. When the distribution of a data set closely resembles the standard normal curve, 68.3% of the data will be within +/- 1 standard deviation, 95.46% within +/- 2 standard deviations and 99.73% within +/- 3 standard deviations from the mean (Coolican, 2004).

which the sample was drawn. The data arising from this study is actually continuous data assumed to be ordinal data and then treated as quasi-interval data. Theoretically, it would be appropriate to use non-parametric data analysis methods. However, as discussed above, by treating the data as quasi-interval data, it is considered acceptable to apply parametric data analysis methods (Coolican, 2004, p252; Tabachnick & Fidell, 1996; Wright, 1976).

Normality

The statistical techniques used to analyse the data arising for the main study assume that the distribution of scores on an independent variable are 'normal' and reflect a symmetrical bell-shaped curve. The data was checked for normality during the course of initial data screening and the Kolmogorov-Smirnov (K-S) test was used to check for normality of distribution, wherein Pallant (2005) advises "a non-significant result (Sig. value of more than .05) indicates normality" (Pallant, 2005, p57). The resultant K-S statistic was below the benchmark for normality of .05 in each case and, again, Pallant (2005) suggests that this may be common in large samples.[15] The histograms and normal probability plots (referred to as Normal Q-Q Plots in SPSS output) in each case display normal distributions as described by Pallant (2005) and Tabachnick and Fidell (2001). These results may reflect the highly subjective nature of the variables linked to the research questions of this study. Furthermore, as discussed elsewhere in this thesis, responses to colour may be idiographic, less predictable and therefore more stochastic.

Level of significance

The level of significance used for data analysis in this study was set at a=0.05. In attempting to draw conclusions or inferences from data analysis results gleaned from a sample, the level of significance represents probability that the characteristics of the sample resembles the characteristics of the population from which the sample was drawn (Argyrous, 2001; Coolican, 2004; Hinton, 2004). As such, the level of significance provides a benchmark or cut-off point for rejecting the null hypothesis. In the bench sciences, the level of significance is often set at a=0.01 or higher as the probability of making an error, in terms of generalizing results from the sample to the population, may have drastic repercussions.

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[15] It was suggested by a reviewer of this thesis that it may be inappropriate to use the Kolmogorov-Smirnov test when looking for non-significant results as in the Null Hypothesis tests of this research. In this case, due to the subjective nature of the research questions, it was highly unlikely that the sample population would reflect normal distribution and the statistical results and findings have been discussed in view of this.

In social research, the convention is to set the alpha level of significance at a=0.05 (Argyrous, 2001; Coolican, 2004). However, it is important to note that while the parametric analysis methods used in the main study suggest that the findings relating to the sample group may also hold for the population, it is unwise to assume that this is true and further studies are required to ascertain the degree to which the findings may or may not be true for the population at large at any level of significance.

Data analysis methods

A number of data analysis methods are common within the EBS field including correlation analysis, analysis of variance (ANOVA), analysis of covariance (ANCOVA), multivariate analysis of variance (MANCOVA), canonical correlation, discriminant function analysis and structural equation modelling.[16]

In selecting data analysis methods for the main study, some methods were discarded because they did not allow for the examination of patterns of response between one independent variable (façade colour) and a set of dependent variables. For example, canonical correlation is used when analysing the relationship between two sets of variables; discriminant function analysis is used to explore the predictive capacity of a set of independent variables; and structural equation modelling allows for the testing of various models in relation to the inter-relationships among a set of variables (Pallant, 2005).

In specific reference to the methods available, Wilkinson and the Task Force on Statistical Inference convened by the *American Psychologist Journal* (1999) acknowledge the plethora of statistical data analysis methods currently available and suggest applying Ockham's razor to

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[16] An anonymous reviewer suggested that the research questions could have been investigated using a Bayesian approach. The Bayesian theorem suggests that posterior circumstances or probabilities are influenced by prior circumstances or probabilities. The starting point is therefore a set of prior probabilities followed by data collection (arising from observations or an experiment) and both of these are used to ascertain a set of posterior probabilities (Salsburg, 2001). The Bayesian theorem is diagrammed as follows:

prior probability →data →posterior probability (Salsburg, 2001)

The Bayesian approach was not considered appropriate for the main study as the focus of this research was to examine patterns of response irrespective of participants' prior views or responses to façade colour. In addition, preliminary study #2 found that it was important to obscure the main aim of the research from participants, to ensure that the results were not confounded by other factors (this is discussed in greater detail in the section below: Face validity of the measurement instrument as well as in the section: Preliminary study #2).

choose 'minimally sufficient analysis' methods (Wilkinson *et al*, 1999, p601). This suggestion echoes Fisher's (1935) advice that sophisticated, complex statistical tests may not necessarily serve the purpose any better than simple, proven tests.

In assessing suitable data analysis methods, the author considered Wilkinson *et al* (1999) and Fisher's (1935) advice and selected methods that were not only familiar and reliable, but would provide sufficient statistical evidence in relation to the research aims and questions. Specific guidance in terms of data analysis methods was provided by Alreck and Settle (1995), Coolican (2004) and Pallant (2005).

Descriptive statistical analysis was used to summarise the data in terms of means and frequencies. Factor analysis was used to investigate the ten dependent variables used in the measurement instrument and the strength of their linkage to the construct: as *aesthetic response*. Correlation analysis, analysis of variance (ANOVA) and analysis of covariance (ANCOVA) were used to examine patterns of response in terms of the four treatments representing the independent variable and ten dependent variables. These methods and their application in relation to the main research questions and hypotheses are discussed in greater detail in the chapter: Results of the Main Study.

Research quality assurance

The key indicators of research quality assurance are considered to be objectivity, internal and external validity, and reliability (Groat & Wang, 2002). One of the main aims of such key indicators of research quality is to ensure that a study can be replicated in different settings and at different times (using the same measurement instruments, visual stimuli and data collection procedures) and achieve the same or similar results (Groat & Wang, 2002; Guba & Lincoln, 1994). In addition to the research quality assurance indicators discussed below, the research protocols relevant to the Main Study of this research project were granted permission by the Human Research Ethics Committee, the University of Sydney (HREC approval number 7289).

Objectivity

Objectivity is a key goal of the research process to ensure that researcher bias or interference is kept to a minimum as results and findings can be confounded or misconstrued by a lack of

objectivity (Groat & Wang, 2002). While it is not possible to completely extinguish researcher bias, the use of standardised measurement instrument and highly regulated experimental methods are considered to assist in maintaining an acceptable degree of objectivity (Groat & Wang, 2002). A standardised measurement instrument that suited the research questions of this study did not exist. However, an instrument was developed from similar studies found in the literature. The resulting measurement instrument was reviewed and tested by members of the Environment-Behaviour Research Group at the Faculty of Architecture, Design and Planning, The University of Sydney.

In addition, the data collection process was sequenced and regulated to ensure that data collection sessions were standardised. Care was taken to ensure that the all aspects of the experimental procedure and especially the discussion of results and findings were objective maintained objectivity and free of unsubstantiated claims and assertions. Finally, commonly used and accepted data analysis techniques such as factor analysis and analysis of variance were applied to the data.

Internal validity

Research designs are open to a number of factors that may impact negatively on internal and external validity. Internal validity has to do with the 'extent to which (the) effect/s found in a study can be taken to be real and caused by manipulation of the identified independent variable' (Coolican, 2004, p114). External validity relates to whether the findings and results of a study can be generalised to other locations or places, populations or people and times (Coolican, 2004).

Specifically in relation to internal validity, factors inherent in a study such as history, maturation, testing, instrumentation, regression, selection, mortality, as well as the interaction of these factors, may impact negatively on internal validity (Campbell & Stanley, 1966; Coolican, 2004). The Latin-square technique is considered a satisfactory technique for controlling the following sources of internal invalidity: history, maturation, testing, instrumentation, regression, selection, and mortality (Campbell & Stanley, 1966; Coolican, 2004). Random assignment and constant rotation is built into the Latin-square technique thereby reducing the possibility of confounding sequence and interaction effects (Campbell & Stanley, 1966). To avoid the possibility of systematic selection producing confounding effects in the study, participants were not grouped prior to the study but were

randomly assigned to each group via controlled assignment of experimental treatment sets. Confounding effects arising from interactions of groups and occasions are considered unlikely, especially in larger Latin-square experiments (Campbell & Stanley, 1966).

Face validity of the measurement instrument

A measurement instrument has face validity if it is clear what is being measured; however, while face validity should be self-evident, the underlying reason for the research should not be evident otherwise the results may be confounded (Coolican, 2004). One of the aims of the Pilot Study #2 was to test the face validity of the measurement instrument used in the main study. Observation, feedback and comments from Pilot Study #2 indicated that participants completed the study without problems or issues relating to the measurement instrument, visual stimuli or procedure. In terms of face validity, participants' comments indicated that they appeared to be unaware of the underlying purpose of the study or the reason for the research. Finally, a dummy question was included (Q18: Which building do you prefer and why) to divert participants' attention away from the main reason for the research.

Content validity of the measurement instrument

Content validity of a measurement instrument has to do with whether the instrument measures what it is intended to measure and Coolican (2004) suggests that research peers and colleagues may use their expertise to evaluate a measurement instrument in this regard. One of the aims of Pilot Study #1 was to investigate the content validity of the measurement instrument used in the main study. Participants in this pilot study included members of the EBS Research Group, the Faculty of Architecture, Design and Planning at the University of Sydney. This participant group, while not a selected using the Delphi technique, met Coolican's (2004) suggestion of employing research colleagues to assess the content validity of a measurement instrument. Participants were asked to assess the individual rating scale items and the measurement instrument as a whole. The main outcomes from this pilot study were that the measurement instrument as a whole was suitable provided a number of relatively minor changes were made to individual rating scale items to improve their content validity. These changes were subsequently applied to the measurement instrument for the main study.

Construct validity

Construct validity has to do with whether the constructs represented by the variables contained within the measurement instrument have theoretical validity (Coolican, 2004). The key constructs and the related variables intended to represent these constructs as incorporated in the measurement instrument have been adapted from studies found in the literature. A full discussion of the constructs and related variables can be found in the section: Research Methodology.

As discussed in the section: Results of the Main Study, the validity of linking the ten variables incorporated in the measurement instrument to the construct *aesthetic response* was also investigated statistically using factor analysis. The results of factor analysis indicated a weak statistical basis for linking all ten variables to the construct *aesthetic response*. However, the results indicated that it is statistically appropriate to link eight of the variables to aesthetic response and that these eight variables shared a strong correlation. These eight variables are: beautiful-ugly, pleasant-unpleasant, stimulating-boring, exciting-dull, like-dislike, harmonious-inharmonious, fits/contrasts with surroundings and sympathetic-unsympathetic.

External validity

In terms of external validity, Campbell and Stanley (1966) suggest that the factors that may impinge on external validity include the possibility of interaction effects between testing and treatments, interaction of selection and treatments, and reactive arrangements. However, other theorists suggest that external validity relates to whether the findings and results of a study can be generalised to other locations or places, populations or people and times (Coolican, 2004; Groat & Wang, 2002). To address the possibility of external invalidity under Campbell and Stanley's (1966) definition, participants in the study were not informed or made aware of the main aims of the study. By obscuring the aims of the study from participants, it was hoped that external invalidity arising from the interaction of testing and treatments could be minimised. In terms of external invalidity arising from the interaction of selection and treatments focuses on the problem of generalising findings from the sample with respect to the population in general given that the sample may not be representative of the population. While complete control in this regard is not possible, increasing the sample size may be one method of addressing this issue (Campbell & Stanley, 1966).

In terms of the main study of this research, an initial sample size of 96 was increased to 288. In addition, while the statistical methods used in this study imply that findings relating to the sample group also hold for the population, it is unwise to assume that this is true and further studies are required to ascertain the degree to which the findings may or may not be true for the population at large. With regard to additional reactive effects, Campbell and Stanley (1966) suggest that the main sources of this type of external invalidity arise from the artificiality of the experimental setting and the participant's knowledge that they are participating in an experiment: the 'Hawthorne effect'. To partially address this possible source of external invalidity, participants in two subsets were tested in surroundings that were familiar. That is, their regular university lecture classrooms. One subset was tested in a situation that could be deemed an artificial experimental setting however, the setting was possibly familiar to many as it was a local church hall. In addition, participants were not informed of the research aims and were advised that there were no right or wrong answers to the questions contained in the questionnaire.

Ecological validity

Levels of ecological validity – that is, the extent to which the findings can be generalized to other settings or places – often have to do with whether findings gleaned from one study can be transferred to other natural or field settings, or vice versa (Coolican, 2004). Coolican suggests that while natural settings may well be richer in terms of realism, their findings may not necessarily be transferable to other settings due to the vast differences in variables across such settings. However, Coolican (2004) suggests that the nature of a study itself has some bearing on levels of ecological validity and that such levels may not be adversely impacted purely due to differences in experimental setting. The main study of this research was conducted within the context of planning policy in Sydney and used a relatively large sample group. A series of subsequent experiments in a range of settings may indicate whether the results of the main study of this research has high ecological validity; but until then, it is recommended that caution is exercised in generalizing the findings from this study.

In regard to generalising the findings from the main study to other locations or places, populations or times, the limitations inherent in the experimental research design and methods employed in the main study are acknowledged. The study involved only four

façade colour treatments in a specific location – on the foreshores of Sydney Harbour – and these can be viewed as major limitations as discussed above. However, it has been suggested that façade colour conveys different meanings in various situations (Foote, 1983; Foster, 1976). Therefore, studies that focus on façade colour may need to be particular to specific locations to minimise invalidity in this respect. For example, in terms of generalising the findings students comprised two of the three sample group subsets, and, as discussed above, there is some debate as to the reliability of university students as participants in research due to the possibility of sampling bias (Coolican, 2004). To partially address this issue, post-graduate part-time students were selected as it was assumed that these students would represent a broader range of ages, work-experience, country of birth, and so, and may therefore be somewhat more representative of the greater population at large.

Reliability

Reliability in research relates to the extent to which findings may be repeated or replicated over a number of occasions resulting in similar and consistent findings (Coolican, 2004; Groat & Wang, 2002). Coolican (2004) suggests that there are two types of reliability: external reliability (referring to the stability of the experimental procedures across time) and internal reliability (the internal consistency of the test or measurement instrument).

External reliability

In terms of external reliability, the measurement instrument and visual stimuli were used in 13 data collection sessions over a period of six weeks with consistent results as detailed in the section: Results of the Main Study. While these consistent results indicate external reliability in a very limited sense, subsequent application of the measurement instrument, visual stimuli and experimental procedure in additional future test sessions would provide further indication of the external reliability of these methods. It is therefore not possible to comment fully on long-term reliability except to say that the procedures used in this experimental study have been documented in detail so that any researcher can follow and replicate the study at any time in the future.

Internal reliability

Internal reliability has to do with whether a measurement instrument is consistent within itself and, while it may not be possible to ensure that participants always respond

consistently, the aim is to provide an instrument that allows them to respond to related variables in similar ways. High internal consistency of a measurement instrument is characterised by a high consistency in terms of a participant's responses and that they tend to respond to similar questions in similar ways (Coolican, 2004; Hinton, 2004; Pallant, 2005). In terms of the measurement instrument, three steps were taken to address the issue of internal reliability.   Firstly, the location of positive and negative rating scale items were divided and swapped on the measurement instrument to ensure a regulated, mixed presentation of rating scale items using the split-half method (Coolican, 2004).

Secondly, the measurement instrument was reviewed and assessed by members of the EBS Research Group, the Faculty of Architecture, Design and Planning, the University of Sydney in Pilot Study #1.   This review was conducted to ensure that the rating scale items were considered internally consistent by a group familiar with research methodologies and the overall aim of the research.

In a third measure for internal reliability, Cronbach's alpha test was applied and this is considered an appropriate method for assessing the reliability of a measurement instrument statistically (Coolican, 2004; Hinton, 2004; Pallant, 2005).

Internal reliability test – Cronbach's alpha

Cronbach's alpha statistic, a commonly used test for internal reliability, measures the variance of participant's scores on each rating scale item relative to overall variance of related rating scale items (Coolican, 2004; Pallant, 2005).   As the rating scale items used in this study differed in terms of content, they were grouped according to content and then Cronbach's alpha test was applied. Cronbach's alpha test was applied to the scores of this study via SPSS 12.0 (Analyze/Scale/Reliability analysis) and the results are detailed in Table 16. It is suggested that an alpha (α) score of 0.7 or greater indicates good reliability (Coolican, 2004; Hinton, 2004; Pallant, 2005). As detailed in Table 16, the resulting Cronbach coefficient for all of the grouped rating scale items is .738 or above, indicting that the rating scale items have good reliability for this sample, with one exception. This exception occurred when Cronbach's test was applied to all ten of the rating scale items.

Table 16.
Cronbach's alpha coefficients for rating scale items

Construct component	Rating scale items	No. items	Cronbach alpha coefficient α
Affective appraisal/ Evaluative component	Beautiful-ugly Pleasant-unpleasant	2	.788
Affective appraisal/ Arousal component	Stimulating-boring Exciting-dull	2	.810
Affective appraisal/ Potency component	Large-small Dominating-insignificant	2	.738
Cognitive judgement/ Size	Large-small Dominating-insignificant	2	.738
Cognitive judgement/ Congruity	Harmonious-inharmonious Fits/contrast w/ surroundings Sympathetic-unsympathetic	3	.822
Preference	Like-dislike Pleasant-unpleasant	2	.871
Overall aesthetic response	All rating scale items	10	-.257
Overall aesthetic response/ Less size-related items	Beautiful-ugly Pleasant-unpleasant Harmonious-inharmonious Sympathetic-unsympathetic Fits/contrasts w/ surroundings Stimulating-boring Exciting-dull Like-dislike	8	.918

It has been suggested that certain items within a scale may act to skew the results from Cronbach's alpha test and lower the resulting overall Cronbach alpha coefficient (Coolican, 2004; Pallant, 2005). In this study, when Cronbach's alpha test was applied to all ten rating scale items grouped together the result was -.257, suggesting poor internal reliability. However, when the two rating scale items relating to size were excluded, the Cronbach alpha coefficient increased to .918, as detailed in the above Table. It appeared that the scores resulting from the rating scale items relating to size skewed the Cronbach coefficient in relation to all ten variables together. This may be due to a level of content incompatibility between eight of the variables and the two variables relating to size.

For the purpose of this study, the measurement instrument was considered to have two sections: Section A comprising the eight variables relating to aesthetic response; and section B including the two variables relating to judgements about size. When the Cronbach alpha coefficients for the variables are grouped into sections A and B, the internal reliability of these two sections are .918 and .738 respectively. An alternative course of action may be to divide the measurement instrument into two distinct instruments with one comprising eight variables relating to aesthetic response and a second instrument relating to judgements about size. In which case, the second instrument may need to include more than two variables to provide an appropriate instrument for testing .with Cronbach's alpha test. This course of action, which had not been undertaken at the time of submitting this thesis, may be carried out during the course of future research.

External reliability – Test-retest

External consistency relates to the notion that, ideally, the scores for a given measurement instrument remain reasonably consistent across different measurement occasions among the same participants (Coolican, 2004).   In general, semantic differential rating scales have been used in a variety of formats and are considered sound in terms of external reliability (Osgood *et al*, 1957; Russell, 1988; Russell, Ward & Pratt, 1981).   Test-retest with the same sample group is a method for checking external reliability (Coolican, 2004). However, it was not possible to conduct the test-retest procedure with the same sample of participants used in the main study due to time restrictions imposed by the lecturers from whose classes the participants were drawn.

Strengths and limitations of the main study

Various aspects of the main study contained inherent strengths, weaknesses and limitations and these are discussed, but not limited by, the following review.

As discussed earlier, the main study focused on examining patterns of response to façade colour, and quantitative data collections methods were employed.   As Groat and Wang (2002) suggest, the strengths of this approach focus on the potential for establishing causality. In addition, Fisher (1935) asserts that the Latin-square technique is the most efficient and statistically sound method for evaluating a number of treatments due to the built-in randomisation and replication features of the technique. As a result, the methods

used in the main study provide one of its key strengths. However, it can also be argued that qualitative data collection methods would be more appropriate for a study that focuses on subjective human responses as the strengths of qualitative research are the ability to focus on meaning and interpretation in terms of human response (Alreck & Settle, 1995; Groat & Wang, 2002). Furthermore, it is suggested that the key weaknesses of experimental research are the tendency to reduce complex aspects of reality to isolated components, a focus on causality and the related notions of universality and determinism, and a tendency to over-generalise findings (Coolican, 2004; Groat & Wang, 2002). The choice of approach and data collection therefore presents a limitation of this study in that patterns of response were identified but not the underlying reasons for these patterns of response. This limitation is acknowledged and stands as an opportunity for further research in this area.

The main study stopped short of investigating the possible effects of a range of demographic factors on the relationship between aesthetic response and façade colour. While some individual differences – such as age, gender and region of birth – were identified and included in the study, a broader range of demographic factors were not included in the study. As Stamps and Nasar (1997) suggest, this is an issue 'ripe for empirical inquiry' (Stamps & Nasar, 1997, p14). In addition, the main study acknowledged, but did not specifically focus on, people with colour vision deficiency or colour blindness. While it is acknowledged that up to 5% of the population has some form of colour vision deficiency, the significance of this demographic variable was not addressed in this research (Sharpe & Jagle, 2001). As mentioned above, this proportion of the population was not considered large enough to warrant specific attention in terms of the population and sample group of this research. As such, this stands as a limitation of this research but also as an opportunity for further research.

PART C: RESULTS

This chapter discusses the results of data analysis of the data arising from the main study. Presentation of the results was guided by Nicol & Pexman (2004) and includes graphic representations in the form of means and scree plots due to their ability to convey patterns of results at a quick glance. The results in respect to the research questions and hypotheses are detailed as follows:

- Research question 1: Façade colour and aesthetic response
  – Results of factor analysis, correlation analysis and analysis of variance (ANOVA);
- Research question 2: Façade colour and congruity
  – Results of ANOVA;
- Research question 3: Façade colour and size
  – Results of ANOVA;
- Research question 4: Façade colour and preference
  – Results of ANOVA;
- Research question 5: Aesthetic response and individual differences
  – Results of analysis of covariance (ANCOVA);
- Research question 6: Aesthetic response and sample group subsets
  – Results of ANCOVA;
- Strengths and limitations of the data analysis results.

Please note, assumptions regarding data and data analysis (relating to the data arising from the main study) are discussed in full in the section Main study.

Results of the main study

Research question 1: Façade colour and aesthetic response

The first research question explored patterns of response in the dependent variables in terms of differences in the independent variable (façade colour). Ten variables were linked to the construct, aesthetic response, and it was anticipated that variations in response would occur, however, the extent or strength of this was not known or predicted. The null and alternative hypotheses are as follows.

H_0: $\mu AR_{T1} = \mu AR_{T2} = \mu AR_{T3} = \mu AR_{T4}$

H_1: $\mu AR_{T1} \neq \mu AR_{T2} \neq \mu AR_{T3} \neq \mu AR_{T4}$

where μ refers to population mean; 'AR' is aesthetic response, and 'T1-4' represents four façade colour treatments.[1]

As discussed above, aesthetic response is considered to comprise affective appraisal as well as cognitive judgements relating to a building's attributes. However, it was not known how faithfully or closely the dependent variables selected for this study represented the construct of aesthetic response. To investigate this statistically, factor analysis was applied to these variables and the results of this analysis are detailed below.

Factor analysis: Ten variables linked to aesthetic response

The validity of linking ten variables to *aesthetic response* was investigated using factor analysis. An exploratory data reduction technique that summarises data and allows for the identification of factors, factor analysis that may explain variations within the data, and the resulting eigenvalues and factor loadings may also provide a statistical basis for linking variables to a given construct (Coolican, 2004; Hinton, 2004; Tabachnick & Fidell, 1996). Factor analysis has been previously applied to data arising from semantic differential rating scales (for example, Coxhead & Bynner, 1981).

Firstly, the data were checked for appropriateness for factor analysis. The data set of 1,152 cases was well in excess of the recommended minimum size for factor analysis of between 150 to 300 cases (Hinton, 2004; Pallant, 2005; Tabachnick & Fidell, 1996). In addition, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Barlett's

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[1] Notational style for null and alternate hypotheses adapted from Arygrous (2001) and Shaughnessy and Zechmeister (1997).

Test of Sphericity were applied, resulting in a score of .901 and p=.000 respectively. For a data set to be considered appropriate for factor analysis, the KMO should be .6 or above and the Sig. value of Barlett's Test should be .05 or smaller (Hinton, 2004; Pallant, 2005). Therefore, applying factor analysis to the data set was found to be appropriate.

The number of factors emerging from factor analysis may vary depending on the number and range of rating scale items under analysis, and results may be considered 'clean' when a factor is loaded with a number of strongly related variables (Pallant, 2005). It is conventional to use eigenvalues greater than 1 as a guide in determining the number of factors (Hinton, 2004; Pallant, 2005). Initial factor analysis revealed two factors with eigenvalues exceeding 1, explaining 51.7% and 17.5% of the variance respectively. These two factors accounted for 69.2% of cumulative variance as detailed in Table 17.

Table 17.
Factor analysis of ten variables linked to aesthetic response.

Variable	Factor loadings		$\underline{h}^2$
	1	2	
Like-dislike	**.889**	-.124	.807
Pleasant-unpleasant	**.865**	.183	.749
Beautiful-ugly	**.798**	-.220	.685
Harmonious-inharmonious	**.778**	.163	.632
Sympathetic-unsympathetic	**.769**	.224	.642
Exciting-dull	**.768**	-.344	.709
Stimulating-boring	**.764**	-.263	.653
Fits/contrasts with surroundings	**.741**	.150	.572
Dominating-insignificant	.221	**.845**	.764
Large-small	.156	**.829**	.712
Eigenvalues	5.170	1.753	n/a
% of variance	51.70	17.53	n/a

Note. n = 1,152 and $\underline{h}^2$ = communalities.

Two key factors emerged from the initial factor analysis. The first included the eight variables relating to the evaluative dimensions of aesthetic response as well as judgements about congruity, and preference. The second factor included the two variables: large-small and dominating-insignificant. A change of shape of the scree plot arising from factor analysis also provides an indication of the principal factors (Hinton, 2004; Pallant, 2005). As illustrated in Figure 58, the scree plot arising from the results of the factor analysis in this case shows a clear break after the second factor.
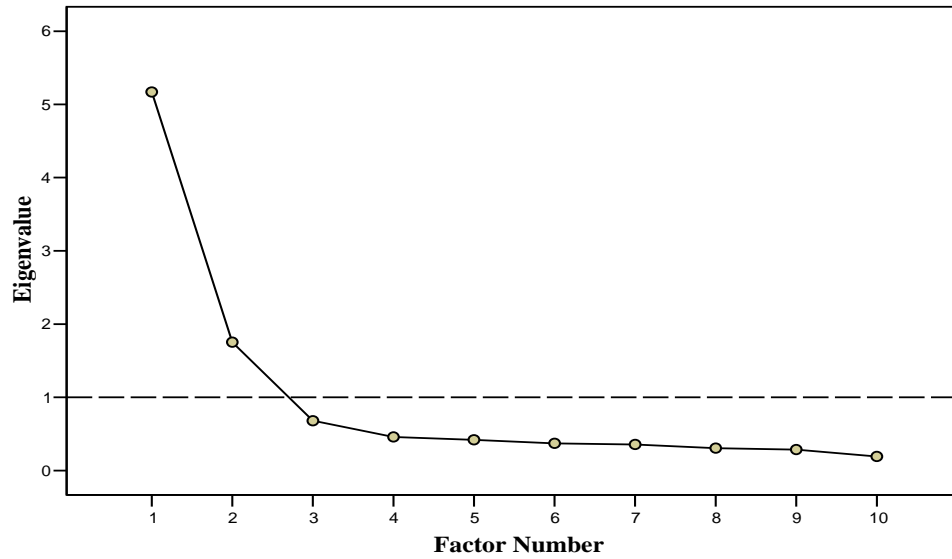
Figure 58. Scree plot: Factor analysis of ten variables.

Varimax and Oblimin rotations were subsequently applied to the data and Table 18 provides the results of Varimax rotation.[2]

Table 18.
Summary of factor loadings of Varimax rotation.

Variable	Factor loadings	
	1	2
	Aesthetic response[r]	*Size/dominance*
Like-dislike	**.897**	-.124
Pleasant-unpleasant	**.846**	.183
Beautiful-ugly	**.824**	-.220
Exciting-dull	**.818**	-.200
Stimulating-boring	**.799**	-.121
Harmonious-inharmonious	**.736**	.300
Sympathetic-unsympathetic	**.716**	.359
Fits/contrasts with surroundings	**.702**	.281
Dominating-insignificant	.221	**.871**
Large-small	.156	**.844**
Rotation sums of squared loadings	5.059	1.864
% of variance	50.59	18.64

Note. *n* = 1,152

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[2] Varimax is an orthogonal rotational approach to factor analysis and assumes that the underlying variables are not correlated and also aims to minimise the number of variables with high loadings on each factor. Oblimin is an oblique rotational approach that assumes the underlying variables are correlated (Pallant, 2005).

The results of the Oblimin rotation are detailed in Table 19. Correlation coefficients above .3 are considered supportive of a strong correlation between factors (Hinton, 2004; Pallant, 2005). The results in this case are below .3 indicating a low correlation between the two factors.

Table 19.
Factor correlation matrix from Oblimin rotation.

	Factor 1 *Aesthetic response*	Factor 2 *Size/dominance*
Factor 1	**1.000**	.120
Factor 2	.120	**1.000**

Factor analysis was then applied to the remaining eight variables – that is, all variables except those relating to size and apparent visual dominance – to determine whether any other secondary factors emerged. Only one factor emerged from this factor analysis which included all eight variable and which explained 64% of the variance, as detailed in Table 20.

Table 20.
Summary of factor loadings and communalities of eight variables.

Variable	Factor loading 1	h^2
Like-dislike	.894	.654
Pleasant-unpleasant	.861	.742
Beautiful-ugly	.809	.601
Exciting-dull	.785	.616
Stimulating-boring	.775	.593
Harmonious-inharmonious	.770	.539
Sympathetic-unsympathetic	.757	.574
Fits/contrasts with surroundings	.734	.800
Rotation Sums of Squared loadings	5.118	
% of variance	63.981	

Note. $n = 1,152$

Both Varimax and Oblimin rotations indicated the same two factors: the first relating to aesthetic response and the second to judgements about building size. As discussed above, the literature suggests that judgements about building size are considered to

contribute to overall aesthetic response to a building. However, the low correlation between these two factors indicated by the factor analysis of this research suggests that they are stand alone factors. Therefore, for the purposes of this research, these two factors will be treated separately.

In conclusion, the results of factor analysis signify that a very weak statistical basis exists for linking all ten variables to the construct: aesthetic response. However, the results show that it is statistically appropriate to link eight variables to the construct *aesthetic response*, and these variables shared strong inter-correlation. A second factor emerged and this included the variables large-small and dominating-insignificant.

Limited use of factor analysis results

The literature indicated that a range of variables representing affective appraisal, affect and cognitive judgements are linked to overall aesthetic response to building attributes. Ten of these variables were used in this study. Factor analysis was herein used to explore the appropriateness of linking these ten variables to aesthetic response. Factor analysis found that two factors emerged, with one of these representing aesthetic response and another building size/dominance. Aside from the factor analysis results discussed above, this research sought to examine patterns of response in respect to groups of variables that represented judgements about congruity, size and preference. Therefore, the factor analysis results were not further applied in respect to these groups of variables.

Correlation: Ten variables linked to aesthetic response

To assess the level of correlation between the variables, Pearson's product-moment correlation analysis was applied to the ten variables. While this test is somewhat redundant given the Oblimin factor analysis rotation above, the results provide greater insight into the levels of correlation between the individual variables used in this study.

The strength of correlation between ten variables linked to aesthetic response was investigated using Pearson's product-moment correlation and the results are detailed in the Table 21.

Table 21.
Correlation of ten variables linked to aesthetic response.

Variables	1	2	3	4	5	6	7	8	9	10
1) Like-dislike	--	.777**	.708**	.718**	.681**	.614**	.590**	.584**	.109**	.066*
2) Pleasant-unpleasant	.777**	--	.651**	.602**	.624**	.632**	.619**	.563**	.211**	.154**
3) Beautiful-ugly	.708**	.651**	--	.641**	.591**	.512**	.508**	.539**	.006	-.003
4) Exciting-dull	.718**	.602**	.641**	--	.681**	.447**	.466**	.447**	-.068*	-.065*
5) Stimulating-boring	.681**	.624**	.591**	.681**	--	.496**	.466**	.407**	.017	-.033
6) Harmonious-inharmonious	.614**	.632**	.512**	.447**	.496**	--	.635**	.611**	.247**	.163**
7) Sympathetic-unsympathetic	.590**	.619**	.508**	.466**	.466**	.635**	--	.587**	.280**	.231**
8) Fits/contrasts with surroundings	.584**	.563**	.539**	.447**	.407**	.611**	.587**	--	.239**	.140**
9) Dominating-insignificant	.109**	.211**	.006	-.068*	.017	.247**	.280**	.239**	--	.589**
10) Large-small	.066*	.154**	-.003	-.065*	-.033	.163**	.231**	.140**	.589**	--

Note. ** Correlation is significant at the 0.01 level (2-tailed);
    * Correlation is significant at the 0.05 level (2-tailed).

Strong correlation occurs among the three variables linked to preference and the evaluative dimension of affective appraisal (like-dislike, pleasant-unpleasant, beautiful-ugly), with the coefficients ranging from .65 up to .77.[3] Correlation was similarly strong among the variables relating to judgements about congruity (harmonious-inharmonious, sympathetic-unsympathetic and fits/contrasts with surroundings), with coefficients ranging from ranging from .59 to .63. The correlation between these two groups of variables was also strong, with coefficients ranging from .51 through to .63.   In addition, the coefficient of the variables linked to the arousal dimension of affective appraisal (stimulating-boring and exciting-dull) also indicated a strong correlation of .68; while the strength of correlation between these two variables and the already mentioned six variables ranged from .41 to .72 – that is, from medium correlation to strong correlation.   In relation to the variables linked to judgements about size (and also the potency dimension of affective appraisal: dominating-insignificant, large-small), the correlation between these two variables is strong at .59; but weak between these two variables and all the other variables.

Analysis of variance: Façade colour and aesthetic response (eight variables)

Analysis of variance (ANOVA) compares the variability of mean scores between groups thought to be due to an independent variable, to the variability within the groups – in which case the variability could be due to chance. This comparison, taking the form of the *F* ratio, provides a basis for assessing the null hypothesis. An *F* ratio (*t* value squared) that is close to or equal 1 indicates no difference between the groups (Argyrous, 2001; Hinton, 2004; Pallant, 2005). The benefit of applying ANOVA rather than a series of *t* tests is twofold. Firstly, it reduces the risk of making a Type 1 error – that is, claiming that a significant difference exists when the difference may be due to a random occurrence (Argyrous, 2001; Hinton, 2004).   In light of the above, ANOVA was conducted for four façade colour treatments on the eight variables that factor analysis suggested were linked to the construct *aesthetic response*.

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[3] Data analysis of the results arising from the main study of this research followed the protocols suggested by Argyrous (2001) and Pallant (2005) wherein correlation coefficients from .10 to .30 indicate a weak correlation; coefficients from .30 to .50 indicate a medium correlation; and coefficients from .50 to 1.0 indicate a strong correlation. It is acknowledged that other disciplines follow different protocols and that the strength of correlation may therefore be considered differently when applying different protocols with respect to correlation coefficients.

As a parametric test, ANOVA rests on an assumption of homogeneity of variance, normally distributed dependent variables and the absence of outliers. Therefore, prior to conducting ANOVA, the following tests were applied to the data. Levene's test for homogeneity of variance was applied to the eight variables and the results are detailed in the following Table. Levene's test provides an indication as to whether the variance in scores for each variable are the same or similar and the assumption of homogeneity of variance is not considered to be violated if the Sig. value is greater than .05 (Coolican, 2004; Pallant, 2005). The results of applying Levene's test indicate that the assumption of homogeneity of variance was not violated, except with regard to one of the eight variables: Fits/contrasts with surroundings. ANOVA is considered to be a robust method with small to moderate violations (Tabachnick & Fidell, 2001). The violation in this case was .032 and, as it represented only one variable of eight, the violation was considered small enough to proceed with ANOVA.

Outliers

The Kolmogorov-Smirnov test was used to check for normality of distribution and the resulting statistics in each case was over .05, indicating normality (Pallant, 2005). The histograms for each case reflect normal distribution as do the Q-Q plots for each variable for each façade colour treatment. Box-plots of each variable for each of the four façade colour treatments indicate no extreme point outliers in any case. The only box-plot in which outliers appeared was for the variable: Exciting-dull for four façade colour treatments. Six outliers appeared on this box-plot representing 0.5% of the total scores. In this case, the six outliers were changed to a less extreme value.[4] Tabachnick and Fidell (2001) suggest that outlier scores can be altered in this way as a means of including the score without the score distorting or biasing the resulting statistical data analysis.

Table 22 provides the mean and standard deviations for the four façade colour treatments on eight variables and Table 23 provides the results of one-way ANOVA for four façade colour treatments on eight variables. The F ratios detailed in Table 23 are all greater than 1, indicating that there are significant differences between the four façade colour treatments. All of the F ratios exceed the critical value for F (3, 1148) of 2.60 at a significance level of $p < .05$ (Hinton, 2004, p364).

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[4] Outliers in this particular study indicate the existence of relatively extreme evaluations in respect to façade colour treatments and are therefore highly relevant to the aims and questions of this research. However, the existence of so few outliers (that is, six of 1,152 or 0.5% of the total evaluations) have led to the decision that there are not sufficient outliers to warrant including them or dealing with them in an alternative manner.

Table 22.

Mean and standard deviations: Façade colour and eight variables linked to aesthetic response.

Variable	Treatments							
	1		2		3		4	
	M	SD	M	SD	M	SD	M	SD
Beautiful-ugly	4.24	1.4	4.09	1.4	3.77	1.5	4.23	1.5
Pleasant-unpleasant	3.78	1.5	3.71	1.4	3.50	1.5	3.90	1.6
Exciting-dull	4.48	1.4	4.43	1.4	4.01	1.5	4.27	1.4
Stimulating-boring	4.15	1.5	4.02	1.5	3.68	1.5	3.84	1.4
Harmonious-inharmonious	3.52	1.5	3.72	1.5	3.89	1.5	4.31	1.6
Sympathetic-unsympathetic	3.74	1.3	3.92	1.4	4.01	1.5	4.33	1.5
Fits/Contrast w/ surroundings	3.51	1.6	3.77	1.6	4.02	1.7	4.59	1.7
Like-dislike	4.13	1.7	3.84	1.6	3.64	1.7	4.19	1.8
Average means:	3.94		3.93		3.81		4.20	

Note. $n = 1,152$ (M represents mean; SD represents standard deviation).

The results detailed in Table 22 suggest that changes in façade colour treatment are associated with variations in respect to the eight variables linked to aesthetic response. Hence, the null hypothesis of Research Question 1 is rejected in favour of the alternative hypothesis: variations in façade colour are associated with differences in people's aesthetic response. However, rejection of the null hypothesis needs to be tempered by the following. Firstly, parametric data analysis methods have been applied to data arising from rating scale items that have not been standardised. In addition, an important assumption for ANOVA – the homogeneity of variance, was violated for the variable: Fits/contrasts with surroundings. Furthermore, the large values for the *F* ratio arising from data analysis do not necessarily equate with large effects sizes and the effect sizes calculated for the variables are minimal.

Effect size was calculated by dividing the sum of squares between groups by the total sum of squares (Eta squared), and Cohen (1988) suggests that .01 and 0.2 is a small effect, .06 is a medium effect and .14 is a large effect. The only variable achieved an effect size of .06 or over was Fits/contrasts with surroundings, and all other effect sizes were below this value.[5] Responses to harmonious façade colour treatments (1 and 2) were similar with total mean scores of 3.94 and 3.93 respectively. Responses for the contrasting façade colour treatments (3 and 4) differed (3.81 and 4.20 respectively), suggesting that a harmonious façade colour treatment scored more positively than the contrasting façade colour treatments.

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[5] Feedback from research colleagues has suggested that the subtlety of effect sizes may reflect the subtlety apparent within the range of façade colour treatments used in the main study. That is, larger effect sizes may have arisen if the range of façade colour treatments included treatments that exhibited extreme or grossly contrasting façade colours.

Table 23.
ANOVA results: Façade colour on eight variables linked to aesthetic response.

Variable and source	df	SS	MS	F (3, 1148)	n^2
Beautiful-ugly					
Between groups	3	42.54	14.18	6.89*	.02
Within groups	1148	2383.46	2.08		
Pleasant-unpleasant					
Between groups	3	24.11	8.04	3.51*	.01
Within groups	1148	2632.55	2.29		
Exciting-dull					
Between groups	3	38.24	2.75	6.44*	.02
Within groups	1148	2271.82	1.98		
Stimulating-boring					
Between groups	3	36.24	12.08	5.67*	.01
Within groups	1148	2446.41	2.13		
Harmonious-inharmonious					
Between groups	3	96.91	32.30	14.02*	.04
Within groups	1148	2645.59	2.30		
Sympathetic-unsympathetic					
Between groups	3	51.91	17.30	8.44*	.02
Within groups	1148	2353.01	2.05		
Fits/Contrast w/ surroundings					
Between groups	3	182.16	60.72	22.51*	.06
Within groups	1148	3096.00	2.70		
Like-dislike					
Between groups	3	56.40	18.80	6.54*	.02
Within groups	1148	3300.47	2.87		

Note. n = 1,152 and p < .05 (n^2 - effect size[6]; df - degrees of freedom; SS - sum of squares; MS - mean squares).

To summarise, changes in façade colour treatment appear to be associated with variations in aesthetic response. Variations are strongest for variables relating to congruity and marginally less strong for variables relating to the evaluative component of affective appraisal, the arousal component of affective appraisal and preference.

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[6] Effect size in this instance has been calculated by dividing Sum of squares between groups by total sum of squares (Pallant, 2005). The resulting effect size is compared with Cohen's (1988) benchmark range for small effects: .01 to .02; medium effect: .05 to .06; and large effect: .08 to .14 (Argyrous, 2001; Pallant, 2005).

Research question 2: Façade colour and judgements about congruity

The second research question sought to investigate whether variations in façade colour treatment led to associated variations in judgements about the congruity of a building relative to its surroundings. In line with earlier EBS studies and as discussed in the section Research Methodology, judgements about congruity were linked to the variables: harmonious-inharmonious, sympathetic-unsympathetic, and fits-contrasts with surroundings. It was anticipated that some association may occur, but the extent of this association was not predicted. The null and alternative hypotheses are as follows.

$$H_0: \quad \mu CON_{T1} = \mu CON_{T2} = \mu CON_{T3} = \mu CON_{T4}$$

$$H_2: \quad \mu CON_{T1} \neq \mu CON_{T2} \neq \mu CON_{T3} \neq \mu CON_{T4}$$

where μ is the population mean, 'CON' refers to judgements about congruity
and 'T1-4' represents four façade colour treatments.

To address this research question, the variables linked to judgements about the congruity of a building (harmonious-inharmonious, sympathetic-unsympathetic and fits/contrasts with surroundings) were investigated using Pearson's product-moment correlation coefficient and ANOVA with respect to the four façade colour treatments.

Correlation: Three variables linked to judgements of congruity

Pearson's product-moment correlations are detailed in Table 24 and the coefficients among the three variables relating to judgements about congruity are all above .50 and can therefore be considered to have strong correlation.[7]

Table 24.
Correlation coefficients for three variables linked to congruity.

Variable	1	2	3
1. Harmonious-inharmonious	--		
2. Sympathetic-unsympathetic	.635**	--	
3. Fits/contrasts with surroundings	.611**	.587**	--

Note. $n = 1,152$. **All coefficient correlations are significant at $p < .01$ (2-tailed).

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[7] As mentioned above, correlation data analysis of the results arising from the main study of this research followed the protocols suggested by Argyrous (2001) and Pallant (2005). It is acknowledged that other disciplines follow different protocols and that the strength of correlation may therefore be different depending on the application of different correlation protocols.

Table 25 provides the means and standard deviations on the three variables and the means plot is illustrated in Figure 59. The strong correlation between the three variables is supported by the close proximity of the means for each variable on the means plot. While the mean scores to hover around the mid point (4), a pattern is evident. That is, the mean scores for the harmonious façade colours are considered to fit marginally more with the surroundings and be marginally more harmonious and sympathetic than the contrasting façade colours.

Table 25.
Means and standard deviations: Façade colour and three variables linked to congruity.

| | Harmonious treatments | | | | Contrasting treatments | | | |
| | 1 | | 2 | | 3 | | 4 | |
Variable	M	SD	M	SD	M	SD	M	SD
Harmonious-inharmonious	3.52	1.5	3.72	1.5	3.89	1.5	4.31	1.6
Sympathetic-unsympathetic	3.74	1.3	3.92	1.4	4.01	1.5	4.33	1.5
Fits/Contrast w/ surroundings	3.51	1.6	3.77	1.6	4.02	1.7	4.59	1.7
Average Means	3.59		3.80		3.97		4.41	

Note. *n* = 1,152
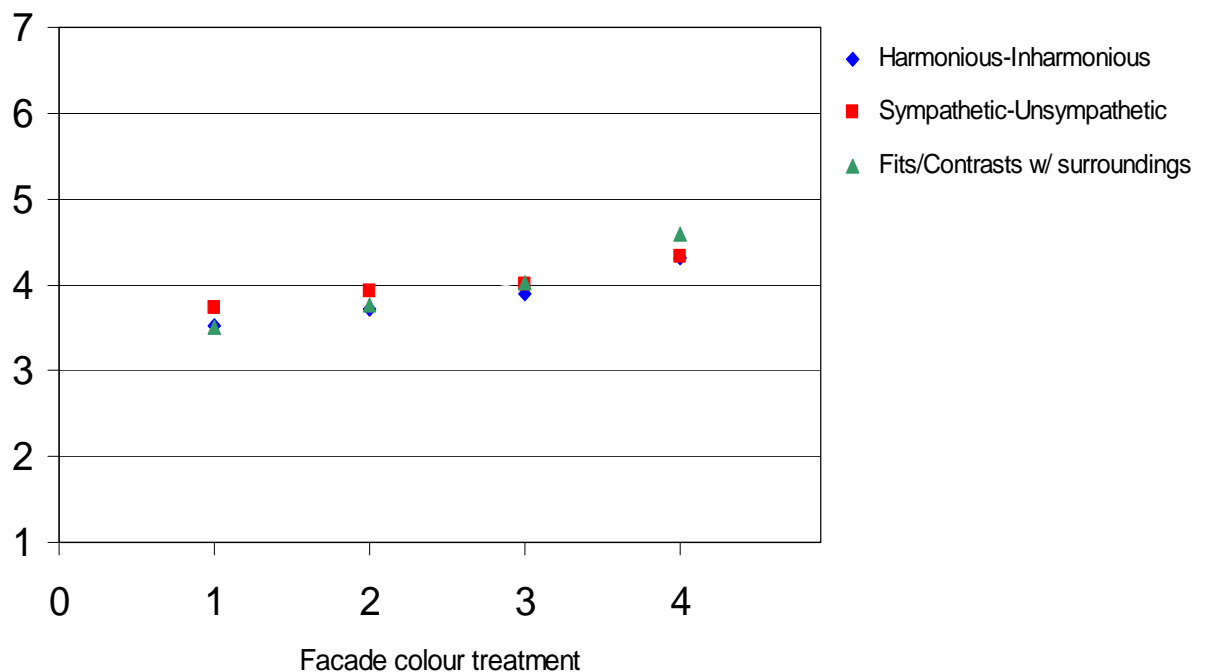
Figure 59. Means plot: Three variables and four façade colour treatments[8].

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[8] The Y axis represents the semantic differential scale of 1 (positive) to 7 (negative) for the three variables. In addition, Treatments 1 and 2 fall into the category of *harmonious* façade colour and Treatments 3 and 4 into the category of *contrasting* as per Preliminary Study #2.

Analysis of variance: Façade colour and judgements about congruity

The ANOVA results for the three variables linked to judgements about congruity are detailed in Table 26. The *F* ratios for these three variables are 14.02, 8.44 and 22.51 at p < .05, and all three exceed the critical value for F (3, 1148) of 2.60.

By exceeding the critical value for the *F* ratio, it can be concluded that there are significant differences between the four façade colour treatments in respect to the variables linked to judgements about congruity. However, in terms of effect size, using Cohen's (1988) benchmarks for assessing effect size as discussed previously, only the variable: fits/contrasts with surroundings exhibits an effect size that can be interpreted as medium. The effect sizes of the other two variables are considered small.

Table 26.
ANOVA: Façade colour and three variables linked to congruity.

Variable and source	df	SS	MS	F (3, 1148)	n^2
Harmonious-inharmonious					
Between groups	3	96.91	32.30	14.02*	.04
Within groups	1148	2645.59	2.30		
Sympathetic-unsympathetic					
Between groups	3	51.91	17.30	8.44*	.02
Within groups	1148	2353.01	2.05		
Fits/Contrast w/ surroundings					
Between groups	3	182.16	60.72	22.51*	.06
Within groups	1148	3096.00	2.70		

Note. *n* = 1,152; * p < .05; n^2 = effect size.

Differences in judgements about congruity between façade colour classifications

Further investigation of the façade colour treatments in respect to the notion of congruity was conducted in terms of the two façade colour classifications identified for this study. As discussed above, the four façade colour treatments comprised two façade colour treatment categories based on similarity of hue of façade colour relative to the colours of the surroundings (Treatments 1 and 2); and two façade colour treatments based on contrast of hue, relative to the colours of the surroundings (Treatments 3 and 4). Preliminary Study #2 categorised these as *harmonious* and *contrasting*, respectively.

Table 27 features the mean scores, standard deviations and *t* test results for the combined façade colour treatments on the three variables: harmonious-inharmonious, sympathetic-unsympathetic and fits/contrasts with surroundings. The façade colour treatments have been combined according to their classification of either harmonious or contrasting. As per Table 27, the mean scores differ between the two combined façade colour treatments. The related *t* test values are well in excess of the cut-off point of 1.96. These results indicate that judgements about congruity vary by up to 13.55% depending on whether the façade colour is harmonious or contrasting.

Table 27.
Means and standard deviations: Façade colour on three variables linked to congruity.

	Harmonious colours 1 & 2		Contrasting colours 3 & 4			
	<u>M</u>	SD	<u>M</u>	SD	df	<u>t</u>
Harmonious-inharmonious	3.62	1.54	4.10	1.52	1151	62.82*
Sympathetic-unsympathetic	3.83	1.46	4.17	1.49	1151	70.42*
Fits/contrasts with surroundings	3.64	1.68	4.30	1.64	1151	59.79*
Average means:	3.69		4.19			
Difference:	0.50 (13.55%)					

<u>Note</u>. *n* = 1,152; *p < .05; Treatments 1 & 2 - harmonious; Treatments 3 & 4 - contrasting.

In conclusion, these results support the alternative hypothesis of this research question; that is, that changes in façade colour treatment are associated with variations in judgements about a building's congruity. While ANOVA results indicated that variations in judgements occurred across the four façade colour treatments, the effect sizes of these variations were considered small (for the variables harmonious-inharmonious and sympathetic-unsympathetic) to medium (fits/contrasts with surroundings).

When the façade colour treatments are grouped according to the categories *harmonious* and *contrasting,* variations in mean scores exceed 13%. In summary, buildings that featured *harmonious* façade colour treatments were judged to be more harmonious, sympathetic and less contrasting relative to the surroundings than the same buildings when featuring *contrasting* façade colour treatments.

Research question 3: Façade colour and judgements about size

The third research question investigated whether changes in façade colour treatment are associated with changes in judgements about the size and apparent visual dominance of a building. It was anticipated that some change may occur, possibly in the vicinity of +/- 5%. The null and alternative hypotheses are as follows.

$$H_0: \quad \mu SIZE_{T1} = \mu SIZE_{T2} = \mu SIZE_{T3} = \mu SIZE_{T4}$$

$$H_3: \quad \mu SIZE_{T1} \neq \mu SIZE_{T2} \neq \mu SIZE_{T3} \neq \mu SIZE_{T4}$$

where μ is the population mean; 'SIZE' refers to judgements about a buildings size, and 'T1-4' represents the four façade colour treatments.

To address this research question, the two variables linked to judgements about size as well as the potency dimension of affective appraisal (large-small and dominating-insignificant) were investigated using correlation and ANOVA data analysis methods.

Correlation: Two variables linked to judgements about size

As discussed earlier, Pearson's correlation coefficient was $r = .589$ ($p < .01$) indicating a strong correlation between the two variables.[9] The means and standard deviations for the two variables across the four façade colour treatments are detailed in Table 28.

Table 28.
Mean and standard deviations: Façade colours and two variables linked to size.

| Variable | Four façade colour treatments | | | | | | | |
| | 1 | | 2 | | 3 | | 4 | |
	M	SD	M	SD	M	SD	M	SD
Large-small	4.31	1.6	4.45	1.6	4.56	1.6	4.66	1.6
Dominating-insignificant	4.06	1.3	4.31	1.4	4.67	1.4	4.69	1.4
Average means:	4.18		4.38		4.61		4.67	

Note. $n = 1,152$

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[9] As mentioned earlier, correlation coefficients from .10 to .30 indicate a weak correlation; from .30 to .50 indicate a medium correlation and from .50 to 1.0 indicate a strong correlation (Argyrous, 2001; Pallant, 2005).

Analysis of variance: Two variables linked to judgements about size

The ANOVA results for the variables: large-small and dominating-insignificant are detailed in Table 29. The *F* ratios for these two variables are 2.66 and 14.25, respectively (p< .05); exceeding the critical value for *F* (3, 1148) of 2.60 (Hinton, 2004, p364). By exceeding this critical value for *F*, it can be concluded that there are significant differences between the four façade colour treatments used in this study in respect to the variables: large-small and dominating-insignificant.

Table 29.
ANOVA results: Façade colours on two variables linked to size.

Variable and source	df	SS	MS	F (3, 1148)	n^2
Large-small					
Between groups	3	19.77	6.59	2.66*	.01
Within groups	1148	2842.17	2.47		
Dominating-insignificant					
Between groups	3	81.11	27.04	14.25*	.04
Within groups	1148	2177.33	1.89		

Note. n = 1,152; p < .05; n^2 = effect size.

As detailed in Table 29 and the means plot (see Figure 60), a greater variance occurred in terms of the variable Dominating-insignificant as compared with the variable Large-small.
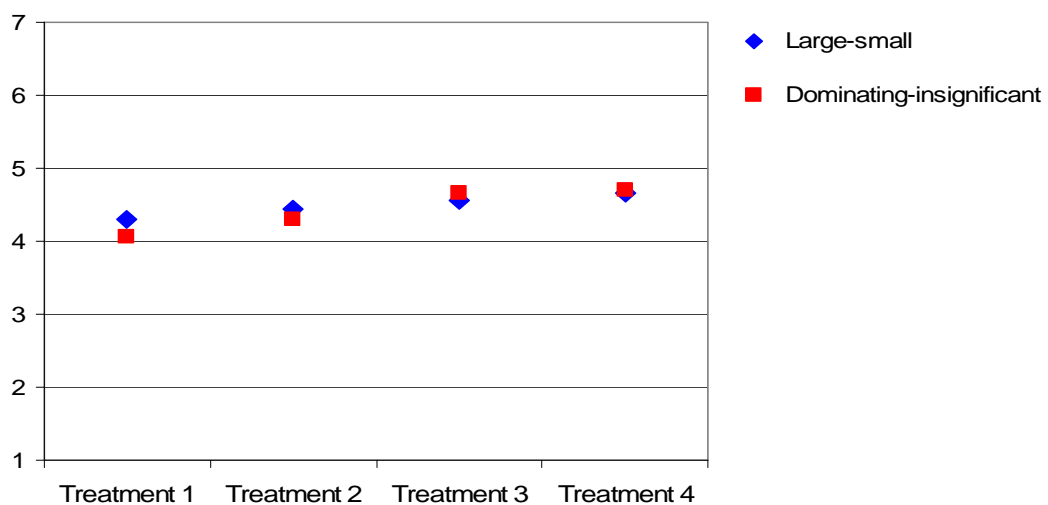
Figure 60. Means plot of the variables: large-small and dominating-insignificant.

175

Table 30 provides additional information about variations in response broken down by treatment and building. Figure 61 displays similarities as well as some differences in patterns of response for the four façade colours for each of the four buildings.

In terms of similarities, the trend for both variables is that all the buildings appeared larger and more dominant when featured with contrasting façade colours as opposed to harmonious façade colours. This trend is characterised by a left-to-right downward slope of all means plotted on the means plot (Figure 61).

In respect to differences, it appears that responses varied depending on the actual size and proportions of the buildings within the visual stimuli images. The two larger buildings (Buildings 1 and 3) and, to a certain extent, Building 2 rated more strongly on the Large-small variable because they were if fact larger in actual size than Building 4. In terms of the variable Dominating-insignificant, participants may have rated this variable in terms of the proportional content and size of the building within the parameters of the visual stimuli rather than in terms of the building's surroundings.

Table 30.
Mean and standard deviations for two variables linked to size.

Building / Façade colour treatment		Large-small		Dominating-insignificant	
		M	SD	M	SD
Building 1:	Façade colour treatment 1	2.85	1.04	3.50	1.11
	Façade colour treatment 2	2.67	1.05	3.08	1.35
	Façade colour treatment 3	2.42	0.68	2.75	1.15
	Façade colour treatment 4	2.29	0.78	2.68	1.25
Building 2:	Façade colour treatment 1	4.04	1.20	4.26	1.32
	Façade colour treatment 2	3.94	0.93	4.11	0.96
	Façade colour treatment 3	4.03	0.99	3.67	1.19
	Façade colour treatment 4	3.82	1.01	3.58	1.36
Building 3:	Façade colour treatment 1	2.44	1.14	3.26	1.21
	Façade colour treatment 2	2.29	0.94	2.86	1.21
	Façade colour treatment 3	2.25	1.09	2.69	1.39
	Façade colour treatment 4	2.13	0.94	2.72	1.12
Building 4:	Façade colour treatment 1	5.44	0.98	4.75	1.15
	Façade colour treatment 2	5.31	1.26	4.74	1.21
	Façade colour treatment 3	5.08	1.30	4.22	1.13
	Façade colour treatment 4	5.11	1.06	4.22	1.28

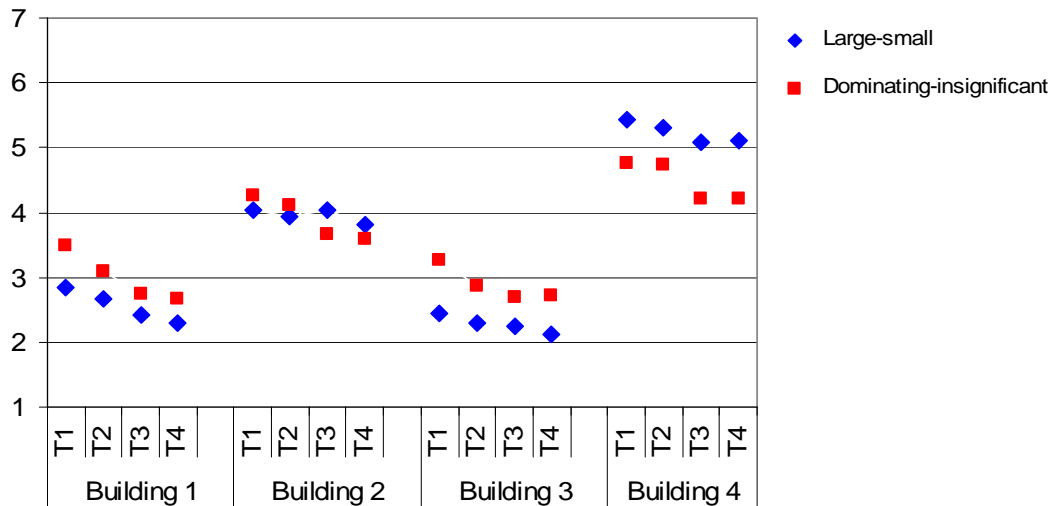Note. $n = 1,152$; Images of the buildings are available in Figure 56.

Figure 61. Means plot of two variables by building and façade colour treatment.

Difference in judgements about size between façade colour treatments

The differences in mean scores for four façade colour treatments in respect to the two variables were investigated further to ascertain the degree of difference expressed as a percentage. By expressing the means as percentages, the variations become immediately apparent. As detailed in Table 31, the mean scores differ from 0.42 percent to 15.51 percent across the four façade colour treatments.

Table 31.
Differences in mean scores for two variables and four façade colour treatments.

	Large-small				Dominating-insignificant			
	T1	T2	T3	T4	T1	T2	T3	T4
Treatment 1	--	3.25	5.80	8.12	--	6.15	15.02	15.51
Treatment 2	3.25	--	2.47	4.72	6.15	--	8.35	8.81
Treatment 3	5.80	2.47	--	2.19	15.02	8.35	--	0.42
Treatment 4	8.12	4.72	2.19	--	15.51	8.81	0.42	--

Note. Differences expressed in percentages; *n* = 1,152

The four façade colour treatments comprised two classifications: harmonious (Treatments 1 and 2) and contrasting (Treatments 3 and 4). Table 32 features the mean scores for the combined façade colour treatments and the percent difference between the mean scores on the two variables: large-small and dominating-insignificant.

Table 32.
Means for combined façade colour treatments.

	Large-small		Dominating-insignificant	
	M	%	M	%
Treatments1 & 2 (*Harmonious*)	4.38		4.18	
Treatments 3 & 4 (*Contrasting*)	4.61		4.68	
Difference:		5.25		11.96

Note. *n* = 288

As detailed in Table 32, the combined mean scores for harmonious and contrasting façade colour treatments indicate that contrasting façade colour treatments may influence judgements about a building's size thereby leading to a building being judged larger and more dominating that the same building with harmonious façade colours.

To conclude, these findings support the alternative hypothesis of this research question. Differences in judgements about size and apparent visual dominance are associated with changes in façade colour. Variations in judgement range from 5% up to almost 12% when façade colour treatments are grouped according to the classifications of *harmonious* or *contrasting* façade colours, with *contrasting* façade colours judged to be larger and more dominant than *harmonious* façade colour treatments.[10]
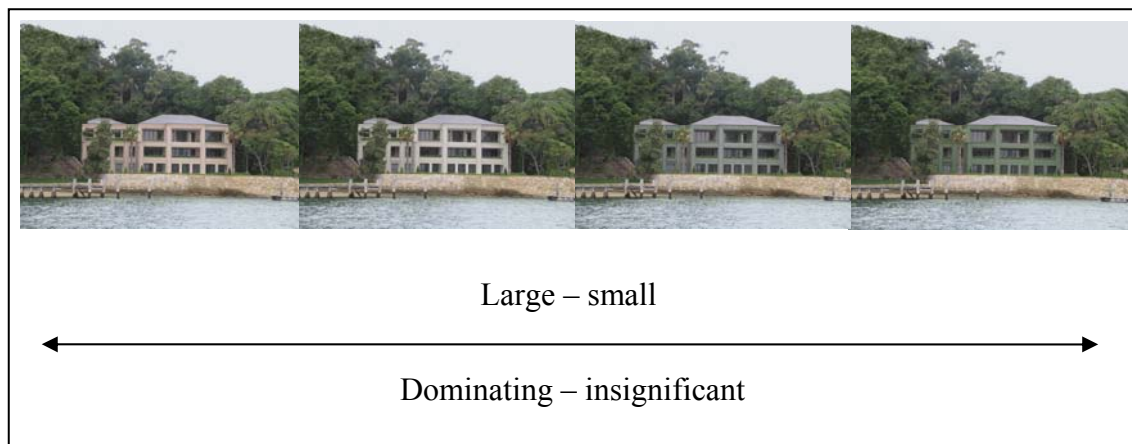
Figure 62. Range of judgements about building size.

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[10] As mentioned earlier, it needs to be reiterated that the classifications of harmonious and contrasting façade colour are relative classifications derived from Preliminary Study #2 wherein the dominant colour of the surroundings was the colour of natural vegetation: green. Classifications such as harmonious or contrasting façade colour are dependent on, and relative to, the colour characteristics of the surroundings and these may vary from setting to setting.

Research question 4: Façade colour and preference

Research question 4 comprised two sub questions: Question 4a investigated variations in preference for a façade colour treatment and whether these are consistent across four buildings. Question 4b focussed on whether variations in preference for a building are consistent irrespective of façade colour treatment. The null and alternative hypotheses are as follows:

H_0: μPREFER $_{T1(B1-4)}$ = μPREFER $_{T2(B1-4)}$ = μPREFER $_{T3(B1-4)}$ = μPREFER $_{T4(B1-4)}$

H_{4a}: μPREFER $_{T1(B1-4)}$ $\neq$ μPREFER $_{T2(B1-4)}$ $\neq$ μPREFER $_{T3(B1-4)}$ $\neq$ μPREFER $_{T4(B1-4)}$

H_0: μPREFER $_{B1(T1-4)}$ = μPREFER $_{B2(T1-4)}$ = μPREFER $_{B3(T1-4)}$ = μPREFER $_{B4(T1-4)}$

H_{4b}: μPREFER $_{B1(T1-4)}$ $\neq$ μPREFER $_{B2(T1-4)}$ $\neq$ μPREFER $_{B3(T1-4)}$ $\neq$ μPREFER $_{B4(T1-4)}$

> where μ is the population mean; 'PREFER' refers to preference rating, 'T1-4' represents four façade colour treatments & 'B1-4' refers to four building.

To address research question 4, preference was linked to the variable Like-dislike, and one-way ANOVA was applied to four façade colour treatments and this variable.

Analysis of variance: Variable linked to preference

As illustrated in Table 33, the *F* ratio for the variable: like-dislike is 12.67 and 6.54 respectively. By exceeding the critical values for F (3, 1148) of 2.60 as per Argyrous (2001), it can be concluded that there are significant differences between the four façade colour treatments and the four buildings in respect to the variable: Like-dislike. The effect size is considered small when Cohen's (1988) benchmarks for assessing effect size were applied.

Table 33.
ANOVA results: Four façade colour treatments and one variable (Like-dislike).

Variable and source	df	SS	MS	F (3, 1148)	n^2
Like-dislike: Building					
Between groups	3	107.56	35.85	12.67*	.03
Within groups	1148	3249.31	2.83		
Like-dislike: Façade colour treatment					
Between groups	3	56.40	18.80	6.54*	.02
Within groups	1148	3300.47	2.87		

Note. n = 1,152; p < .05; n^2 = effect size.

Research Question 4a: Preference for façade colour irrespective of building

Research Question 4a focussed on whether preference for the four façade colour treatments was consistent across the four buildings that were featured in the visual stimuli of the main study. Table 34 details the means, standard deviations and preference rankings for four buildings and four façade colour treatments on the variable Like-dislike. Ranked percentages have been used to clearly identify the differences in preference for the four façade colour treatment relative to each of the four buildings.

Table 34.
Preference ranking by façade colour treatment/building.

Building / Façade colour treatment	n	M	SD	%[11]	rank
Building 1					
Façade colour treatment 1 (dark green)	72	4.65	1.60	12.86	4
Façade colour treatment 2 (grey green)	72	4.00	1.93	4.17	2
Façade colour treatment 3 (off white)	72	3.61	1.80	0.82	1
Façade colour treatment 4 (terracotta)	72	4.33	1.80	3.46	3
Building 2					
Façade colour treatment 1	72	4.21	1.66	2.18	3
Façade colour treatment 2	72	3.99	1.24	3.91	1
Façade colour treatment 3	72	4.07	1.59	11.81	2
Façade colour treatment 4	72	4.80	1.66	14.83	4
Building 3					
Façade colour treatment 1	72	3.97	1.70	3.64	3
Façade colour treatment 2	72	3.94	1.73	2.60	2
Façade colour treatment 3	72	3.71	1.76	1.92	1
Façade colour treatment 4	72	3.97	1.72	5.03	4[12]
Building 4					
Façade colour treatment 1	72	3.67	1.62	10.92	4
Façade colour treatment 2	72	3.45	1.41	10.16	2
Façade colour treatment 3	72	3.17	1.74	12.91	1
Façade colour treatment 4	72	3.61	1.64	13.64	3
Treatment 1 average Mean score		4.12			
Treatment 2 average Mean score		3.84			
Treatment 3 average Mean score		3.64			
Treatment 4 average Mean score		4.18			

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[11] This figure represents that difference in percent between the mean score for each façade colour treatment/building combination and the mean score for treatment.

[12] Building 3, façade colour treatments 1 and 4 shared the same mean; however, façade colour treatment 4 had an upper bound of 4.38, .01 higher than façade colour treatment 1. Hence the difference in rankings.

As detailed in Table 34, preference for a façade colour treatment was not consistent across the four buildings featured in this study. The preferred façade colour treatment was façade colour treatment 3 (off-white) in three out of four instances – classified as a *contrasting* façade colour treatment as per Preliminary study #2, discussed earlier. The least preferred façade colour treatment was treatment 1 (dark green) in two instances and treatment 4 (terracotta pink) in two instances, categorised as *harmonious* and *contrasting* façade colour treatments respectively.

To summarise, preference for a façade colour treatment varied by up to 14.8% depending on the building on which it was featured. Figure 63 features the overall ranking of four façade colour treatments (across all four buildings featured in the visual stimuli) depicted on Building 1.

Like – dislike
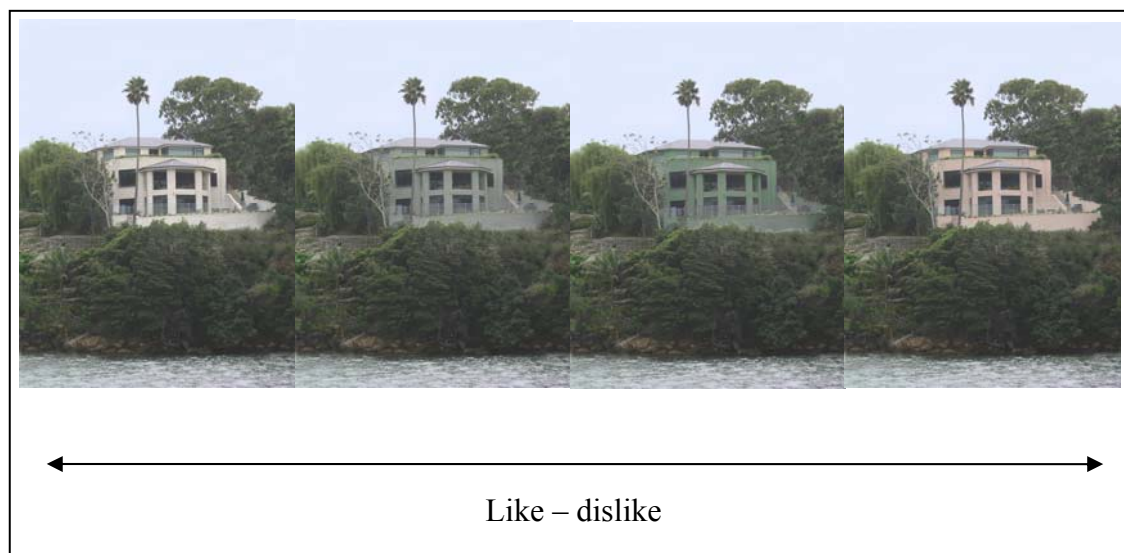
Figure 63. Overall preference ranking of four façade colour treatments.

Research Question 4b: Preference for a building irrespective of façade colour

Question 4a focussed on whether preference for a building is consistent irrespective of variations in façade colour treatment. To address this question, the means, standard deviations and preference rankings for four buildings and four façade colour treatments on the variable Like-dislike were identified and compared.

Table 35.
Preference rankings by building/façade colour treatment.

Building / Façade colour treatment	n	M	SD	%[13]	rank
Building 1/Treatment 1	72	4.65	1.60	12.05	4
Building 2/Treatment 1	72	4.21	1.66	1.40	3
Building 3/Treatment 1	72	3.97	1.70	1.79	2
Building 4/Treatment 1	72	3.67	1.62	5.76	1
Building 1/Treatment 2	72	4.00	1.93	3.61	4
Building 2/Treatment 2	72	3.99	1.24	6.56	3
Building 3/Treatment 2	72	3.94	1.73	1.03	2
Building 4/Treatment 2	72	3.45	1.41	0.58	1
Building 1/Treatment 3	72	3.61	1.80	13.01	2
Building 2/Treatment 3	72	4.07	1.59	4.68	4
Building 3/Treatment 3	72	3.71	1.76	4.87	3
Building 4/Treatment 3	72	3.17	1.74	8.65	1
Building 1/Treatment 4	72	4.33	1.80	3.59	3
Building 2/Treatment 4	72	4.80	1.66	12.41	4
Building 3/Treatment 4	72	3.97	1.72	1.79	2
Building 4/Treatment 4	72	3.61	1.64	4.03	1
Building 1 average Mean score		4.15			
Building 2 average Mean score		4.27			
Building 3 average Mean score		3.90			
Building 4 average Mean score		3.47			

Note. n = 1,152

Rankings in Table 35 indicate that preference for a building was not consistent across four façade colour treatments. While Building 4 ranked first across all façade colour treatments, second place varied from Building 1 to Building 3 depending on façade colour treatment. Similarly, the last ranking place varied from Building 2 to Building 1 depending on façade colour treatment. Preference for a particular building varied from the mean score for each building by as much as 13% in some cases due to variations in façade colour.

The preference rankings are also illustrated in the means plot featured in Figure 64. While the means tend to hover around the mid point, it is clear that there is some level

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[13] This figure represents that difference in percent between the mean score for each building/treatment combination and the mean score for each building.

of difference in terms of preferences for the four buildings not consistent in respect to the four façade colour treatments.
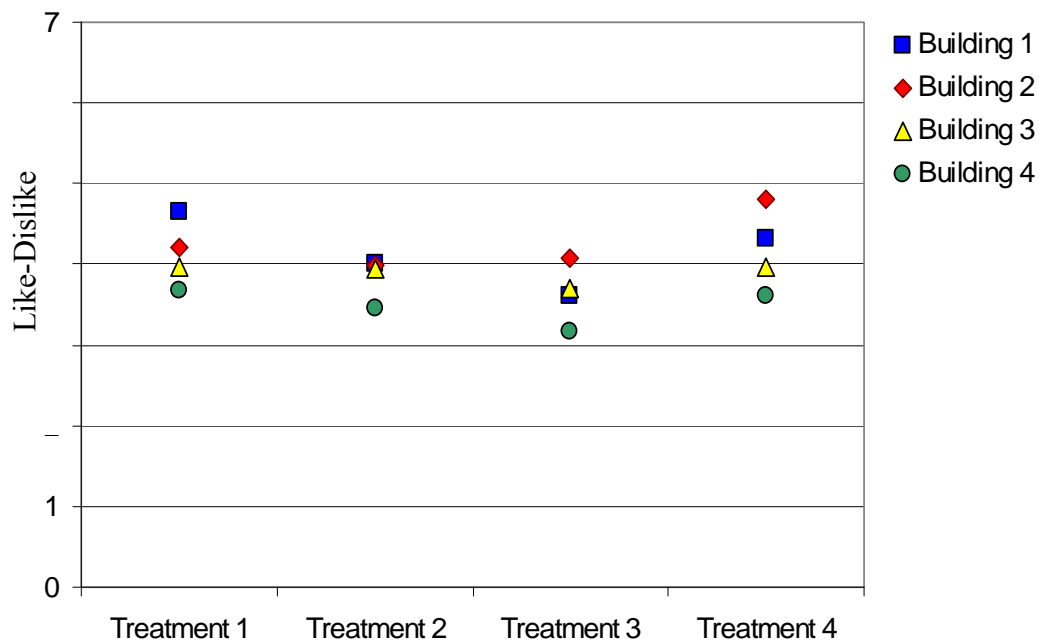
Figure 64. Means plot of the variable: Like-dislike.

In terms of the hypothesis of research question 4b, preference for a building is not consistent across the four façade colour treatments. Preference varied by at least 5% in eight of the sixteen options, indicating that the null hypothesis should be rejected in favour of the alternative hypothesis.

In conclusion, these results suggest that preference for four façade colour may not be consistent across different buildings. This study found that an off-white or grey-green façade colour is preferred; while the least preferred façade colour treatments are dark green or terracotta pink. This indicates that preferences may not be in line with classifications such as *harmonious* or *contrasting* façade colours. These results also indicate that preference for a building may be varied by changing or modifying façade colour. Both of these findings have implications in terms of planning policy as well as in respect to buildings branded 'eyesores'.

Research question 5: Façade colour and individual differences

The fifth research question explored whether variations in *aesthetic response* to four façade colour treatments are associated with patterns of variation in a range of individual characteristics. The individual characteristics for the purposes of this study were limited to gender, age, country of birth and familiarity (in terms of familiarity with a building featured in the visual stimuli). It was not predicted whether there would be associations in respect to individual differences, and the null and alternative hypotheses are as follows:

$$H_0: \quad \mu AR_{(T1*IND)} = \mu AR_{(T2*IND)} = \mu AR_{(T3*IND)} = \mu AR_{(T4*IND)}$$

$$H_5: \quad \mu AR_{(T1*IND)} \neq \mu AR_{(T2*IND)} \neq \mu AR_{(T3*IND)} \neq \mu AR_{(T4*IND)}$$

where μ is the population mean; 'AR' refers to *aesthetic response*[r], and 'IND' refers to the individual characteristics: gender, age, country of birth & familiarity.

Analysis of covariance (ANCOVA) was used to address the fifth research question of the main study. ANCOVA allows for the investigation of two independent variables in respect to one or more dependent covariates (Pallant, 2005). A benefit of applying ANCOVA, which rests on the assumptions of a normally distributed population as well as homogeneity of variances, is that it applies statistical analyses to control for Type 1 errors – that is, that claiming a statistical difference when one does not exist (Hinton, 2004; Pallant, 2005).

In this case, four façade colour treatments were investigated in conjunction with the four variables relating to individual differences (gender, age, country of birth and familiarity) in respect to the dependent variables representing aesthetic response (that is, beautiful-ugly, pleasant-unpleasant, harmonious-inharmonious, sympathetic-unsympathetic, fits/contrasts with surroundings, exciting-dull, stimulating-boring, and like-dislike).

ANCOVA also rests on assumptions relating to normal distribution, linearity, homogeneity of variance and the absence of outliers. Preliminary testing was conducted to check for these and the results of this testing is discussed in the section dealing with Research Question 1, above. To re-cap, correlation was applied to the eight variables representing *aesthetic response* and this is detailed in Table 21, above. Table 21 indicates that correlations are positive with medium to strong correlations among all of the variables.

ANCOVA: Façade colour and individual differences

ANCOVA results for each of the individual characteristics (gender, age, country of birth and familiarity) and the independent variable of façade colour treatment with respect to the dependent variables related to aesthetic response are detailed in Tables 36- 39.

Table 36.
ANCOVA results: Façade colour treatment*gender on eight variables

Variable and source	df	SS	MS	F[14]	Sig.
				(3, 1148)	
Treatment*gender					
Beautiful-ugly	3	11.463	3.821	1.843	.138
Pleasant-unpleasant	3	17.297	5.766	2.526	.056
Stimulating-boring	3	23.351	7.784	**3.680**	**.012**
Exciting-dull	3	23.351	2.249	1.136	.333
Harmonious-inharmonious	3	10.241	3.414	1.483	.217
Sympathetic-unsympathetic	3	7.661	2.554	1.246	.292
Fits/Contrasts w/ surroundings	3	10.835	3.612	1.340	.260
Like-dislike	3	26.999	9.000	**3.148**	**.024**

Note. n = 1,152; p < .05.

In terms of evaluating responses for eight variables linked to aesthetic response by façade colour treatment and the variable gender, the results in Table 36 show that the F ratio exceeds the critical value in the two cases highlighted in bold. In terms of the significance levels of this interaction effect, the Sig. values from the Test of Between-Subjects Effects provides an indication of significance and a Sig. value less than .05 is considered to indicate a statistically significant difference (Pallant, 2005). The Sig. value for the variables: Stimulating-boring and Like-dislike was less than the benchmark value of 0.5, indicating a statistically significant effect for the variables Like-dislike and Stimulating-boring when comparing responses to façade colour by the variable gender (Pallant, 2005).

In relation to evaluating responses for eight variables linked to aesthetic response on four façade colour treatments by age, the results of Table 37 indicate that the *F* ratio exceeds the critical value of 2.60 in the four cases highlighted in bold. The Sig. values highlighted in bold are below the benchmark of 0.5, indicating a statistically significant effect for the variables: beautiful-ugly, stimulating-boring, exciting-dull and like-dislike.

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[14] The critical value for the F ratio (3, 1148) is 2.60 (Argyrous, 2001).

Table 37.
ANCOVA results: Façade colour treatment*age on eight variables

Variable and source	df	SS	MS	F	Sig.
				(3, 1148)	
Treatment*age					
Beautiful-ugly	3	30.054	10.018	**4.898**	**.002**
Pleasant-unpleasant	3	7.112	2.371	1.034	.377
Stimulating-boring	3	31.740	10.580	**5.022**	**.002**
Exciting-dull	3	27.163	9.054	**4.638**	**.003**
Harmonious-inharmonious	3	6.585	2.195	.952	.415
Sympathetic-unsympathetic	3	3.631	1.210	.589	.622
Fits/Contrasts w/ surroundings	3	9.710	3.237	1.206	.306
Like-dislike	3	27.747	9.249	**3.244**	**.021**

Note. n = 1,152; p < .05.

In terms of evaluating responses for eight variables linked to aesthetic response on four façade colour treatments by country of birth, the results detailed in Table 38 indicate that the *F* ratio did not exceed the critical value of 2.60 in any of the cases. The results indicate that country of birth does not appear to elicit differences in variables linked to aesthetic response in respect to the four façade colour treatments.

Table 38.
ANCOVA results: Façade colour treatment*country of birth on eight variables

Variable and source	df	SS	MS	F	Sig.
				(3, 1148)	
Treatment*region of birth					
Beautiful-ugly	3	7.608	2.536	1.241	.294
Pleasant-unpleasant	3	2.563	.854	.373	.772
Stimulating-boring	3	6.118	2.039	.957	.412
Exciting-dull	3	3.555	1.185	.600	.615
Harmonious-inharmonious	3	2.456	.819	.356	.785
Sympathetic-unsympathetic	3	3.427	1.142	.559	.642
Fits/Contrasts w/ surroundings	3	.622	.207	.078	.972
Like-dislike	3	6.969	2.323	.810	.489

Note. n = 1,152; p < .05.

In relation to evaluating responses for eight variables linked to aesthetic response on four façade colour treatments by familiarity, the results detailed in Table 39 indicate that the *F* ratio exceeds the critical value of 2.60 in the three cases highlighted in bold. The Sig. values highlighted are below the benchmark of 0.5, indicating a statistically significant

effect for only two variables: beautiful-ugly and exciting-dull. These results suggest that familiarity appears to elicit significant differences in two variables linked to aesthetic response (beautiful-ugly and exciting-dull) in respect to the four façade colour treatments.

Table 39.
ANCOVA results: Façade colour treatment*familiarity on eight variables

Variable and source	df	SS	MS	F (3, 1148)	Sig.
Treatment*familiarity					
Beautiful-ugly	3	21.932	7.311	**3.568**	**.014**
Pleasant-unpleasant	3	5.995	1.998	.875	.454
Stimulating-boring	3	3.463	1.154	.541	.655
Exciting-dull	3	18.129	6.043	**3.083**	**.027**
Harmonious-inharmonious	3	4.657	1.552	.676	.567
Sympathetic-unsympathetic	3	3.959	1.320	.645	.586
Fits/Contrasts w/ surroundings	3	12.520	4.173	1.567	.196
Like-dislike	3	20.496	6.832	**2.392**	.067

Note. n = 1,152; p < .05.

In conclusion, the above results suggest that the null hypothesis should be rejected in favour of the alternative hypothesis: that variations in variables linked to aesthetic response are associated with patterns of variation in a range of individual differences. However, a significant effect was limited to a number of key variables: beautiful-ugly, exciting-dull, stimulating-boring and like-dislike. So, while technically the null hypothesis should be rejected, there is only minimal evidence to support the alternative hypothesis – that is, that variation in individual differences may be associated with variations in *aesthetic response* to façade colour. The variables that appear to be influenced by individual differences are summarised in Table 40.

Table 40.
Variables influenced by gender, age, country of birth and familiarity

	Gender	Age	Country of birth	Familiarity
Beautiful-ugly		✓		✓
Pleasant-unpleasant				
Stimulating-boring	✓	✓		
Exciting-dull		✓		✓
Harmonious-inharmonious				
Sympathetic-unsympathetic				
Fits/contrasts with surroundings				
Like-dislike	✓	✓		

Research question 6: Façade colour and group differences

The sixth research question focused on whether differences in *aesthetic response* to façade colour treatment was associated with group differences in respect to the three sample group subsets of the group: post-graduate students from the Faculty of Architecture, post-graduate students from non-Architecture Faculties and members of the general population. It was anticipated that aesthetic response may vary between the subsets especially between students from the Faculty of Architecture and the other two subsets due to a possible educational bias among students from the Faculty of Architecture. The null and alternative hypotheses are as follows.

H_0: $\mu AR_{T1\text{-}4 \text{ (Subset 1)}} = \mu AR_{T1\text{-}4 \text{ (Subset 2)}} = \mu AR_{T1\text{-}4 \text{ (Subset 3}}$

$H6$: $\mu AR_{T1\text{-}4 \text{ (Subset 1)}} \neq \mu AR_{T1\text{-}4 \text{ (Subset 2)}} \neq \mu AR_{T1\text{-}4 \text{ (Subset 3}}$

where μ is population mean; 'AR' refers to *aesthetic response*[r]; T1-4 represent four façade colour treatments and Subsets 1-3 represent 3 subsets of the sample population.

ANCOVA: Façade colour and group differences

ANCOVA was used to address the final research question of this study. Four façade colour treatments were investigated in conjunction with the variable relating to the sample group subset in respect to the eight dependent variables representing *aesthetic response*. Results of two-way ANOVA are detailed in Table 41.

Table 41.
ANCOVA results: Façade colour treatment*group (sample group subset) on eight variables

Variable and source	df	SS	MS	F (3, 1148)	Sig.
Treatment*Sample sub-set					
Beautiful-ugly	3	8.390	2.797	1.353	.256
Pleasant-unpleasant	3	12.801	4.267	1.868	.133
Stimulating-boring	3	15.306	5.102	2.403	.066
Exciting-dull	3	16.199	5.400	**2.747**	**.042**
Harmonious-inharmonious	3	5.524	1.841	.800	.494
Sympathetic-unsympathetic	3	3.681	1.227	.598	.616
Fits/Contrasts w/ surroundings	3	5.344	1.781	.661	.576
Like-dislike	3	12.082	4.027	**4.027**	.240

Note. $n = 1,152$; $p < .05$.

The critical value for the *F* ratio (3, 1148) of 2.60 is exceeded in respect to two variables: Exciting-dull and Like-dislike. The Sig. value highlighted in bold is below the benchmark of 0.5, indicating a statistically significant effect for only one variable: exciting-dull.

Given such a minor level of statistical justification as detailed in Table 41, it is difficult to reject the null hypothesis in favour of the alternative hypothesis. Therefore, the null hypothesis holds – that is, that differences in patterns of aesthetic response to façade colour treatment are not associated with group differences in respect to the three sample group subsets of the main study: post-graduate students from the Faculty of Architecture, post-graduate students from non-Architecture Faculties and members of the general population.

Strengths and limitations of data analysis

It is important to reiterate that data analysis was underpinned by two key assumptions. Firstly, the data arising from the main study was actually continuous data rendered as ordinal data and then treated as quasi-interval data as discussed in the first section of this chapter. As discussed earlier, it is acknowledged that the responses of a subjective nature are a combination of emotional reactions, cognitive judgements and connotative meanings and these may be non-linguistic and therefore difficult to quantify. The imposition of intervals on the measurement instrument via the inclusion of labelled anchor points enabled the identification and subsequent quantification of continuous data. This quantification process does not imply that the underlying data is anything other than continuous and highly subjective.

The second assumption underpinning data analysis related to the use of parametric statistical analysis methods to address the research questions of this study. The use of parametric statistical analysis methods implies that the findings, which relate specifically to the sample group, may be generalised in regard to the population from which the sample was drawn. However, it is unwise to assume that this is true and further studies are required to ascertain the degree to which the findings may or may not hold true for the population as a whole. This is a key limitation of the data analysis results discussed in this chapter.

The above data analysis results relates to the four façade colour treatments used in this study. In using four treatments, this study used a very small proportion of the enormous range of possible façade colour treatments. Furthermore, only two classifications of façade colour (harmonious and contrasting) were represented and these were depicted using two façade colours each. The results therefore need to be considered in view of such a limited range of façade colour treatments.

It regard to the small effect sizes indicated by the data analysis, feedback from colleagues suggested that these small effect sizes may have arisen due to the subtlety of façade colour treatment used in the main study. That is, if the visual stimuli featured façade colour treatments that were more exaggerated in terms of their classifications of harmonious or contrasting, and if the treatments within these classifications exhibited less subtlety, the effect sizes may have been larger. Subsequent studies of a similar nature may shed some light on this hypothesis.

Only a third of the sample group comprised members of the general public. While landscape preference and assessment studies often use university and college students, the use of such a narrow sample of participants can weaken the conclusions and findings of a study. Partially to address this limitation, and, as discussed above, members of the general public comprised a third of the sample group while the remaining two thirds comprised part-time, graduate university students. The rationale being that part-time graduate students are more likely to reflect the demographic characteristics of the general public than full-time, under-graduate university students.

Factor analysis was applied in this study as an exploratory measure to ascertain the variables that best summarised or supported the construct: aesthetic response from the ten variables derived from the literature and linked to this construct. Factor analysis has been found to exhibit differences in correlations when applying different factor analysis methods (Coxhead and Bynner, 1981). However, SPSS software has greatly improved the application of factor analysis, allowing for multiple rotations of the data provided large sample sizes are used (Hinton, 2004; Pallant, 2005; Tabachnick & Fidell, 1996). In this study, patterns of correlation suggested a very strong correlation between the variables linked to aesthetic response (like-dislike, beautiful-ugly, pleasant-unpleasant, harmonious-inharmonious, sympathetic-unsympathetic, fits/contrasts with surroundings,

stimulating-boring, and exciting-dull). While the number of variables linked to this construct is limited, the strength of correlation indicates that these variables provide a robust indicator of the construct aesthetic response in terms of the relationship with façade colour.

Despite the weaknesses and limitations mentioned above, this study found a robust statistical basis for asserting that changes in façade colour are associated with differences in judgements about a building's size. Variations in judgements with regard to the variable Large-small exceeded 5%; and variations in judgements with regard to the variable Dominating-insignificant exceeded 11% when comparing harmonious and contrasting façade colour treatments. In addition, in regard to judgements about the congruity of a building relative to its surroundings, a robust statistical basis found that variations in reponse exceeded 13% when comparing harmonious and contrasting façade colour treatments. These strong results may provide support for implications embedded in planning policy that suggest that harmonious façade colours contribute positively to scenic amenity and the minimisation of visual contrast. In addition, these results are supported by the findings of Preliminary Study #2, which used qualitative methodology to identify and classify harmonious façade colour and contrasting façade colours.

PART D: DISCUSSION AND CONCLUSIONS

This section includes a discussion and extrapolation of the research findings and the

significance of the research includes the following:

- Examination and extrapolation of the research findings;
  - Environmental colour mapping using digital technology;
  - Façade colour classifications;
  - Façade colour and aesthetic response;
  - Façade colour and congruity;
  - Façade colour and size;
  - Façade colour and preference;
  - Façade colour and individual differences;

- Limitations of the research findings

- Significance of the research

  - Key recommendation for planning policy: A new approach to façade colour evaluation

- Future research directions

Examination and extrapolation of the research findings

This research provides new knowledge in regard to the interface between façade colour and aesthetic response. The results discussed above suggest that some weaknesses in the planning instrument that prompted this research initially. Firstly, the planning instrument may have relied on assumptions in relation to façade colour that are not necessarily supported by empirical evidence. A key assumption appears to be that responses to façade colour are universal and predictable. Secondly, that people prefer buildings along the harbour-side to be effectively colour-camouflaged ensuring that they are almost indistinguishable from the natural surroundings. And, thirdly, that people prefer buildings with harmonious façade colours as opposed to contrasting façade colours

In addition, the findings from this research seem to suggest that an alternative to the current, prescriptive approach to planning guidelines relating to façade colour may be inappropriate. This suggestion is based on the evidence discussed above whereby responses to façade colour varied and were not found to be universal or necessarily predictable. This section discusses the full range of findings from the research and provides some recommendations for planners in respect to façade colour as well as some directions for future research.

Environmental colour mapping using digital technology

Environmental colour mapping is considered to be a reliable process for isolating and identifying environmental colour characteristics (Foote, 1983; Iijima, 1995, 1997; Lenclos, 1976; Porter, 1997). This research incorporated applied digital technology into a number of stages of the process via a case study approach. It was found that incorporating digital technology into the process provided an effective technique to isolate, identify and manipulate environmental colour characteristics.

Façade colour classifications

This research found that façade colours can be classified using terms harmonious and contrasting. Within the context of this research, harmonious façade colours are those that exhibit hue similarity relative to the colour characteristics of the surroundings. Contrasting façade colours are those that exhibit variation in hue relative to the colour characteristics of the surroundings.

However, a key point here is that façade colour classifications are relative to the colour characteristics of the surroundings. In the main study of this research, these classifications related to buildings surrounded by natural vegetation, the main colour characteristic of natural vegetation in this instance being green. Therefore, the façade colour classifications were relative to the hue of green.

This research found that façade colour classifications were not watertight and some overlap occurred between façade colour classifications. Two façade colour treatments initially classified as contrasting were later classified as harmonious leading to the conclusion that responses to façade colour may not be completely universal and predictable. Figure 65 illustrates façade colours classified as contrasting and harmonious as well as the two façade colours classified as both contrasting and harmonious. However, as discussed above on page 118, simultaneous contrast (an effect that occurs automatically between the façade colours and the colours of the surroundings) causes some of the façade colours to appear brighter and more highly saturated. The façade colour classifications of harmonious and contrasting need to be considered in light of this effect.
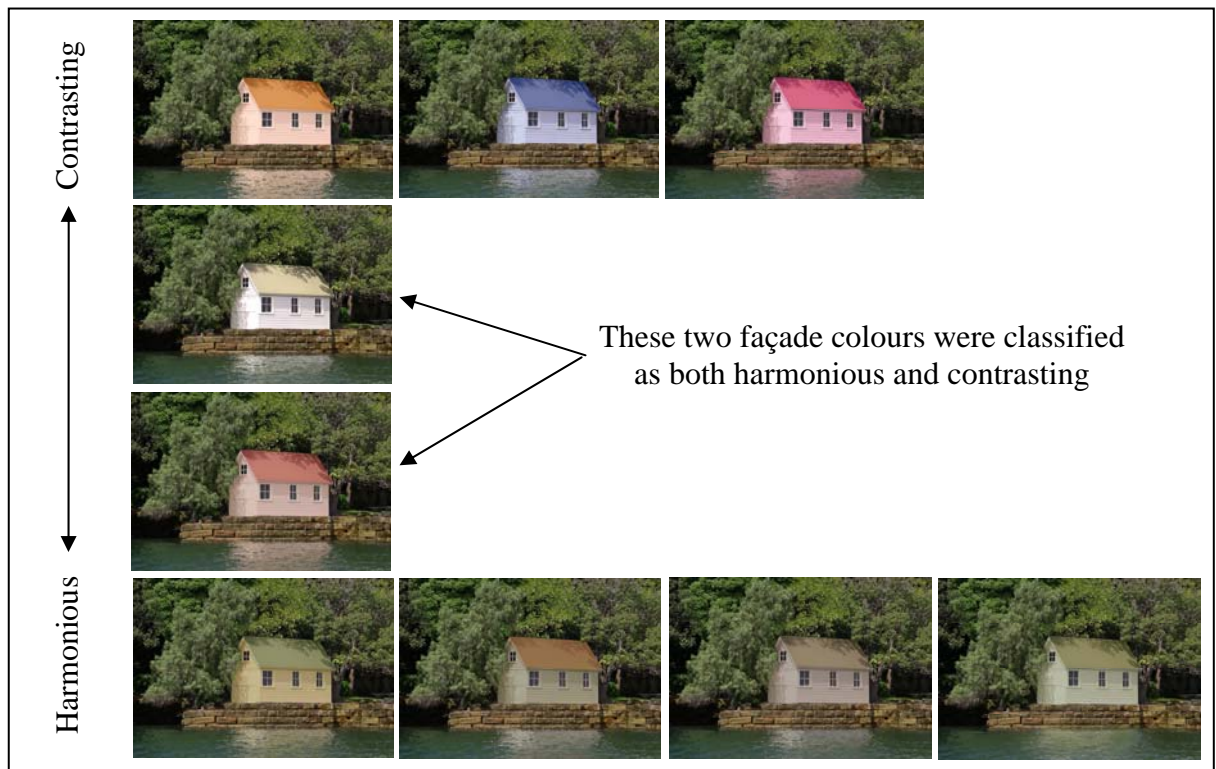
Figure 65. Façade colour classifications: Harmonious to contrasting.

Façade colour and aesthetic response

This research investigated the relationship between aesthetic response and façade colour. As expected, aesthetic response was found to vary in relation to the four different façade colour treatments that featured in the visual stimuli of the main study. In addition, overall aesthetic response varied between the two classifications of façade colour. Figure 66 illustrates that façade colour treatment 4 scored higher in terms of overall aesthetic response, followed by treatments 1, 2 and 3.
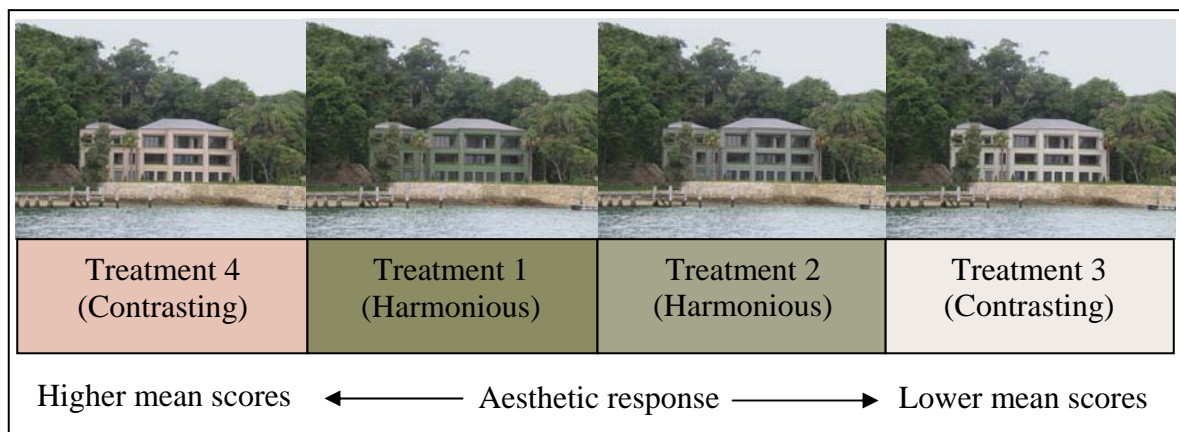
Figure 66. Façade colour and aesthetic response (as featured on Building 3).

Of the ten variables initially linked to aesthetic response, eight were found to have a strong correlation: like-dislike, beautiful-ugly, pleasant-unpleasant, exciting-dull, stimulating-boring, harmonious-inharmonious, sympathetic-unsympathetic, fits with surroundings-contrasts with surroundings. Variables linked to judgements about a building's size were found to be statistically separate to the variables linked to aesthetic response.

These results are significant because current planning policy in Sydney tends to assume that the notion of scenic quality rests on a lack of contrast in general and a lack of contrast in terms of façade colour. This study shows that positive overall aesthetic response occurs with contrasting façade colour as well as harmonious façade colour.

Façade colour and preference

The results relating to façade colour and aesthetic response need to be tempered by the findings in respect to façade colour and preference whereby preference for most preferred façade colour treatment was façade colour treatment 3 (off-white). The status of least

preferred façade colour treatment was equally shared by treatment 1 (dark green) and treatment 4 (terracotta). Preference for a particular building varied from the mean score for each building by as much as 13% in some cases due to variations in façade colour treatment. Figure 67 illustrates façade colour and preference ratings depicted on Building 3.
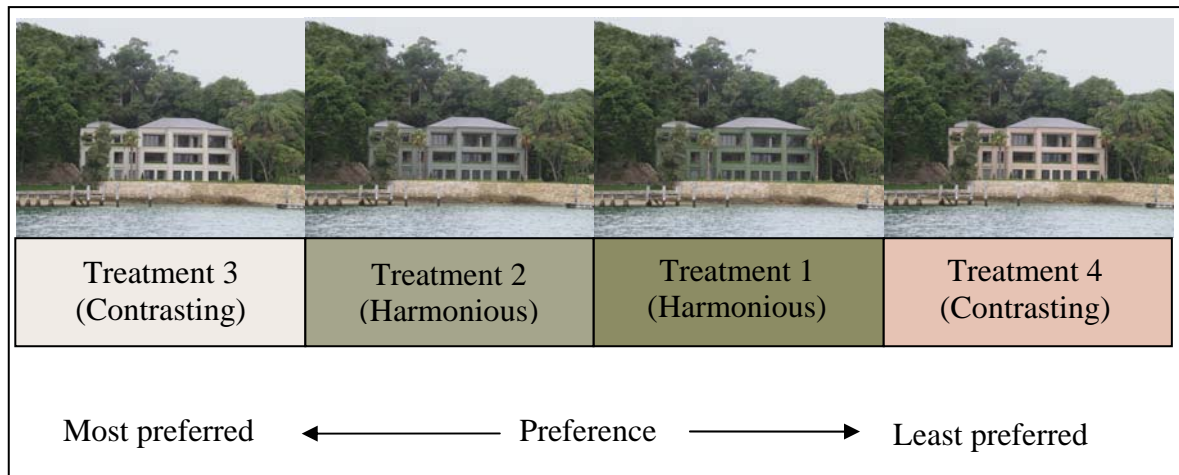
Figure 67. Façade colour and preference (featured on Building 3).

Again, these results are significant because preference for façade colour includes both contrasting and harmonious façade colours and is not limited to just harmonious façade colours, as planning policy would suggest.

Façade colour and size

This research found that façade colour influences judgements about a building's size and apparent visual dominance. Differences in judgements about building size exceeded 5% between harmonious and contrasting façade colours, with contrasting façade colours appearing larger. Differences in judgements about dominance reached nearly 12% between harmonious and contrasting façade colours, with contrasting façade colours making a building appear more dominant.

Differences in judgements about building size and dominance were consistent across all four buildings featured in the visual stimuli, but the effect size varied marginally among the buildings. Building 1 (illustrated in Figure 68), for example, exhibited the largest difference in judgements about building size and dominance across the four façade colour treatments. (As mentioned above, the notion of harmonious and contrasting façade

colours are relative to the colours of the surroundings and, in this case, the surrounding colour is predominantly green).
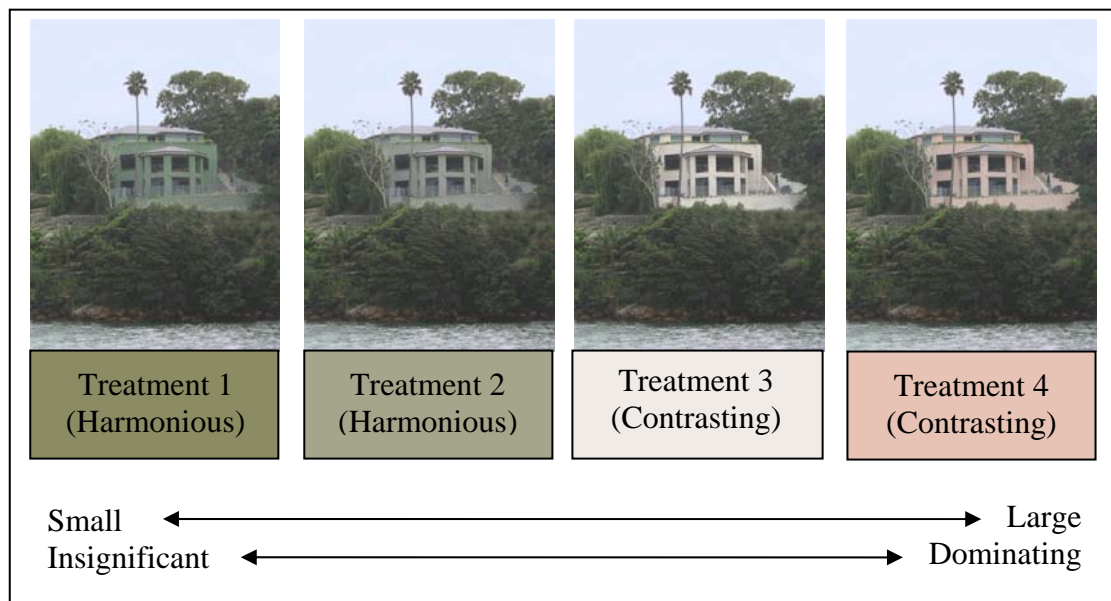
Figure 68. Façade colour and judgements about size (as featured on Building 1).

The role of façade colour in terms of judgements about a building's size and visual dominance may be useful for architects and planners. The façade colour of buildings or structures that are likely to impact on visual amenity may be manipulated to match the colour characteristics of their surroundings to minimise the appearance of their size and visual dominance.

Façade colour and congruity

Façade colour appears to influence judgements about a building's congruity. That is, as a building's façade colour changes, so too do judgements about the building's congruity relative to its surroundings. In this study, buildings that featured harmonious façade colours classified were found to be more harmonious and sympathetic, and to 'fit' in terms of their surroundings. However, the effect size in relation to the variables representing congruity was statistically small and the mean scores of all four façade colour treatments tended to hover around the mid point. This indicates that façade colour may actually play a lesser role in judgements about a building's congruity relative to its surroundings than perhaps other attributes such as style and size.

It needs to be noted that these findings relate to images of buildings situated in natural surroundings where the dominant colour characteristics of the surroundings are green. The results may have varied for images that featured buildings whose surroundings featured elements other than natural elements.

Façade colour and individual differences

Four variables were used to represent the construct: individual differences. Variations in aesthetic response were found to be associated with differences in these variables. While the significance values were low, gender, age and familiarity appear to be associated with variations in overall aesthetic response to façade colour. These results lend some support to the notion that responses to colour in general (and façade colour in particular) may be somewhat more idiographic and less predictable than the literature suggests.

As discussed earlier, some planning instruments contain guidelines relating to external building colour that appear to be underpinned by the assumption that responses to colour are universal and predictable. This view is upheld by some colour theorists (for example, see Albers, 1963; Munsell, 1912; Otswald, 1916). However, more recent colour theorists suggest that responses to colour may not be universal and predictable, but perhaps more idiographic and stochastic (for example, see Hard & Sivik, 2001). Given the limited range of façade colour treatments used in this study as well as the limited range (in terms of age and country of origin) of participants, it seemed inappropriate to investigate these notions further within the context of this study, thereby providing an opportunity for a more in-depth future study.

Façade colour and planning policy

The results from this research indicate that variations in aesthetic response to façade colour appear to vary depending on hue rather than on the façade colour classifications of harmonious and contrasting (as illustrated in Figure 66 above). Variations in preference for façade colour, as illustrated by Figure 67, adds weight to this assertion. These particular findings do not support current planning policy in Sydney wherein harmonious façade colours are recommended over contrasting façade colours. However, as discussed earlier, harmonious façade colours are associated with positive judgements about a building's congruity relative to its surroundings albeit to a small degree. This particular finding does support current planning policy in respect to façade colour.

Limitations of the research findings

This research contains some strengths and a range of limitations, many of which have been discussed in some detail within each of the preceding chapters. However, the key limitations of the research are reiterated as follows.

The effectiveness of the environmental colour mapping process using digital technology process was investigated using only one case study. Ideally, a number of case studies should be conducted to examine the effectiveness and reliability of this process.

The research examined responses to façade colour without investigating the reasons for such responses. On the whole, the research employed mostly quantitative research methods and the construct of aesthetic response was considered to comprise ten variables. As discussed above, aesthetic response is a complex human response and limiting the complexity of such as response to ten variables represents a key limitation of this research. However, this limitation also stands as an opportunity for further research in relation to the nature of the relationship between façade colour and aesthetic response wherein an equally large study employing qualitative methods may provide a richer and deeper understanding of the nature of this relationship.

The results of the Main Study relate to only four façade colour treatments as illustrated on digital photographic images of four buildings on Sydney Harbour. Caution needs to be exercised therefore in terms of generalising the findings from the Main Study to other settings or the real world and this stands as a key limitation of the research. In addition, only a small number of façade colour treatments featured in Preliminary Study #2 and the Main Study. This small number of façade colour treatments represented a tiny fraction of the huge gamut of possible façade colour treatments. Furthermore, the research focussed on examining responses to one façade colour exhibited as an overall homogenous colour as opposed to a range of façade colours within the one façade of a building.

In addition, the research focussed on the topic of aesthetic response to façade colour within the context of urban design and planning in Sydney. As such, the research may have limited relevance to other locales. As discussed above, planning policy with respect

to façade colour in places such as Italy, Sweden, Norway and Greece appears to be quite different to Sydney.

The visual stimuli featured two residential buildings and two boatsheds, and the results of the Main Study relate to these two buildings. It would be unwise to generalise the findings discussed above to other types of buildings such as industrial structures, commercial buildings, places of worship, institutions of learning and so on.   This limitation represents a direction for future research.

The data analysis and subsequent discussion of the data analysis findings focussed on the key research questions as detailed in the section on Methods. To maintain an appropriate focus on these research questions, other research questions and avenues of investigation were by-passed. For example, Research Question 5 focussed on investigating patterns of response to façade colour in terms of individual differences solely to identify whether patterns of response varied along with individual differences – that is, to determine whether responses to façade colour can be classified universal or not. By focussing on this, the research did not venture further and specify levels of difference in terms of the four characteristics chosen to represent individual differences: gender, age, region of birth and familiarity. This stands as a limitation of this research but also an opportunity for further investigation in terms of the data gathered during the course of this research.

Finally, the data analysis was underpinned by a number of assumptions about the data as discussed in the Results of the Main Study chapter. These assumptions include the conversion of continuous data to ordinal data to quasi-interval data; the use of parametric data analysis methods; the assumption of normality; and the level of significance applied to the results of the data analysis.   These assumptions are considered to be somewhat contentious and the results of the Main Study need to be examined in view of these assumptions.

Significance of the research

This research has some significance across a number of areas from urban design and architecture to planning policy. Various aspects of the research have already added to the body of knowledge in regard to urban design in terms of environmental colour mapping

and façade colour classification. The results of the Main Study have particular relevance to planning policy in Sydney and one key recommendation is discussed below.

Environmental colour mapping using digital technology adds to the body of knowledge in respect to previously published environmental colour mapping studies. The process discussed in Preliminary Study #2 provides an effective means of identifying, isolating and manipulating environmental colour characteristics with possible applications in architectural practice and urban design. The process also has potential for use in corporate design and marketing.   Details of the process have been published in a peer-reviewed journal and are due to be included in a book section as follows:

O'Connor, Z. (2006). Environmental colour mapping using digital technology: A case study. *Urban Design International*, 11 (1), 21-28.

T. Porter & B. Mikellides (Eds.) (In press) *Colour for architecture (2nd edition)*. London: Studio Vista.

The façade colour classifications identified in Preliminary Study #2 add to the body of knowledge relating to the nature of the relationship between aesthetic response and façade colour. A discussion of the façade colour classifications applied in this study has been published in a peer-reviewed journal as follows:

O'Connor, Z. (2006). Bridging the gap: Façade colour, aesthetic response and planning policy. *Journal of Urban Design*, 11 (3), 335-345.

The findings from the Main Study relating to the influence of façade colour on judgements about a building's size and visual dominance has some significance in the area of planning policy.   This knowledge is particularly useful for architects and planners in respect to buildings or structures that are likely to impact on visual amenity and in relation to buildings or structures that are likely to impact negatively on the visual quality of particular locations. Manipulating the façade colour of such buildings and structures may provide a means or minimising the 'eyesore' tag often assigned to power stations, factory buildings and the like.

The findings of the Main Study have particular relevance to planning policy in Sydney and have prompted a key recommendation identified and developed during the course of this research.   This recommendation provides a new approach to façade colour within the context of planning policy in Sydney.

Key recommendation for planning policy: A new approach to façade colour evaluation

In response to the findings of this research, a new approach to façade colour evaluation is proposed. Illustrated in Figure 69, the model of façade colour evaluation provides an alternative to the existing, prescriptive planning policies and guidelines relating to façade colour in Sydney. This model has been proposed for the following reasons.

The model allows for façade colours to be evaluated in a participatory manner by a panel of interested parties such as citizen, resident and community representatives as well as architects and planners. This participatory approach runs against current practice in Sydney whereby panels of experts may be convened to provide advice and solutions with respect to planning policy. The outcomes of such panels are then foisted onto citizens, residents and architects with minimal opportunity for discussion, involvement or recourse.
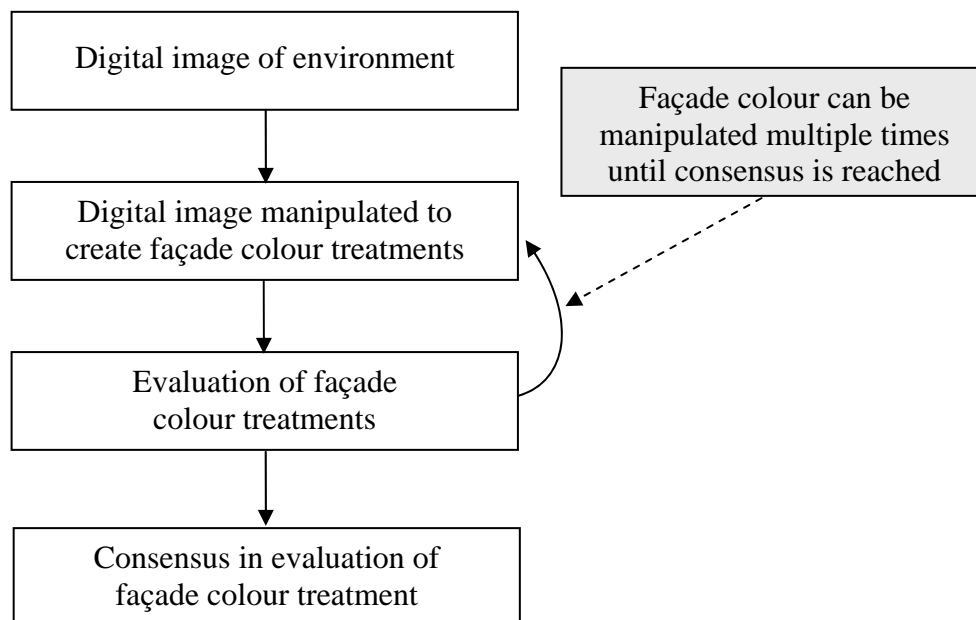
Figure 69. Model of façade colour evaluation.

The model allows for a range of façade colour options to be created and evaluated until consensus is reached with respect to a façade colour for a particular building in its unique location. The findings from this research indicate that aesthetic response to façade colour may vary and that judgements about harmonious and contrasting façade colours are not necessarily fixed. Furthermore, this research indicates that façade colour may influence judgements about the congruity of a building relative to its surroundings. The literature reveals that there is no single, accepted theory to describe or predict the nature of the relationship between colour and aesthetic response, and that theories relating to the notion

of colour harmony are diverse and contradictory. The model therefore allows multiple façade colours to be created digitally and evaluated by a broader panel of interested parties until consensus is reached regarding façade colour. This approach allows for greater freedom of expression for architects and building owners while also acknowledging the needs of concerned citizens and residents. The democratic approach underlying the operation of the model would provide a firm basis for the legitimacy of outcomes from the model from a legal perspective. The simplicity of the model, the ease with which alternative façade colours can be created, the legitimacy of outcomes and the ease with which panels could be formed for evaluation purposes means that the model is both feasible and desirable.

The model acknowledges that responses to colour may be more idiographic than universal; and perhaps more stochastic and less predictable than current planning policy seems to suggest. The model also makes some allowance for the various influences that may impinge on the relationship between aesthetic response and colour, such as individual differences, and cultural, temporal and contextual factors. Specifically in relation to contextual factors, simultaneous contrast is an effect that was found to interfere with the classification of façade colour using the terms harmonious and contrasting – as per preliminary study #2. The model provided above would also allow for the evaluation of different façade colours within a given environment and, in doing so, would also allow for the interference of the simultaneous contrast effect.

Some planning instruments in Sydney recommend that buildings should be colour-camouflaged and that external colours should closely match the colours of the natural surroundings. However, by allowing for a range of façade colours to be evaluated, the model suggests that colours other than green (as recommended by current planning guidelines) may be possible and or preferable for a particular building or location. In this way, the model reflects Appleton's (1975) assertion that "the creation of an artificial environmental capable of stimulating as aesthetic response in prospect-refuge terms does not depend on the slavish imitation of natural forms in man-made structures" (Appleton, 1975, p201).

The model allows for the creation of multiple façade colour options represented via digital photography and computer software. In this way, the model allows for the many ways that external colour may be used by architects and designers.

As mentioned above, design panels and urban design experts often provide advice on the suitability of façade colour in respect to urban developments in Sydney. However, this approach inhibits any level of citizen or community participation wherein any such participation tends to be either on a non-participation level or a tokenistic level as described by Arnstein (1969). The benefits of citizen and community participation and involvement with respect to planning issues are clearly articulated by Arnstein (1969) and the proposed model was designed to reflect these benefits.

By allowing for evaluation by a broad group of interested parties, the model also incorporates Fincher's (2003) call for planning policy that acknowledges diversity within Australian communities. In doing so, the model adopts a similar methodology used in respect to watershed management planning in the United States of America (see Webler & Tuler, 2001). The Q-sort technique elicits judgments by directing participants to sort visual stimuli into defined categories and is considered an effective tool for capturing patterns of subjective responses to a set of stimuli that feature objective physical characteristics as discussed in Preliminary Study #2 above. Earlier versions of the model of façade colour evaluation have been presented at an international conference and published in a peer-reviewed journal and details of these publications can be found in Appendix H.

Future research directions

During the course of this research, many avenues for further research became apparent and some of the possible future research directions have already been mentioned above. Some additional future research directions relate specifically to examining the methods used herein. For example, further case studies need to be conducted to investigate the effectiveness of environmental colour mapping using digital technology as only one case study was used to investigate this process in Preliminary Study #1. Similarly, the reliability of the findings arising from the F-sort and Q-sort methodology used in

Preliminary Study #2 need to be examined and further studies that mimic and expand on the methods used may shed light on the reliability of these findings discussed here.

This research examined responses to façade colour rather than investigating the underlying reasons for these responses. This research therefore acts as a basis from which to conduct further studies that focus on the nature of aesthetic response to façade colour from a qualitative perspective. In addition, during the course of the research, a number of future research directions became obvious and these included the following:

- Plot the findings arising from this research in terms of the two dimensions of affective descriptors of environments as defined by Russell, Ward and Pratt (1981) and mentioned in the Context chapter of this research;

- Investigate perceptual effects (discussed in the Context chapter) and their possible influence on aesthetic response to façade colour;

- Investigate the role of façade colour specifically in terms of scenic amenity and visual quality;

- Investigate the role of façade colour in relation to Lynch's notion of imageability;

- Examine the role of façade colour in relation to traditional and heritage-related façade colours with the aim of creating an evolving rather than a static palette of façade colours for specific locations;

- Investigate the effectiveness of architects' use of façade colour specifically among users and observers.[1]

Finally, this research investigated aesthetic response to façade colour in relation to small scale buildings situated natural surroundings. It would be interesting to compare and contrast the findings from this research with further studies that focussed on aesthetic response to façade colour in relation to larger scale buildings and structures (including industrial and commercial buildings) in other settings such as urban or rural environments.

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APPENDIX

RESPONSE TO THE BUILT ENVIRONMENT

This research session is interested in your <u>overall impression of a building in the context of its surroundings</u>.

The album handed to you contains four photographs and four questionnaires. Please look at each photograph one at a time and complete a questionnaire before looking at the next photograph and completing the next questionnaire.

There are no right or wrong answers, so please just answer each question as honestly as possible by placing a tick in the box that best corresponds with your response.

Before starting, please answer these questions about yourself.   The answers on this page and the questionnaires will be kept <u>strictly confidential</u>.

1)   What is your gender?   Male ☐   Female ☐

2)   What is your age?

10-20	21-30	31-40	41-50	51-60	61-70	71+
☐	☐	☐	☐	☐	☐	☐

3)   What is your country of birth?   _____

4)   Are you: short-sighted ☐   long-sighted ☐   colour-blind ☐

QUESTIONNAIRE

1) Which photograph are you currently looking at?

Photograph (please write down the code number):

_____

2) Is the building at the centre of the photograph familiar to you?

yes	☐	☐	☐	☐	☐	☐	☐	no

3) How would you rate this building in its surroundings?

like	☐	☐	☐	☐	☐	☐	☐	dislike
incongruous	☐	☐	☐	☐	☐	☐	☐	congruous
pleasant	☐	☐	☐	☐	☐	☐	☐	unpleasant
contrasting	☐	☐	☐	☐	☐	☐	☐	harmonious

nice	☐	☐	☐	☐	☐	☐	☐	disgusting
incompatible	☐	☐	☐	☐	☐	☐	☐	compatible
relaxing	☐	☐	☐	☐	☐	☐	☐	distressing
disorderly	☐	☐	☐	☐	☐	☐	☐	orderly
tranquil	☐	☐	☐	☐	☐	☐	☐	hectic

complex	☐	☐	☐	☐	☐	☐	☐	simple
monotonous	☐	☐	☐	☐	☐	☐	☐	alive
ugly	☐	☐	☐	☐	☐	☐	☐	beautiful
large	☐	☐	☐	☐	☐	☐	☐	small
prefer	☐	☐	☐	☐	☐	☐	☐	don't prefer

bad	☐	☐	☐	☐	☐	☐	☐	good
sympathetic	☐	☐	☐	☐	☐	☐	☐	unsympathetic
disorganised	☐	☐	☐	☐	☐	☐	☐	unified
conspicuous	☐	☐	☐	☐	☐	☐	☐	discreet
exciting	☐	☐	☐	☐	☐	☐	☐	dreary

VISUAL RESPONSE TO THE BUILT ENVIRONMENT

Thank you for taking part in this survey.

This survey is interested in your **visual impression of a building in the context of its surroundings.**

You have been given four photographs and four questionnaires. **Please look at each photograph one at a time and complete a questionnaire before looking at the next photograph and completing the next questionnaire.**

The questionnaire uses a rating scale similar to the example below. There are no right or wrong answers, just record your answer by placing a tick in the box that best corresponds to your response as per the example below.

EXAMPLE

How would you rate Sydney?

	Extremely	Very	Fairly	Neither	Fairly	Very	Extremely	
expensive	☐	☐	☑	☐	☐	☐	☐	inexpensive

1) Which photograph are you currently looking at?

Please write down the photograph's number: _____

2) Is the building at the centre of the photograph familiar to you?

Yes ☐   No ☐   Don't know ☐

3) How would you rate this building in relation to its surroundings?

Please remember: we're just interested in how you think the building looks in relation to its surroundings.

	Extremely	Very	Fairly	Neither	Fairly	Very	Extremely	
large	☐	☐	☐	☐	☐	☐	☐	small
boring	☐	☐	☐	☐	☐	☐	☐	stimulating
beautiful	☐	☐	☐	☐	☐	☐	☐	ugly
inharmonious	☐	☐	☐	☐	☐	☐	☐	harmonious
dominating	☐	☐	☐	☐	☐	☐	☐	insignificant
fits with surroundings	☐	☐	☐	☐	☐	☐	☐	contrasts with surroundings
unpleasant	☐	☐	☐	☐	☐	☐	☐	pleasant
exciting	☐	☐	☐	☐	☐	☐	☐	dull
unsympathetic	☐	☐	☐	☐	☐	☐	☐	sympathetic
like	☐	☐	☐	☐	☐	☐	☐	dislike

Now turn to the next photograph & complete the questionnaire on the next page.

4) Which photograph are you currently looking at?

Please write down the photograph's number: _____

5) Is the building at the centre of the photograph familiar to you?

Yes ☐   No ☐   Don't know ☐

6) How would you rate this building in relation to its surroundings?

Please remember: we're just interested in how you think the building looks in relation to its surroundings.

	Extremely	Very	Fairly	Neither	Fairly	Very	Extremely	
large	☐	☐	☐	☐	☐	☐	☐	small
boring	☐	☐	☐	☐	☐	☐	☐	stimulating
beautiful	☐	☐	☐	☐	☐	☐	☐	ugly
inharmonious	☐	☐	☐	☐	☐	☐	☐	harmonious
dominating	☐	☐	☐	☐	☐	☐	☐	insignificant
fits with surroundings	☐	☐	☐	☐	☐	☐	☐	contrasts with surroundings
unpleasant	☐	☐	☐	☐	☐	☐	☐	pleasant
exciting	☐	☐	☐	☐	☐	☐	☐	dull
unsympathetic	☐	☐	☐	☐	☐	☐	☐	sympathetic
like	☐	☐	☐	☐	☐	☐	☐	dislike

Now turn to the next photograph & complete the questionnaire on the next page.

7)   Which photograph are you currently looking at?

Please write down the photograph's number: _____

8)   Is the building at the centre of the photograph familiar to you?

Yes ☐   No ☐   Don't know ☐

9)   How would you rate this building in relation to its surroundings?

Please remember: we're just interested in how you think the building looks in relation to its surroundings.

	Extremely	Very	Fairly	Neither	Fairly	Very	Extremely	
large	☐	☐	☐	☐	☐	☐	☐	small
boring	☐	☐	☐	☐	☐	☐	☐	stimulating
beautiful	☐	☐	☐	☐	☐	☐	☐	ugly
inharmonious	☐	☐	☐	☐	☐	☐	☐	harmonious
dominating	☐	☐	☐	☐	☐	☐	☐	insignificant
fits with surroundings	☐	☐	☐	☐	☐	☐	☐	contrasts with surroundings
unpleasant	☐	☐	☐	☐	☐	☐	☐	pleasant
exciting	☐	☐	☐	☐	☐	☐	☐	dull
unsympathetic	☐	☐	☐	☐	☐	☐	☐	sympathetic
like	☐	☐	☐	☐	☐	☐	☐	dislike

Now turn to the next photograph & complete the questionnaire on the next page.

10)   Which photograph are you currently looking at?

Please write down the photograph's number: _____

11)   Is the building at the centre of the photograph familiar to you?

Yes ☐   No ☐   Don't know ☐

12)   How would you rate this building in relation to its surroundings?

Please remember: we're just interested in how you think the building looks in relation to its surroundings.

	Extremely	Very	Fairly	Neither	Fairly	Very	Extremely	
large	☐	☐	☐	☐	☐	☐	☐	small
boring	☐	☐	☐	☐	☐	☐	☐	stimulating
beautiful	☐	☐	☐	☐	☐	☐	☐	ugly
inharmonious	☐	☐	☐	☐	☐	☐	☐	harmonious
dominating	☐	☐	☐	☐	☐	☐	☐	insignificant
fits with surroundings	☐	☐	☐	☐	☐	☐	☐	contrasts with surroundings
unpleasant	☐	☐	☐	☐	☐	☐	☐	pleasant
exciting	☐	☐	☐	☐	☐	☐	☐	dull
unsympathetic	☐	☐	☐	☐	☐	☐	☐	sympathetic
like	☐	☐	☐	☐	☐	☐	☐	dislike

Now turn to the next photograph & complete the questionnaire on the next page.

Finally, please answer these questions about yourself.   Please be assured that all your answers will be kept strictly confidential.

13)   What is your gender?   Male ☐   Female ☐

                                          18-24   25-34   35-44   45-54   55-64   65+
14)   What is your age?   ☐   ☐   ☐   ☐   ☐   ☐

15)   What is your postcode?   _____

16)   What is your country of birth?   _____

17)   Are you: short-sighted ☐   long-sighted ☐   colour-blind ☐   don't know ☐

18)   Which building do you prefer and why? _____

        _____

        _____

        _____

Thank you very much for taking part in this survey.
Your contribution is greatly appreciated.

Appendix C – Participant Information Statement

The University of Sydney   **Faculty of Architecture**

NSW 2006 AUSTRALIA   Environment-Behaviour Studies

Zena O'Connor   Wilkinson Building G04
PhD Candidate   Telephone +61 2 9351 5287
Facsimile +61 2 9351 3031
Email zoco4227@mail.usyd.edu.au

Participant Information Statement

Title of the study
Visual response to the built environment.

Purpose of the study
This study forms part of a PhD investigative study into visual response to the built environment. We are specifically interested in your visual impressions about the buildings and how they appear in relation to their surroundings. Outcomes from this study may assist architects and planners to understand the factors that influence people's response to the built environment.

Method
In this study you will be given a set of questionnaires and photographs. Please look at the photographs one at a time and complete a separate questionnaire for each photograph. It should take about 10 minutes to complete the whole questionnaire.

Personal information and confidentiality
Personal information such as your name and address is not required. However we ask some questions only to compare demographic information. This information as well as your answers will be kept confidential and only used for the purpose of this study. The raw data from this study is only available to the researchers listed below. Should you be interested in the outcomes from this study please contact the researchers listed below.

Participation
Participation is voluntary and you are permitted to withdraw from the project at any time without penalty or prejudice. Should you at any time have difficulty in understanding the Participant Information Sheet, the Consent Form or the proceedings, please notify the researcher. It is important that you give your honest opinions. Unlike examinations, there are no right or wrong answers, so please answer each question as truthfully as possible.

Researchers
Student: Zena O'Connor (Phone: 02 9351 5287; email: zoco4227@mail.usyd.edu.au)
Supervisor: Professor Gary T Moore (Phone: 02 9351 5924; email: gtmoore@arch.usyd.edu.au)

Many thanks
Professor Gary T Moore & Zena O'Connor

Page 1 of 1

Important notice
Any person with concerns or complaints about the conduct of a research study can contact the Manager for Ethics Administration, University of Sydney on (02) 9351 4811.

Appendix D – Participant Consent Form

The University of Sydney **Faculty of Architecture**

NSW 2006 AUSTRALIA   Environment-Behaviour Studies

Zena O'Connor   Wilkinson Building G04
PhD Candidate   Telephone +61 2 9351 5287
                                                       Facsimile +61 2 9351 3031
                                                       Email zoco4227@mail.usyd.edu.au

Participant Consent Form

I have been asked to participate in the following survey:

Title: Visual response to the built environment
Researcher: Zena O'Connor (Phone 02 9351 5287)

I give my consent by signing this form on understanding,

1. The general purpose and methods of the survey;
2. That I may withdraw at any time and may refuse to answer questions put to me by the researchers;
3. That any information obtained in this survey, if published, will not contain the names and address or any other personal information about the participants;
4. That I understand that any concerns or complaints about the conduct of a research survey can contact the Manager for Ethics Administration, University of Sydney (Phone 02 9531 4811; fax 02 9036 9310; email gbriody@mail.usyd.edu.au);
5. That I confirm that I have read the Participant Information Statement and Consent Form.

Full name of participant:

_____

Signature of participant:

_____ Date: _____

Page 1 of 1

Appendix E – Samples of visual stimuli used in the main study

Please note, due to reproduction issues some of these images appear darker and some lighter than the images used as visual stimuli in the main study. The visual stimuli images used in the main study were reproduced in a commercial photography lab. In addition, the proportional scale of all visual stimuli was identical in the visual images used in the main study and not as reproduced in this Appendix.

B21
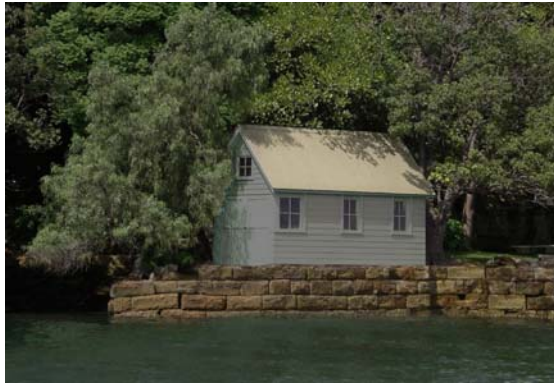

B22

B23

B24

B31

B32

B33

B34

B41

B42

B43

B44

B51

B52

B53

B54

Appendix F – Latin-square presentation format of visual stimuli

The Latin-square technique was used to standardise the presentation format of the set of visual stimuli and ensure that the visual stimuli was constantly rotated prior to assignment to participants. Tables 42 to 45 represent the visual stimuli presentation formats rotated as per the Latin-square technique. The ninety-six presentation formats have been divided into four tables only to assist with pagination.

Table 42.
Presentation formats 1 to 24

Rotation	Presentation format				Rotation	Presentation format			
1	B21	B32	B43	B54	**13**	B21	B34	B42	B53
2	B43	B21	B54	B32	**14**	B42	B21	B53	B34
3	B32	B54	B21	B43	**15**	B34	B53	B21	B42
4	B54	B43	B32	B21	**16**	B53	B42	B34	B21
5	B21	B32	B44	B53	**17**	B21	B33	B44	B52
6	B44	B21	B53	B32	**18**	B44	B21	B52	B33
7	B32	B53	B21	B44	**19**	B33	B52	B21	B44
8	B53	B44	B32	B21	**20**	B52	B44	B33	B21
9	B21	B33	B42	B54	**21**	B21	B34	B43	B52
10	B42	B21	B54	B33	**22**	B43	B21	B52	B34
11	B33	B54	B21	B42	**23**	B34	B52	B21	B43
12	B54	B42	B33	B21	**24**	B52	B43	B34	B21

Table 43.
Presentation formats 25 to 48.

Rotation	Presentation format				Rotation	Presentation format			
25	B22	B31	B43	B54	**37**	B24	B31	B42	B53
26	B43	B22	B54	B31	**38**	B42	B24	B53	B31
27	B31	B54	B22	B43	**39**	B31	B53	B24	B42
28	B54	B43	B31	B22	**40**	B53	B42	B31	B24
29	B22	B31	B44	B53	**41**	B23	B31	B44	B52
30	B44	B22	B53	B31	**42**	B31	B52	B23	B44
31	B31	B53	B22	B44	**43**	B44	B23	B52	B31
32	B53	B44	B31	B22	**44**	B52	B44	B31	B23
33	B23	B31	B42	B54	**45**	B24	B31	B43	B52
34	B42	B23	B54	B31	**46**	B43	B24	B52	B31
35	B31	B54	B23	B42	**47**	B31	B52	B24	B43
36	B54	B42	B31	B23	**48**	B52	B43	B31	B24

Table 44.
Presentation formats 49 to 72.

Rotation	Presentation format				Rotation	Presentation format			
49	B22	B33	B41	B54	**61**	B24	B32	B41	B53
50	B41	B22	B54	B33	**62**	B41	B24	B53	B32
51	B33	B54	B22	B41	**63**	B32	B53	B24	B41
52	B54	B41	B33	B22	**64**	B53	B41	B32	B24
53	B22	B34	B41	B53	**65**	B23	B34	B41	B52
54	B41	B22	B53	B34	**66**	B41	B23	B52	B34
55	B34	B53	B22	B41	**67**	B34	B52	B23	B41
56	B53	B41	B34	B22	**68**	B52	B41	B34	B23
57	B23	B32	B41	B54	**69**	B24	B33	B41	B52
58	B41	B23	B54	B32	**70**	B41	B24	B52	B33
59	B32	B54	B23	B41	**71**	B33	B52	B24	B41
60	B54	B41	B32	B23	**72**	B52	B41	B33	B24

Table 45.
Presentation formats 73 to 96.

Rotation	Presentation format				Rotation	Presentation format			
73	B22	B33	B44	B51	**85**	B24	B32	B43	B51
74	B44	B22	B51	B33	**86**	B43	B24	B51	B32
75	B33	B51	B22	B44	**87**	B32	B51	B24	B43
76	B51	B44	B33	B22	**88**	B51	B43	B32	B24
77	B22	B34	B43	B51	**89**	B23	B34	B42	B51
78	B43	B22	B51	B34	**90**	B42	B23	B51	B34
79	B34	B51	B22	B43	**91**	B34	B51	B23	B42
80	B51	B43	B34	B22	**92**	B51	B42	B34	B23
81	B23	B32	B44	B51	**93**	B24	B33	B42	B51
82	B44	B23	B51	B32	**94**	B42	B24	B51	B33
83	B32	B51	B23	B44	**95**	B33	B51	B24	B42
84	B51	B44	B32	B23	**96**	B51	B42	B33	B24

Appendix G – Sample group characteristics

Sample group characteristics – gender

The gender breakdown of the sample group is detailed in Table 46 and it is clear from this Table that the gender breakdown of the sample group closely parallels the gender breakdown of the population of Sydney, with a difference of around 3%.

Table 46.
Sample group characteristics: gender.

Gender	No. in sample	Percent	ABS Stats: Sydney[1]
Male	552	47.9	49.2
Female	600	52.1	50.8
Total	1,152	100.0	100.0

Sample group characteristics – age

The age range of participants fell into six age groups as detailed in Table 47 along with the corresponding age breakdown for the population of Sydney. There are some differences between the age group breakdown of the sample and the population of Sydney. A higher proportion of younger people occurred in the two sample group subsets that comprised post-graduate university students. This skewed the age group breakdown of the sample group to reflect a higher than usual proportion of younger people than the population of Sydney.

Table 47.
Sample group characteristics: age.

Age group	No. in sample	Percent	ABS Stats: Sydney[2]
Age: Under 18	0	0.0	24.4
Age: 18 to 24	260	22.6	9.9
Age: 25 to 34	504	43.8	16.0
Age: 35 to 44	184	16.0	15.7
Age: 45 to 54	112	9.7	13.4
Age: 55 to 64	60	5.2	8.8
Age: 65+	32	2.8	11.8
Total	1,152	100.0	100.0

---

[1] Australian Bureau of Statistics (2003). *Census of population: Basic community profiles*. Canberra ACT: ABS.
[2] Ibid.

Sample group characteristics – region of birth

Participants in the main study reported a wide range of regions of birth as detailed in Table 48. This Table also includes the regions of birth of the population of Sydney.

Table 48.
Sample group subsets by region of birth.

Region of birth	Subset 1 percent	Subset 2 percent	Subset 3 percent	Total	ABS stats: Sydney[3]
Australia, New Zealand & Oceania	59.4	8.8	61.4	46.2	68.3
Europe and the UK	7.3	4.2	21.9	10.8	12.4
Africa & the Middle East	3.1	3.1	1.0	2.4	3.3
North-east Asia	12.5	56.2	3.1	23.9	4.5
South-east & Southern Asia	13.5	8.3	5.2	9.1	8.3
North America & Canada	1.0	4.2	6.2	3.8	0.6
South America	3.1	1.0	0.0	1.4	1.0
Africa	0.0	5.2	2.0	2.4	1.0
Other/not stated	0.0	0.0	0.0	0.0	0.4
Total	100.0	100.0	100.0	100.0	100.0

Note. Subset 1: Graduate Architecture students; Subset 2: Graduate (other) students; Subset 3: General public.

The differences between the sample groups and the population of Sydney by region of birth are apparent. This is partially due to the relatively higher proportion of students from North-east Asia, North America, Canada and Africa enrolled in post-graduate courses within various Faculties at the University of Sydney; with a corresponding lower proportion of students born in Australia, New Zealand, Oceania, Europe and the UK. In addition, Subset 3 (General Public) contained a relatively larger proportion of people born in Europe, the UK, North America and Canada than Subsets 1 and 2 with a corresponding smaller proportion of people born in Africa, the Middle East, North-east, South-east and Southern Asia.

---

[3] Australian Bureau of Statistics (2001).

Sample group characteristics – familiarity

In terms of the level of familiarity with the buildings featured in the visual stimuli, participants reported minimal familiarity as detailed in Table 49.

Table 49.
Familiarity of building featured in visual stimuli.

	Frequency	Percent	Cumulative
Yes	61	5.3	5.3
No	1,086	94.3	99.6
Don't know	5	0.4	100.0
Total	1,152	100.0	

Appendix H – Publications & presentations arising from this research

Books

O'Connor, Z (In press) Digital colour mapping: An Australian case study.   In T. Porter and B. Mikellides (Eds.), Colour for architecture (2nd edition). London: Taylor and Francis.

Peer-reviewed publications

O'Connor, Z. (2006). Environmental colour mapping using digital technology: A case study. *Urban Design International, 11 (1),* 21-28. Available online at: http://www.palgrave-journals.com/udi/journal/v11/n1/abs/9000161a.html

O'Connor, Z. (2006). Bridging the gap: Façade colour, aesthetic response and planning policy. *Journal of Urban Design, 11(3),* 1-11.

O'Connor, Z. (2005). Colour harmony: An elusive concept. *Color Research and Application*. (Under review)

Published conference papers

O'Connor, Z. (2004). Environmental colour mapping using digital technology. In D. Miller & J.A. Wise (Eds.), *Design with Spirit: Proceedings of the 35th Annual Conference of the Environmental Design Research Association* (pp 71-80). Albuquerque, NM: Environmental Design Research Association.

O'Connor, Z. (2004). Concord v discord: A new approach to environmental colour harmony. In *Spatial Environments Agreeable for Human Beings: Proceedings of the 6th International Symposium for Environment-Behaviour Studies* (pp 250-256). Tianjin, China: Baihua Literature & Art Publishing House.

O'Connor, Z. (2003). Pixel perfect? Environmental colour mapping using digital technology. In S. Hayman (Ed) *Proceedings of the 37th Annual Conference of the Australian & New Zealand Architectural Science Association* (pp 686-716). Sydney, Australia: Australian & New Zealand Architectural Science Association.

Conference papers

O'Connor, Z. (2006, May) From conflict to concord: façade colour and aesthetic response (Preliminary findings). Paper presented at the *37th Annual Conference of the Environmental Design Research Association*, Atlanta, GA.

O'Connor, Z. (2005, May) Environmental colour harmony & preference: A case for diversity? Paper presented at the *36th Annual Conference of the Environmental Design Research Association,* Vancouver, Canada.

Appendix I – A summary of selected colour notation systems

This summary includes a brief resume of selected colour notation systems and is provided to give a basic understanding of such systems. Not intended as a comprehensive review of the gamut of extant systems, this summary comprises a description of some systems that are commonly referred to in the literature. The systems, included here in alphabetical order, often include reference to key or primary colours but do not generally include formulae for colour harmony.

CIE 1931 XYZ colour space

The Commission Internationale de l'Eclairage (CIE) is an international authority on light, illumination and colour (see http://www.cie.co.at/cie/). The CIE 1931 XYZ colour space was developed in 1931 to identify colour in the form of light-waves – that is, the visible light range section of the electromagnetic spectrum as illustrated in Figure 71.
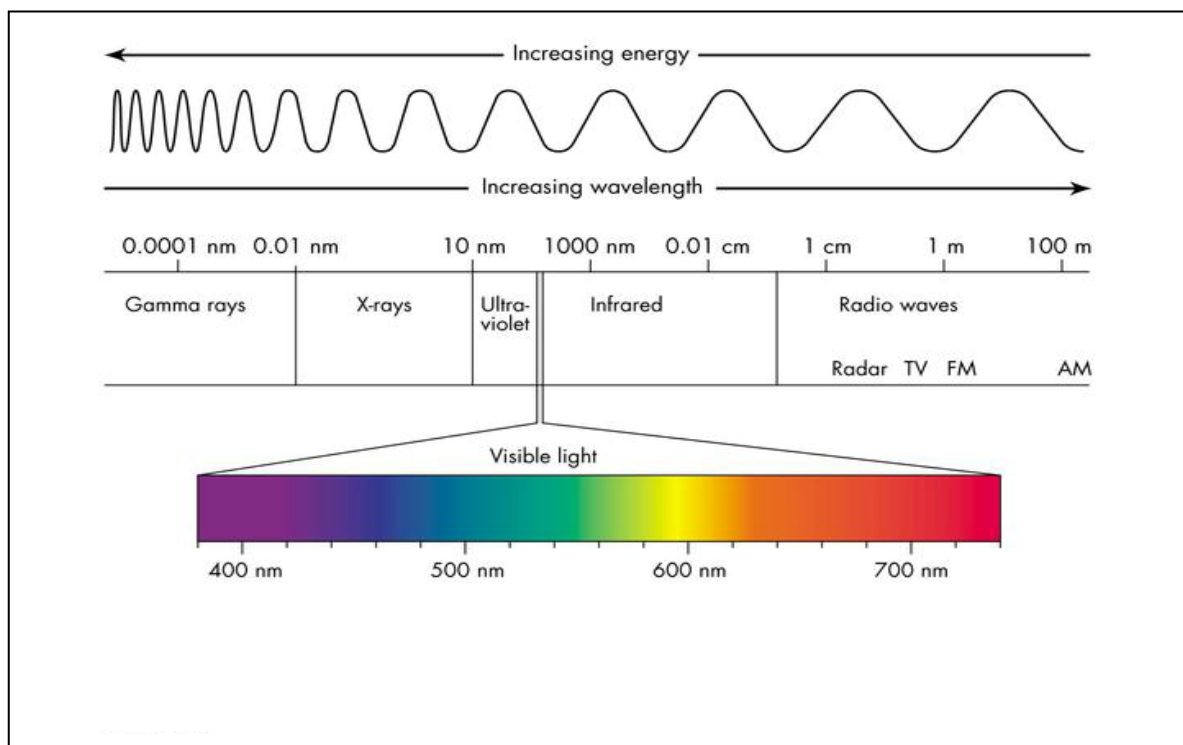

Figure 70. The electromagnetic spectrum (Image: www.mhhe.com).

The CIE publishes internationally-accepted standards relating to colour as well as illumination and light, and has developed the CIE 1964 standard observer that provides a

precise definition of a standard of light for use in colour-matching. Illustrated in Figure 71, the CIE 1931 XYZ colour space mathematically identifies colour using three values: X (red), Y (green) and Z (blue) and can mathematically identify the entire gamut of distinguishable colours using the three-dimensional space (CIE, 2007).


Figure 71.
The CIE XYZ colour space.
(Image: Sakurambo; CIE).
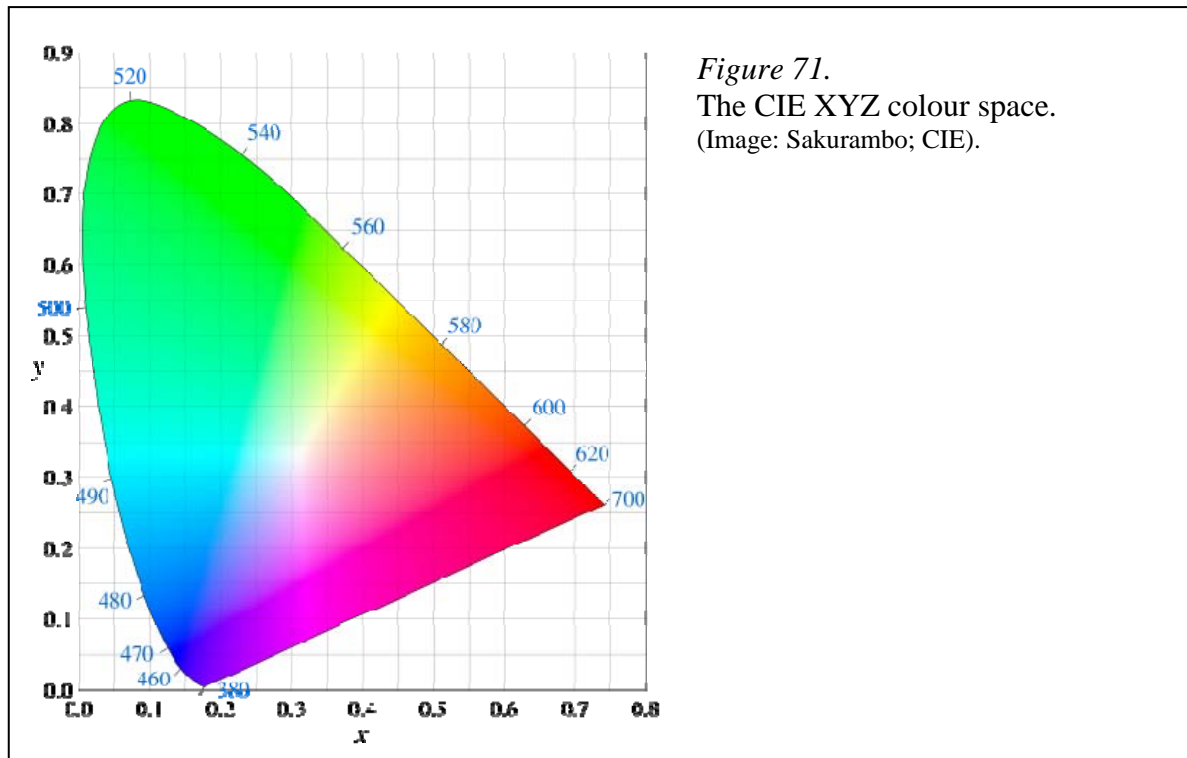
The CIELAB system, developed subsequent to the CIE 1931 XYK colour space, is primarily used in electronic colour imaging systems such as computer monitors. It is a three-dimensional colour space wherein a colour sample can be identified by the co-ordinates L (referring to lightness in regard to luminance levels) and the opponent colours of red-green (a) and blue-yellow (b) (Hill, Roger & Vorhagen, 1997). The gamut of colours within the CIELAB system is compressed and tends to deteriorated when translated into the CIEXYZ or sRGB systems (Hill *et al*, 1997).

CMYK model

Prior to digital printing technology, the CMYK colour model was commonly used in the printing industry (Feisner, 2000). The key colours in the CMYK model are: cyan (C), magenta (M), yellow (Y) and black (K) and the CMYK model is illustrated in Figure 72. The CMYK four colour printing process is used to create a wide gamut of colours in the

printing industry and does not include definitions for such notions as colour contrast or colour harmony (Feisner, 2000).

Figure 72.
The CMYK model.
(Images: http://en.wikipedia.org/wiki/CMYK)
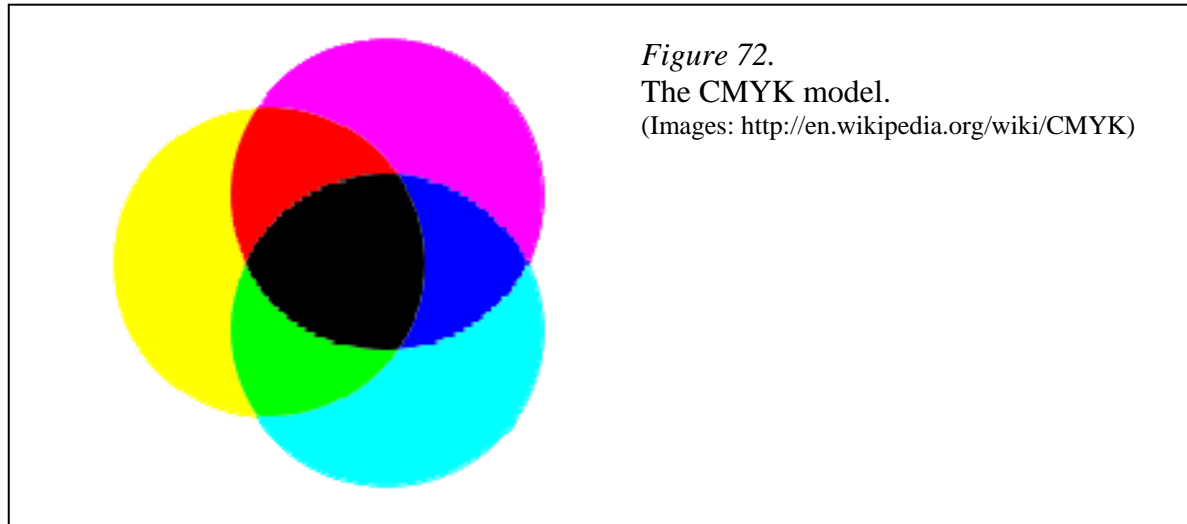
International Colour Consortium (ICC)

The International Color Consortium was convened in 1993 to develop an international specification that allows for fidelity of colour across computer operating systems and applications. The ICC Color Profile defines colour attributes and can translate colour specifications with high fidelity between different colour gamuts such as sRGB, L*a*b* and the CIE XYZ colour space. The L*a*b* colour space, developed for computer application, is based on the CIE XYZ colour space and represents a larger gamut of colour than sRGB. As it has a larger gamut of colours, it is ideal for use with digital photographic images. The ICC Color Profile is to be released as an international standard (ISO 15076) and is already widely referred to in other ISO standards.

Munsell colour system

Developed in the early 20th century, this colour system aimed to provide a means of identifying and notating colour as well as a methodology for creating colour harmony (Kuehni, 2002). Munsell identified colour using the attributes of hue, value and chroma (saturation) wherein tone occurred in a range of ten values and chroma up to twelve values (Kuehni, 2002). Figure 73 illustrates a section of the Munsell colour model.
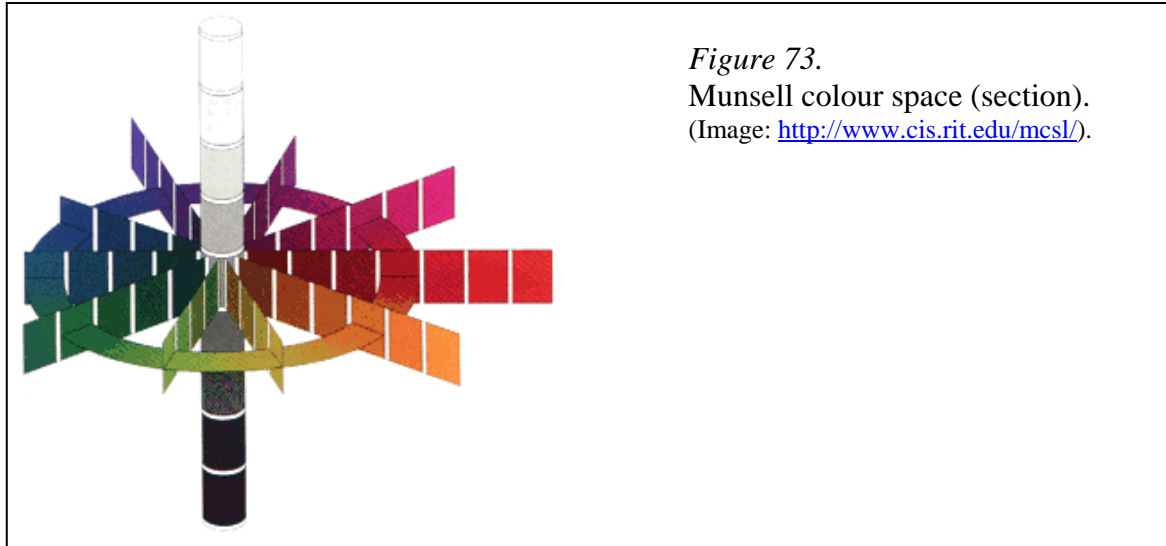
Figure 73.
Munsell colour space (section).
(Image: http://www.cis.rit.edu/mcsl/).

Under the Munsell system, there are five principal hues: red, yellow, green, blue and purple. A colour sample is identified using three numbers for hue, value and chroma based on the Munsell colour wheel model, illustrated in Figure 74.
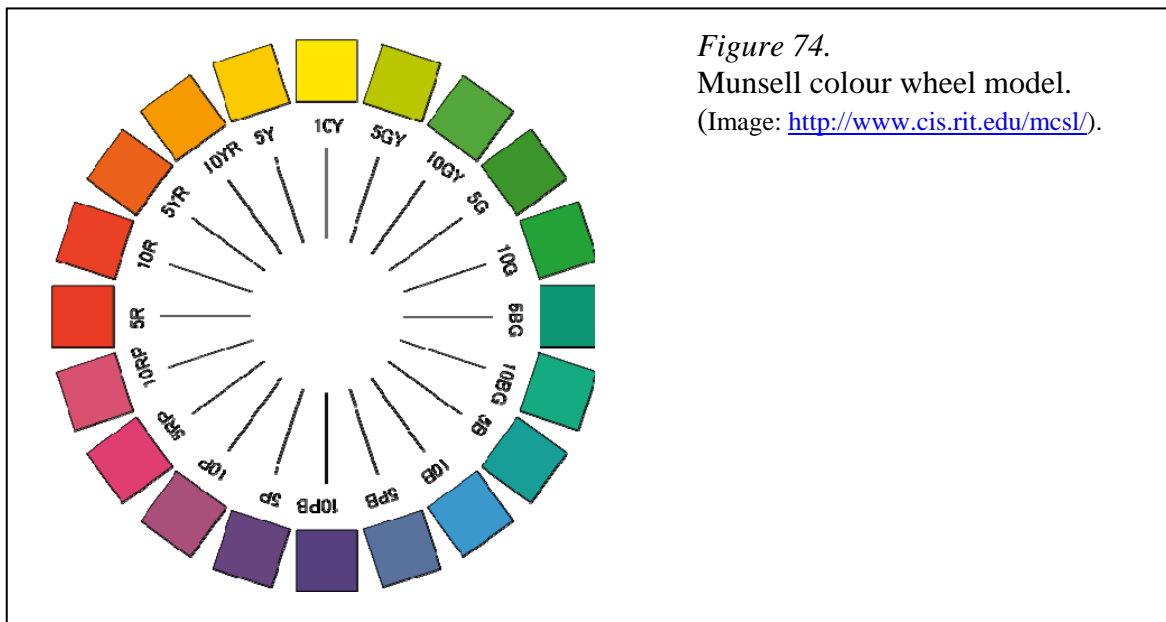

Figure 74.
Munsell colour wheel model.
(Image: http://www.cis.rit.edu/mcsl/).

A sample colour may be identified as 5G 5/10. 5G representing a mid green as per the Munsell colour wheel model; 5 representing a mid level tone (that is, tonal level 5 of 10) and saturation level 10 (of a maximum saturation level of 12).

The Munsell system is still widely used and the Munsell Color Science Laboratory continues to offer a range of Munsell Colour System products and services as well as tertiary education up to PhD level (see http://www.cis.rit.edu/mcsl/about/history). The Munsell Color Science Laboratory website provides access to current research as well as a range of colour notation and colour matching products and services.

NCS system

The Natural Colour System (NCS) evolved from the research of Ewald Hering whose research focussed on human colour perception and who determined that four "psychological" primary colours exist: red, green, blue and yellow (Hard, Sivik & Tonnquist, 1996a, p180). Under the NCS system, the six primary colours are red, green, blue, yellow plus white and black. Colour is described and classified using the key properties of hue, whiteness/blackness (luminance) and chromaticity (saturation) (Hard, Sivik & Tonnquist, 1996a, 1996b). Under the NCS system, contrasting colours are considered to be red-green, yellow-blue and white-black; also referred to as complementary colours (Hard & Sivik, 2001). The NCS system is a proprietary system owned by the Scandinavian Colour Institute AB, and a large range of colour identification, definition and management tools and products are available (see NCS http://83.168.206.163/webbizz/mainPage/main.asp). Figure 75 depicts the NCS colour model.
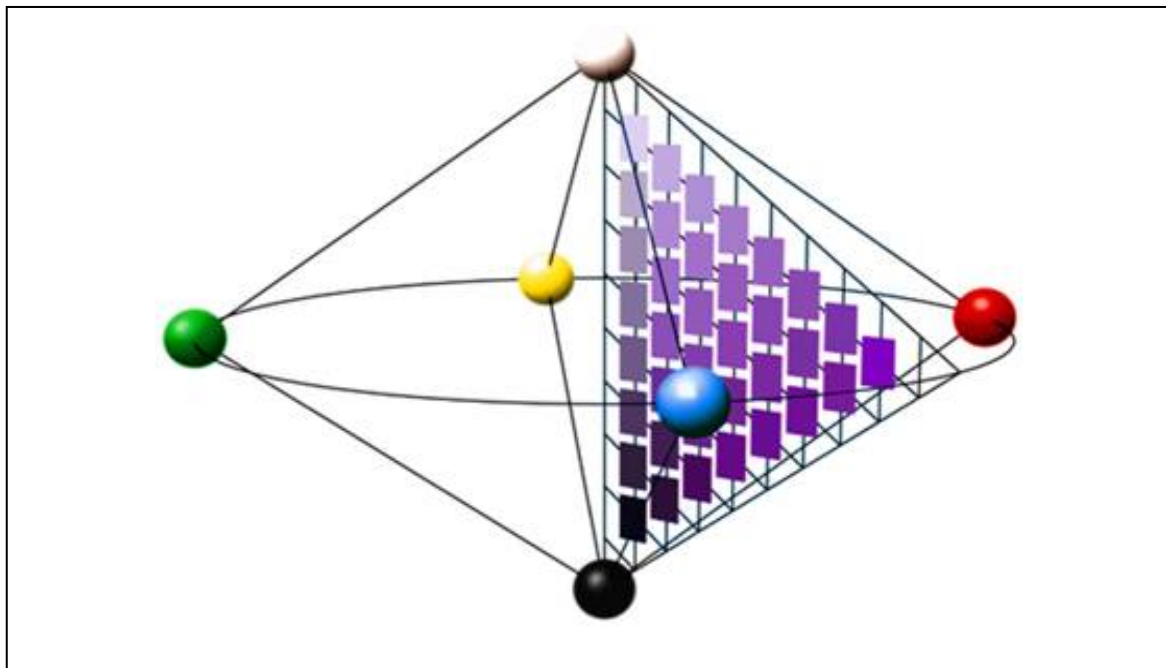
Figure 75. The NCS colour model (Image: http://83.168.206.163/webbizz/)

Under the NCS system, any colour sample can be identified using the NCS system and Figure 76 illustrates a segment of the NCS colour wheel model and identifies red Y90R.
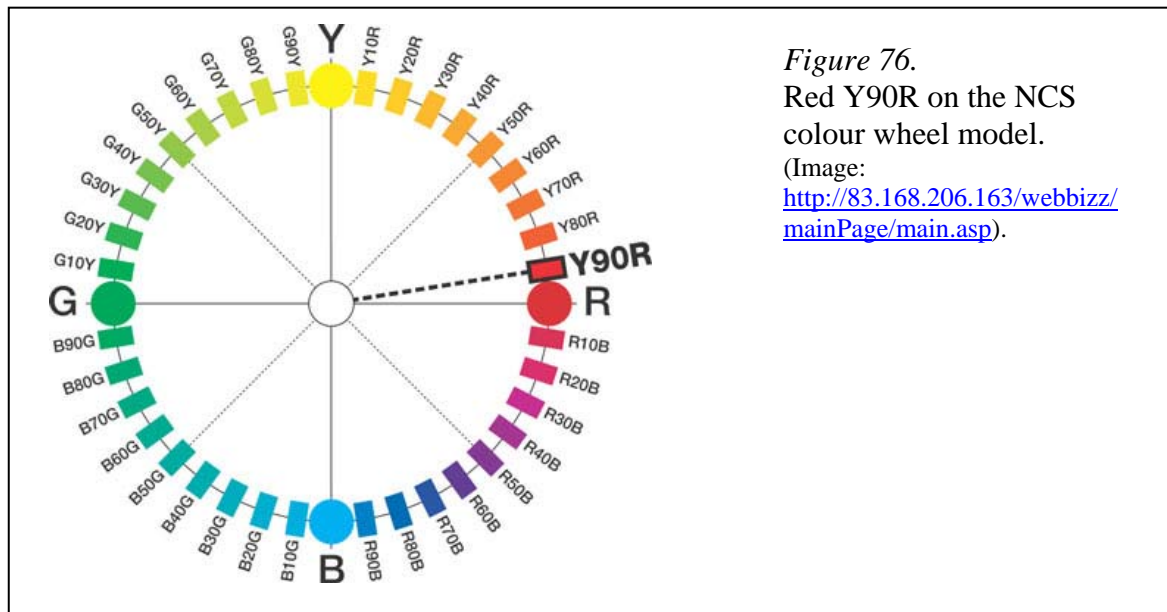

Figure 76.
Red Y90R on the NCS colour wheel model.
(Image: http://83.168.206.163/webbizz/ mainPage/main.asp).

Pantone colour system

The Pantone system is a colour-matching system used frequently in graphic design, interior design, fashion and textile design as well as paint specification. Widespread use of the system allows designers to specify colours to printers, paint manufacturers, textile dyers and the like. Since the 1960s, Pantone have made available for purchase a range of products (including the Pantone Matching System, a booklet of standardized colour samples in a fan-shaped format) specifically for colour matching and identification. The full range of Pantone colour-matching products as well as colour guides and trend reports are available online at http://www.pantone.com/
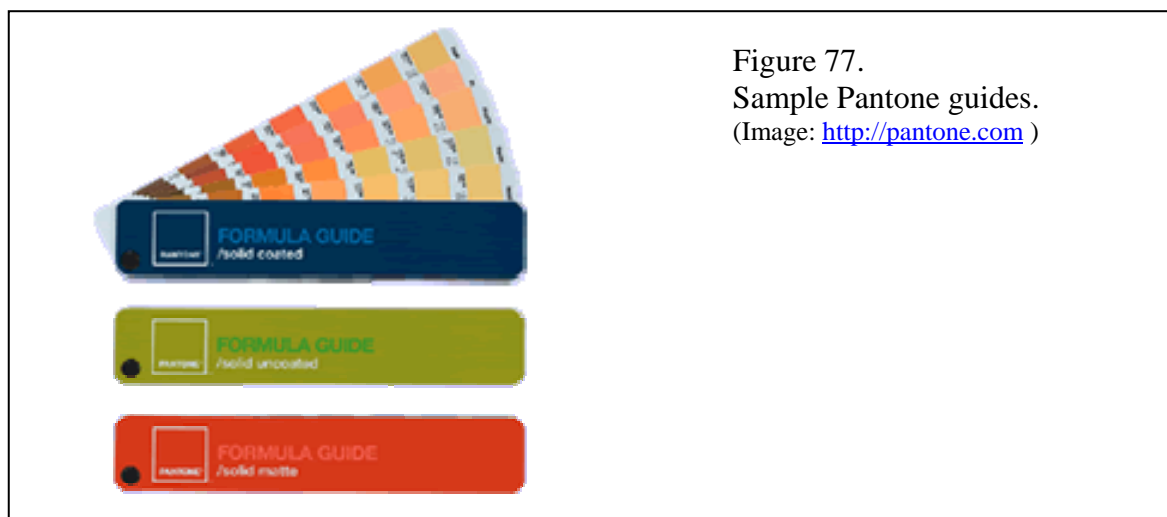

Figure 77.
Sample Pantone guides.
(Image: http://pantone.com)

sRGB colour space

Based on the 1931 CIE (International Commission on Illumination) colour space, the sRGB colour space evolved from a corroboration between Hewlett Packard and Microsoft to provide an identifiable gamut of colours for use with computer monitors, digital printers and the Internet.(Microsoft, 2006). The sRGB colour space is illustrated in Figure 79. wherein X, Y and Z represent red, green and blue respectively. The sRGB colour space is used to identify and reproduce colour, and is widely used in computer software programs such as Microsoft Word, Excel and Powerpoint. A drawback of the sRGB colour space is that it is limited and does not have the capacity to identify or reproduce a large gamut of colours. The sRGB system does not provide definitions or descriptions of notions such as colour harmony. An alternative system to sRGB found within Microsoft software applications is the HSL system wherein colour is described using hue (H), saturation (S) and luminance (L).

Figure 78.
The sRGB colour model.
(Image: www.microsoft.com).