Design for nature and the nature of design ability: A study connecting birding, Visual Communication design and scientific illustration

Cherry Denise Barlowe

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Abstract

This thesis uses a series of case studies and reflective practice to ask how can visual communication design expertise be directed to make a significant contribution to environmental education and knowledge, more specifically the interpretation and information languages of the field of Ornithology. While contributing to improvement of ornithological field guides these graphic design investigations also question how a critical awareness of visual communication and illustration expertise and processes might result in improved visual communication and experiences for the experienced or amateur bird observer whether in the field or visiting zoos, sanctuaries and national parks.

The aim is therefore two fold: on one hand, it seeks to improve graphic information systems for bird identification and with this environment protection and appreciation. On the other, it reflectively analyses the design research process involved in this project in order to question how the Visual Communication design researcher can make a significant contribution to cultural and environmental fields, which have traditionally been outside Visual Communication design’s predominately commercial scope of concern. To do this it uses multiple research methods including visual formal analysis to investigate the existing, visual language and design systems of bird field guides, their strengths and weaknesses. The case study on bird identification practice using observation, visual audit strategies, interviews and surveys, identify needs and concerns of users to set the direction for two design-led case studies in the development of color and icon systems. Direction was drawn from visual communication theories including Gestalt and more particularly Edward Tufte’s working at the intersection of image, word, number and art to develop the systems of bird visual representation.
Design for nature and the nature of design ability

The outcomes of this research project are multiple. Data collected from case-study interviews, surveys, and bird enclosure observations resulted in a set of recommendations to the Perth Zoo for improving the placement, design and educational effectiveness of the Zoo’s interpretative panels, exhibits and displays. It also led to the development of an industry standard, digital colour pallet specific to one native Western Australian bird which applied will bring bird field guides up to date with technical advances in design and production. Specifically the digital rendering of birds and accurate and consistent digital and print reproduction. Another outcome was the development of a visual information system here named ‘Identicon’ to make the recognition of bird shapes, colour, and identifying features easier to learn and therefore assist in identification of different bird categories and sub species. Finally a reflective practice project was used to contribute to building knowledge about the specific nature of visual communication design expertise in response to the need to bring this design discipline in line with the understanding of expertise in other design disciplines; industrial design, engineering, architecture, and product design.
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Without the generosity, assistance and support of so many people a PhD. would not be realised. Many of these acts extend beyond the reasonable such as giving up personal time to engage in interview process, or trample through bird droppings to collect fallen feathers. Without these acts of generosity the project would not have progressed with such fluid momentum as it did.

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I am grateful to my husband Toya for his unrelenting ability to make me feel I can conquer the world. And special thanks go to my son James, my parents, Brian and Evelyn, sister Janine and brother Michael because their pride in my work motivated action even when tiredness took hold.
Declaration

I, Cherry Denise Barlowe declare that this thesis:

Contains no material which has been accepted for the award to the candidate of any other degree or diploma, except where due reference is made in the text of the examinable outcome; and to the best of my knowledge contains no material previously published or written by another person except where due reference is made in the text of the examinable outcome.

Cherry Denise Barlowe

February 2013
Table of Contents

2 Abstract
4 Acknowledgements
5 Declaration
10 Figures
16 Charts
18 1. Introduction
18 1.1 Research as a creative, systematic activity
18 1.2 Wearing two hats
20 1.3 Theoretical overview
20 1.3.1 VC design practice, expertise and research
20 1.3.2 Edward Tufte: visual visionary
24 1.4 Multiplicity: when one method will not do
24 1.4.1 Tacit knowledge and reflective practice
24 1.4.2 The reflective practitioner
24 1.4.3 Protocol studies
24 1.4.4 Grounded theory
30 1.5 Significance of the research
31 1.6 Limitations
31 1.7 Conclusion
31 1.8 Thesis Structure
34 2. To speak of birds: bird field guides, ornithology and systems of visual representation
34 2.1 Introduction
34 2.2 Why birds? The evolution of bird watching in Australia
37 2.3 The field guide a visual tool for identification
37 2.3.1 Defining bird field guides
37 2.3.2 Reviewing Australian bird field guides
2.4 Learning how to identify birds

2.5 Problems with guides encountered by birders

2.6 Spatial representations: an aid to building knowledge memory and visual awareness abilities

2.7 Bird identification: dual coding, gestalt and icon design theory

2.8 The origins of naturalistic and semi-naturalistic bird illustration

2.9 Contemporary bird field guides: a process of trial and error

2.10 Bird field guide illustration

2.11 Bird field guide design: time for change

2.12 Conclusion

3. Perth Zoo Case Study: an investigation into the world of the birder and activity of bird identification

3.1 Introduction

3.2 Why a Case study and why the Zoo?

3.2.1 Ethical considerations

3.3 Case study methods: Grounded theory analysis

3.3.1 A cacophony of data

Non-participatory observation

Online survey

Grounded theories

3.4 Zoo Case study: People and birds

3.4.1 Non-participant observation of Wetlands and Walk-in bird exhibits

3.4.2 In-depth interview one

3.4.3 In-depth interview two

3.4.4 Online survey

3.5 Conclusion

4. Colour Standardisation in the creation and performance of bird field guides

4.1 Introduction

4.2 Colour standardisation: a language for VC designer, printer, client and audience
Design for nature and the nature of design ability

103  4.3 Colour in bird nomenclature
105  4.4 Robert Ridgway & colour standardisation
107  4.5 Data analysis: towards the advancement of Ridgway’s system
     4.5.1 Stage one: colour names used to describe the blue-winged kookaburra
     4.5.2 Stage two: colour differentiation
     4.5.3 Stage Three: Comparison of bird colour descriptions with bird
         illustrations in field guides
125  4.6 Ridgway meets the 21st Century: the process from design brief
     to design result
     4.6.1 Technologies: digital cameras and flat bed scanners
     4.6.2 Data comparison between swatches created using digital photos and
         flatbed scanning
135  4.7 Perceptual colour palette for the Blue-winged Kookaburra
     conversion to Ridgway’s (1912) colour standards and nomenclature
139  4.8 Conclusion
140  5. Digital Scientific Illustration & Identicons
140  5.1 Introduction
140  5.2 Time for change: traditional versus digital bird illustration
141  5.3 Vector fills the gap
144  5.4 Traditional to digital illustration and Icon to Identicon: attending
     to the design process from brief to result
144  5.5 Digital illustration: An advanced visual system of representation
     to support colour standardization
     5.5.1 Prototype one: combination of traditional and digital illustration
     5.5.2 Prototype two (Illustration): combination of traditional and digital
         illustration
     5.5.3 Prototype three (Illustration): digital photograph to digital vector
         illustration
     5.5.4 Prototype four (Illustration): digital vector illustration.
     5.5.5 Prototype five (Illustration): digital illustration
     5.5.6 Prototype six (Illustration): digital illustration
157  5.6 Icon to Identicon: an advanced graphic system of representation
     for bird field guides
     5.6.1 Icon to Identicon: a design action research cycle
     5.6.2 Design principles and processes in the creation of an Identicon
5.6.3 Prototype One (Identicon): Visual analysis and discussion

6. Ways of knowing in Visual communication design and Scientific illustration

6.1 Introduction

6.2 Limitations & strengths of reflective practice

6.3 Capturing my design thinking

6.3.1 Setting the scene

6.4 Nigel Cross’s creative strategies imbued in design thinking

6.4.1 Problem Formulation: Problem defining / problem scoping, setting and changing goals, attachment to concepts, co-evolution of problem and solution

6.4.2 Solution generation: fixation, attachment to concepts, creativity and sketching

6.4.3 Process strategy: structured process, opportunism and modal shifts

6.5 Design activity under the microscope

6.6 Discussion: VC design and scientific illustration compared with Cross’s creative strategies embedded in design thinking

6.6.1 Problem defining / Problem scoping

6.6.2 Setting and changing goals

6.6.3 Co-evolution of problem and solution

6.6.4 Fixation

6.6.5 Attachment to concepts

6.6.6 Creativity and Sketching

6.6.7 Structural process

6.6.8 Opportunism and Modal shifts

6.7 Emergent theories beyond Cross and into further studies

6.7.1 Two Hats: The design thinking associated with skills across two domains.

6.8 Conclusion

7. Conclusion

References

Image References
Design for nature and the nature of design ability

Figures

<table>
<thead>
<tr>
<th>Page No.</th>
<th>Fig.1_1 Space and time</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>Fig.1_2 Colour and Information</td>
</tr>
<tr>
<td>25</td>
<td>Fig.1_3 Layering and separation</td>
</tr>
<tr>
<td>25</td>
<td>Fig.1_4 Small multiples</td>
</tr>
<tr>
<td>26</td>
<td>Fig.1_5 Text and figure in flatland</td>
</tr>
<tr>
<td>37</td>
<td>Fig.2_1 John Gould</td>
</tr>
<tr>
<td>37</td>
<td>Fig.2_2 Frank Chapman</td>
</tr>
<tr>
<td>38</td>
<td>Fig.2_3 John Latham</td>
</tr>
<tr>
<td>38</td>
<td>Fig.2_4 Baily, illustration by Fuertes 1889</td>
</tr>
<tr>
<td>45</td>
<td>Fig.2_5 Example of dual coding theory taken from Simpson &amp; Day (2004) Field guide to the Birds of Australia pp.164-165</td>
</tr>
<tr>
<td>43</td>
<td>Fig.2_6 Albrecht Durer</td>
</tr>
<tr>
<td>47</td>
<td>Fig.2_7 Pisanello</td>
</tr>
<tr>
<td>47</td>
<td>Fig.2_8 Conrad Gessner</td>
</tr>
<tr>
<td>48</td>
<td>Fig.2_9 Pierre Belon</td>
</tr>
<tr>
<td>48</td>
<td>Fig.2_10 Hans Hoffman</td>
</tr>
<tr>
<td>48</td>
<td>Fig.2_11 Audubon</td>
</tr>
<tr>
<td>49</td>
<td>Fig.2_12 Osgood Wright 1895</td>
</tr>
<tr>
<td>49</td>
<td>Fig.2_13 Reed 1915</td>
</tr>
<tr>
<td>50</td>
<td>Fig.2_14 Peterson 1934</td>
</tr>
<tr>
<td>51</td>
<td>Fig.2_15 Peterson 1934</td>
</tr>
<tr>
<td>51</td>
<td>Fig.2_16 Griffith 2010</td>
</tr>
<tr>
<td>52</td>
<td>Fig.2_17 Huet 2010</td>
</tr>
<tr>
<td>52</td>
<td>Fig.2_18 Ippolito 2010</td>
</tr>
<tr>
<td>52</td>
<td>Fig.2_19 Lewington 2010</td>
</tr>
<tr>
<td>53</td>
<td>Fig.2_20 Marques 2010</td>
</tr>
<tr>
<td>53</td>
<td>Fig.2_21 Mikel 2010</td>
</tr>
<tr>
<td>54</td>
<td>Fig.2_22 Paschalis 2010</td>
</tr>
</tbody>
</table>
Design for nature and the nature of design ability

54 Fig. 2_23 Rose 2010
54 Fig. 2_24 Sill 2010
55 Fig. 2_25 Peterson 1934
55 Fig. 2_26 Peterson 2008
55 Fig. 2_27 Herbert Beyer: Bauhaus 1925-1933
56 Fig. 2_28 Roger Tory Peterson 1934 *A Field Guide to the Birds* New York: Houghton Mifflin
57 Fig. 2_29 Roger Tory Peterson 2010 *Birds of Eastern and Central North America* 6th edn. New York: Houghton Mifflin
57 Fig. 2_30 Michael Morcombe, 2004 *Field Guide to Australian Birds*. Queensland: Steve Parish Publishing
58 Fig. 2_31 David Sibley 2000 *The Field Guide to the birds* National Audubon Society
114 Fig. 4_1 Blue: n. Colour of a cloudless sky *Dictionary.com* Unabridged. (v.11) 2101)
114 Fig. 4_2 Blue-winged Kookaburra
128 Fig. 4_3: Image of Blue-winged Kookaburra used for the colour ‘sampling’ process.
129 Fig. 4_4 Colour samples for the Blue-winged Kookaburra
131 Fig. 4_5 Four primary wing feathers from the Blue-winged Kookaburra placed on the flat bed scanner and scanned.
132 Fig. 4_6 Samples of dominant colours captured using RGB and CMYK codes.
133 Fig. 4_7: Collection of 6 feathers from the Blue-winged Kookaburra displaying the colours seen in the bird’s wings, black and breast.
133 Fig. 4_8 Colour samples of the light blue the Blue-winged Kookaburra not captured when collecting the fallen feathers.
134 Fig. 4_9 Colour sampling of the bird’s back, tail, wings, head, breast, beak, legs and talons.
136 Fig. 4_10 24 Colour swatches from the Scanning process.
136 Fig. 4_11 51 Colour swatches from the digital camera process
137 Fig. 4_12, 19 out of 24 instances where the colours generated from the scanned feathers were perceptually and RGB numerically close to those generated from the digital camera.
138 Fig. 4_13 Sample of Fosters ISSC-NBS colour conversion of Ridgway’s 1912 Color
Design for nature and the nature of design ability

Standards and Color Nomenclature.

139  Fig.4_14 Final digital Colour palette for the Blue-winged Kookaburra based on Robert Ridgway's 1912 Colour standards and nomenclature.

141  Fig.5_1 Detailed Artistic Renderings
141  Fig.5_2 Silhouettes
141  Fig.5_3 Line drawings
142  Fig.5_4a Outline of feather shape filled with Bradley Blue
142  Fig.5_4b Outline of feather shape filled with Ivory Yellow
142  Fig.5_5 Jennifer Fairman (2010)
143  Fig.5_6 Frank Ippolito (2009)
143  Fig.5_7 Paul Mirocha (2009)
143  Fig.5_8 Chris Vest (2009)
144  Fig.5_9 Gary Carlson (2011)
144  Fig.5_10 Eric Olson (2011)
144  Fig.5_11 Gale Mueller (2011)
145  Fig.5_12 Visual Research of Blue-winged Kookaburra. Storr & Johnstone (1995)
145  Fig.5_13 Visual research of Blue-winged Kookaburra. Barlowe (2008)
145  Fig.5_14 Visual research of Blue-winged Kookaburra. Australia Zoo (2008)
145  Fig.5_15 Profile image of Blue-winged Kookaburra. Reptile Park 2005
146  Fig.5_16 Preliminary sketch of Blue-winged Kookaburra
146  Fig.5_17 Illustration technique: palest colour
146  Fig.5_18 Illustration technique: shade darker
146  Fig.5_19 Illustration technique: details
146  Fig.5_20 Prototype 1
147  Fig.5_21 Adobe Illustrator Live Trace experimentation
148  Fig.5_22 White patches represent highlighted area
148  Fig.5_23 White patches filled with a colour from the Blue-winged Kookaburra palette
148  Fig.5_24 Blue-winked Kookaburra Image for Prototype 2
148  Fig.5_25 Prototype 2 sketch
148  Fig.5_26 Prototype 2
149  Fig.5_27 Live trace conversions of Prototype 2
150  Fig.5_28 Live trace conversions of Prototype 2 close up of 256 and 100
Design for nature and the nature of design ability

151 Fig.5_29 Prototype Three: Digital photograph to digital vector illustration. Top: Digital photograph Bottom: Vector live trace

152 Fig.5_30 Outline shape of Blue-winged Kookaburra filled with a neutral colour

152 Fig.5_31 Placement of shadow, tint and texture areas

152 Fig.5_32 Mid tan and white blended to create tonal/tint shift from dark tan to light

153 Fig.5_33 Prototype Four

153 Fig.5_34 Image reference for Prototype Five placed in Adobe Illustrator and digitally rendered

154 Fig.5_35 Attention to line work and clear shapes

154 Fig.5_36 Close up of feathers

154 Fig.5_37 Prototype Five

155 Fig.5_38 Image reference for Prototype six

155 Fig.5_39 Chris Pope acrylic illustration

155 Fig.5_40 Screen capture while working on Prototype Six

156 Fig.5_41 Individual feathers converted to a symbol in Adobe Illustrator

156 Fig.5_42 Final digital Colour palette for the Blue-winged Kookaburra based on Robert Ridgway’s 1912 Colour standards and nomenclature.

156 Fig.5_43 Illustration technique applied to the Blue-winged Kookaburra’s beak

156 Fig.5_44 Prototype Six

158 Fig.5_45 Profile view of the Blue-winged Kookaburra as basis for icon development process

159 Fig.5_46 Tracing of prominent features

159 Fig.5_47 Master sketch

159 Fig.5_48 Reductive sketch to the primary shapes and prominent features

160 Fig.5_49 First digital drawing of the icon – each colour represents a layer in Adobe Illustrator

160 Fig.5_50 Colour palette for Icon development

162 Fig.5_51 Figure-ground

162 Fig.5_52 Proximity and Good Continuing

162 Fig.5_53 Detailed illustration positioned next to an Identicon to display the effectiveness of Economy in Identicon design

163 Fig.5_54 Identicon Prototype 1
Design for nature and the nature of design ability

Fig. 5.55 Eye patch is removed because it is not a field mark.
Fig. 5.56 Identicon Prototype 2. Black silhouette is replaced with Mars Yellow.
Fig. 5.57 Top of beak accentuated using Chaetura black.
Fig. 5.58 Identicon Prototype 3. Black silhouette is replaced with Mars Yellow.
Fig. 5.59 Prototype 3 development options a, b and c.
Fig. 5.60 Identicon Prototype 3.
Fig. 5.61 Detailed Illustration and Identicon Prototype 1 positioned together.
Fig. 5.62 Detailed Illustration and Identicon Prototype 2 positioned together.
Fig. 5.63 Detailed Illustration and Identicon Prototype 3 positioned together.
Figure 5.64 Detailed illustration and Identicon Prototype 3 positioned in the context of a field guide.
Fig. 6.1 Reflection—in–action 1.
Fig. 6.2 Reflection—in–action 1.
Fig. 6.3 Phase One: ‘Open coding’ applied to Reflection—in–action: Scientific illustration process.
Fig. 6.4 Phase Two: Theoretical and substantive coding’ applied to Reflection—in–action: Scientific illustration process.
Fig. 6.5 Scoping the problem | Reflection—in–action Digital Scientific illustration.
Fig. 6.6 Scoping the problem | Reflection—in–action Identicon.
Fig. 6.7: Problem defining | Reflection—in–action: Sketching the icon.
Fig. 6.8: Setting and Changing Goals | Reflection—in–action: Constructing the icon: Prototype One.
Fig. 6.9 Co-evolution of problem and solution | Reflection—in–action: Illustration Prototype One Sketching.
Fig. 6.a Art Nouveau style Chair designed by Hector Guimard (France 1920).
Fig. 6.b Pre-designed style of Art Nouveau by Seymour Chwast.
Fig. 6.c Design A is the original design and Design B is an example of a design based on a pre-designed solution.
Fig. 6.10 Fixation | Reflection—in–action: Illustration Prototype Six.
Fig. 6.11 Fixation | Reflection—in–action: Illustration Prototype Six continued.
Fig. 6.12 Sketching | Reflection—in–action: Illustration Prototype Four.
Fig. 6.13 Structural Process | Reflection in action Scientific illustration Prototype three.
Design for nature and the nature of design ability

190 Fig.6_14 Structural Process | Reflection in action Identicon Prototype two
191 Fig.6_15 Opportunism and Modal shifts | Reflection in action- Identicon design
Prototype three
191 Fig.6_16 Opportunism and Modal shifts | Reflection in action- Scientific
illustration Prototype Four
193 Fig.6_17 Modal Shifts and Conflict | Reflection in action- Scientific illustration
Prototype Five
194 Fig.6_18 One person two expertise | Reflection in action- Identicon Prototype
Three
194 Fig.6_19 Spatial representation abilities | Reflection –in– action- Identicon
Prototype One
195 Fig.6_20 Meditative state | Reflection –on– action- Scientific Illustration
196 Fig.6_21 Tacit-motor activity | Reflection –on– action- Icon Design
196 Fig.6_22 (a) Tacit-motor activity | Reflection –in– action- Icon Design Prototype
One
196 Fig.6_22 (b) Tacit-motor activity | Reflection –in– action- Icon Design Prototype
One
197 Fig.6_23 Tacit-activity: The silent partner | Reflection –on– action
197 Fig.6_24 Tacit-knowledge: The silent partner | Reflection –in– action
197 Fig.6_25 Tacit-knowledge: The silent partner | Reflection –on– action
Charts

Chart 3.1 Frequency of colour nomenclature used to describe the colouration observed on the Blue-winged Kookaburra

Chart 3.2 Prominent feature of the Blue-winged Kookaburra

Chart 3.3: Survey Questions

Chart 3.4 Responses to Question One: Length of time the respondent has been identifying birds

Chart 3.5 Responses to Question Two: What lead to your interest in identifying birds? The number of respondents who chose option 3.i, 3.ii, 3.iii, 3.iv or 3.v

Chart 3.6 Responses to Question Three: How did you learn to identify birds? The number of respondents who chose option 3.i, 3.ii, 3.iii, or 3.iv

Chart 3.7 Responses to question Four (a) ‘Do you currently, or have you ever referred to a bird field guide/s to assist you when identifying birds?’ The number of respondents who answered yes and no.

Chart 3.8 Responses to Question 4 (b) ‘What is the name of your favourite field guide or guides?’ The number of respondents for each field guide listed.

Chart 3.9 Responses to Question 4(c) ‘What makes this field guide better than others?’ The number of respondents who answered 4c.i, 4c.ii, 4c.iii, 4c.iv, 4c.v, 4c.vi and 4c.vii

Chart 3.10 Responses to Question 4(d) ‘Is there anything you would add to a field guide to make it easier to use and easier to identify birds?’ The number of respondents who answered yes and no.

Chart series A: Colour naming for Blue-winged Kookaburra.

Chart series B: Colour differentiation for Blue-winged Kookaburra.

Chart set C: Field guide comparisons: comparing bird colour descriptions with bird illustrations in field guides.

Chart A 1. Colour naming for Blue-winged Kookaburra: lesser and medium covert sections of the wings.

Chart B1. Conversion of participant colour naming for the lesser & medium coverts of the wing to RGB swatch.

Design for nature and the nature of design ability

Chart Series D: Colour Comparison Chart across four Australian Field guides
Chart series D1: Colour Comparison Chart of seventeen field marks for the Blue-winged Kookaburra across four Australian bird field guides.
Chart D1 (a) Instances of different colours used to represent the seventeen field marks of the Blue-winged Kookaburra across four Australian field guides.
Chart D1 (b) Instances of the same colours used to represent the field marks of the Blue-winged Kookaburra across four Australian field guides.
Chart D1 (c) Instances of perceptually similar colours used to represent the field marks of the Blue-winged Kookaburra across the four field guides.
1. Introduction

1.1 Research as a creative, systematic activity

As a definition of research, this thesis draws on the Organisation for Economic Co-operation and Development designation of research as 'Any creative systematic activity undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications.' (Organisation for Economic Cooperation and Development, 2001, para.2). The creative, systematic activity reported on in this thesis is the investigation of visual communication (VC) design expertise in the development of visual systems of representation and identification for bird field guides. In particular this thesis focuses on such issues as how VC design expertise, also known as graphic design, can be directed to make a significant contribution to environmental education and knowledge, more specifically the interpretation and information languages of the field of ornithology. The element of using this knowledge is also employed to identify and document the actual act of design cognition (Cross, 2006, 2011) as it occurred.

1.2 Wearing two hats

This thesis emerged from two competing but overlapping strands of expertise in my own life. I define this dual expertise as wearing two hats, laterally applying de Bono’s (1999) imagery of thinking hats. One strand is my creative life as an experienced and successful designer and illustrator with over twenty-five years practice in the field of corporate graphic design. The other is my research life as a university academic with more than fifteen years’ experience teaching graduate and undergraduate courses in the discipline of graphic design and illustration. In this thesis, the two strands come together in the dual activity of creating a design solution to a design problem and in theorising and investigating the actual act of design cognition in the creative process (Cross, 2006; 2011). These two strands define the structure of this thesis and are the basis for the design orientated project and the research
Design for nature and the nature of design ability: Chapter 1 | Introduction

led practice that lie at the heart of this study.

From the first strand of expertise, my experience as an illustrator in VC design, came a number of critical questions that originated with my first engagement with the visual representation of Australian birds. As a professional designer, the moment I picked up an illustrated field guide to Australian birds, it stood out clearly to me that this item did not fulfil the main objective of field guides, which is to identify Australian birds by their unique field marks, such as colour or shape. To the experienced designer’s eye, field guides contain a great deal of detailed information and large amounts of text that provide a wealth of wonderful knowledge, but they are presented in a way that is complex and difficult to use. From the designer’s perspective, what appeared to be missing was an iconic representation of individual birds. Such an icon would allow a bird watcher in the field, known as a birder, to identify a bird by recalling the icon immediately to mind, rather than by having to engage in a process of visual reduction to connect the information the eye was seeing with the representation in the field guide. My designer’s experience told me that a visual icon would in fact accomplish this process for the birder. A symbol of a bird sitting alongside a detailed illustration would make it easier and quicker for a birder to learn the field marks and readily apply that knowledge. This realisation became a challenge to investigate ways of creating a simplified visual system that presented the unique field marks of Australian birds. The result was the development of the design artifact presented in this thesis, namely the Australian bird Identicon. However, any such visual system would have to be based on the knowledge and needs of birders, rather than imposed by an external designer. This meant gathering data to investigate whether a visual system was necessary and, if so, how to set about designing it. Finding a method to gather data to address this aspect of the challenge resulted in an in-depth case study of experienced birders and at the Perth Zoo. This case study is reported in chapter 3.

The second strand of expertise, my academic experience, led me immediately to question how I recognised that the visual system in bird field guides was not meeting the needs of the viewer. As a designer, my response to my self-posed question was that this moment of realisation stemmed from my intuitive design knowledge of how visual information is communicated, based on years of design education and practice. However, while both the question and the answer fascinated me, they did not satisfy my need as an academic researcher to understand how and why this process took place. To say that I knew because I intuitively knew or because my tacit design knowledge told me so was inadequate. The challenge here became to find a way to identify and investigate the intuitive or tacit knowledge of myself as designer by identifying and documenting the actual act of design cognition as it occurred. Many researchers in the field of design have been intrigued by the concept of tacit knowledge and have investigated in an effort to research design thinking.
For example, Swann (2005) has validated this as a valuable area of research in design cognition while others such as Barrett, 2007; Cross, 2006, 2011; Crossan, 2003; Kinsella, 2006, 2007a, b; Putnam, 2000; Romer, 2003; Schön, 1983, 1985, 1987, 1991, 1995; Scott, 2007 have carried out studies in an effort to investigate this elusive concept. In order to identify my tacit design knowledge I needed to be able to articulate my own design cognition processes. However, the intuitive design expertise that is embedded in the cognition processes is experiential and process-based and is thus difficult to access, assess and define. Therefore, the methods selected to accomplish this research had to be complementary to the discipline of design research and at the same time offer a means to access, identify and explore these experiential processes. The following section discusses how the work of both Michael Polanyi (1958, p.69) on identifying tacit knowledge by ‘linking the art of doing to the art of knowing’ and of Donald Schön (1985, 1987, 1991, 1995) on reflection-in and on-action offered possible methodological positions and methods for undertaking this research.

1.3 Theoretical overview

This study positions VC design in the context of theories of visual cognition and design expertise in relation to the central research through design problem of this thesis, namely, the problem of visual systems of information used in ornithological field guides for bird watching and bird identification (Frayling, 1993; Jonas, 2006; Zimmerman, et al., 2007).

This study argues that one aspect of VC design expertise is particular skills in ‘visualisation’, (Cross, 2004, p.427), and another is the potential to be instrumental in the construction of ‘information environments’ that are complex and address social and environmental issues (Frascara & Winkler, 2008, p.4).

This section begins with a discussion ‘that links a vision of the social goals and responsibilities that can give’ VC ‘design significance with actual and operational requirements of research informed practice’ (Storkerson, 2008, p.1). The work of Jorge Frascara and Dietmar Winkler on the challenges for VC design to engage in projects that address complex social and environmental concerns is then discussed. Practising designers whose projects speak to Frascara & Winkler’s (2008) challenge and also theorise the design process are also introduced. These include Karel van der Waarde, David Sless, Edward Tufte, Colin Ware, Rick Poyner, John Bains, Ellen Mazur Thomson and designer Jeremy Aynsley. In particular Tufte’s (1990) visual theories are explored for their contribution to the development of scientific illustration in the advancement of visual systems for bird identification in field guides.

Next, theoretical understandings of tacit knowledge and reflective practice are introduced in order to establish appropriate methods to capture both the tacit and focal levels of
Design for nature and the nature of design ability: Chapter 1 | Introduction

awareness in the design process case studies in this thesis. Tacit knowledge was a term that emerged from the theoretical work of Michael Polanyi (1958, 1967, 1969), and his interpretation of this concept has been used to frame the investigation of tacit knowledge in this thesis. The work of Donald Schon (1983, 1985, 1987, 1991) is then discussed, as Schon's theories of reflective practice provided the reflective practice methods with which to capture the tacit knowledge that informed the design action to produce the design artifacts of this thesis.

Following the discussion of Schon's research, the theoretical work of K. Anders Ericsson (1993, 1998, 2006, 2009), Bryan Lawson (2004, 2006), and Nigel Cross (2002, 2004, 2006, 2011) is introduced. Their research offers methods of investigation that can reveal the design thinking embedded within reflective practice. In particular their expertise in approaches to protocol studies provided the methodological tools to research design thinking. However, Cross (2006), Loyd, Lawson and Scott (1995) identified a major limitation of protocol analysis in that it only addressed the 'thinking aloud' comments of the subjects. They noticed this as a weakness in terms of not accessing the many modes of thought that occur simultaneously during the design thinking process. The final part of this section introduces grounded theory and the work of Barney Glaser (1967, 1992, 2002a, 2002b, 2004, 2008), Anselm Strauss (1967, 1990), Kathy Charmaz (2006, 2008) and Naresh Pandit (1996). Then grounded theory was identified as the most appropriate method for revealing and documenting the actual design thinking, which occurred in the design process in this thesis. Grounded theory is discussed in detail in chapter 3 and chapter 6.

1.3.1 VC design practice, expertise and research

Over the last decade, conceptions of design have shifted from author led and author driven design to a more human centred design ethic (Frascara & Winkler, 2008) . In this shift, the function of the VC designer is moving from that of the design driver to that of design facilitator whose role is to assist users. Within this framing designers have been further challenged to design explicit solutions that support people to make intelligent and conscious choices based on informative design solutions (Acosta, 2003; Barnard, 2005; Bruinsma, 2002; Dodson, 1996; Good, Matravers & Clarkson, 2008; Helfand, 1993; Karabeg, 2003; Lupton, 1996; McCoy, 1990; Morrow, 2002; Noble & Bestley, 2005; Pentagram, 1979; Poyner 2003, 2004; Rand, 1985; Thiel, 1983; Tufte, 1990, 1997; Wildbur & Burke, 1998). An example of this shift can be seen in the design work of Karel van der Waarde (2004, para.2) takes up this challenge to support people to make intelligent and conscious choices based on informative design solutions. Van der Waarde's design work specialises in the development of websites and paper-based medium that provide medical
information media such as instruction leaflets and information architecture for patients, doctors and pharmacists. Van der Waarde’s research focused on the fact that, although medical leaflets were seen as important by patients, they were often hard to understand and difficult to read. His design research identified that attempts to change medical information media had been unsuccessful because they were not based on the perceptions of patients’ needs. His solution involved bringing all stakeholder parties together as a group ‘so that the legal, economic, technological and social issues can be considered’ (Van der Waarde, 2004, para.3). This collaboration between designer, project contributors and end users empowered all users and produced successful paper and screen-based information that was based on patients’ perceived needs.

Design research by David Sless (2011) also focuses on re-evaluating the role and position of the end-user audience in the design process. Sless’ work concentrates on developing ordinary everyday forms, timetables, instructions, bills and website’s that the public is confronted with daily because these are the primary instruments of communication that connect institutions and individuals. Like van der Waarde, Sless works in collaboration with all parties involved with each design problem and it is through this collaboration of information contributors, end-users and design experts that Sless’ highly regarded information systems are accomplished.

Rick Poyner, author, critic, lecturer and curator specialising in design, media and visual culture and John Bains, visual communication design practitioner and historian share the aim to better articulate what visual communication design should and does do and the skills of the visual communication designer have assisted in the maturation of design. An example is Poyner’s (2001) publication of Typographica, which is an in-depth study of the thinking behind typographer Herbert Spencer’s innovative work in the founding, editing and designing of the magazine Typographica. Poyner identifies principles, theories, innovation and ideas embedded in Spencer’s design practice (Poyner 2005; DesignObserver 2010). Moreover, graphic designer, print maker and librarian Ellen Mazur Thomson and design historian Jeremy Aynsely also engage in research to build a deeper understanding of the processes and practices of design, in particular those linked to print technologies, publication and print based communication that build a history of practice and expertise rather than of designed objects as in the past (Aynsely 2010).

This study is grounded in human centered design philosophy of Frascara & Winker (2008) and seeks to support end users to make choices based on informative design solutions that are similarly user centered. It applies their design paradigm in practice in the way that it approaches design research as collaboration between the designer as researcher and the end user, as demonstrated in the case study presented in chapter 3.
1.3.2 Edward Tufte: visual visionary

The work of designer Edward Tufte is of particular interest to this thesis. Tufte's publications include Beautiful Evidence (2006), Visual Explanations (1997), Envisioning Information (1990), The Visual Display of Quantitative Information (1992), and Data Analysis for Politics and Policy (1974). The theoretical underpinning of Tufte's work is 'Cognitive science' (Tufte in Zachry & Thralls, 2004, p.447). Tufte declares that his understanding of design principles as a cognitive science is in alignment with both Ware's (2008, p.166) theories of ‘visual thinking’ and the ‘Gestalt laws of visual organisation’ (Behrens 2004, para.11) as a new and powerful perspective to think about the science of visual communication design. Tufte and Ware (2008) are interested in designs that help people to reason about how the data may be used, Tufte declares, ‘At their best, graphics are instruments for reasoning’ (Tufte in Zachry & Thralls, 2004, pp.448).

Tufte’s principles of visual display are based on the idea that good visual design outcomes are achieved through the direct correlation of design principles and the thinking task to be understood. For example, as in the case of this present research, if the end user thinking task is to understand bird identification, the task calls for the ‘design principle’ to ‘show’ bird identification (Tufte in Zachry & Thralls, 2004, p.448). Recognising design principles is a cognitive activity that can be used to support a cognitive task. Tufte is interested in designs that ‘help people to reason about how data may be used’ (Tufte in Zachry & Thralls, 2004, p.448).

Tufte’s work foregrounds the need to promote ‘seeing and thinking on an intellectual level’ as the link between science and art (Tufte as cited in Zachry & Thralls, 2004, p.450). In this study, while I support Tufte’s theories, design objectives and outcomes, I argue that the link is not between science and art but rather between science and design. The design-oriented projects used to investigate the central research problem of this thesis are driven by design theory, principles and practice for meeting the needs of a particular audience, which means that the aesthetics are driven by the brief. This point is discussed in detail in chapter 6 of this thesis. The divergence from Tufte’s theoretical basis here is that Tufte’s use of art rather than design could be interpreted as the outcome driven by the artist’s expressive needs and not by the information requirements, which does not align with the aims and objectives of this study.

Nevertheless, Tufte's (1990) design work has provided important insights for this thesis, particularly his establishment of a set of principles for information design that reveal potential for the development of graphic systems for bird field guides. Tufte (1990) joins theory and practice to offer a systematic way of visualising complex ideas and information, such as ‘space and time’ (p.20) (Fig.1_1), ‘colour and information’ (p.83) (Fig.1_2), ‘layering and
Tufte describes flatland design and its visual strategies as:

The intersection of image, word, number, art. The instruments are those of writing and typography, of managing large data sets and statistical analysis, of line and layout and colour. And the standards of quality are those derived from visual principles that tell us how to put the right mark in the right place (Tufte, 1990, p.9).

Tufte's theories and principles embody those established by Gestalt theorists Max Wertheimer, György Kepes and Rudolf Arnheim, as well as Edwin Abbott's Flatland: A Romance of Many Dimensions (1884) and John White's The Birth and Rebirth of Pictorial Space, (1957).

Tufte's systematic sets of principles are applied for the design and organisation of complex data such as timetables, which he refers to as visual systems for 'time and space' (1990, p.10). Tufte also deals with notation for dance movements known as systems for movement notation.

The outcomes of Tufte's solutions include human wayfinding (directional signs, maps), movement (dance notation), understanding data sets, and consumer decision-making (product choice).

This thesis draws on Tufte (1990) and Ware's (2008) understanding of design principles as a cognitive science with the theories of Gestalt laws of visual organisation as a new and powerful perspective to think about the science of VC design (Schwartz & Heiser, 2006; Verstegen, 2006; Wertheimer, 1944).

1.4 Multiplicity: when one method will not do

1.4.1 Tacit knowledge and reflective practice

This section introduces the work of Polanyi and discusses how his theories were fundamental to the development of Schön's theories of practitioner reflection, which are employed in this thesis. Polanyi's (1966, p.4) theories of tacit-knowledge begin with the premise 'that we can know more than we can tell'. This means that although we might understand this as a concept we find it difficult to 'say exactly what it means' (p.4). For example, a VC designer knows where to position design elements on a page to create a
meaningful and clear piece of communication. Yet, when asked to explain ‘how’ he or she knows where to position each element the VC designer often struggles to communicate the source of their knowledge.

In order to become aware of ‘tacit knowing’ it is important to view it as an act of ‘indwelling’. Indwelling suggests not ‘looking at things’ but rather being present to or ‘dwelling in them’ and involves attending from the ‘proximal’ (tacit) to the ‘distal’ (focal) (Polanyi 1966, p.18). When the connection between tacit knowledge and focal knowledge is understood it shifts our mode of attention from the act of doing to the ‘knowledge’ that ‘lies in our ability to’ act (Polanyi, 1966, p.17). For example, in the case of the VC designer, rather than attending to the process of moving elements around the page the designer needs to ‘dwell’ on design e.g., design principles, theories, percepts, experiences and aesthetics. The reflective process requires the practitioner’s not simply to accept that the element is positioned in that spot because ‘it feels right’. But rather to ask, “why does it feel right to place that element there?” In essence, reflective practice has the potential to engage the practitioner with what underlies the explicit knowledge that is fundamental to practice (Howell 2002; Miller, 2005; Polanyi, 1966; Smith, 2003; Swann 2005; Sveiby, 1997; Ware, 2008).

Polanyi (1966), Schon (1985, 1987, 1991), Smith (2003), Swann (2005), Howell, (2002), and Miller (2005) support the reflective practitioner who can be either practitioner or researcher or both, who integrates reflective methods, to investigate personal tacit knowledge because pursuing the ‘hidden truth’ (Polanyi, 1966, p.25) is essential to the understanding of practitioner cognition, and to the improvement of practice.

1.4.2 The reflective practitioner

Schön (1987) took the theoretical work of Polanyi’s (1966) tacit knowledge and developed ‘an epistemology of practice’ to examine the methods of capturing tacit knowledge of creative practitioners in action (Smith, 2001, p.3). The ‘epistemology of practice’ offers practitioners, for example designers ‘new way of seeing’ and ‘a new possibility for action (Schon 1983, p.141). The epistemology consists of two separate methods of engaging with practice and they are reflection-on action and reflection-in action (Schon, 1983, 1985, 1987). Both Reflection-on and reflection-in action are critical reflective practice methods whereby the practitioner dwells
Design for nature and the nature of design ability (engages with the interior world) on design. The former is carried out after the practitioner has completed the design process and the latter while engaged in the act of doing design. Both methods provide the tools to make ‘explicit the action strategies, assumptions, models of the world, or problem settings that were implicit’ in the action of design practice (Schön 1995, p.26) and both tools are employed in this thesis.

The tools for capturing both reflection-on action and reflection-in action include those for working alone, working within a team or with a mentor. For example, the lone or the collaborative reflective practitioner can use journalising to record his or her thoughts, also known as ‘reflective writing’ (Taylor, 2003, p.?). Alternatively, the lone or collaborative practitioner could use video or audio apparatus to record his or her thoughts, which are recorded while practitioner ‘talks aloud’, also known as ‘verbal reports’ (Ericsson & Simon, 1993, p.2). Importantly, reflective practice whether it is through collaborative discussion or working alone can reveal the modes of thought embedded in skillful practice (Lloyd et al., 1995; Schon, 1985).

For this study, working alone was used for the reflection and analysis processes. Working alone while engaged in reflection-in and -on action was appropriate because this approach demanded my full engagement in the process without the influence or direction of an exterior source. Working alone without external influence was important because I wanted to explore the layers of personal percepts towards uncovering experiences that would lead to insights into my tacit knowledge (Boud et. al, 1985; Dewey, 1933; Mezirow, 1990; Rogers, 2001). The analysis of the verbal reporting was also carried out alone, because I could reflect-on my own verbal reporting, which, according to the literature, adds to the depth of enquiry (Swann, 2005; Schön, 1995; Smith, 2003; Polanyi, 1958, 1967; Miller, 2005; Rust, 2004).

The tools offered by Schön for the analysis of reflective practice data are based on action research methods. In general terms, action research is a ‘fact-finding’ method that focuses on identifying, ‘problems’, ideas and actions within the practitioners practice ‘with a view to improving the quality of action within it’ (Burns, 2000, p.443). Essentially, the ‘descriptive’ (Kumar, 1966, p.20) reports that are collected while engaged in reflection-in and –on practice are analysed to ‘identify, evaluate and formulate’ (Burns, 2000, p.445) the ideas and actions to which the practitioner ‘will attend’.
Design for nature and the nature of design ability: Chapter 1 | Introduction

(Scöhn, 1983, p.165). Reflective practice analyses are structured around a set of questions, or critical incidents (Rogers, 2001, pp.38-39) that the practitioner can focus on when processing the data (Seibert & Daudelin, 1999; Langer, 1989; Loughran 1996). Next the practitioner will determine the ‘order they will attempt to impose on the situation’, and finally he or she will ‘identify both the ends to be sought and the means to be employed’ in order to implement change (Scöhn, 1983, p.165). These methods support the reflective practice outcome of ‘learning and enhanced personal and professional effectiveness’ (Rogers, 2001, p.55).

Although reflection-in and –on action is valid as a method for the investigation of the practitioner in terms of their action. As a problem-solving tool it does not adequately interrogate design thinking, which is the aim of the reflective practice for this study. In order to fulfill the aim of using reflective practice methods to gain insight into design cognition, it was necessary to expand the analysis methods beyond action research, which lead to a branch of reflective practice, which is design Protocol Studies. Protocol study researchers often draw on Scöhn’s approach to reflection-in and –on, action but rather than using action research protocols for the analysis process they apply word and concept sequence analysis to the verbal data sets (Ericsson, 2006).

1.4.3 Protocol studies

Ericsson (2006) labels Protocol studies as empirical, stating they are derived through observation and comparison of new data to already established verbal data sequence sets. For example, a protocol study on an individual VC designer’s cognition when engaged in the process of design development would demand that the VC designer engage in reflection-in action, which entails verbalising thoughts while engaged in the design process. Next the VC designer’s verbalisations would be recorded verbatim by the researcher and then the word and concept sequences would be compared with an existing protocol study containing similar thoughts and concepts which in turn would be based on thoughts and concepts used by other, equally experienced VC designers (Cross, 2002, 2004, 2006, 2011; Ericsson, 2006, 2009).

An impressive number of protocol studies focus on building knowledge on design thinking, including the exemplary work of Ericsson (1993, 1998, 2006, 2009), Lawson (2004, 2006), Cross (2002, 2004, 2006, 2011) and Binder, et. al., (2011). The combined research outcomes of protocol studies offer an understanding of thought processes that are assigned to specific tasks, for example those carried out by expert chess players, mathematicians, architects and engineers to name a few. However, there has been discussion amongst protocol researchers that protocol methods are not good at capturing the complexities of talking aloud data and for validating the ‘individual differences’ (Ericsson, 2006, p. 235) in expert
performance (Cross, 2006, 2011; Ericsson, 2006; Ericsson & Simon, 1993; Lawson, 2004, 2006; Lloyd et.al, 1995). Because my interests lie in the designer’s ‘individual differences’ in design cognition and in uncovering the layers of tacit knowledge embedded in design action, the limitations highlighted by Protocol experts led me to investigate other methodologies and methods for analysis. The idea was not to find one method to replace reflective practice and protocol studies methods but rather to build a multiple methods framework that draws on the best attributes of each.

1.4.4 Grounded theory

The established limitations of Schön’s reflective practice analysis tools and the shortcomings of protocol studies drove a broad enquiry into qualitative research methods. The journey uncovered potential supporting methods including, experimental ethnography (Ellis & Bochner, 1996), interpretive content analysis (Reinharz, 1992), content analysis (White & Marsh, 2006), narrative analysis (Andrews, et.al, 208; Riessman, 1993) and grounded theory (Charmaz, 2008; Glaser, 1978, 1992; 2004, 2008; Pandit, 1996; Strauss & Corbin, 1990; Strauss & Glaser, 1967). Although all of these theories contributed to the theoretical mix, grounded theory played the biggest role.

When exploring the methods, tools and processes associated with grounded theory it became clear that there were strong similarities between this method and VC design ideation and idea development processes. Both demand the researcher and or designer set aside predetermined ideas or solutions about the data as a whole and to engage with the independent properties and elements in a way that allows for the emergence of concepts and theories (Charmaz, 2008; Glaser, 1978, 1992; 2004, 2008; Lawson, 2006; Pandit, 1996; Purcell, 1998; Strauss & Corbin, 1990; Strauss & Glaser, 1967; Roozenburg, 1991).

The strong working similarities across the two processes reinforced grounded theory as a relevant research method for a study that explores design issues and design thinking. To explain, grounded theory is a method for developing theory that is grounded in the data; theory emerges during the research process and is a result of the interplay between analysis and data collection (Charmaz, 2008; Glaser, 2004, 2008; Strauss & Glaser, 1967). Grounded theory was originally developed in 1967 for research into sociology by Barney Glaser and Anselm Strauss and since then has been adopted by, for example, psychology, anthropology, nursing, social work, education, management, and now visual communication design. The implementation of grounded theory into a diverse set of disciplines has necessitated the adaptation of the methodology to meet disciplinary needs, and this study is no exception (Goulding 2002).
This research draws on the emergent quality of the grounded method and tests the capacity for grounded methods to provide insight into tacit knowledge. Glaser (2002a) asserts that grounded concepts and constructivist grounded categories come from the words of the participants, in terms of the description and the phenomena they attribute meaning to. In this manner, the grounded method can uncover patterns the participant is not mindful of (Glaser 2002a). This suggests that tacit knowledge, which by its nature lives in the realm of subconscious cognition and activity, could be revealed through grounded theory methods.

The methodology used for this thesis applied a composite procedure of non-participatory observation, in-depth interviews and surveys in a case study carried out at the Perth Zoo and later reflection-in and -on action, and ‘incident’ oriented coding scheme in the development of the design artifacts (Charmaz, 2008, p.82). The underlying connection follows the succession of observation, interviews, survey and self governed reflection-in and -on action produced by me (the researcher). The definitions and procedures for the grounded theory methodology emerged from the experimental work carried out throughout the duration of this thesis, the well documented work of grounded theorists Glaser (1978, 1992, 2002a, 2002b, 2004, 2008) and Charmaz (2006, 2008) and the work of design protocol researchers Cross (2006, 2012) and Binder et.al (2011).

These theories and related methods combined provided a range of probes for investigating the manner in which the designer, experienced in VC design, illustration and research works and thinks through drawing on intuitive and tacit-knowledge and skills acquired through years of practice and on their subjective experience (Crouch 2007). Finally, Cross’s (2004, 2006) theories of design expertise provide a model to distinguish and classify visual communication’s cognitive approaches and disciplinary practices in relationship to other design disciplines including architecture, engineering, product design and instruction design.

To conclude, the methods for this study were selected specifically to support disciplinary research in VC design and the methodology steeped in emergent-grounded theories opens up opportunities to discover new knowledge and reveal tacit-knowledge hidden in design practice. Methods such as reflective praxis, formal visual analysis, formal case study, and design-oriented project based test cases provide a model of flexibility and rigorous investigation for the profession.
1.5 Significance of the research

The research reported in this thesis addresses a significant problem with the visual presentation of birds in current Australian ornithological field guides. The research contributes to the field of VC design research in two ways. Firstly it provides a method to improve systems of representation offered in bird field guides by integrating the expertise of VC design with the knowledge of experienced bird observers. This method draws from Grounded Theory and from reflexive praxis to support this integrated approach. Secondly, the research was applied to produce a design artefact, Identicons, to address the problem of visual depiction of birds in Australian bird field guides. The Identicon simplifies and clarifies the identification of bird shapes, colour, and features, making these easier to learn for the lay person, the novice and the enthusiast bird watcher, therefore fostering greater awareness and protection of Australian birds. The artefact is an exemplar of the method developed and as such could be applied to other areas of VC design work by practising VC designers to identify and resolve visual depiction issues. That is, while the artefact was designed specifically for bird field guides, it has the potential to meet other identification needs of professionals in the natural sciences and to inform the general public. For example Identicons could be used to identify dangerous household spiders or poisonous plants in order to assist with appropriate medical action and to handle the relocation or disposal of these arachnids and plant species.

Another significant result of this research was that data collected from case-study interviews, on-line surveys and bird exhibit observations resulted in a set of recommendations to the Perth Zoo for improving the placement, design and educational effectiveness of the Zoo’s interpretative panels, exhibits and displays. It also led to the development of an experimental digital colour palette specific to one native Western Australian bird, at industry standard, which when applied will bring bird field guides up to date with technical advances in design and production, specifically the digital illustration of birds and accurate and consistent digital and print reproduction.

Finally, in Cross’s (2011, p.2) important work Design Thinking: Understanding how designers think and work, Cross points out that some of the design domains ‘get less coverage in the book simply because less research has been conducted in them’. VC design, which Cross refers to as Graphic Design, is mentioned in one paragraph only in this work, and the research addresses the social activity of design and not the individual creative strategies associated with design thinking. The lack of research specific to VC design identifies a gap in existing research that validates a study such as this present work, which can make a preparatory contribution to the current pool of knowledge on VC design as part of an evolving design discipline. In addition, although the reflective case study is a contribution from a sole VC
designer, it nevertheless provides an opening for establishing VC design cognition as a valid area for future research, rather than assuming, as Cross (2011, p.2) does, ‘that many aspects of design thinking are common across the different domains’, and therefore that creative thinking strategies are the same across all design domains.

1.6 Limitations

As a practitioner reflecting on my own practice, in order to understand and analyse my own design activity in this thesis, I first had to acknowledge my interpretive values, social and personal spheres would influence data and analysis (Crouch, 2007, p.108). At the same time, this reflective praxis had to embrace my cultural circumstances, education, experiences, and beliefs to ensure that I connected with my own intuitive knowledge and my actions. However, the nature of this meant that any insights and conclusions can be interpreted as singular to my circumstances, and it would require further studies of VC design and illustration activity to determine the applicability of the results to other design fields.

1.7 Conclusion

This chapter has identified how the thesis emerged from two complimentary but differing strands of experience and expertise; my expertise as an illustrator and designer and my experience as an academic. The chapter has also identified the questions that emerged from these strands, different ways to explore how to answer them and the significance of the research emerging from these questions. The final section of this chapter gives the thesis structure

1.8 Thesis Structure

Following Chapter 1, the thesis is divided into six principal chapters and a conclusion.

Chapter 2: To speak of birds: bird field guides, ornithology and systems of visual representation discusses the evolution of the bird field guide and presents the iconography of field guide design and bird illustration, the relationship between VC design and field guides, identification tools, and the influence of perceptual theories of dual-coding, gestalt and spatial awareness on the bird identification process.
Design for nature and the nature of design ability : Chapter 1 | Introduction

Chapter 3: Perth Zoo Case Study examines how VC design can make a significant contribution to cultural and environmental fields, specifically to promote the care of birds and their environments through information systems that advance bird identification for the birder and to enrich the experience of birds for the visitor. This case study investigates and defines individual approaches to bird identification by enlisting the assistance of 12 volunteer Zoo docents (volunteer guides) who engaged in two in-depth interviews and 100 birders from an on-line birding forum that responded to a survey, all with a minimum of two years experience in identifying birds in the field. During the final analysis, the data revealed emergent insights that identified issues pertaining to colour constancy and standardisation in bird field guides that required further investigation and endorsed the execution of a design-test project to develop icon devices as an advanced visual system of representation of birds as an additional identification strategy for bird field guides.

Chapter 4: Colour Standardisation in the creation and performance of bird field guides investigates the role of colour perception, constancy and standardisation in the creation and performance of field guide design. Two test cases offer insight into how a graphic designer diagnoses and solves a design problem; the lack of colour constancy and colour standardisation in field guide design and solves the problem. The outcome of this chapter is a sample colour pallet for the Blue-winged Kookaburra. The intention of this palette is to provide insight into how to create a digital colour palette that can be reproduced consistently across bird field guides, while at the same time giving the colours an international name so that they can be verbally articulated consistently, regardless of the language or the country where birds are being identified. Another outcome includes recommendations for updating the visual communication of bird field guides bringing them into alignment with the current approaches to graphic design and print production technologies. The final analysis and outcomes of these issues provided insights that defined and contributed to the sixth and seventh chapters.

Chapter 5: Digital scientific illustration and Identicons presents two design-oriented project based reflective case studies that are used as a vehicle to resolve issues pertaining to the visual representation of birds in bird field guides, colour constancy and standardisation as identified in the Perth Zoo case study. It achieves this through the creation of a digital illustration technique to support the digital colour-coding system developed through the Blue-winged Kookaburra case study. Also, the production of an icon device that I have named Identicon provides the average person with an insight into the value of visual communication strategies in order to make bird identification information accessible and functional.
Chapter 6: Ways of knowing in Visual communication design and Scientific illustration. The discussion offers my reflective practice as evaluated using Cross’s theories of cognitive approaches to design activity. In addition, it presents design issues and concepts that may provide insight into VC design and illustration tacit knowledge and expertise. Declaring VC design expertise is critical in facilitating further opportunities for cross-disciplinary projects as well as signalling to all how VC design could contribute to the visual effectiveness of their passion whether discipline, profession, hobby, or study.

Chapter 7: Conclusion. The conclusion offers a summary of the main findings and recommendations for future studies.
2. To speak of birds: bird field guides, ornithology and systems of visual representation

2.1 Introduction

This chapter investigates the origins and character of bird field guide design, from the aesthetic and genteel approach in the 1600s, to the first modern field guide in 1930, and through to today (Dunlap, 2005). It achieves this through a review of the literature around bird field guides, ornithology and formal visual analysis of bird field guides. The chapter begins with a brief introduction to the evolution of bird watching in Australia. It then provides an overview of the development of modern bird field guides and their usage, noting issues with visual information display that affect novice bird watchers. Next, it identifies the under utilisation of spatial representation theories in the design of bird field guides to improve the education process of novice birders, in particular dual coding theory and theories of gestalt and icon design. It then provides a brief history of the origins of naturalistic and semi-naturalistic bird illustration in field guides, maintaining that illustrative techniques for birds are still grounded in natural sciences and aesthetics and little attention has been paid to theories of visual and spatial perception. Finally, this chapter argues that today's field guides are influenced by the aesthetic, design and production practices of the past and have not yet benefited from advances in print and colour technologies, graphic design and illustration expertise.

2.2 Why birds? The evolution of bird watching in Australia

Birds attract the attention of ornithologists and birders for a number of reasons. Roger Pasquier (1977), for example, suggests that studying birds offers rewards that can positively impact the life of the novice bird watcher, or as they are often called birder, because as a hobby, bird watching satisfies the hunter, collector and adventurer. Pasquier notes that
birds are visible in country and city environments, that they are not dangerous to humans and that their poetic beauty and grace transcends colour and design to include the human fascination with flight. Birds are a reminder of the interconnectedness of all living things and their dependency on the same conditions as humans for their well-being.

Since 1900, when members of the Field Naturalists’ Club of Victoria came together with interstate and country ornithologists and New Zealanders to establish the Australasian Ornithologists’ Union, the protection of useful and ornamental native birds has been a prime concern to the bird watching fraternity and to birding and scientific/natural history groups (Libby, 2001). The Union attracted a substantial national and international membership, with the most striking contribution coming from individual naturalists and ornithologists, not associated with or representing any institution, but rather unified by their common love for birds. These individuals were self-reliant and often talented field observers and collectors for whom identification and protection were a key concern (Libby, 2001). Kenn Kaufman (as cited in Porter, 1997, para.28), bird illustrator and photographer, believes birding is more popular today than ever before because it provides a challenge to technology, which has improved lives but has kept people ‘indoors and isolated’. Birding mobilises people to focus on things that are alive and independent. It provides physical exercise, a mental challenge, and the possibility of discovery. The accessibility of birds makes them more popular than other aspects of nature study – even a tiny inner city park may be visited by dozens of birds. Birding provides a means of connecting with nature, no matter where.

Bird watching begins with the act of watching birds and after time can turn into a hobby whereby the simple act of watching expands to the desire to accurately identify and name the bird (Chap, 2006). The transition from watching to naming a bird involves the study of birds, beginning with learning to recognise bird families and their species. The accurate identification of a species demands that the birder study and remember specific field marks that distinguish one bird from another. Field marks can include colour, feather pattern, form, and flight sequences. The combination of knowledge and concentrated practice eventually enables the birder to accurately identify birds.

The interested birder can extend that interest from hobbyist to scientist through the engagement with formal tertiary study in the field of ornithology. Ornithology as defined by The Cambridge Encyclopaedia of Ornithology (1991) is the scientific study of birds. The name comprises two Greek words, ‘ornis’ meaning ‘bird’ and ‘logia’, a suffix form of ‘legein’ meaning ‘to speak’, with ornithology meaning ‘to speak of birds’ (Cambridge Encyclopaedia of Ornithology, 1991, pp.1-3). Specifically, ornithology is to speak of birds with knowledge and expertise gained through asking questions and searching for answers. Ornithologists ask ‘what, how and why’ questions about birds, covering bird anatomy and physiology,
movement, history from the ancient to the modern bird, distribution and migration, navigation, populations, breeding, and relationship to and with people (Robin, 2001, p. viii). The history of ornithology in Australia celebrates the development of a field-based science and the experiences of identifying the distinctively Australian wildlife. It is about birds in the bush and birds in ‘gardens and changing urban environments. It includes laboratory and aviary studies, and expeditions to remote parts’ (Robin, 2001, p. viii).

Bird observation and identification are central to the practice of ornithology, with the novice birder needing to learn how to identify birds in the field before they can embarking upon the advanced scientific study of birds. Possessing skills and experience in bird recognition as well as having the ability to apply the information presented in bird field guides are essential to understanding the what, how and why of birds in the field. A high skills base is important for amateurs and bird watching clubs whose field activities assist scientists in building knowledge, and is also essential for building public interest and awareness. Bird identification and observation is also the realm of those who are simply interested in birds as a hobby and as an adjunct to urban and country life, and for those wishing to preserve and protect Australian wildlife (Pasquier, 1977).

The ornithologist and the novice employ a variety of methods to cover field investigations, including field surveys and observation techniques to record and chart aspects of bird behaviour such as mating rituals, nesting cycles, and feeding. Advanced field studies can involve banding individual birds by placing numbered aluminium or coloured band around the bird’s leg, which enables scientists to track the migration of specific birds (Pasquier, 1977). The study of birds would not be complete without laboratory investigations that reveal things undiscoverable in the natural environment. For example, studying the anatomy and physiology of birds requires dissection and the examination of the internal parts of birds to see how they function or to make comparisons between related species. Other laboratory studies investigate inherited and learned behaviour (Pasquier, 1977). However, before embarking on advanced studies, both the ornithologist and the novice birder must learn to identify birds in the field. The basic tools required for this begin with a pair of binoculars and a field guide. Field guides illustrate the birds found in specific areas, describe identifying marks, habitats, voices, and ranges. Many people prefer to consult more than one guide (Chap, 2006). Field guides are therefore an essential tool for the entire bird watching community.
2.3 The field guide a visual tool for identification

This section investigates the origins and character of bird field guide design, from the aesthetic and genteel approach in the 1600s, to the first modern field guide in 1930 and through to today (Dunlap, 2005). While the work of American ornithologist and artist Roger Tory Peterson (1908-1996) lies at the root of modern bird illustration, today’s bird guides are nevertheless grounded in the artistic and aesthetic conventions of earlier bird illustrators and authors such as John Gould (Fig.2_1), Frank Chapman (Fig.2_2), John Latham (Fig.2_3), and Florence Merriam Bailey (Fig.2_4). Today’s field guides are influenced by past aesthetic, design and production practices and have not benefited from advances in print and colour technologies, graphic design and illustration expertise. Further, with illustrative techniques for birds still grounded in natural sciences and aesthetics, little attention has been paid to theories of visual and spatial perception such as Allan Paivio’s (1986) dual-coding theory, John Campbell’s theories of spatial awareness in visual perception, Diane Lindwarm Alonso’s (1998) understandings of spatial visualisation ability, and Daniel Schwartz’s and Julie Heiser’s (2006) spatial representations in learning. All of these offer valuable insight into how individuals consciously process visual information, which this study posits has implications for bird field guide design.

2.3.1 Defining bird field guides

The primary function of a bird field guide is for outdoor use and it is therefore designed with field experience in mind, which commonly demands that the birder work with a field guide in one hand and binoculars in the other. Therefore, unlike standard books, economy of size, shape and weight is essential to functionality in the field. Recorded sizes (dimensions and weight) of four widely used Australian field guide publications are as follows:

- **The Slater Field guide to Australian Birds** (Slater & Slater, 2009): 21.3x11.43x2.8cm, 680g
- **The Field Guide to the Birds of Australia** (Pizzey & Knight, 2003): 23.1x16x3.5 cm, 1.179kg;
- **Field Guide to Australian Birds: Complete Compact Edition** (Morcombe,
As there is minimal size differentiation between the smallest (Slater’s at 21.3x11.43x2.8cm and 680g) and the largest (Pizzey & Knight at 23.1x16x3.5cm and 1.179kg), and as the price differentiation between the most and least expensive is around $6, Pizzey & Knight (2003) suggests that it is content rather than overall weight and size of a guide that influence the purchaser of a field guide.

Bird field guides are usually independent publications, the exception being when a journal or periodical includes a small field guide to substantiate content. Ordinarily, field guides are books, manuals, guides or websites designed primarily as a learning tool for identifying a living creature within its natural environment. For example, birds that inhabit a particular geographical location might be covered by a field guide such as Birds of Australia’s Top End (2001), Birding Sites around Perth by Ron Van Delft, Birds of Box Hill by Tess Kloot, or Bayside Birds: The Inland by Frank Stewart, or a particular species of birds by a guide such as Shorebirds: An identification guide to the waders of the world (1991). Publications that do not qualify as field guides include bird reference books dealing with topics such as how to attract birds to your backyard, bird flight paths, breeding habits of birds, birds and their nests, or bird biology (Herbarium, 2008).

2.3.2 Reviewing Australian bird field guides

Bird field guides provide visual representations of birds in illustrations, images and photographs, and descriptive textual information about birds needed for identification in the field. They offer information on birds that is categorised by family and species, for example, raptors and hawks and harriers. A field guide offers an illustration and text per species; illustrations include the male, female and juvenile. In addition guides provide a map highlighting the distribution of the species. Textual information includes the detailing of prominent features such as colour and plumage markings, calls, movement and flight patterns, as well as the common and scientific names of the bird. Less common information includes the lifecycle of birds, nests, eggs, and identification keys (Keller, 2004; Simpson & Day,
A study of reviews of Australian bird field guides by professional bird watchers indicates that very little attention has been paid by the authors and publishers to distinguishing between the needs of the novice and the experienced birder. This insight is important because if the purpose of a field guide is to inform and support learning, then field guides need to be designed to cater for the birder’s level of expertise. The problem with the current generically targeted field guides is that the amount of information can deter new birding enthusiasts from engaging in bird identification. As later chapters in this study show, information supplied by a large selection of amateur birders supports this conclusion regarding the problems with current field guides (see Chapter 3).

Of all reviews examined, only two noted differentiation between skill levels of birders, with all others giving a generalised commentary on content, form and usability. For example, a review of Michael Morcombe’s (2004) Field Guide to Australian Birds considers this guide ‘Possibly the best for new or beginner birders, features ease of navigation through colour tabbed indexing of 26 bird groups’ (Sandbrink, 2002, para.3). Another review suggests that The Slater Field Guide to Australian Birds is ‘a must for serious naturalists in Australia, be they beginners or experts’ (CSIRO, 2012, para.2). A more thorough study of the content of Australian bird field guides was therefore warranted. A detailed examination and comparison of the content of Field Guide to the Birds of Australia (Simpson & Day, 2004), Field Guide to Australian Birds (Pizzey & Knight, 2003), Field Guide to Australian Birds: Complete Compact Edition (Morcombe, 2004) and The Slater Field Guide to Australian Birds (Slater & Slater, 2003), all published in Australia, revealed no evidence that the information offered was targeted at birders with different levels of knowledge and experience.

2.4 Learning how to identify birds

Apart from field guides, the other essential tool for bird observation and identification in the field is binoculars, which allow the observer to take a closer look at a bird that is beyond the active view of the naked eye. They are also used to track birds in flight and to study the behaviour of birds without disturbing their habitat. An optional extra tool for birders is the note pad, used for noting observations including bird calls, movements, feather patterning, markings and colour, which become helpful when used in conjunction with information in a field guide and which maybe be consulted while in the field or later. However, even with binoculars, bird identification is complex, difficult and involves the development over time of visual literacy regarding bird species and visual perceptual skills. The learning process involved in developing the ability to successfully identify birds in the field can seem...
Design for nature and the nature of design ability: Chapter 2 | To speak of birds

overwhelming for novice birders. Upon first opening a field guide, the novice is confronted by single pages with illustrations of up to fifteen birds of the same species, a demographic map for each bird, and written descriptions (Fig.2_5). As later chapters in this study reveal, experienced bird watchers confirmed this as an issue for novice birders.

Pasquier (1977) and Robin (2001) seek to reassure the novice that the process becomes easier with practice, arguing that with time and study it will become clear that birds fall into natural groupings based on family, habitat, colour and song. The field guide is central to this learning process, offering advice on observation and identification procedures, such as colour and field marks. Pizzey & Knight (2003, p.3) in The Field Guide to the Birds of Australia, explain the importance of field markings and colour stating that: ‘few birds share exactly the same markings ... Keen eyed humans, whose colour vision is comparable to that of birds, can readily tap into this system that birds themselves have evolved’.

Pizzey & Knight (2003, p.12) clarify the first step towards identifying a bird, which is to learn the working parts of birds such as ‘wing-coverts’, ‘primaries’ and ‘undertail-coverts’. Next is to understand that there are ‘tracts or tufts of contrasting plumage’ on each bird ‘that increase the range of available field marks’. Then, recommending the aid of binoculars, they list a process of ten steps required to identify a bird’s features and behaviour. These include: noting bill-size, shape and colour because the bill can tell much about what kind of bird it is; noting size, shape and colour of legs and feet; checking colour markings of face, head, throat, breast, and undertail-coverts, upper parts, rump and wings; noting eyebrow, eye-ring, wingbars or breastband; noting length and shape of tail; noting tail movements. Their final advice is to make notes, because this will ‘sharpen your observing ability, defeat the tyranny of faulty memory, and become a priceless personal memory’ (Pizzey & Knight, 2003, p.12).

The novice field birder is advised to choose one geographical location for identification purposes and study a maximum of three birds that inhabit that locality. Before going into the field the novice birder refers to field guide visual representations of those birds, noting and learning their distinguishing shape and features while reading text explanations about their breeding, nesting, feeding, calls, flight and movement as well as migratory behaviour. The intention is to memorise ‘contextual cues’ (Bower, 1975, p. 216) relating to each bird, including differentiating male, female, and immature bird coloration, markings, habitat, in-flight wingspan and call. With identification information assigned to memory, the novice birder is prepared to exercise this knowledge in the field with binoculars, notebook and trusty guidebook. Birding authorities claim that with time, the novice should be able to work without the guide, drawing on skills learned through experience (Robin, 2001; Pettingill, 1985; Pasquier, 1977; Buteo, 2007; Winston, 2004; Ornithology.com, 2007; Morcombe, 2004).
However, as later chapters in this study show, contrary to Pasquier’s (1997) and Robin’s (2001) argument that people will eventually recognise the natural groupings of birds, in reality bird identification is a difficult process. Amending and improving bird guides to make them more effective tools for identification for new birders.

2.5 Problems with guides encountered by birders

Chapter 3 in this study identifies significant problems associated with current bird field guides through a major case study involving over 100 participants. Problems included the limited usefulness of current guides and the fact that they could alienate the novice birder and those who wish to identify birds on a casual basis. Major issues identified were in the overall function of the design, the textual description of the birds and the illustrations. In particular, participants identified a lack of consistency between the live bird’s field marks and the colouration as depicted in the illustrations and the textual descriptions of birds. Further, the illustrations of birds lacked what case study participants described as scientific representation, for example in the treatment of feet and legs and in the representation of individual field marks (also referred to as the ‘jizz’ of a bird). Scientific representation in illustration in this context refers to the accuracy of the illustration that ‘is guided by knowledge of science, acting according to scientific principles’ as ‘opposed to mere traditional, artistic expression (Oxford English Dictionary, 2012).

Two explanations for the difficulties in developing bird recognition and identification skills may lie firstly, with the way the information is visually displayed in field guides, and secondly, with an individual’s ability to use visual memory and recall. Campbell (2007), Alonso (1998) and Schwartz (2006) identify memory and recall as pivotal to learning and applying visual identification processes. Campbell’s (2007) theory of spatial awareness in visual perception together with Alonso’s (1998) theory of spatial visualisation ability and Schwartz & Heiser’s (2006) spatial representations in learning theories offer insights into how individuals consciously process visual information, which this study posits could have implications for bird field guide design.

Alonso (1998), Campbell (2007), Bright (2003), Shelton (2001, 2004), and McNamara (2001, 2004) argue there are two levels of abilities in seeing; firstly, perceiving and interacting with an environment or object and secondly, spatial awareness. Spatial awareness refers to a person’s ability to observe and understand an environment or object in terms of how they (that is, the person’s body) physically fit within an environment, or the ways in which they can physically react/interact with an object (Bright & Egger, 2003; Shelton, 2004). The physical mechanisms of spatial awareness begin with the person using their eyes to assess
the environment/object, during which action they engage relevant sources of information which at the most basic level assist them to determine how safe the environment/object is and how to orientate and negotiate their bodies through the environment or with the object. Further information absorbed depends on how that environment/object is going to be used. Regarding bird identification in the field, the person extends safety and navigation to incorporate learned contextual cues about the bird that they want to identify, such as habitat, bird colouration, movement and call sounds. In other words, skills in spatial awareness become more complex and influential as an immediate response to how the person wants to interact with the environment.

Alonso (1998) and Swartz & Heiser (2006) connect spatial visualisation with an individual's level of skill in imagining objects in a three-dimensional space, such as a birder would when imagining where a bird's nesting habitat might be within an environment. The actions involved are based on a learned visual consciousness ability to scan an environment looking for contextual cues that support knowledge about, for example, a bird's nesting habits and environment. This enables the observer to use an imaginative process to predict where the bird or nest might be. Abilities involved with spatial visualisation involve functional colour and lighting (Bright, 2003), the visual perception of objects (Campbell, 2007), recognition of spatial patterns (Liqiang, 2007), and principles in spatial memory and perspective taking (Shelton, 2004). Abilities in spatial awareness are learned and as such can be developed and applied when needed, which raises the question of whether knowledge and understanding of theories of spatial awareness and skills development in spatial awareness could be applied to field guide design and as a strategy that supports the learning involved in identifying birds in the field.

2.6 Spatial representations: an aid to building knowledge memory and visual awareness abilities

Schwartz and Heiser (2006, p. 283) define spatial representations as both external drawings and internal visualisations that utilise people's perceptual-motor systems. Spatial representations support learning in reading, maths and science, and are used within the visualisations of ideas and thinking that are central to innovation and scientific discovery. According to Schwartz and Heiser (2006, p.2), people have extensive memories for pictures. In fact, if people saw a million 'vivid' images (vivid referring to reduced detail and high colour contrast) they would retain '986,300' in the near term and would recognise '731,400 after a year' (Schwartz & Heiser, 2006, p.2).

The reference to vivid illustrations raises questions about the importance of colour, which
is pivotal to building the memory required for bird identification. Tufte (1990) states that human eyes are acutely sensitive to colour variations, and that, under contrived testing conditions, a trained colourist has the ability to distinguish among one million colours, and many viewers have the ability to determine at least twenty thousand.

Vivid image theory is grounded in Paivio’s (1986, p.259) ‘dual coding theory’, which draws on extensive research into imagery, memory, language, and cognition (Clark & Paivio, 1991; Schwartz, 2006). According to Paivio (1991, p.259), dual coding implies ‘that verbal and non-verbal codes corresponding to the same object (e.g., pictures and their names) can have additive effects on recall’. For example, one can think of a bird in terms of the word bird, or by forming a mental image of a bird. Moreover, when the verbal and image systems are connected and related, one can think of the mental image of the bird and describe it in words, or conversely read or listen to the word bird, and build a mental image. Paivio (2006, p.3) breaks this process down, designating verbal units as ‘Logogens’ and non-verbal units as ‘Imagens’.

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Fig.2_5 Example of dual coding theory taken from Simpson & Day (2004) Field Guide to the Birds of Australia pp.164-165
According to Paivio (2006, p.3) a Logogen is a unit containing information that underlies the use of words. Imagens contain information that promotes mental images. Imagens operate simultaneously, enabling the processing of all available parts of the image at the same time. Logogens, on the other hand, function sequentially, meaning words appear one at a time in a syntactically appropriate sequence forming a sentence (Clark & Paivio, 1991; Moreno, 2009; Schwartz, 2006). The figure above, taken from Simpson & Day (2004) Field Guide to the Birds of Australia, illustrates Paivio's Imagens and Logogens at work. On the left hand page there is text or Logogen that describes bird species features, flight, size, voice, and habitat, and on the right hand page a visual representation or Imagen that reinforces the information in the text.

This use of Logogen and Imagen contradicts the basic principles of dual coding as identified by Paivio (1975), which is all about simplicity and the purpose of reinforcing connections between visual and written text in the human brain. Paivio's dual coding theory implies that visual and verbal/textual information is represented and processed in independent though interconnected cognitive systems. The visual system is for processing concrete objects and events, and the verbal system for dealing with language based information (Paivio, 1975, 2002; Ryu et al., 2000). The interconnectedness means that nonverbal information can be transformed into verbal information, or vice versa. For example, a bird can be thought of in terms of the word bird, or by forming a mental image of a bird. In addition, one can think of the mental image of the bird and then describe it in words, or conversely read or listen to the word bird then form a mental image (Paivio, 1986).

When using dual coding theories for learning, integration occurs when the learner builds connections between the verbal and visual-based models, doubling the chances of memory retrieval (Clark & Paivio, 1991; Mayer, 2007; Moreno, 2009; Paivio, 2006; Schwartz & Heiser, 2006). Experiments carried out by dual coding researchers, Allan Paivio (1975) and Lionel Standing (1973) suggest that image and text should be positioned together, so that the student can read the text and see the image simply by moving their eyes.

While Imagens and Logogens may intersect when processing information, in the case of the bird field guides discussed in this chapter it appears that greater emphasis is on the Imagens. The emphasis on Imagens aligns with the two dual coding hypotheses developed by Paivio (2006). The first is ‘that nonverbal and verbal codes, being functionally independent, can have additive effects on recall’ (Paivio, 2006, p.4). Experiments carried out by Paivio and Lambert suggest that the Imagen is ‘mnemonically stronger’ (contributes more to the additive effect) than the Logogen (Paivio, 1986, p.250).

Paivio's (2006, p.4) second hypothesis, named the 'perceptual peg', proposes that 'compound images that link pairs are formed during a presentation and then reinstated during recall by
Design for nature and the nature of design ability: Chapter 2 | To speak of birds

A concrete stimulus. In other words, a compound image of an actual Galah that highlights the bird’s primary colours of pink and grey will establish a link between the pink and grey when presented. The link is then reinstated during recall by a concrete stimulus such as Galah. The two hypotheses support the theory that the non-verbal code is stronger than the verbal code, notwithstanding that the duality is better than the non-verbal code alone. This study demonstrates that the application of Paivio’s (2006) dual coding theory has the potential to improve the education process for novice birders, specifically its application to developing bird identification skills.

Paivio’s (1986, 2002, 2006) dual coding theory could be used to develop a system which includes descriptive text that better supports the bird illustration or bird Imagen. The Imagen, rather than following the traditional detailed representation of birds, could take the form of a vivid image of the bird in the case of field guide design. As will be argued in later chapters, a vivid image or high colour contrast image presented in a simple form suggests an icon when considered within visual communication design terms.

The application of dual coding theory to field guide design directs the positioning of bird images (visual system) and descriptive text (language system) on the same page. This strategy should support the learning, processing, storage, and retrieval of bird identification information by users. Therefore, Paivio’s (1986, 2002, 2006) dual coding theory, when considered with regard to the learning of bird identification strategies, could theoretically include iconic devices of birds in conjunction with descriptive text that highlights the essential features of a bird for identification.

2.7 Bird identification: dual coding, gestalt and icon design theory

When in the field, the birder relies on the perceptual motor system to navigate and identify objects within a bird’s habitat. Paivio (2006) recognises that the perceptual motor system uses fragments of an object (Imagen) rather than remembering it as a whole, which in turn elicits a descriptive word (Logogen). Imagens could be described as a visual shorthand embedded in the tacit-knowledge of visual perception abilities. Imagens are tacit because they have to work instantly, without hesitation or thought. Although humans are born with the perceptual motor system abilities needed to recall just the right amount of visual information to recognise and label an object or environment, this ability is tractable and therefore can be built through repetition and learning processes. The fundamental meaning of Imagens correlates with Gestalt theories, especially when discussing imagining and then recalling an object. ‘The appearance of parts is determined by wholes’, which in turn
Design for nature and the nature of design ability: Chapter 2 | To speak of birds

relates to icon design (Behrens, 2004, para.10). All three theories are key concepts that could contribute to simplifying the bird identification process.

2.7.1 Icon design

Icon design is the visual manifestation of Gestalt laws of visual organisation. In other words, the process of icon development and refinement to the final device akin to the laws of Gestalt involves the mastery of visual perception and visual simplification to discern key pattern, colour and shape and just the right amount of visual information to capture the whole bird (Behrens 2004; Caywood 1997; Hufnus 2000). A detailed description of icon device creation is presented in Chapter 5 of this thesis.

In a VC design context, vivid images fall under icon design, which in essence is the production of a simplified graphic device that reflects the object/thing it represents. In these terms the dual coding process for the birder involves looking at the image and then reading the name. How many times the individual has to do this is dependent on numerous individual cognitive factors, but it has been shown to be the most effective combination for learning and recall (Paivio, 1986, c2009; Clark, 1991; Schwartz, 2006). The visual analysis of bird field guides and the case study discussed in Chapter 3 show that current field guides do not offer vivid images and also exhibit problems with the textual placement of bird species’ names and field marks. Where field guides do highlight bird features, they do not use vivid images, but rather traditional and artistic illustrations.

The complex and systematic design process involved to produce an icon is reductive, meaning the VC designer begins with a detailed image of an object and reduces its form, shapes, elements, and colouration to the simplest form of all of these that still communicates the object without the viewer questioning what it is. This systematic process of reductive thinking is learned during the VC design education process and is practised by VC designers when engaged in designing an icon for a company, business or product.

This study is informed by the combined understanding of the role of the field guide, the scientific illustrator, and the impact of theories such as dual coding, gestalt, colour constancy, colour standardisation and icon design in establishing a balance between scientific knowledge and functional visual understanding of how to identify a bird.
2.8 The origins of naturalistic and semi-naturalistic bird illustration

The evolution of naturalistic and semi-naturalistic representation of birds was captured through the work of Schulze-Hagen, Steinheimer, Kinzelbach and Gasser (2003, pp.459-462) whose primary aim was to research the history of avian taxidermy in Europe from the Middle Ages to the Renaissance. In order to identify the beginnings of taxidermy, they researched visual representations of birds and it was through these images that they could identify where the illustrator used ‘stuffed’ birds as models. Their combined research of textual and pictorial sources focused primarily on central Europe between the 12th and 17th centuries. Schulze-Hagen et al., (2003, pp.462-464) referred to the visual representations of birds as ‘art’ and then further labelled the artistic approaches as ‘naturalistic’ and ‘realistic’, meaning birds were depicted as a close representation but this was based on the painter’s experience and perception. Works by artists such as Albrecht Durer (Fig.2_6) and Antonio Pisanello (Fig.2_7), who used oil paint to capture the intricate details of birds, were also included. They also refer to ‘semi-naturalistic’ representation used in bird albums and books, which is illustrative rather than artistically naturalistic. The semi-naturalistic illustrators included Conrad Gessner (1516-1565) (Fig.2_8), and Pierre Belon (1517-1564) (Fig.2_9), who used techniques such as wood cut and engravings.

Schulze-Hagen et al. (2003, pp.462-463) maintain it was not until the mid-1500s to early 1600s that basic taxidermy mounts of the entire bird were preserved for scientific purposes, which meant they were then available to act as models for naturalistic representation. Even so, many artists, for example such as Albrecht Durer (Fig.2_6) and Hans Hoffmann (1530-1591/92) (Fig.2_10), preferred to create their images using live or freshly dead birds. The reason for naturalist artists preferring live and freshly killed birds over the stuffed models was probably due to the primitive results of taxidermy at the time, such as assembly errors, twisted feathers and unnatural posture, which would make it difficult to create accurate naturalistic representations. Mounted bird specimens were the preferred reference for semi-naturalistic illustrations for the first bird books, such as Gessner’s Historiae animalium liber III (1555), and Belon’s L’Histoire de la nature des oyseaux (1555).
It was not until the spread of photography during the 19th century that naturalist artists had an alternate method to killing in order to acquire the necessary detail for scientific representation (Schulz-Hagen et al., 2003, p.473). However, the introduction of photography did not decrease the killing of birds for scientific purposes, as evidenced in an article written in 1912 by American zoologist Walter Bradford Barrows entitled Michigan Bird Life. He states ‘absolute and full knowledge of birds can be obtained only by studying them alive, by killing and preparing them for preservation’ (Barrows as cited in Alphonsus 1918, p.225). Schulz-Hagen et al. (2003, P.474) confirm that the combined use of taxidermy; live birds and photographs ‘are the basis of the illustrations in all good bird books...and ... play a crucial role in education, research and theory’.

2.9 Contemporary bird field guides: a process of trial and error

The development of bird representation in field guides from the early guides to those found in current bookstores was a process of trial and error and, according to Libby Robin (2001), the trial and error approach was a distinctive feature of taxidermist and explorer ornithologist John Gould (1804-1881). Robin (2001, pp.2-7) argues that Gould set the foundations of the contemporary emphasis of bird guides on artistic / naturalistic illustrations. He achieved this by employing his talented wife, Elisabeth, to paint detailed representations of birds that focused on the beauty of the plumage rather than on scientific accuracy. Their combined effort continues to be influential into the twenty-first century.

Gould's interest in Australian birds began when his brothers-in-law, based at Yarrundi on the upper Hunter River in Australia, sent him samples of bird specimens. Gould used the specimens to produce a small volume entitled A Synopsis of the Birds of Australia and the Adjacent Islands (1837-38). The market success of this venture inspired Gould to commit, rather rashly, to publishing the first part of a seven-part book entitled Birds of Australia. However, working from stuffed bird skins and birds pickled in spirits Gould had difficulty in accurately visualising Australia's peculiar and exotic bird species, which resulted in illustrations that were inaccurate and fanciful. When he recognised the faults in his work, Gould recalled the first part
of the series, and set sail for Australia in 1839 to observe and record the birds first hand in the field. The revised publication of *Birds of Australia* (1848), was thus grounded in fieldwork observation and understanding, and set the foundations for the development of an illustrative language which continues to inform Australian bird publications. The eventual seven-folio volume of *Birds of Australia*, published in 1848, was regarded at the time as ‘the most important, from an ornithological point of view, of all Gould’s work’ (Waterhouse, 1885, p.ix).

At around the same time as Gould the American-born John James Audubon (1785-1851) (Fig.2_11), like Gould, dedicated his life to drawing and painting nature, in particular birds. His preference was to draw from life but he was known to create models by shooting birds, and using wire to position them in natural poses. In the same manner as John and Elizabeth Gould, Audubon painted naturalistic representations that focused on the ‘depth and detail’ of plumage (Audubon, 2005, para.2). Importantly Audubon’s approach advanced that of the Gouls in his attempt to highlight the bird’s field marks. His attempts were criticized as creating theatrical rather than naturalistic representations, however, it must be noted that Audubon was the first artist to explore the idea of highlighting species field marks. With his first publication in 1839, *The Birds of America*, Audubon was acknowledged as America’s preeminent wildlife artist (Audubon, 2005).

Up to this point, the discussion in this chapter has revolved around the development of visual representations of birds that have been published in books and not in what we know today as field guides. The environmental historian Tom Dunlap (2005) notes that the earliest documented American field guide appeared in 1889, being Florence Merriam Bailey’s *Birds Through an Opera-Glass*, which was illustrated by Louis Agassiz Fuertes (Fig.2_4). According to Dunlap (2005, pp.2-4), the intention of this guide was to introduce women to birds around the home and at the same time, by way of ‘calling for observation and careful records, offered women a way into the public, masculine sphere of science’. Bailey was also the first to provide a simple measurement of each bird in inches, a landmark in the provision of identification details by bird guides. It is also important to note that Fuertes, Bailey’s illustrator, was one of America’s finest bird artists, with a reputation and talent equal to Audubon and Peterson (Fuller 2008).

In 1895, Mabel Osgood Wright (Fig.2_12) published *Birdcraft*, which advanced
Bailey’s book by using ‘photo reproductions, in colour, of paintings by James Audubon’ and other bird artists rather than the wood engravings used by Bailey (Dunlap, 2005, p.3). Dunlap (2005) argues that, although more descriptive than wood engravings, the photo reproductions were too artistic and lacking in the diagnostic features required for identification purposes. Dunlap (2005) goes on to argue that the early bird books and guides from the late 19th century offered detailed illustrations based on a combination of science and sentiment, technical details and romantic prose. Nevertheless, these early guides helped foster bird observation as a new scientific activity and a genteel recreation. The authors, from their experience as birders, developed the informational content for other birders. The design was heavily influenced by the cost of printing, which saw some guides using black and white, an inexpensive alternative to colour (Dunlap, 2005). For example, Peterson’s first Guide to the Birds of North America was printed in black and white with an insert of four colour pages, which meant that the illustrations of the birds had to be reduced to postage stamp size in order to display as many birds in colour as could fit, approximately 20 birds per plate (Dunne 2009). The design of this time, as evidenced in Gould and Audubon, also capitalised on the variety of illustrative techniques available, including the artistic conventions of natural history illustration and the fine arts, with some linking text to images, and some not.

From the first depictions of birds for ornithology and identification purposes, as noted in the works of Gesner in 1551 (Fig.2_8) and Audubon 1839 (Fig.2_11), hand rendered techniques of illustration have been preferred, including etchings, engravings, watercolour, and oil paints. As noted, the combination of scientific observation and artistic and genteel aesthetics was intended to appeal to early audiences. Dunlap (2005) argues that current techniques using traditional artist methods such as watercolour, acrylic and oil paints appeal to the audience’s interest in bird imagery, which fulfills aesthetic expectations by meeting the artistic paradigm set in the early guides such as Florence Merriam Bailey’s (Fig.2_4) Handbook of Birds of the Western United States (1902) (Fuller, 2008) and Chester Reed’s (Fig.2_13) Bird Guide, Part 2: Land Birds East of the Rockies (1906). These guides were in turn influenced by the artistic styles of authors including John Gould and his wife Elizabeth Coxen in books such as their five-volume Birds of Europe, published between 1832 and 1837 (Dunlap, 2005).
A significant turning point for field guide design occurred in 1934 with the production of *Field Guide to the Birds of North America* by American Roger Tory Peterson (Fig.2_14) Dunlap (2005). Peterson’s guide established the design language and conventions of today’s bird field guides by laying the foundations for a move toward the scientific and functional (Leo 1996, p.17). Leo points out that Peterson’s compression of information served the purpose of reducing the total page numbers while maintaining the overall size of the guide to fit into a birder’s pocket i.e., 18.3cm in height, 11.2cm in width, and 123 pages in length. Peterson was not the first to reduce the dimensions or number of pages in a bird reference book; this innovation resides with Florence Merriam Bailey when she published her *Handbook of Birds of the Western United States* in 1902. Her book was 18.5 x 10.1cm in size and had 223 pages (Dunlap 2005). By comparison, Daniel Giraud Elliot’s *A Monograph of the Bucerotidae, or Family of the Hornbills* (1882), was 36.4 x 28.4cm, c600 pages (Biblio 2010). In addition, although Peterson’s visual representation of birds followed the artistic conventions of his predecessors (Fig.2_14) by using traditional techniques, it was his philosophy ‘that the study of natural history should be the primary avenue for creating environmentalists’ (Wiessinger 2008, para.1). Peterson’s use of arrows to point out bird field marks and his ability to identify with the birder’s needs in field guide design and illustration differentiated his field guides from others.

Creating a visual shorthand, Peterson reduced visual and textual information to the essential and also created a system of patternistic drawings for identifying birds at a distance and in their native habitat (Institute, 1994). Peterson’s identification system was ‘visual rather than phylogenetic; it uses shape, pattern, and field marks in a comparative way’, rather than focusing on evolution (Peterson cited in Wiessinger, 2008, para.17). In addition, Peterson emphasised bird families, pointed out identifying features using small arrows (Fig.2_15) and included maps as a quick reference to location of the species, as in his field guide *Birds of Eastern and Central North America* (Peterson, 2002; Law, 1988). Peterson’s combination of visual and written information provided the birder with essential details to learn and easily recall when in the field. Alternatively, they could carry the guide and flip through the illustrations until they found a bird that looked similar to what they had seen (Dunne, 2009). Ultimately, Peterson’s innovations shifted the focus of bird identification from the specialist with a shotgun to the world of watchers and protectors of birds (line, 1996).
The visual analysis process carried out for this study revealed that today's field guides, for example, the *Sibley Guide to Birds* (2005), and *Birds of Europe* (2000), follow the artistic conventions of the early bird guidebooks with their natural history illustrations or fine art accompanied by text describing bird details such as colour, form, plumage patterns, and posture. This means that, although current field guides are designed and illustrated with identification support in mind, the majority of the main images of birds are still artistic, as evidenced in the works of David Allen Sibley (Dunne 2009; Sibley 2006), and more recently, John Sill (2008), Dougalis & Paschalis (2008) and Gina Mikel (2008). Although aesthetically pleasing by drawing attention to the natural beauty of the bird, this illustration system does not address 21st century technological advances in colour and print nor in perceptual and spatial representation theory.

### 2.10 Bird field guide illustration

Bird illustration has long been the domain of scientific and naturalist illustrators with distinct objectives. However, a review to gauge current bird illustrator's opinion of their field revealed a gap in this rhetoric. The review was carried out by contacting current bird illustrators who are at the top of their field and requesting them to complete an online survey. Current illustrators from across the world were identified through an Internet search, which located a number of professional Illustrator websites that detailed each illustrator's work history and experience. A survey was designed to investigate these illustrators' understanding of their field, and to establish whether they shared common aims, theories and principles of practice. The survey asked respondents to describe the role of a bird illustrator. Ten prominent illustrators with current experience in bird illustration for scientific purposes were then invited by email to take part in the survey, with nine responding. The Illustrators were Ian Griffith, British natural history illustrator (Fig.2_16); Caroline Huet, French nature artist (Fig.2_17); Frank Ippolito, American natural science illustrator (Fig.2_18); Ian Lewington, British bird illustrator (Fig.2_19); Diana Marques, Portuguese scientific illustrator (Fig.2_20); Gina Mikel, American bird and wildlife illustrator (Fig. 2_21); Paschalis Dougalis, Greek bird and wildlife illustrator (Fig.2_22); Chris Rose, British wildlife artist (Fig.2_23); and John Sill, American wildlife biology and illustration (Fig.2_24).
The nine participants responded promptly, within two or three days of receiving the invitation and survey. Each provided rich and detailed responses and included permission for their names to be used in this thesis. The responses revealed a desire to share their world, and the immediacy, openness and richness of the responses indicated that the opportunity to talk about their field in a research context was a rare event and was welcomed, thus providing additional evidence for the relevancy of the work of this thesis.

To follow are highlights of their understanding of the role of a bird illustrator for field guides and other scientific literature. Senior Artist/Senior Principal Scientific Assistant to the American Museum of Natural History, Frank Ippolito (2009) stated that ‘Natural Science Illustration forms a bridge between the naturalist and their myriad audience. The scientific illustrator uses visual design and problem solving skills, as well as well-honed observational skills, to effectively communicate complex natural phenomena in all its beauty and nuance. It is, by definition, art in the service of science’.

The scientific artist, Gina Mikel (2008), whose clients include the Smithsonian Institute, Minnesota Department of Natural Resources, California Science Centre Foundation and the Field Museum of Natural History, highlighted the tension between generalisation and detail, and also between accuracy and aesthetic engagement ‘to create images of the species that are well matched to how the species looks when found in nature. An illustration can (and, ideally does) provide a better image than a photograph, in that background information can be cut out, the features of the bird can be generalized, and the artist can achieve greater three-dimensionality, colour, and textural detail. ...If a scientist is overseeing the field guide, the illustrator’s role is to be guided by the scientist. Finally, the bird illustrator’s role, as an artist, is to create images that are compelling and engaging’.

Similarly, John Sill (2008), the illustrator for the Bird Identification Calendar published by the Massachusetts Audubon Society, argued that an ‘artist has more control than a photographer especially in capturing the ‘nuances of a species’, the bird’s ‘specific attitude' and ‘precise plumage’. Caroline Huet (2008), who paints ornithological, accurate representations of birds especially from Brittany stressed the importance of accuracy and detailing
to reduce confusion and establish difference, ‘I give a big importance for the essential elements which allow to identify a bird... to avoid the confusion with another bird looking like it’. Diana Marques (2009), a freelance scientific illustrator commissioned by the Smithsonian Institute, National Museum of Natural History, Department of Entomology, and Systematic Entomology Laboratory, believed that the scientific illustrator offers ‘reliable, detail-oriented and proficient services’ and ‘...accurate and engaging biological and scientific illustrations’. Marques also stated that she strived to combine ‘skilled techniques with an insightful understanding of the subject matter to deliver creative and effective messages’.

The major recurring theme identified in the responses of all nine illustrators was finding the balance between aesthetics and accuracy. Significantly, they saw their role as communicating for and to scientists, with the role of the designer being to create visual information necessary to ensure the balance between generalisation and detail, between colour and texture. The responses point to the importance of scientific accuracy, so that the bird illustrator must prioritise with precision the naturalistic qualities of each bird and present differences by highlighting form, colour, texture or plumage peculiar to the bird. The participants advocated that scientific illustrators must ensure the finished illustration is visually engaging in order to foster appreciation, and highlighted the importance of simplification or generalisation, to make the process of learning the salient features of the species easier, and to help build an informed memory that can be used later when identification is required. As these illustrators are all successful artists whose work is in demand because of its highly individualistic character, their illustrations are also individualistic in the colours they choose and the field marks they select to highlight. These are world-class illustrators and their bird representations are detailed and expressive, which reveals their highly developed observational and technical skills. However, within the theoretical basis of this research, their illustrations are located more within an artistic frame of illustration than a scientific one. What might assist in scientific depiction of birds is a set of guidelines and techniques that support accuracy and consistency of the representation bird species, regardless of the illustrator. That is the premise of this thesis that a better system might be developed, and this is the question that is discussed in later chapters.
2.11 Bird field guide design: time for change

Little attention has been given to field guide design since Peterson’s innovations in 1934 (Dunlap, 2005). A visual analysis of current field guide design conducted as part of this study indicates that, while the influence of contemporary design principles can be seen in the cover design, typography and layout, the illustration style, particularly for the visual representation of birds, is still reliant on conventions based on two hundred years of aesthetic traditions of bird illustration (Hauffe, 1998; Iwasaki 1994).

It is not clear when the first graphic designer contributed to the visual language of bird field guides. However, there is some evidence of subtle adjustment to font selection, style and layout that indicates graphic and stylistic trends over the past forty years. For example, when comparing Roger Tory Peterson’s first edition of *A Field Guide to the Birds* published in 1934 (Fig.2_25) with a recent edition published in 2008 (Fig.2_26), a shift in design style is noticeable (Callaway 2008). The 1934 publication reveals a Bauhaus influence, particularly the sectioning of the design and the use of red, black and a neutral colour, (grey, cream, beige, white), as the main colours for the design (for comparison, refer to Fig.2_27). The 2008 edition of Peterson’s guide uses current design elements and principles such as a glossy dust cover for the book, white background, and deep etched image. A serif font is used on both covers. The 1934 publication uses a font the likes of Bookman or Century and the kerning (space between each letter) is open, which was common for that time due to the use of a letterpress; in letterpress printing each letter of the alphabet is formed as an individual moveable block made from metal and positioned by hand. In comparison, the 2008 publication uses a contemporary serif font, like Caslon, with precise and controlled kerning set by using a computer. Finally, the print production qualities of the latter publication reveal the use of technology capable of capturing minute detail in the imagery, which was not available when the first publication was printed.

interior design and print production values of bird field guides since Peterson's 1934 guide (Fig.2_28). For example, a comparison of Peterson's first guide with a later 2010 publication (Fig.2_29) shows that the 464 page design includes maps by making the text column smaller so the map stands alone from the text. Then the name of the bird is set bold, and ranged left, which visually connects the map to the body of the text. In the original guide the image and heading were centered above the centered/justified text, which is a formal approach to layout. In addition, the advancement of print values is evident in the detail of colour and texture of the illustrations in the 2000 guide, although these are due to advancements in print technology rather than to a specific design decision.

When comparing Peterson's 1934 and 2010 guides (Fig.2_28 & Fig.2_29) with Michael Morcombe's 2004 guide (Fig.2_30) fundamental conventions of field guide layout become apparent. The layout of each page comprises a one-column grid, with four main horizontal subdivisions. These support the order of text and images. The descriptive text and maps are positioned on the left hand page, bird imagery on the right. Bird illustrations are rendered in artistic traditional techniques such as watercolour, acrylics and oil paints, and multiple

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Fig.2.29 Roger Tory Peterson 2010 Birds of Eastern and Central North America 6th edn. New York: Houghton Mifflin

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Fig.2.30 Michael Morcombe, 2004 Field Guide to Australian Birds. Queensland: Steve Parish Publishing.
birds are positioned on the page together with feature highlights indicated by text and an arrow pointing to the relevant area. A field guide that breaks the layout model is David Sibley’s (2000) *The Sibley Guide to Birds*, (Fig.2_31). Rather than having one page for text and the other for images, Sibley’s guide integrates text and images on both pages. This is achieved by using a two-column grid subdivided into five horizontal bands for each page, with the images and text placed within the confines of this grid. The overall design maintains visual order by placement of bird images close within the boundaries of four of the six subdivisions. The maps are consistently positioned within the sixth subdivision and species information in the first.

The visual analysis of the five Australian field guides, and less detailed analysis of nineteen international guides (listed at the end of this chapter) indicates that visual communication design principles and practices have contributed to the advancement of the visual communication in bird field guides. For example, contemporary guides use contemporary layout and typography and have benefitted from advancements in print technologies, as indicated in the level of detail captured in the bird images. However, little consideration has been given to the visual system of representation of birds for identification, with which this study is most concerned.
The current visual system continues to use artistic renderings with arrows or lines pointing to prominent features of the bird, revealing little influence from current graphic design knowledge of theories and methods of visual communication, visual systems of representation and sophisticated computer rendering and print technologies. These discoveries prompted the shaping of the design-led briefs within this research, to investigate the use of design expertise to modify and improve the existing system of representation for identification purposes in birding field guides, bringing them up to date with more effective visual solutions derived from the application of contemporary design knowledge and digital and reproduction technologies.

2.12 Conclusion

Field guides offer bird illustrations in conjunction with descriptive text to guide amateur birders and professional ornithologists to build the necessary knowledge and visualisation skills to identify birds. The visual representations of birds in artistic, photographic, line work and silhouette are the central communication device of field guides. Their role is to visually group and differentiate species through the graphic depiction of shapes, size, coloration, and feather pattern when birds are still and in flight. They must be scientifically accurate and point to identifying features in order to aid instant differentiation and recognition in the field. Fundamentally their role is the building of visual recognition skills.

This chapter has identified that current approaches to the visual representation of birds in bird field guides underutilise theories of gestalt, icon design and spatial representation. In particular, current approaches do not take full advantage of knowledge gained from Paivio’s (2006) dual coding theory, based on the concept that Imagens (non-verbal/ images) and Logogens (verbal/ textual) together support learning and recall. Where field guides do incorporate some aspect of Paivio’s (2006) Imagens and Logogens these are complex and detailed rather than simple and vivid. The chapter has established that ‘Vivid’ images (Schwartz & Heiser 2006, p.2), for example an iconic device that represents a bird species’ field marks and text that supports those field marks, together ‘double the chances of retrieval’ for a birder wanting to identify the same bird when out in the field. Finally, the historical account of the development of naturalistic and semi-naturalistic representation of birds and the interviews carried out for this study with contemporary bird illustrators substantiate the contention that current approaches to the visual representation of birds are still based on artistic and individualistic perception rather than on scientific accuracy and consistency. The next chapter, Perth Zoo Case Study, explores bird field guides from the view of the birder, both novice and expert ornithologist.
3. Perth Zoo Case Study: an investigation into the world of the birder and activity of bird identification

3.1 Introduction

This chapter details the methods, processes, and outcomes of a case study carried out at the Perth Zoo. This case study was pivotal to my understanding of the world of the birder and the activity of bird identification, both of which I had little to no experience with. The objectives of the case study were, first to gather information about birders, bird identification and bird colouration to determine whether my idea of ‘Identicons’ (icon device discussed in chapter 6) as an additional visual aid in bird field guides had potential for further development. Second, to use the research data as a way of understanding where VC design might advance the current visual systems used to support the learning of bird families and species, both within the Zoo exhibits and bird field guides.

The chapter opens by stating the aims and objectives of the study and why a Zoo was selected over other environments. Next the questions that drive the study are presented and the methods used to address those questions are defined. Then a description of each method, namely non-participation observation, in-depth interviews, online survey, and formal visual analysis is given, and extracts from each are presented. The data collected are analysed using Grounded methods and finally the results are discussed, providing insight into ways in which VC design theories and expertise can contribute to the issues and concerns that surround bird identification.

3.2 Why a Case study and why the Zoo?

For this study, in order to determine the VC needs of people who engage in bird identification, it was necessary to expand the information gathering process beyond literature to include
advice from people with experience in this field, all which pointed to the need for a case study.

While Shuttleworth (2008), Kumar (1996) and McGloin (2008) note the criticism that case studies can be narrow in focus and thus non-representative of a collective, they nevertheless maintain that case studies provide a more realistic response than the purely statistical survey. The strength of a case study is that the researcher can blend both statistical with qualitative processes, making for a rich collection of data that can gather statistics but also investigate issues at depth using interviews and observation methods. In addition Shuttleworth, Kumar and McGloin reinforce that the narrative nature of case studies makes for more compelling reading than pages of statistics. Finally, from a design research perspective, a case study approach supports Frascara and Winkler’s (2009, p.13) four conditions for developing useful advanced research in design; the case study aim and objectives ‘belong in the design discipline’, the methods used are a ‘model for the profession’, the topic is ‘socially relevant’ and the process ‘involves the users’.

The Zoo environment was chosen over bird parks to access people interested in birds because it not only provides an appropriate contextual framework to engage with people experienced with bird identification and delivers access to birds in a manageable environment, but it also has a strong research program designed to provide support for PhD candidates.

Although my project was outside of the usual scientific parameters that the Perth Zoo supports, and in spite of the fact that the research committee knew very little about ‘design’, they could see the potential contribution this case study could make to their commitment to expand ‘community engagement and awareness in conservation’ of wildlife (Perth Zoo, 2009, p.110). In short, they supported the project aim to contribute to the science of Ornithology through the investigation of visual systems and practices in bird identification and to uncover how VC design could contribute to the building of knowledge about bird identification and how this knowledge could be applied to expand peoples’ engagement and awareness in conservation of birds.

The support provided by the Perth Zoo included a one-year contract and a research supervisor, Dr. Wen Haur Cheng BVMS (Hons) BSc., who was selected based on the match of his expertise to my field of investigation. Dr. Haur’s role extended to ensuring that facilities to support the progress of the project were made available and liaising with internal Zoo staff when their expertise was required to advance the project.

The Zoo provided a controlled environment that enabled the gathering of a wealth of research data that met the aims and objectives of the project. Firstly, in order to expand people’s engagement and awareness in the conservation of birds, I required firsthand
experience and understanding of how people interact with birds within an environment, and in this case a bird exhibit. What behaviour did they display? Did they talk about the birds? Where did they walk and how long did they spend in the exhibit? Next, it was important to investigate the visual systems and practices in bird identification, and this expertise required me to go beyond what was available in books to seek advice from expert birders. It was essential to understand the practice of these experts; how they identified birds, what strategies they used, and if they displayed any special or heightened abilities in spatial awareness. It was also critical to know their usage and expert judgement of visual systems; what was their opinion of current visual systems (illustrations, photographs, silhouettes, line drawings) used as strategies for bird identification; which field guides did they refer to and what were their opinions of the design and illustrations in those guides; how well did the field guides function according to their needs.

Finally, within the aim to investigate visual systems in bird identification, the research needed to identity how VC design expertise can build information systems that advance bird identification for the birder and educate the Zoo visitor to care for and appreciate birds, both in the zoo and in their daily environments. This question was investigated through the application of emergent Grounded methods, whereby the question itself becomes a reference point when analysing the data generated by the research questions. In effect, the question becomes an ‘axial’ code, which is a ‘condition’ used to examine the data once it has been subjected to ‘open coding’. This process allows for ‘selective’ codes, ideas, insights to emerge that are relevant to the initial question (Dey as cited in Urquhart, 2001, p.3).

These questions made clear the methods for data collection and analysis. Specifically, non-participant observation of the Zoo visitor’s interaction with bird exhibits, in-depth interviews with Zoo staff with expertise in the identification of birds, the distribution of an on-line survey to bird identification experts, non-participant observation of birds in order to sketch, and photograph them, and artifact collection in the form of bird feathers in order to analyse feather colouration specific to bird families and species. All data were collected and analyzed applying Grounded theories as determined earlier in chapter 2 of this thesis.

3.2.1 Ethical considerations

Ethics approval for the research was obtained from Swinburne University, according to requirements of the Swinburne Ethics Committee, and from the Perth Zoo research committee. The case study was monitored by the Zoo, which required the presentation of findings twice during the year, first in a mid-year report and then in a formal paper and poster presentation, which was delivered to a group of sixty zoological experts. The Zoo contract also included a request to position components of the case study work in a way
that was relevant to the Zoo community, for example, concepts for interpretive signs, and ideas to engage visitors with the bird exhibits.

3.3 Case study methods: Grounded theory analysis

The Zoo case study applies a ‘descriptive’ approach by using the data analysis results as a prelude to the design-oriented projects presented later in this thesis (Tellis, 1997, p.1).

In VC design terms, the Zoo case study is likened to the design process of a design brief development. In this process, after the initial meeting with the client the designer collects brief related information, both textual and visual. The collection could include research into the client’s field of expertise if this field new to the designer, which involves interviews with the client, interviews with the end-user of the proposed product/object, and a visual audit of the client’s current visual material and that of their competitors. Upon completion of this process the information is carefully analyzed with the intent to define the brief within a framework that allows for issues and ideas to emerge that clarify and validate the brief.

3.3.1 A cacophony of data

The collection of data spanned three months across three research stages. Stage one was non-participant observation. Time of year and time of day were important for these observations. In order to have the best lighting conditions for viewing birds in a natural setting midsummer in Perth, Western Australia was selected and observations were carried out from December 1 to December 9, 2004. Times of the day for observations were 10am, 1pm, and 3pm. These were selected following the recommendations of Zoo docents, that is, experienced volunteer guides who were also experienced birders, for the most popular visiting times for the general public, including school groups, young families and international visitors.

Stage two consisted of two sets in-depth interviews with twelve interviewees in each set: the first set from February 8 to March 11, 2005 and the second set from March 3 to March 17, 2005. Stage three was an on-line survey distributed on August 22, 2006 and the resultant 100 responses returned by September 31, 2006. All interviews, surveys, and observations were administered, collected, and analysed by me as the researcher.
Sample groups

Sample groups were necessary to gather knowledge and understanding of how visitors engage with birds when visiting a bird exhibit and to determine the bird identification strategies used by experienced birders in the field. This called for sample groups that were determined by the type of data required for the case study and were also related to the Zoo research board requirements for concepts for interpretive signs, and ideas to engage visitors with the bird exhibits (Bouma, 2001; Burns, 2000b; Haigh, 2007; Kumar, 1996; Merriam, 1988; Mohd Noor, 2008; Shuttleworth, 2008; Tellis, 1997).

Initially, to gauge visitor interaction and behaviour, the intention was to gather a sample group from among the visitors to Perth Zoo. In effect, to approach them as they entered the exhibit and then, with their permission, follow them and ask a series of set questions. However, approaching members of the general public engaged in recreational activity did not sit well ethically and was discouraged by the Zoo. Instead, a non-participant observation approach was designed that allowed for observation of the Zoo visitors without any interaction. Therefore all observations were carried out at two exhibits, the Australian Wetlands exhibit and the Walk-in Bird exhibit.

This approach established what Burns (2000, p.90) and others refer to as a probable ‘stratified convenience sample’, which increases the data accuracy by ensuring that all groups are represented in the sample, and where ‘convenience’ refers to the ease of gathering the sample. In essence, the sample was defined by whoever entered the exhibit over three consecutive days during three one-hour periods starting at 10am, 1pm and 3pm. A time allowance of one hour per observation was determined in consultation with the Zoo Ethics Committee, based on the advice that birds cope with an unknown visitor (i.e., unknown to the birds) for up to an hour, after which the potential for stress on the bird increases.

The ‘stratified convenience sample’ approach was also important for gathering the knowledge of the Zoo docents. However, rather than an open invitation to all zoo volunteers, criteria were developed to attract docents with experience as birders. Burns (2000, p. 465) recognises this approach as ‘criterion-based sampling’ within a ‘stratified convenience sample’. The recruiting process involved using a poster that invited volunteers to join a six-month research project and the criteria for participation required them to have a minimum of two years of experience in identifying birds in the field and be prepared to participate in two one-hour, one-on-one interviews. Copies of the poster were exhibited in the central office of the Perth Zoo and the docents’ house where they met each day for briefings, lunch and socialising. Within twenty four hours of displaying the poster twelve docents had volunteered. These docent volunteers are referred to in the study as ‘interviewees’. Due to their differing levels of experience in bird identification the interviewees were
easily organized into ‘stratified’ layers, specifically the novice birder and the practising specialised/ expert in bird identification (Burns, 2000, p.90). They therefore provided the case study with a cross-section of the expertise required, based in one convenient location (Burns, 2000; Flyvbjerg, 2004; Kumar, 1996; Yin 1994).

While this sample promised qualitatively rich data, it was small, raising concerns about the narrowness of focus and reliability of data (Ambert, 1995; Burns, 2000; Tellis 1997). Therefore, the sample base was expanded to gain a wider body of responses by using the data gathered in the interviews in interview two to develop an online survey. The survey was distributed to an online forum called BirdAus, frequented by 200 Australian native bird enthusiasts. The criterion for participation was the same as for the interview, a minimum of two years’ experience in identifying birds in the field. Again the response was swift, and within 48 hours of posting the survey 45 responses were received and by the end of the week 100 responses had been submitted. The quick reaction, the large number of respondees and detailed responses to the open questions in the survey suggested the strong desire for birders to discuss their expertise and hence the uniqueness and importance of the survey. This response, along with the 12 volunteer interviewees, and the exceptional level of sharing from the experienced bird illustrators discussed later in this chapter, further validates the need for this and future studies on bird related issues.

The data validity was reinforced by merging and comparing data from both in-depth interviews and the survey, which established a strong representation of people (112) who practised bird identification strategies and worked with bird field guides (Burns, 2000b; Kumar, 1996; Bouma, 2001a). The data collection process then began with non-participant observation.

Non-participatory observation

The purpose of observation and notation of visitor interaction with the Australian Wetlands and Walk-in Bird exhibits was to answer five questions: (1) How do visitors interact with the bird exhibits? (2) How long do visitors spend in the exhibit? (3) How do they interact with the birds? (4) Do they follow a particular route through the exhibit? (5) How do they use the information interpretive panels provided within the exhibit?

Non-participatory observation was deemed as appropriate for recording the behaviour of visitors as they walked through and interacted with the bird exhibits. It involved the researcher assuming the role of a silent observer of the ‘phenomena of interest in the environment studied’ (Mohd Noor, 2008, p.1604) and ‘recording events on the spot’ (Burns, 2000, p.413). The researcher’s role is to minimise their interaction with the sample group.
and to focus on the events as they unfold. Taking on the role of a non-participant observer required careful attention to determine the best sites from which to view the exhibits and the Zoo visitors as they moved through them and in this case a seated position enabled me to take field notes while integrating quite inconspicuously into the environment.

Visitors’ interactions with the exhibits were recorded. The recording apparatus is dependent on the situation under observation. In this case it involved a camera to capture the environment as found on the day, a watch for tracking the time of events, and a journal to note the events and conversation as they played out (Ambert, 1995, Belk, 2006, Bouma, 2001a, Burns 2000, Kumar 1996). In keeping with the grounded theory methods established throughout this thesis, conversations and events were noted using keywords and phrases (Borgatti, 2009; Charmaz, 2006-08; Dick, 2005; Glaser and Strauss, 1967; Glaser, 2002a-b, 2008; Goulding, 2002; Pandit, 1996).

Belk (2006) stipulates that non-participant observation demands a pre-determined focus in order to keep the researcher on track and not be distracted by unnecessary events. Subsequently, the focus of the observation was on the behavioural activities of individuals and or groups who entered the exhibit, what they said, and where they walked and the length of their stay.

A side project to the case study and as part of the research contract with Perth Zoo was to determine the effectiveness of the existing interpretive panels in supporting visitors’ identification of birds within the exhibits. This was achieved firstly through non-participant observation of how often visitors interacted with the panels, and noting how they used them. Secondly the functionality and legibility of the panels and the communication link between the information displayed and the actual birds in the exhibit were assessed. In order to do this, formal visual analysis was conducted to establish the effectiveness of the interpretive panels in attracting viewers’ attention and fostering a deeper engagement with the exhibits through the provision of educative information. Finally, recommendations were presented to the Zoo Management Board.

In-depth interviews

Stage two of the research was in depth interviews. Participatory methods were incorporated in the interview process to achieve what Reinharz (1992, p.181) describes as ‘egalitarian relation whereby the researcher adopts an approach of openness, reciprocity, and mutual disclosure’. Open dialogue was necessary as the field of investigation was not my area of expertise, and it provided opportunities for open-ended questions that could be put to debate during the interview process. The questions were formulated to generate knowledge and understanding of expert strategies of how birders visually engage with the environment and the identification strategies as used and perceived by experienced birders,
Design for nature and the nature of design ability: Chapter 3 | Perth Zoo Case Study

with the intention to determine the potential for VC design to make a significant research contribution to bird identification. As a result, each interview established the opportunity for ‘emergent data’ as defined in grounded theory (Calloway, c1996; Charmaz, 2006; 2008; Glaser, 1992; 2002a; 2004a), with insight and knowledge being transferred between the interviewee and myself as researcher (Yin, 1994).

The locations of interviews is important, as Burns (2000) notes, because interviews require consideration to provide an atmosphere that will put the interviewee at ease, encouraging valid responses. Encouraging open and valid responses demands sensitive interpersonal skills on the part of the interviewer to direct the questions towards critical issues while at the same time encouraging a valid response from the interviewee’s perception of reality (Bouma, 2001b; Burns, 2000b; Calloway, c1996; Kumar, 1996). Furthermore, repeated contact through more than one interview process (in this case, two) can increase rapport and reveal the contributor’s perspective rather than that of the researcher, because the interviewee uses spoken language that is natural to them and they have equal status to the researcher in the dialogue (Burns 2000).

Burns (2000), Bouma (2001) Kumar (1996) further state that in-depth interviews call for structured prompts to encourage the interviewee to disclose their knowledge, perceptions, and expertise. For example, when an interviewee answers a question, the researcher reinforces their response with comments such as, ‘I see, Can you tell me more? and What happened next?’ Non-verbal communication techniques such as eye contact and nods are used to create a warm, accepting interpersonal context while ensuring the interviewee continues to speak (Burns, 2000 p.426).

In order to simplify the interview process, a pro forma was designed which included a set of questions and space for recording interviewee’s responses. The questions for the in-depth interviews were deliberately open-ended as appropriate to ‘grounded’ research, the aim being to foster a relatively uninhibited relationship between the interviewee and researcher. In keeping with the grounded theory methods established for the non-participant observation field notes, the in-depth interview process was also based on noting keywords and phrases (Borgatti, 2009; Charmaz, 2006-08; Dick, 2005; Glaser and Strauss, 1967; Glaser, 2002a-b, 2008; Goulding, 2002; Pandit, 1996).

The interviews were conducted throughout February and March 2005. The first set took place in the Walk-in exhibit with interviewees on February 8, 10, 12, 14, 15, 17, 18 and March 11, 2005 between 9am and 3.15pm. Dates and times were determined by the availability of interviewees. The purpose of these interviews was twofold: to understand what inspired their interest in birds and what drove them to continue with the practice of bird identification; to determine how experienced birders engage visually with an environment,
Design for nature and the nature of design ability: Chapter 3 | Perth Zoo Case Study

and the strategies and techniques they draw on to navigate, read and interpret that environment.

Set two took place in the Australian bird aviaries of the World of Birds exhibit on March 3, 9, 10, 12, 15, 16 and 17 between 11am and 1.15pm. This location was essential because the focus of the interview demanded the interviewee observe and determine the field marks of a selection of Western Australian birds. This meant the interviewee needed to stand in close proximity to the bird to make the necessary observations. The objective of these interviews was to determine strategies of identification when looking at a bird directly in front of the interviewee, what do they see first, second, third and fourth. Stemming from this was to determine the most prominent field mark of each bird presented to the interviewee.

Several interviewees brought Australian field guides with them and I took the initiative to use these as a focus for discussion. The interviewees revealed a common desire to share their favourite field guide and to discuss what did and did not work for their birding needs in terms of effective VC design.

After each interview, handwritten interview data were transcribed into the computer and analysed using a comparative process and theoretical coding in order to determine recurrent and emergent themes, key words and concepts (Burns, 2000; Dick, 2005; Frascara, 2008; Glaser, 2004; Tuana, 2004; Yin, 1981; 1994). As discussed later in this chapter, analysis provided recommendations for bird field guide design that meet contemporary design standards including current approaches to print and production technologies.

Online survey

The data from the 12 interviews provided the basis for the content of an online survey that focussed on field guide effectiveness and individual approaches to bird identification, which was distributed to the Perth Zoo staff and the online forum BirdsAus. The online survey was designed to develop further questions that emerged from the non-participant observations and interviews, and to collect data on Australian field guides from a wider group of people with bird watching experience. The survey questions were directed to determine the following: popular field guides and the reasons for their popularity; what is missing in field guide design; what design elements / systems work to support identification. The survey results were then examined to determine if VC design expertise could contribute to addressing design issues identified by the survey respondents.

The survey was distributed on September 6, 2006 by email to Perth zoo staff, and BirdAus, an Australian-based online forum frequented by Australian native bird enthusiasts. 100
Responses to the survey were returned via email between August 22 and September 31, 2006. The questions, a combination of open and closed, generated responses both as quantitative figures and qualitative expression of personal experiences, perception and beliefs necessary to understand and define end-user requirements in a bird field guide and individual approaches to bird identification.

Grounded theories

In gathering the data for this study, Grounded theory research methods were the foundation of the observation process interviews, and survey. These methods were primarily observing, questioning, taking notes, and analysing data without preconceived notions (Charmaz, 2008; Glaser, 2004). This supported a relaxed approach to each procedure in which I as observer focused on events and results as they happened or appeared rather than being driven by agendas based on preconceived notions about what may or may not occur.

The grounded theory method includes a comparison process and theoretical coding that provide the potential for advanced concepts to emerge from the data that cover and transcend the discipline in focus (Glaser, 2002a). Grounded methods provide the basis for emergent cross-disciplinary insight that in this case included unexpected contributions of design knowledge and expertise to enrich the zoo visitors’ experience when visiting bird exhibits as well as bird appreciation, protection and environmental sustainability necessary to this study (Charmaz, 2006; 2008; Dick, 2005; Glaser, 1992; Institute, 2008).

The note taking method used for the observation process (and later for the interviews) involved using key words at the time of the process rather than relying on memory. The key words became the basis to formulate key concepts, theories and patterns. This method was expanded to include quoting comments from zoo visitors and later interviewees (when applicable) and translating some key words into descriptive memos. The quotations were an effective way of capturing Zoo visitors’ reactions to the bird exhibits and interviewees’ responses to questions and shape to a narrative that accurately represented their experience of bird exhibits and the birds.

The results of the observation and analysis of the visitors’ interaction with the Zoo exhibits contributed to: (a) the focus of this study; the identification strategies designed for people involved in identifying birds and, (b) providing recommendations to the Zoo Management Board on the VC design effectiveness of the current signage systems used in these exhibits.
**Grounded analysis process**

Comparison is at the core of the grounded theory process: comparing interview-to-interview, survey-to-survey, and survey-to-interview until theory emerges. When theory begins to emerge, the data are compared to the theory (Dick 2005). The data analysis procedure involves three stages (1) Open coding. (2) Substantive and theoretical coding and memo writing. (3) Results, recommendations and conclusions (Borgatti, 2009; Charmaz, 2006; 2008; Dick, 2005; Glaser 1992; Pandit, 1996; Strauss & Corbin, 1990).

**1) Open Coding**

Open coding is the generation of ‘indices’ (incidents of key words and phrases) (Glaser, 2002, para.9). ‘Open coding is the part of the analysis concerned with identifying, naming, categorizing and describing phenomena found in the text’ (Borgatti 2009, para.5). This process fractures the data and assists to remove any meaning that the researcher may have constructed during the data collection process and supports a fresh interpretation of the data. For example, birds, interpretation, perception, colour naming, colour differences, and field guides were just some of the ‘indices’ that emerged as a pattern of words and phrases used by the case study sample groups and the observation process.

**2) Substantive categories and theoretical coding and memo writing**

The indices are analysed for ‘substantive categories’ and theoretical categories. For instance, from the indices listed above, perception can be isolated as a theory that is substantive to the study but also transcends as an important theory to many disciplines, and birds are a substantive theme of the case study (Glaser, 2000, para.39). During the process of discerning indices and comparing codes, the ‘theoretical categories conceptualise how the substantive codes may relate to each other as hypothesis to be integrated into a theory’; they ‘weave the fractured story back together’ (Glaser, 1978, p.72). This is achieved through writing descriptive memos that are informed by a combination of inductive and deductive thinking (Pandit, 1996). According to Borgatti (2009) memo writing involves looking for phenomenon that could include ‘events or variables’ that lead to the occurrence (para.18), examining the context, meaning the ‘specific locations and conditions’ (para.19), looking for causes and context that involve the participants’ ‘action strategies’ (para.21) and any ‘goal-oriented activities’ that are in ‘response to the phenomenon (para.21), and finally consequences ‘of the action strategies, intended or unintended’ (para.22). To illustrate, a key word that emerged from the data was perception, which inspired the following memo writing.

What phenomenon does perception represent for (a) the birder identifying a bird (b) a birder engaged with a bird field guide (c) zoo visitor within a bird.
exhibit and (d) VC designer engaged in the process of designing?

Perception involves how people innately and consciously process visual information. It informs how to navigate an environment, to note and address danger, assists in attaching meaning to what they see, includes theories of spatial representation, and dual coding whereby they make strong memory connections through combination of image and text and Gestalt laws of visual organization—how to connect patterns, sections, colours and shapes that inform a ‘whole’.

Perception is generally a singular activity and unique to each person, it can become social when people engage in discussion of what they perceive. The social interaction of perception can enrich an experience—VC design can enrich a zoo visitor or birders experience by pointing out elements and perceptual combinations that may have been missed. Perception is informed by social conditions of the individual but can be expanded through knowledge.

Birders use their innate perceptual motor system to navigate an environment and to identify a bird in its natural environment, their innate perceptual abilities can be increased through knowledge and learning.

The above memo-writing sample represents the process applied to all indices. The memos are then compared and analysed for common themes and theories. For example, the above memo reveals theories of spatial representation, dual coding and Gestalt laws of visual organization. It also points to themes of social interaction, knowledge, and learning. These theories and themes are compared across all memos to identify the next level of data interpretation, which translates as the ‘theorizing write-up of ideas about substantive codes and their theoretical coded relationships’ (Glaser, 1998, p.177).

As coding progresses, theoretical propositions are made, which may be ‘about links between categories, or a core category, which appears central to the study’ (Glaser, 1998, p.177). It has a pace, a detachment from outcome, and an openness that encourages emergent insight.

A theoretical proposition that emerged from the above example involved the connection between the birder and VC designer to exploit the innate Gestalt laws of visual organisation that assist in the observing details of patterns, colours, and shapes that inform a ‘whole’.

The application of these laws by the birder can be seen in their use of field guides to expand their innate levels of awareness and to practise this knowledge in the field. The VC designer’s knowledge, on the other hand, is developed through formal education and years of application through practice. The formal property of education means the VC designer has a more developed awareness of the process than the birder and has extended abilities to use this knowledge to assist in the development of visual information systems that
Design for nature and the nature of design ability: Chapter 3 | Perth Zoo Case Study

could simplify or enrich visual perception abilities for the birder and the zoo visitor.

(3) Results and conclusions

The final stage of the grounded theory analysis process is the generation of recommendations by comparing and reducing data to key theories, conclusions, and results. Results from the grounded theory analysis in this study are discussed later in this chapter after the description of the observation, interview, visual analysis, and survey processes.

3.4 Zoo Case study: People and birds

This case study generated a large amount of data that, if told in full, would take up the majority of this thesis. Instead this chapter captures highlights from each stage of the gathering process, beginning with the observations carried out in the Australian Wetlands and Walk-in Bird exhibits, followed by the in-depth interviews one and two and finishing with the online survey.

3.4.1 Non-participant observation of Wetlands and Walk-in bird exhibits

Non-participant observation of the Australian Wetlands and World of Birds exhibits refers to the recording of all that occupies this environment, including the design of the exhibit the birds that inhabit, the space and the people who visit. As noted earlier, a time limit of one hour for any research time spent in a bird exhibit was based on the Perth Zoo ethics committee requirements to minimise stress on the birds.

The purpose of observing and noting visitor interaction with the bird exhibits was to determine visitor engagement with the environment. Observations about the visitors included: sex, approximate age/s, time spent in the exhibit, keywords used in conversations relating to the exhibit, and interactivity with the environment (for example, where the visitors walked and whether they referred to the bird interpretive panels).

In order to observe how visitors interacted with birds within the zoo exhibits, I took an unobtrusive seated position in both exhibits. The best position in the wetlands was a bench overlooking the main lake and just in front and to the right of the entry, and for the walk-in a wooden bench, where I could sit quietly while still providing space for other people to sit next to me or stand on the landing. Both ensured a complete view of the exhibit.
Design for nature and the nature of design ability : Chapter 3 | Perth Zoo Case Study

I used a journal to record behaviour and conversation and a watch to note time and behaviour. This procedure was carried out for both exhibits. The wetlands extended over three days, Thursday December 9, Friday December 10 and Saturday December 11, with three sittings per day at 10am, 1pm and 3pm. The walk-in exhibit was given the same observation times of 10am, 1pm and 3pm but over two days rather than three days because it was approximately one-sixth the size of the Wetlands exhibit and its hidden location meant that it was less popular to Zoo visitors.

Walk-in exhibit

The environmental design of the Walk-in exhibit emulated a tropical rainforest setting as found in northern Australia and Papua New Guinea. At the time of this observation, the bird exhibit featured Eclectus Parrots, Siamese Fireback Pheasants, Nicobar Pigeons, Emerald Doves, and Speckled Back Ducks. The structure of the exhibit was comprised of steel pipes wrapped in wire netting, which although useful in housing the birds, lacked visual appeal, as did the entrance door, which was made of the same material. Fortunately, once inside the exhibit, the structure retreated and the lush foliage and birds became the centre of attention. The size of the exhibit was approximately 16 meters long by 10 meters wide and 12 meters high, and the proportions were generous enough to enable the birds to fly from one end to the other.

Day one, Friday December 3. The first visitors arrived at 10:10am, a female in her late twenties with a child (approximately three years old) in a stroller; she positioned the stroller on the viewing platform then crouched next to the child and pointed out the ducks. Much to the delight of herself and the child, two Eclectus Parrots flew from the back of the exhibit, over their heads and onto a perch just behind them. The woman turned the stroller and they both laughed and pointed at the parrots; the parrots looked down at them and cackled to each other. After five minutes, the woman and child left the exhibit and the parrots sat on their perch for a further five minutes then flew to the back of the exhibit.

The first observation and the sequence of events that occurred set the pattern for all following observations for this exhibit. Each time a visitor or group of visitors entered the exhibit they would walk to the front of the viewing platform, the Eclectus parrots would fly from the back of the exhibit over the visitors heads and perch just above them and look down. Every visitor young or old had the same reaction of sheer delight and pleasure at the boldness and playfulness of the parrots.
**Australian Wetlands Exhibit**

The wooden decked platform offered the perfect view of the Australian wetlands exhibit, beginning with a lake that boasted Blue-Billed Ducks, Yellow-Billed Spoonbills, Freckled Ducks and Black Swans. From the lake, it was possible to see a bank where a pair of Brolgas nested, a great White Egret wandered and a flock of glossy Ibis pecked for food. However, the majority of visitors paused for only a 30 seconds, presumably to observe the birds and environment, then promptly moved through the exhibition following a carefully designed boardwalk that meandered through the wetlands and into the home of the Estuarine Crocodile, which happens to be one of the most popular attractions of the Zoo. The following are excerpts captured from the observation process.

Day one. The first observation involved a group of 26 primary school children approximately 7 years old and two teachers who entered the exhibit at 10.12am. The group of children were lead by one teacher with the other at the rear. The genteel calm of the environment was shattered by the amount of noise the children produced and with the teachers attempting to shout control over the cacophony. It was clear that the teachers’ intent was to herd the children directly to the crocodile exhibit and the Wetlands were a means to an end. As quickly as they entered, they disappeared along the boardwalk and reappeared ten minutes later behind me as they left the exhibit. I was astounded at the noise level and how well the birds seemed to handle the invasion of their environment, with only the birds that were resting on the fence near the entrance flying deeper into the exhibit when the children entered. The next day two further groups of school children and teachers entered the exhibit and followed the same course of interaction, trajectory, and behaviour.

Day one. At 3pm, in contrast to the discord of the school entourage, a middle-aged male and female entered the exhibit and walked up to the viewing platform. They observed the environment and birds without speaking for two minutes, the male uttered something to the female then they both turned in circles as though looking for something, which turned out to be the interpretive panels. They walked over and spent two minutes looking at the information on the panels in an attempt to identify one of the birds they had just seen, then back to the viewing platform where they spent another minute before following the decking through the environment. Unfortunately, I could not hear the couple’s comments, however their behaviour reinforced my concern regarding the position of the interpretive panels. Firstly, their effort to locate the panels and the fact that they were the only two visitors out of the total 180 across the observation times to refer to the panels indicated that the location did not support their function; to communicate a meaningful message of the exhibit with the intention of imbuing a positive experience for the visitor while fostering understanding and empathy for flora, fauna and environment (Woodward, 2005, para.2).
The nine hours of observation in the Australian Wetlands exhibit over the three days yielded data of about 180 visitors and confirmed that 10am on Thursday and Friday was the most popular time, attracting an average of 42 visitors covering primary-age school groups, families with young preschool children and some middle-aged singles and couples. At the same time on Saturday, numbers were reduced to 14 visitors due to lack of school groups. The next time slot at 1pm attracted an average of 12 visitors, including individual caregivers with school-age children, middle-aged couples, and singles. The 3pm time slot was the least popular for all age groups, attracting an average of 5 visitors.

The walk-in exhibit attracted fewer numbers of visitors than the Wetlands exhibit, specifically, twenty visitors over six, one-hour observations. The most popular times were 10am and 1pm, and the only person to enter the exhibit at 3pm was a Zoo docent on the second day. However, those who entered stayed an average of four minutes in comparison to 30 seconds as observed in the Australian Wetlands exhibit. I believe the reason they stayed longer was due to the absence of a draw-card, such as the crocodile in the Wetlands exhibit. In other words, the visitor chose to enter the bird exhibit for the sole purpose of participating in this environment, not using it as a pathway to see something else.

The next observation determines the usefulness of the interpretive panels in supporting identification of birds.

**Australian Wetlands exhibit: Formal visual analysis of the Interpretive panels**

The observation process also involved the formal visual analysis of the design and production quality of the interpretive panel in the Australian Wetlands. The analysis was informed by both the interpretive and information design literature and by my twenty-five years’ experience as a visual designer.

Interpretive design is ‘a vital part of how people experience the places they visit’ – zoos, heritage sites, national parks, monuments, countryside, museums, and galleries’ (Masters & Muschamp, 2003). The interpretive design interface includes print, digital, video, audio and panels (Woodward, 2005). Woodward (2005, p.1) explains that the intention is to inspire the visitor to engage with the environment or object ‘beyond the superficial visual experience towards a deeper, more meaningful engagement with issues, ideas and attitudes’. Successful interpretive design includes providing visual and textual information that communicates a key theme or message that is educational, promotes enjoyment, and stimulates an emotional and behavioural response such as encouraging the visitor to take action. It also represents the organization, for example, zoo, museum, or natural heritage site, in alignment with their
vision (Davidson, 2007; Masters and Muschamp, 2003).

To be effective, VC (typography, imagery, text, layout, visual hierarchy) should be easy to read and understand as it guides the viewer through the information. Colour in particular should be used to represent the real world as some 'readers may accept the 'printed' colour as a representation of the real-world' (Heidi et al 2007). Clear and legible text should help focus visitor attention on meaningful elements within the display and impart an explanatory story about these elements (Ham, 1992 in Heidi et al 2007). Typography – the layout of the text – should be easy to read as 'a means of solidifying' the desired message (McClurg-Genevese, 2005). Finally, according to Tufte (1990, p.9), the final design should be simultaneously informative and artistic in order to capture the visitor’s imagination and involvement.

The interpretive panel was positioned on the back fence of the exhibit, which was next to the entrance and hidden from the view of visitors. Within the Wetlands exhibit the visitor did not encounter the panel until leaving the exhibit, which meant that the only way for the visitor to find the panel on entering the exhibit was to turn 180 degrees. That is, if the visitor wanted to identify a bird that was wading on the lake, they had to change direction and walk back to the entrance. Then, while in front of the panel, they had to remember what they had just seen, find it on the panel, and walk back to the lake to identify the bird. Therefore, the position of the interpretive panel did not encourage visitors to identify the birds, making it ineffective in its primary task of educating and engaging visitors to take action.

The results of the visual analysis indicated that the information design and the placement of the panels required review and redesign to achieve a level that supports visitor interaction and identification of birds. In addition, the illustrations of the birds were printed in low resolution and were blurred, with the result that salient details and features of birds were difficult to define. The overall visual appeal of the design including layout, text, and typography offered information without artistic imagination, which Tufte (1990) asserts is essential in the final design outcome.

Walk-in bird exhibit: Formal visual analysis of the Interpretive panels

In the same manner as the Australian Wetlands exhibit, the interpretive panels in the Walk-in Bird exhibit were positioned next to the entrance/exit doors, which meant they were often not seen until people were leaving the exhibit. Again, the design of the exhibit encouraged the visitor to walk forward, not to stop, and look back. Subsequently, as for the Wetlands exhibit, only two out of the total visitors to this exhibit referred to the interpretive panels.
The interpretive panels in both exhibits had identical issues; specifically the use of blurred images, lack of information, basic VC design and poor positioning, all of which resulted in ineffectual communication and the panels not being used by visitors.

The following section introduces the two in-depth interviews beginning with interview one. This interview established the interviewee’s personal experience in bird identification, identified how they engaged visually with the environment, for example what strategies they used for reading the environment, and at the same time teased out opinions on the effectiveness of the Zoo’s interpretive panels and the design of the bird exhibits. Then interview two used a variety of guiding questions looking for open-ended answers; it focused the interviewee to determine the prominent features of a set of pre-selected birds. Consequently, the data stayed within the framework of the questions and in comparison to the data collected from the observations and interview one, this simplified the grounded theory analysis process. This section will highlight interviewee responses and also weaves into the discussion the insights, theories and concepts that emerged from the grounded theory analysis.

3.4.2 In-depth interview one

The Walk-in Bird exhibit was selected as the location for the first interview because as a bird exhibit, it was appropriate to the discussion of birds and their environment and because it was a refreshing location to escape the extremely high temperatures experienced during times of the interviews.

With the location and interview times established, it was necessary to create a course of rapport-building and study-specific questions. As a preamble, I thanked the interviewee for volunteering and provided information regarding the interview aims and methods. Interviewee’s were informed that disclosure of information was based on their own guidelines of what they deemed appropriate to share and that whatever they said would remain confidential, with names being replaced by codes in any documentation.

The questions for stage one interviews included: (1) When did your interest in birds begin? The purpose of the question is for the researcher to understand the interviewee’s ‘perception of themselves...and of their experiences’ within the discussion of birds of birding (Burns, 2000, p.425). This question will provide some of the essential background information to the life of a birder, which the researcher has no experience of. (2) What is your opinion of this environment? This question draws the interviewee to provide their ‘perception of the environment’ as a whole, which acts as a precursor to question three that draws their attention to the details. The purpose of questions two and three is for the researcher to
understand the interviewee’s observation and spatial awareness skills that are important to the birder (Burns, 2000, p.425). (3) Tell me what you see in this environment from this vantage point? You are free to list hidden details, obvious points, use technical language or non-technical, or describe, whatever is comfortable for you. (4) What is your opinion of the interpretive panels? Question four provides an opportunity for the researcher to understand the interviewee’s perception of the way the information is displayed on the interpretive panels. The responses generated from the question will assist the researcher to understand what information is and is not important to the birder.

Discussion

Interview one revealed insight into the interviewees’ life journeys that lead to their passion and commitment to birds and their environments. The process provided invaluable information for the researcher on birders including the types of observation skills and how they read and decoded the environment.

Interview one generated twelve hours of enriching interview responses, but this is far too much documentation to include in this chapter. Instead to follow is a snapshot of some of those responses and the insights, theories and concepts that emerged from the grounded theory analysis. For each of the five questions asked, examples from the interview data are given. These identify the main theme that emerged from each question.

**Question One: When did your interest in birds begin?**

Interviewee one (a woman in her sixties) stated her interest in birds began as a child. She believed living on a farm and attending a small primary school in a forest setting was the perfect environment to foster her interest in nature including birds. She continued to work and live in the country and taught as a primary school teacher in small country towns. The exposure to birds for many years meant she gathered interesting stories of bird encounters, which she shared with her students. She continues to share when taking guided nature walks around the Perth city suburbs as part of the Guild League of Bird Lovers of which she is a member. Interviewee one (as well as four other interviewees) believed the way to engage a person with birds is to characterise the birds within a story, a real life account, or through sharing facts about birds, their behaviour, calls, and flight patterns. For example:

> It is the stories that gets them hooked on birds. It is all about the stories that put the birds and their behaviour in context for people who are not aware of birds (Interviewee 1).
Question Two: What is your opinion of this environment?

Next, the interviewees were requested to provide their opinion of the environmental design and to observe and describe the surroundings that make up the Walk-in exhibit. A pronounced pattern of observation emerged in the way the interviewees related to and described the environment.

All interviewees had a positive opinion of the Walk-in exhibit environmental design. For example, Interviewee four (a woman in her early fifties) was born in Scotland and migrated to Perth Western Australia in search of an environment that would provide the sort of 'nature experience she was looking for'. Her interest in birds is part of her overall interest in nature. Interviewee 9 (a woman in her late fifties) migrated from New Zealand in order to explore the Australian natural environment. Her 'interest in birds exploded' since volunteering as a docent for the Perth Zoo. Her weekly encounter with the birds at the Zoo increased her awareness that 'birds have wonderful personalities, they are very curious' and entertaining.

Both exhibits are pleasant and welcoming— and visually pleasing. The environmental design considers natural life-like exhibits, encouraging visitors to stop and enjoy the sights (Interviewee 4).

I love this environment the trees lead you right into the environment as well as providing living trees for the birds. I like the logs of wood randomly scattered around and the water element is calming. I love the decking it allows you to look out and over it. Even the dry leaves that have fallen on the netting is nice, it creates a natural canopy effect (Interviewee 9).

Interviewee four, interviewee nine and others used phrases such as ‘visually pleasing’, ‘enjoy the sights’, ‘senses are heightened’ and ‘visual diversity’, which link to theories of visual perception discussed in chapter 2, particularly spatial awareness, which refers to the human ability to perceive an environment and make aesthetic judgments (Bower et al., 1975; Campbell et al., 2007). In this case the interviewee is making a note of the natural, life-like aspect of the bird exhibits, which points to the success of the environmental design of the exhibit to engage a visitor with the environment.

Interviewee five (a man in his late fifties) was born in Oxford, Britain and migrated to Australia as a child with his family. He explained that his interest birds ‘began at a very young age’ and believed this interest was triggered by the fact that he ‘lived near a lake where there were waterfowl and geese’ and his fascination for birds grew from then. Interviewee five commented on the intimate and natural appeal of the Walk-in exhibit:

I like this aviary because it is more intimate; you are part and parcel because it is all around you. This environment is very natural (Interviewee 5).
The interviewee's reference to 'intimate' infers the space had a friendly, warm, or hospitable atmosphere (Oxford American Dictionary, 2010). When coupled with the word 'natural', this points to the overall impact of the environmental design elements and features applied to the space, for instance, the dimensions, foliage, water features, space, activity and focal points.

**Question Three: Tell me what do you see in this environment for this vantage point?**

Interviewee seven (a man in his early sixties) explained that his interest in birds started at an early age and came naturally because ‘birds are easy to access, they are one of our wildlife that you can see and they are more obvious than our native mammals’. Interviewee seven, Interviewee four and others indicated that their approach to observation began at a macro level, taking in the overall colours and shapes visible in the environment. They then moved in stages to finally observing micro levels of visual information including small areas of colour. This method of observation can be analysed using spatial awareness theories and Gestalt laws of visual organisation. For example, Interviewee seven (below) drew on his abilities of spatial observation to describe the environment in terms of ‘contextual cues’ (Bower et al., 1975; Campbell et al., 2007), which include colour and shape and constitute the basics of what the viewer is seeing. This description can also be analysed in terms of Gestalt laws of visual organisation. This involves recognition of objects/colour/shape which, when grouped in terms of similarity and proximity, form a whole. For instance, interviewee seven mentioned leaves, which are likely to be of a similar shape and when grouped together in close proximity form the 'whole' tree, shrub or plant.

The first thing that comes into your mind is colour and shape, and that helps to set up or give you the basics of what you are looking at. Then you might see the leaves that are making the overall shape and then the flowers...then you take in what is around it, the wild life (Interviewee 7).

I notice the variety of leaves, tall shapes and rounded shapes. There are nice textures, larger leaves against spindly leaves. I then see the movement of the ducks; the water has a mirror effect making the area look bigger than it is. The Birds are adding to the colour (Interviewee 4).

Interviewees seven and four revealed a well-developed skill in spatial observation and Gestalt laws of visual organisation that aligned directly with skills and expertise held by the VC designer. This is demonstrated in their ability to identify the visual ‘contextual cues’ relevant to a specific environment, for example, beginning with colour, and shape and then categorising those into the specific elements of leaves and flowers (Bower, 1975, p.216). Then
the organisation of those cues into ‘patterns’ that can be categorised down further into to minute details of texture and reflection, all of which are essential to the composition of the environment as a whole (Behrens, 2004, para. 10).

With concentrated practice, these skills become so fine-tuned that they become tacit, which means hidden within the process and activity of observation, allowing the birder or designer to carry out other important cognitive processes such as identifying the bird for the birder or solving a VC problem for the designer (Polanyi, 1966; Rust, 2004; Sveiby, 1997).

**Question Four: What is your opinion of the Interpretive panel?**

A further question that activated the interviewees’ observation skills invited them to provide an opinion of the visual display of information offered on the interpretive (information) panels within the Walk-in exhibit. The interviewees offered feedback that provided insight into a preference for illustrations over photographs when identification of birds is required. For example, interviewee two (a woman in her early sixties), when asked her opinion of the interpretive panel, stated that she preferred illustrations of birds rather than photos.

> The illustrations without the background are better than the photos because it is easier to see the bird (Interviewee 2).

Interviewee two has always loved birds and has two aviaries that home thirty birds. She believes that not enough people appreciate birds and this is substantiated by the lack of people who spend time in the Zoo bird exhibits.

Interviewee eight, (a woman in her late sixties) a retired librarian and avid birder since she was a child, pointed out the control an illustrator has not only for removing background information but also for capturing the best angle of the bird for identification purposes.

> I prefer drawings or paintings because photographs don’t pick out all the detail. Getting the bird at exactly the right angle with photography is difficult (Interviewee 8).

The collective preference for illustration to represent birds on the interpretive panels reinforces the consensus for illustration over photographs in the literature review of scientific illustration noted in chapter 2.

**Interviewee determined discussion: Bird field guides**

The interviewees’ interest in birds and identification strategies inspired four of the twelve to bring along their favourite field guide and others to mention them. The interviewees
disclosed a complex and interesting relationship to their favourite field guide based on the combination of praise and criticism that focused on the visual representation of the birds, the quality of the information presented and form/function of the guide. The interviewees were keen to call attention to the design and function issues of field guides within a desire for the development of the perfect field guide. As an illustration, Interviewee seven gave the following opinion.

It is my Bible (Michael Morcombe's (2004) Field Guide to Australian Birds), because it includes information on eggs and nests as well as the usual information found in bird field guides and not many field guides include nest and egg details (Interviewee 7).

Interviewee seven wanted information beyond fundamental bird identification information from his guide, which revealed him to be an experienced birder who demanded knowledge that met his level of experience. His request was for additional visual and textual information that displayed the identification markers for bird eggs and nests.

Michael Morcombe uses drawings and photography some of the bird sketches and maps are not very accurate which is disappointing. He supports Western Australian natural heritage by including sub species of birds, which is excellent (Interviewee 5).

Interviewee five and others also noted the inaccurate bird illustrations offered in Michael Morcombe’s (2004) field guide. Their comments indicate their belief that the illustrations were not scientifically accurate. Interviewee ten, (a man in his mid-sixties) who has been an avid birder for more than 20 years, suggested the colours in Morcombe’s guide were not convincing and that, although he preferred illustrations over photos, the colours were not accurate to the live bird. He also suggested that because of this inaccuracy it ‘is incredibly difficult to look at the book (field guide) and identify the bird’ (Interviewee 10).

Interviewee eight argued that Simpson and Day’s (2010) field guide was comprehensive, however the size was too bulky for fieldwork and also the colouration of the birds was often inaccurate. The issue of size and weight of guide for fieldwork was also criticised by interviewee eleven in relation to Pizzey and Knights (2003) field guide. Interviewee eleven (a woman in her late forties) grew up in a small Australian country town that she recalls was the perfect environment to admire birds. Her admiration of birds inspired the desire to identify them and eventually to spending time drawing them. She suggested that the Pizzey and Knight (2003) guide was so heavy that she kept it in the car rather than taking out in the field with her.

I brought along my favourite field guide, it is always with me I keep it in my
car just in case I need it. Even though I like it, there are problems that need ironing out. It is Pizzey and Knight’s it is the most comprehensive and it has great illustrations but too heavy for the field that is why I keep it in the car (Interviewee 11).

Comments by Interviewee twelve (a woman in her early fifties) who was born in Perth Western Australia recalled her interest in birds began with watching the behaviour of doves when she was a child. Her interest in birds has expanded over the years to now enjoying the rewards of being an experienced birder and working as a docent at the Perth Zoo. Interviewee twelve supported the conclusions drawn from the literature in chapter 2. That is, that by drawing attention to the natural beauty of the bird, field guide illustration, although aesthetically pleasing, does not address technological advances in colour, digital illustration and print nor in perceptual and spatial representation theory.

The illustrations are beautiful but probably too artistic and not so good for identifying field marks (Interviewee 12).

During the discussion with interviewees eleven, three, five and eight, they asserted that the colours in bird illustrations presented in bird field guides were not accurate to the live bird, which added to the other issues of colour that emerged in the case study data.

Looking at bird books either illustrations or photographs are both not good or accurate in comparison to seeing the bird in the wild. The illustrations are the better of the two because they do not have a background and they can make shape and texture cleaner. But often the colour is not accurate. It is incredibly difficult to look at the book and identify the bird (Interviewee 11).

Summary

As the researcher, I established the interview process to gain some understanding into the world of the birder. Interview one revealed that most of the interviewees’ passion for birds began as children and grew over the years to include all of them engaging in the pastime of identifying birds, some keeping birds in aviaries, and two drawing them for pleasure and all of them volunteering to be docents at the Perth Zoo. Importantly, the interview process uncovered the fact that all interviewees had sophisticated skills in observation and spatial awareness. These perceptual abilities enabled them to navigate environments safely as well as to identify the essential contextual cues that can lead to the identification of a bird, for example, colour, shape and texture. This was important information to the researcher because it established the birder as holding a high level of perception, which was important when it came to developing the digital illustration and Identicons for bird field guides.
Although I did not invite the interviewees to discuss the design and content of bird field guides, four interviewees brought their favourite field guide with them. The action of the interviewees alerted me to the importance of field guides to the birder and to including discussion of guides into the interview process. The discussion revealed two important issues with field guides. Firstly, that there were issues with the lack of scientific accuracy of the bird illustrations, and secondly, that the inaccuracy included the colour of the bird. One interviewee pointed out that the lack of accuracy in bird representation and colouration meant that it was very difficult to identify a bird from looking at the field guide. These comments caught my attention as the researcher as important and worth further investigation. Because the formal function of a field guide is to offer visual and text based information to assist in the identification of birds, in this instance a birder was pointing out that some guides were not fulfilling their function.

Finally, interview two uncovered a collective preference for illustrations over photographs to represent birds on the Zoo’s interpretive panels. This information aligns with the literature presented in chapter 2 and further reinforces the importance of illustration for the natural sciences in the 21st century.

3.4.3 In-depth interview two

Interview two was carried out in order for the researcher to gain a better understanding of the experienced birders’ visual perception abilities. An additional purpose of interview two was to have firsthand experience with the way birders deal with the visual information presented to them when asked to identify the field marks of a live bird in front of them.

The twelve interviewees who engaged in interview one volunteered to be a part of Interview two also. The World of Birds exhibit at the Perth Zoo was selected as the best location for the interviews because, unlike the Walk-in bird exhibit or the Australian Wetlands, which were large, open exhibits with a net to keep the birds enclosed, The World of Birds exhibit was comprised of a selection of small aviaries that housed one or two species. The small aviaries made it possible for the interviewee to stand close to the aviary, making it for easy for the interviewee to observe the bird.

Five bird species native to Western Australia exhibited in the World of Birds exhibit at the Perth Zoo were used as the focal point for the interviewees. The birds were selected on the basis that they were native to Western Australia, available in the World of Birds exhibit and provided a cross section of bird families. The birds were the Blue-winged Kookaburra (Halcyonidae), Eclectus Parrot (female) (Psittacidae), Torres Strait Pigeon (Columbidae), Barking Owl (Strigidae), and Bush Thick-knee Curlew also known as the Little Curlew.
Design for nature and the nature of design ability: Chapter 3 | Perth Zoo Case Study

(Burhinidae) (Montgomery, 2010).

The interview questions were semi-structured, and directed each interviewee towards providing quantitative data in terms of words and phrases that could be converted to numerical data on how many times specific words and phrases were used by the interviewees (Hoepfl, 1997, para.32).

The interview process called for the interviewee’s arriving at the World of Birds exhibit at a pre-determined date and time. The time between 10am and 1pm was based on the best lighting conditions in midsummer Perth for observation of the birds. Each interviewee was positioned in front of a small aviary that housed the bird in focus, for example the Blue-winged Kookaburra, and asked to perform the following perceptual tasks. (1) Describe colouring (patterns, colour and shades), and the physical features (size, bill, legs, feet, wings) of the bird in front of you. The first question asked the interviewee to provide their perception of the bird as a whole, which acted as a precursor to the following three questions that drew their attention to observing the prominent features of the birds. (2) Describe the same bird but provide only four of the most prominent features. (3) Describe the same bird but provide only two of the most prominent features. Finally, (4) describe the same bird but provide only the single most prominent feature. The responses generated assisted the researcher to determine the interviewee’s Gestalt perception skills of recognising the visual organization of form, shape, pattern or configuration that work together to create the essential features of the bird species that lead to identification (Grill-Spector & Kanwisher, 2005).

The results of interview two revealed colour-naming issues that each interviewee experienced when describing the bird in front of them. Interview two was the second time issues with colour in naming and description emerged, which further validated the need for colour to be researched in terms of how VC design could contribute to this issue in the context of bird identification.

The semi-structured questions directed the interviewees to respond in a pattern that supported the desired quantitative data whereby words could be compared for similarities and differences. To follow is a discussion of the interview responses to the questions. In the same manner as interview one, interview two generated twelve hours of interview responses. Rather than including the entire documentation, which is too much reporting to include in this chapter, highlights are presented. The selection of highlights was determined by the main themes that emerged from each question.
Discussion

Question one: Describe colouring (patterns, colour and shades), the physical features (size, bill, legs, feet, wings), and behaviour (swimming, flying, pecking, fishing, interacting with other birds) of the bird in front of you.

Question one generated responses that described the entire bird including colour and physical features. The question demanded the interviewees rely on their observation skills. Below is an example of Interviewee one’s response, which captures how each interviewee responded to question one when looking at the Blue-winged Kookaburra.

The Blue-winged Kookaburra has dark-black and blue speckles on its wings, with sky blue interspersed amongst white and black patches. In comparison to the size of the bird’s head its beak is oversized. The top mandible is dark and the lower mandible is white. This kookaburra has a short tail that hinders its moveability, which subsequently reduces the amount of prey they can catch. (Interviewee 1).

Grounded theory analysis of each of the 12 interviewees’ responses to question one revealed a significant issue with the description and naming of the colours they were looking at in front of them. Apart from the occasional match of the same name, overall each interviewee used different colour names. The colour names are displayed in Chart 3.1 below.

| Chart 3.1 Frequency of colour nomenclature used to describe the colouration observed on the Blue-winged Kookaburra |
|----------------|----------------|----------------|----------------|
| Wings | Breast | Crown of head |
| Colour | Frequency | Colour | Frequency | Colour | Frequency |
| Blue | 5 | Buff | 6 | Faun | 2 |
| Cerulean blue | 1 | Cream | 2 | Grey | 1 |
| Pale blue | 1 | Faun | 2 | Grey-brown | 2 |
| Royal blue | 1 | Camel | 1 | Brown | 4 |
| Lighter blue | 1 | Beige | 1 | Black | 2 |
| Navy blue | 1 | Pale tan | 1 | Dark | 2 |
| Azure blue | 1 | Orange-brown | 1 | White | 2 |
The remaining interview questions guided the interviewees to observe the bird then to
describe four essential features when identifying it in the field, which could include colour
and or physical features. From those four, interviewees were then asked to narrow down to
two and finally the one most essential feature for identification.

The following table shows the single most prominent feature of the Blue-winged Kookaburra
as selected by different interviewees.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Number of interviewee’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue colour on the wings</td>
<td>5</td>
</tr>
<tr>
<td>Bird’s oversized beak</td>
<td>3</td>
</tr>
<tr>
<td>Overall shape and size of the bird</td>
<td>3</td>
</tr>
</tbody>
</table>

As this table shows, although a number of interviewees saw the beak, or shape as the most
prominent feature of the Kookaburra, in fact the most commonly identified main feature
Design for nature and the nature of design ability: Chapter 3 | Perth Zoo Case Study

was the blue colour of the wing plumage.

Blue colour on the wings (Interviewee 2)

The heavy beak shape (Interviewee 6)

General overall shape and size (Interviewee 4)

In order to determine prominent features of the Blue-winged Kookaburra it could be argued that the interviewees drew on their knowledge of categorisation, firstly according to bird taxonomy, to determine the bird species features as well as generalised bird feature categories of beak, head, crown, breast, back, scapulars, tertiary wings, primary wings, tail, legs, feet, and claws. Then they employed their skills of Gestalt laws of visual organization that are central to VC design expertise, which meant including but observing beyond the generalised bird feature categories to encompass details of texture, pattern, and colour. Next, reductive thinking skills were necessary to reduce detailed information to the salient visual elements that inform the whole. This involved recognition of pattern clusters that, when combined, determined prominent feature/s, for instance a field mark, a physical identifier or extend beyond visual cues to involve behaviour unique to the species.

The in-depth interview process provided insights into essential skills and knowledge shared by the birder and the VC designer, specifically spatial awareness, and Gestalt laws of visual organisation. As previously explained, these skills are innate to humans, but can also be developed through education and practice. The birder has developed them through the process of learning how to identify birds and practising that knowledge in the field, and the VC designer has developed them through education and the practice of their discipline. The interviewees also brought attention to design, colour and bird representation issues in current Australian bird field guides. However, in order to investigate these issues, a larger sample group was required. Therefore, a survey was developed with the purpose of expanding the sample base. To gain access to the widest possible range of participants this survey was placed online on BirdAus, which is a forum designed for birders to share their knowledge and experience of Australian birds. The survey generated 100 responses from experienced birders.

3.4.4 Online survey

The online survey was developed to expand the sample base from the twelve Perth Zoo interviewees to a target of an extra one hundred birders with a minimum of two years’ experience with identifying birds. The aim of the survey was to determine if VC design expertise could contribute to addressing design issues indicated by the respondents. The survey asked specific questions that revealed the birder’s personal opinion about the design
and effectiveness of their favourite Australian bird field guides and asked them to share their stories about what inspired them to become birders and their approaches to identifying birds.

BirdAus, an online birding forum, was chosen to distribute the survey because it has two hundred subscribers who, according to one Perth Zoo interviewee, participate in regular online discussions.

The survey was based on a series of quantitative and qualitative questions that required the respondent to either tick a multiple choice question or provide a detailed response to an open-ended question. The reason for providing the option to respond to an open-ended question was to allow for the respondents’ personal views to be represented.

The recruiting process for the online survey was based on the same ‘criterion-based sampling’ process as for the in-depth interviews (Burns, 2000, p.465) as explained earlier in this chapter. That is, the respondent required a minimum of two years’ experience with identifying birds. Subsequently, the recruiting criteria influenced the first question in the survey ‘How long have you been involved with identifying birds?’ (Chart 3_3).

The survey consisted of four questions of which a number had a list of options to choose from, as shown in Chart 3_3 below.

<table>
<thead>
<tr>
<th>Chart 3_3: Survey Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Question One</strong>: How long have you been involved with identifying birds? Options: 2-5 years, 5-10 years, 10-20 years, 21-30, 31-40, 50+</td>
</tr>
<tr>
<td><strong>Question Two</strong>: ‘What lead to your interest in identifying birds?’</td>
</tr>
<tr>
<td>i) Do not recall.</td>
</tr>
<tr>
<td>ii) Having a pet bird or birds at home.</td>
</tr>
<tr>
<td>iii) A friend or family member introduced me to birds</td>
</tr>
<tr>
<td>iv) Reading books and or watching wildlife programs</td>
</tr>
<tr>
<td>v) Other, please describe</td>
</tr>
<tr>
<td><strong>Question Three</strong>: How did you learn to identify birds?</td>
</tr>
<tr>
<td>i) Self taught through reading books/ field guides.</td>
</tr>
<tr>
<td>ii) Taught by a birding mentor or through course work.</td>
</tr>
<tr>
<td>iii) A friend or family member introduced me to birds</td>
</tr>
<tr>
<td>iv) Other, please describe</td>
</tr>
</tbody>
</table>
### Chart 3.3: Survey Questions

<table>
<thead>
<tr>
<th>Question Four (a): Do you currently, or have you ever referred to a bird field guide/s to assist you when identifying birds? Yes or No. If yes, please answer Four (b), Four (c) and Four (d), if no go straight to question 5.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question Four (b): What is the name of your favourite field guide or guides, please tick one of the following or provide the name of the field guide if it is not listed.</td>
</tr>
<tr>
<td>Question Four (c): What makes this field guide better than the others?</td>
</tr>
<tr>
<td>i) The written descriptions of the birds.</td>
</tr>
<tr>
<td>ii) The colour drawings of the birds.</td>
</tr>
<tr>
<td>iii) The photos of the birds.</td>
</tr>
<tr>
<td>iv) The black and white drawings of the birds.</td>
</tr>
<tr>
<td>v) The size of the guide.</td>
</tr>
<tr>
<td>vi) The format, it is easy to navigate and find the birds you want.</td>
</tr>
<tr>
<td>vii) Other, please describe.</td>
</tr>
<tr>
<td>Question Four (d): Is there anything you would add to a field guide to make it easier to use and easier to identify birds? Yes or No If yes, please describe.</td>
</tr>
</tbody>
</table>

The online survey generated large amounts of informative data that is too extensive to include in this chapter. Instead, the following sections provide a discussion of the results that emerged from the grounded theory analysis. Comparable to the data generated from the in-depth interviews for each of the five questions asked, examples from the survey data are specified. These acknowledge the main idea that emerged from each question.

### Survey Question One

Survey Question One displays the number of years individual respondents had engaged in identifying birds. The results far exceeded the minimum requirement of two years to average between ten and twenty years. The results of question one established the depth of expertise brought to the survey.
Design for nature and the nature of design ability: Chapter 3 | Perth Zoo Case Study

Chart 3.4 Responses to Question One: Length of time the respondent has been identifying birds

<table>
<thead>
<tr>
<th>Options</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-5</td>
<td>5</td>
</tr>
<tr>
<td>5-10</td>
<td>21</td>
</tr>
<tr>
<td>11-20</td>
<td>53</td>
</tr>
<tr>
<td>21-30</td>
<td>12</td>
</tr>
<tr>
<td>31-40</td>
<td>4</td>
</tr>
<tr>
<td>50+</td>
<td>1</td>
</tr>
</tbody>
</table>

Survey Question Two

Question Two (Chart 3.5) asked the respondents to reveal the circumstances that lead to their interest in identifying birds. The purpose of this question was to establish the context in which an interest in birds and bird identification can arise. This was important background information for the research because the projects presented later in this thesis are designer-led, meaning there is no direct client but rather the designer establishes the brief based on self-generated research. Question two aligns with the sort of question a VC designer would ask when negotiating and establishing a brief with a client because it provides a broader context of the individual birder, their interests, experiences and the types of media and people that have influenced them.

Chart 3.5 Responses to Question Two: What lead to your interest in identifying birds? The number of respondents who chose option 3.i, 3.ii, 3.iii, 3.iv or 3.v

<table>
<thead>
<tr>
<th>Options</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Do not recall</td>
<td>3</td>
</tr>
<tr>
<td>ii) Having a pet bird or birds at home.</td>
<td>7</td>
</tr>
<tr>
<td>iii) A friend or family member introduced me to birds</td>
<td>23</td>
</tr>
<tr>
<td>iv) Reading books and or watching wildlife programs</td>
<td>18</td>
</tr>
<tr>
<td>v) Other, please describe</td>
<td>49</td>
</tr>
</tbody>
</table>
The chart 3_5 (above) revealed that 23 of the respondents became interested in birds because a friend or family member had introduced them. However, the majority of forty-nine respondents had personal stories to share as to the source of their interest in birds. The main two main themes to emerge from their stories were firstly, 'curiosity ignited by one bird or one incident' as shown in the comments (below) by respondents three and thirty-three. Secondly, 'a long-term love of nature that grew to include birds' which is revealed in the comments (below) by respondents seven and nineteen.

By chance I went to Gypsy Point Lodge at a Bird Week with Emu Tours. I really enjoyed the activity and went on from there (Respondent 03).

I unexpectedly and fortuitously saw a Tawny Frogmouth with a borrowed pair of binoculars which I was using to observe features of trees near to my parents' home in Perth, thus kindling an interest in looking at birds, which steadily became a serious interest (Respondent 33).

A love of the bush and trying to ID every bird I see. I try to name every plant as well (Respondent 07).

I have always had a strong interest in Natural History, but I think bird watching came about from living in a two-storey house in Dubbo. The living area of this house was upstairs, with a lot of window area and a veranda, which gave a great view of birds in the surrounding trees (Respondent 19).

Survey Question Three

Question Three (Chart 3_6) invited the respondents to share how they learned to identify birds. This question was designed to understand how many of the respondents used field guides in the initial stages of learning to identify birds. This question is important to the VC designer because it defines the market for a particular design project, in this case a bird field guide. Understanding the market is one of the essential parameters for any design brief. The results from this question showed that sixty-four respondents were self-taught through reading field guides.

<table>
<thead>
<tr>
<th>Options</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Self taught through referring to field guides.</td>
<td>65</td>
</tr>
<tr>
<td>ii) Taught by a birding mentor or through course work.</td>
<td>21</td>
</tr>
</tbody>
</table>
From the sixty-five who responded to Question three option (i), two respondents added that they also attended training through either their work place (respondent 61) or through course work education (respondent 64). A further two explained they were self-taught but then added to their skills through the advice of mentors (respondents 01, and 02).

Those four respondents who selected option (iv) ‘others’ stated they learned how to identify birds by joining clubs.

The results of question three substantiated the importance of field guides in the initial stages of learning bird field marks and how to identify birds. From a VC design perspective, this knowledge is pertinent to the establishment of a design brief for bird field guides because it means that the information must be accessible to the beginner as well as the experienced birder.

**Survey Question Four**

Question Four (a) (Chart 3_7) Asked the respondents if they currently, or had ever referred to a bird field guide/s to assist them when identifying birds. If they answered yes, then they were directed to answer Four (b), Four (c) and Four (d). If they answered ‘no’ to the question then they had now completed the survey. The intention of question four was establish an understanding of field guide design from the perspective of the birder’s needs.

<table>
<thead>
<tr>
<th>Options</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>100</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>

The response to question four was universal in that all one hundred respondents were either currently referring to or had referred to a bird field guide. Again, this result further
demonstrated the importance of bird field guides in the life of a birder and that both the beginner and experienced birder referred to bird field guides.

Survey Question Four (b)

Question Four (b) (Chart 3_8) requested the respondents to name their favourite field guide or guides and if their favourite guide was not listed to provide the name under the option ‘others’.

<table>
<thead>
<tr>
<th>Options</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td>3</td>
</tr>
</tbody>
</table>

The results for question four (b) pointed to Pizzey & Knight (2003) as the most popular and Storr & Johnstone (1995) as the least favourite. The field guides listed under the option ‘others’ were Higgens (1990) Handbook of Australian, New Zealand and Antarctic birds also referred to as HANZAB published by Oxford University Press, then Harrison (1991) Seabirds: An Identification Guide, Published by Mifflin Harcourt and Svensson et al. (2001), published by Collins.

These results reconfirmed the importance of field guides to the birding community and validated the use of the four major Australian field guides throughout this thesis as a viable
Survey Question Four (c)

Question Four (c) (Chart 3_9) inquired into what made the respondents’ favourite field guide better than others. The respondents were given a series of multiple choices that were based on VC design elements. The respondents could choose one or more of the options and the option of ‘others’ was included to allow the respondents to share opinions that were not listed but were important to them.

Question Four (c) was designed specifically to investigate the respondents’ opinion of the VC design elements used in a bird field guide. This question directed the respondents to think about the design and to discern what design element/s made their favourite field guide better than other field guides. Again, this type of question is typical when defining a VC design brief and the answers built towards establishing the design element and function parameters.

<table>
<thead>
<tr>
<th>Options</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) The written descriptions of the birds.</td>
<td>37</td>
</tr>
<tr>
<td>ii) The colour drawings of the birds.</td>
<td>54</td>
</tr>
<tr>
<td>iii) The photos of the birds.</td>
<td>2</td>
</tr>
<tr>
<td>iv) The black and white drawings of the birds</td>
<td>3</td>
</tr>
<tr>
<td>v) The size of the guide</td>
<td>28</td>
</tr>
<tr>
<td>vi) The format, it is easy to navigate and find the birds you want.</td>
<td>32</td>
</tr>
<tr>
<td>vii) Other, please describe</td>
<td>31</td>
</tr>
</tbody>
</table>

Analysis of the results to Question Four (c) revealed that fifty-four respondents believed that it was the colour drawings of the birds in their chosen field guide that made it better than other field guides. This was followed closely by the written description of the birds. The large number of respondents selecting the option that it was the colour drawings of birds in their favourite field guide that made it better than others points to the importance
of the bird drawings and the colouration of the birds in field guides.

The format and ease of navigation, and the size of the guide, rated similarly. Other elements that were not listed that made their guide better than other field guides included distribution maps, as described by respondent fifteen (below) and bird drawings with arrows to point out field marks, highlighted by respondent eight (below). In addition to the distribution maps, respondents forty-one and fifty-seven were clear that the fact that their favourite field guide had the maps positioned next to the description and the image of the bird was why it was better than other field guides.

The inclusion of distribution maps are critical (Respondent 15).

Morecombe Compact is small but still has useful information, particularly the well-labelled images (arrows to pertinent field marks) (Respondent 08).

The colour drawings of the birds are important, but the main reason I use Simpson and Day is because all the information I need for bird identification is contained in the one area - I do not have to go to other pages to see colour plates or find other vital information like distribution maps (Respondent 41).

Text and Distribution maps opposite the colour plates (Respondent 57).

**Survey Question Four (d)**

Question Four (d) (Chart 3_10) asked the respondents if there was anything they would add to a field guide to make it easier to use and easier to identify birds. If the respondent chose the option ‘yes’ then they were invited to elaborate on what those additions would be.

Question Four (d) was developed to understand what is currently missing in the VC design of field guides. This type of question is critical when establishing a design brief as it reveals the design needs and desires of the market. More respondent quotes are displayed for this question because they are key to the design-led projects carried out for this thesis.

<table>
<thead>
<tr>
<th>Chart 3_10 Responses to Question 4(d) ‘Is there anything you would add to a field guide to make it easier to use and easier to identify birds?’ The number of respondents who answered yes and no.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Options</strong></td>
</tr>
<tr>
<td>--</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>
Fifty-eight out of the one hundred survey respondents answered yes and provided detailed responses on what would improve a bird field guide. The analysis of the responses defined three common issues: the lack of labelling or highlighting of bird field marks also known as the ‘jizz’ of the bird; a desire for more improved bird illustrations; a lack of scientific rigour in both the bird description information and bird illustrations.

**Respondent issue of lack of ‘labelling or highlighting bird field marks’**

Pizzey and Knight would benefit greatly from labels on pertinent field marks (Respondent 08).

Better field mark text and plumage variations in the illustrations (Respondent 12).

The original Pizzey & Doyle (1980) had little arrows pointing to the important field marks, which was very useful and not in the current guide (Respondent 48).

**Respondent desire for more ‘improved bird illustrations’**

All field guides can be improved, particularly in the area of illustrations (Respondent 19).

Better field mark text and plumage variations in bird pictures. The plumage colour is often not correct to the live bird; it is not accurate (Respondent 12).

Better treatment of feet and legs and better colour to match the real bird (in the illustrations) (Respondent 36).

**Respondent issue of the lack of scientific rigour in bird description and illustration**

Most are fairly good but there are too many errors of information in the written description and the bird images, which is disappointing (Respondent 59).

Some alternative ways of identifying birds via their characteristics. More scientific like: type of beak, colour of beak, colour of legs, colour of eyes, colour of breast (Respondent 78).

Not one (field guide) is correct and only by using several references can you begin to put the facts together. But they are often inaccurate and use inconsistent field mark sequencing (Respondent 38).

The respondents’ comments provide insight into issues in field guide design and function indicating that the guides do not support the market’s needs, which is further justification for the research in this thesis.
These comments from the respondents point to a need for the design of a field guide to include visual representations of birds that highlight more bird field marks. The desire for more emphasis on field marks aligns with the VC design expertise in Gestalt laws of visual organisation that supports the discernment of prominent colour and or pattern groupings that reduce complex detail to minimal elements. VC design can apply this theory through the use of icon design whereby the development of a bird ‘icon’ to emphasise the bird species field marks would meet the birder’s needs. The concept for a bird ‘icon’ that is designed to support the current identification strategies offered in bird field guides is one of the major contributions of this study. It was developed as a design-led test case, and the results are discussed in chapter 5.

The other prominent comment was for ‘improved bird illustrations’. The common theme that emerged from the respondents’ comments was that the bird illustrations were often not accurate to the live bird, particularly the colouration of the live bird. These comments point to the lack of colour standardisation in the bird illustrations, which, when aligned with results from the in-depth interview two, foreground the VC design issue that is identified in this thesis.

The final issue as identified by the survey respondents was the lack of what they saw as scientific rigour in the bird description and bird illustrations. This issue is significant in that it does not align with the primary purpose of a bird field guide, which is identifying birds in the field (Herbarium, 2008). This purpose suggests that the visual and text based information need to be accurate in order for the reader to use that information to accurately identify a bird when seen live. Again this issue is seen as a significant VC design issue that will be investigated in the next chapter.

**Survey conclusion**

The survey responses supported the importance of VC design to bird field guide design and functionality. Data revealed the need to incorporate visual systems of information and bird representation, which communicate scientific information to support the learning process by making it accessible to the novice birder as well as the ornithological expert.

### 3.5 Conclusion

This chapter determined the VC design needs of birders through the engagement of a case study carried out at the Perth Zoo. The case study provided a research environment to gather information from people with experience in bird identification and in particular their opinions of bird field guide design. The types of research methods used for the case
study were non-participant observation, in-depth interviews and an online survey. The combination of data gathering processes produced a large amount of rich data that were analysed using Grounded theory methods. The conclusion for this chapter reviews the main findings that establish the aim and objectives for the following chapters.

The data gathered from observations, interview one and two, visual analysis of the interpretive panels and survey established key words and substantive themes and theories. The key words that emerged during Grounded theory analysis of the data generated from the non-participatory observation, interviews, and visual analysis of the interpretive panels at the Perth Zoo included: accurate colour, accurate illustrations, bird watching, colour names, ducks, eco-system, environment, field guide, field marks, illustrations, knowledge, natural, observe effectively, people, shape, sight, sound, storytelling, time, jizz, colour, shape, size, sound, and texture. From those key words, six substantive themes and theories of where VC design could contribute to the VC needs emerged:

(1) Colour theory: standardisation, constancy and nomenclature to address colour naming issues for birders and print production issues in field guides and on interpretive panels.

(2) Theories of perception: spatial observation, dual coding and Gestalt laws of visual organisation theories to support bird identification strategies for the birder and to incorporate into bird field guide design and bird representation.

(3) Scientific illustration theory: to ensure accurate bird representation in field guides and on interpretive panels.

(4) Icon design theory: to address the need for visual representation of bird field marks in field guides and on interpretive panels.

(5) Interpretive design theory: Interpretive panel design: the integration of storytelling, factual knowledge, and principles of Gestalt laws of organisation to encourage the appreciation of birds and other native flora and fauna in zoos, museums, sanctuaries and national parks.

The patterns that emerged from the interviews offered important contributions to this case study, significantly demonstrating that both birders and VC designers possess well-developed skills in spatial awareness, categorisation and Gestalt laws of visual organisation, although acquired differently. The difference in the acquisition of these skills is that through the practice of bird identification the birder develops them intuitively. In contrast, the VC designer learns these skills firstly through the design educative system and then intentionally enhances them through daily practice of design. Importantly, this link substantiates the contention that VC design can offer skills, knowledge, and expertise that will assist birders in the identification of birds in the field. The assistance is realised in the deliberate employment of these skills in the advancement of the current visual systems used in bird
field guides and interpretive panels.

The following chapters will test this link in expertise through the application of spatial awareness theories, categorisation and Gestalt laws of visual organisation to the VC issues identified in this chapter. Specifically, the lack of colour standardisation in both the nomenclature and the colouration of birds in bird field guides is addressed. The procedure and results of these projects are the subject of the next two chapters.
4. Colour Standardisation in the creation and performance of bird field guides

4.1 Introduction

This chapter presents an analysis of the data from the Perth Zoo case studies, which led to the development of the digital scientific illustration and Identicons that are central to this thesis. This chapter begins with an introduction to theories of colour standardisation, colour consistency and colour nomenclature in terms of VC design and for Ornithology. It then discusses the importance of colour as a common language for designers, printers, ornithologists and birders. Next, it discusses the work of the famous colour theorist Robert Ridgway and justifies the expansion of his colour standards and colour nomenclature for use in the 21st century. Finally, a designer-led brief to develop a colour palette for the Blue-winged Kookaburra that incorporates Ridgway’s colour palette and nomenclature is introduced.

4.2 Colour standardisation: a language for VC designer, printer, client and audience

Colour standardisation is essential for clear communication between the VC designer, illustrator, and client, and the client’s audience, otherwise known as the ‘market’. In the case of this thesis, the audience is the ornithologist and the birder. Colour standardisation is a method of precisely identifying and reproducing colour that is commonly used by ‘printers, designers, and paint dye manufacturers’ (Bloomer 1990, p. 91-92). Ernst-Peter Fischer (2009), science historian and author for the online Virtual Colour Museum, maintains that colour standardisation developed due to the human desire to understand, order and reproduce nature’s colour phenomena. The results included designers’, artists’ and printers’ inks and dyes that emulated the visible spectrum. An early colour-circle, commonly known as a colour-
wheel, was introduced by Robert Fludd in 1630 and a more well-known colour-wheel by Isaac Newton in 1702 (Fischer, 2009). The colour-wheel then evolved over two hundred and seventy five years, and was eventually adapted into a standard system logically organised in order to reproduce the same colour in a consistent manner by the painter Albert Henry Munsell (1858-1918), and his colour system eventually became the most widespread and utilised artist-based colour system.

Then in the early 1900s there emerged a new breed of artist, the graphic designer, who, unlike the traditional artist, produced commercial work for clients and relied on print technologies to produce work in multiples (Pantone, 2009). Graphic designers and their work demanded a new colour language for communication between designer, manufacturer, retailer and customer (Pantone, 2009). This need caught the attention of a printer named Lawrence Herbert, who in 1963 developed a new colour matching system, which he termed the Pantone Matching System (Pantone MS).

The Pantone MS is a linear colour system comprised of colour swatches with a code relating to each swatch (Pantone, 2009). The VC designer can select a colour and move either before or after that colour, in a linear fashion, to select the right hue for the project. The Pantone MS nomenclature is a code comprised of numerals and letters. For example, if the VC designer wants to print a logotype in a red colour, they would search through the Pantone Colour Selector, select a specific red that met their colour requirements, note down the code that is located under the swatch of red colour, for example Pantone 199, and tell the printer to apply Pantone 199 when printing the logotype. The printer refers to a printer’s Pantone guide and follows the formula for Pantone 199, which is ‘12 oz of Rubine Red and 4 oz of Pantone Yellow and mixes them together (Pantone 2012, para. 6).

The impact of Herbert’s innovation still resonates in the daily working lives of VC designers, their clients, and target audiences worldwide. His colour standardisation is not only based on a carefully considered colour palette, the Pantone MS, but also on a carefully planned nomenclature. His colour language therefore makes a smooth transition between the creative and the client’s expectations and also communicates directly to the people who buy their products – the market. For a practising VC designer, the Pantone MS is the first source to turn to when searching for a colour, as has been my own experience of producing more than six hundred design projects across twenty five years of practice in the VC profession. However, artists and illustrators are a different matter. The Pantone MS is a system used primarily by VC designers and printers, not by artists. The illustrations for bird field guides are produced by artists and illustrators who mix colours by hand using their individual personal visual judgement for colour selection. The Pantone MS has little relevance to these professionals as a system for colour standardisation, due its numerical
nomenclature. To explain, for the expert designer, the red colour on the Red Breasted Robin is easily recognised as, for example Pantone 172, but for the birder this nomenclature has no relevance or meaning. For this reason, for the purposes of this present research it became necessary to investigate an alternative colour system that would meet the requirements of the birding world by supporting the birder when learning the colour names for bird species, and would also meet the market requirements of a printed object in bird field guides.

The following section discusses the importance of colour in the process of bird identification. In addition, it further substantiates the need for a colour nomenclature for the birding community that is not based on numbers but rather on names that the birder can relate to.

4.3 Colour in bird nomenclature

There is a significant issue in the colour nomenclature currently used in bird field guides when describing the colouration on the bird. In simple terms, the colour names are often too generalised and therefore open to individual perception. For example, the colour name Blue to describe the blue colouration on the crown, breast and back of a Rock-Thrush does not provide any indication of whether the blue colour is Dark Blue, Light Blue, Mid Blue, Blue-grey, Mid-blue-grey, and the list of possibilities could continue. The issue of vague colour names is not limited to the description of the bird but is also inherent in the scientific and common names of the bird. However, as the focus of this study is the colour standardisation in the printed representation of the bird illustration in field guides, an investigation into the official names of bird families and species is outside the scope of this work. It should be noted, however, that any discussion of bird nomenclature occurs in a global context because Ornithology is not unique to Australia. Bird naming was well underway in Europe and America before Captain Cook arrived on the shores of Australia and Joseph Banks and Johann Reinhold Forster collected Australian birds (Masi, 2011).

In Ornithology, colour is one of four key elements used when identifying birds. Colour is equally as important as bird sounds, form/shape and texture recognition. Even a glimpse of colour can help a bird observer determine the species of a bird, especially if the colour fits with a species form, plumage, wingspan, or beak shape. Therefore, colour has long been included in the common or local names and descriptions of birds around the world, for example Blue Fairy Wren, Ruby-crowned Kinglet, and Purple Finch. However, although colour is an obvious choice to include in a bird’s name, problems arise when using generalised colour names to describe the bird in bird field guides. The issues are due to differences in regional interpretation and individual perceptions of colour (Fregeres, 2005).
In the early history of ornithology, there was no standardisation of either bird names or bird colours. Not only did the common name of a bird species differ according to the geographical location, but also the colour reference. For instance a bird with red colouration could be referred to as Red, Rustic, Reddish, Ruddy, Rufous, or Rufus (Whatbird, 2010). The use of Rufus/Rufous as a colour name dates back to King William Rufus II (1056-1100), who was also known as the Red King due to his ruddy complexion, red cheeks, and blond hair. Then in late 18th century Britain the word Rufus, meaning reddish, emerged in Latin, and has been applied ever since to the naming and describing of birds such as the Rufous Hummingbird, Rufous-crowned Sparrow, and Rufous-winged Sparrow.

In Australia, Rufus and Rufous are commonly used in current field guides, but as the data from the Perth Zoo interviews shows, because of the European origins of this name, Australian birders are confused as to the visual interpretation of that colour name. Seven out of the twelve interviewees in this case study stated that when they were new to bird identification they had to look up the meaning of Rufus/Rufous, and when they did they were still confused as to the hue it represented.

Over time, and as the interest in natural sciences and ornithology expanded, scientists and birders recognised the confusion that was generated through localised nomenclature particularly when discussing bird families and species in a scientific context (Fregeres, 2005). The confusion that arose out of localised nomenclature inspired 18th century scientists to develop scientific naming conventions. At this time, natural scientists were exploring in search of new flora and fauna. Individual scientists began to use Latin names in an attempt to reduce confusion, however, like localised names it soon became clear that Latin alone lacked the standardisation required. It was not until 1735 that Carl Linnaeus developed a scientific binominal (double-name) system to support international standardisation of nomenclature for all living organisms. Linnaeus developed the binominal system as a universal language for use when referring to living organisms, in order to avoid the confusion of language, region, and culture barriers (Port, 2007).

Binominal nomenclature is a formal system that provides two Latinised names for organisms; the ‘genus’, which groups bird species into a principle taxonomic category, and a second name that is formulated on a specific characteristic that identifies the species within the genus (Port, 2007, para.7). For example, Alcedo Azurea, whereby Alcedo (the genus) establishes the bird as a kingfisher, and Azurea identifies the characteristic that is unique to the species, in this case colour. Azurea is the Latin name for Azure, which is a blue colour (Simpson & Day 1996). The Binominal system works efficiently until colour is introduced in the name, for example the Azurea used above. In spite of Linnaeus’ scientific approach he did not consider the limitations that colour in bird nomenclature creates due
to the interpretation and understanding according to the culture or geographic location of the observer (Fregeres, 2005, 2009; Waggoner, 2000; Poley, 2007; Port, 2007).

It was not until Robert Ridgway, an American ornithologist and botanist, published his book *Color Standards and Color Nomenclature* in 1912 that a colour-system finally met the colour standardisation needs of scientists in the fields of Zoology, Pathology and Mineralogy (Evisum, 2001). The importance of Ridgway’s lifetime commitment to colour standards and colour nomenclature and the continuing influence of his work on bird identification are discussed in the following section. In particular, this section discusses the relevancy of his work in terms of the illustration of birds and the standardisation of bird colouration in the print publication of bird field guides.

### 4.4 Robert Ridgway & colour standardisation

Ridgway (1912) called into question colour nomenclature in the natural sciences after reviewing colour studies of the time. Ridgway recognised that the focus of these colour studies was the physics of colour that supported the needs of the artist and art related industries, and that none were relevant to the zoologist, botanist, pathologist, or mineralogist. A system that resolved the lack of colour standardisation for the natural sciences became a priority for Ridgway, and his work on colour standardisation resulted in two books, *A Nomenclature of Colors for Naturalists and Compendium of Useful Knowledge for Ornithologists* (1892) and *Color Standards and Color Nomenclature* (1912).

In his first book, Ridgway explained that he used the Axiom of Chromatologists as the scientific basis of the colours. The Axiom of Chromatologists states that the colours of nature are emulated through ‘various combinations’ of primary red, blue and yellow mixed with white and black to achieve absorption or refraction of light (1892, p.23). Following these rules and by mixing each colour by hand Ridgway created one hundred and eighty six colour swatches. The colours were then arranged by positioning the same class of colour together on one page. For example, one page was designated for blue, one for bluish-green, and another for red. However, Ridgway (1892, p.25) discovered that some colours did not fit neatly within one class, and therefore his placement of those colours was arbitrary and not scientific.

The unscientific approach to the final arrangement and inadequacies in some of the colour mixtures were not satisfactory for Ridgway and he subsequently spent another twenty years reworking his first book. In his second book *Color Standards and Color Nomenclature* (1912), Ridgway expanded the palette from one hundred and eighty six to one thousand, one hundred and fifteen. This time Ridgway abandoned the Axiom of Chromatologists as the
basis for colour mixing and replaced it with the theories of J.H. Pillsbury. Pillsbury’s colour theory was based on the solar spectrum, that is, six primary colours and intermediate hues, expanded by including hues that connect violet with red, thus creating a solar spectrum colour wheel that is made up of thirty-six equal segments. Pillsbury’s colour theory included precise instructions of the measurements and mixing combinations to arrive at the thirty-six colour segments. Then, in order to achieve shades (neutral grey additive) and tints (white additive) for each of the thirty-six colours Pillsbury created a wheel that provided the incremental amounts of black and white required (Ridgway, 1912).

With both colour wheels to guide him, Ridgway (1912) mixed each colour by hand, beginning with the thirty-six from the solar spectrum. Next he systematically added measured amounts of black to achieve shades and then in the same precise manner added measured amounts of white to the original thirty-six colours to achieve a series of tints. The thirty-six equal segments of colour and systematic series of shades and tints meant that Pillsbury’s theory, when applied by Ridgway, produced colour swatches that were based on a scientific formula and the colours fell into a simple scientific order (Ridgway, 1912).

The naming of Ridgway’s colours was derived from an audit of colour nomenclature literature of the time. The decision for the final colour names was based on two main sources. Firstly, from Ridgway’s previous work on colour nomenclature published in 1886, and secondly, from colour samples and names developed by Frederick Wampole for the American Mycological Society. Examples of the one thousand one hundred and fifteen names from Ridgway’s book include, Dull Lavender, Deep Dull Lavender, Dark Lavender, Slate Violet, Vinaceous Lavender, and Dull Indian Purple (Ridgway, 1912, plate XLIV).

One of the primary purposes for Ridgway’s (1912) colour palette and colour nomenclature was and still is for the bird illustrator to perceptually select colour swatches that match the colours of the bird they are illustrating. Once the colour swatch is chosen, the illustrator follows Ridgway’s mixing guide to mix the colour and then applies the paint to illustrate the bird. Ridgway’s traditional hand mixing approach and reliance on the illustrator’s perception of the final colour was well suited to 1912. However, in 2012 digital technologies can now achieve accurate colour standardization in printed material well beyond the ability of human skill and without reliance on the perceptions of individual illustrators. Yet many bird illustrators still rely on the traditional and less scientific approach of hand mixing colours. Thus, in the context of bird illustrations, Ridgway’s (1912) colour system and nomenclature do not adequately meet the demands of colour standardisation in the 21st century. However, Ridgeway’s colour palate is still the most commonly used system by bird field guide illustrators. The challenge of this present research therefore became how to adapt and advance Ridgway’s system to a 21st century digital environment. In order to
Design for nature and the nature of design ability: Chapter 4 | Colour Standardisation

provide further evidence for the need for a systematic advancement on Ridgway’s system, more quantifiable research was necessary. To achieve this, a series of systematic analysis stages were carried out on the data collected from the Perth Zoo case study. To follow is a discussion of these stages and the results.

4.5 Data analysis: towards the advancement of Ridgway’s system

Grounded theory data analysis and reduction were used to analyse the responses to Interview two, as discussed in chapter 3. Because in this case the interviews were one-on-one, the units were based on key words, which in turn generated sequences of words about the subject along with their contexts. The key words that emerged from the data included shape, size, colour and pattern. The most significant issue to emerge from both the interviews and the field guides was colour. Subsequently, colour was analysed further to determine a deeper understanding of issues surrounding its application and use in bird identification and field guides.

The analysis of the data from the Perth Zoo case studies Interview two was carried out in three stages. Stage one involved analysing the interviewees’ comments describing the colouring of the four live birds in front of them at the Perth Zoo and listing the colours they could see on those birds, including solid colours and shade. In Stage two that information was converted into a visualization of the colour differentiations for each bird. Stage three emerged from an analysis of the visualization of the data in stage two. The results of the stage two analysis meant that a more detailed investigation of the four most commonly used bird field guides was necessary in order to compare bird colour descriptions with bird illustrations of the same bird in each guide.

For each stage, a series of detailed charts was developed: for stage one chart series A; for stage two chart series B; for stage three chart series C. Each chart series comprised a large amount of data plus data analysis. For example, chart series A comprised twelve separate charts. Each chart reported the colour names used by twelve interviewees for one particular anatomical section of one of four birds. The four birds were the Blue-winged Kookaburra, Eclectus Parrot, Torres Strait Pigeon and Barking Owl, all observed live in the Perth Zoo case study. The seven individual sections described for each bird were the head, eye, wings, tail, back, underparts and neck, shoulders and rump.
**Chart series A: Colour naming for Blue-winged Kookaburra.**

| Chart A 1 | Wings: lesser and medium covert sections |
| Chart A 2 | Breast |
| Chart A 3 | Crown |

**Chart set A: Colour naming for Eclectus Parrot**

| Chart A 1 | Wings: lesser and medium covert sections |
| Chart A 2 | Breast |
| Chart A 3 | Crown |

**Chart set A: Colour naming for Torres Strait Pigeon**

| Chart A 1 | Wings: lesser and medium covert sections |
| Chart A 2 | Breast |
| Chart A 3 | Crown |

**Chart set A: Colour naming for Barking Owl**

| Chart A 1 | Wings: lesser and medium covert sections |
| Chart A 2 | Breast |
| Chart A 3 | Crown |

Chart series B also comprised twelve separate charts.

**Chart series B: Colour differentiation for Blue-winged Kookaburra.**

| Chart B 1 | Wings: lesser and medium covert sections |
| Chart B 2 | Breast |
| Chart B 3 | Crown |

**Chart set B: Colour differentiation for Eclectus Parrot**

| Chart B 1 | Wings: lesser and medium covert sections |
| Chart B 2 | Breast |
These charts documented the variations in colour in names used to describe the seven different anatomical sections of the four birds by twelve interviewees and by the four most frequently used bird field guides. Chart series C comprised four charts. These charts compared the colour names used to describe the seven anatomical sections of four birds in four bird field guides with the illustrations in those guides.

As the description of all charts shows, this research generated a significant amount of data and data analysis. Due to the word limits of this thesis, the presentation of all twenty-eight charts was not possible. Therefore, for each chart series only one full chart is given as an example of the data. Each of the selected charts reports data for the Blue-winged Kookaburra. A full description of the entire chart series is given below.
4.5.1 Stage one: colour names used to describe the blue-winged kookaburra

In stage one the interview responses from the Perth Zoo case study were analysed for incidents of colour names used to describe anatomical sections of the four birds. Chart A1 below gives the responses of twelve interviewees, listed from one to twelve, for the lesser and medium covert sections of the wings of the Blue-winged Kookaburra. It also gives the formal dictionary definition of the colours named by each interviewee. Appended to chart A1 are the colour names used to describe the Blue-winged Kookaburra in the four field guides that were identified by interviewees as those most commonly used by birders. The visual inconsistencies revealed in these results led to the development of Stage three of the data analysis, discussed in more detail in later sections of this chapter.

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Colour Names</th>
<th>Dictionary Definitions of Colour Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>Dark black, blue</td>
<td>Blue: n. Colour of a cloudless sky, the primary colour between green and violet in the visible spectrum, an effect of light with a wavelength between 450 and 500 nanometers (Dictionary.com Unabridged (v.11), 2010).</td>
</tr>
<tr>
<td>Two</td>
<td>Cerulean blue, pale blue, royal blue</td>
<td>Cerulean blue: n: a light blue to deep blue colour with a greenish tinge (Dictionary.com Unabridged (v.11), 2010). Pale blue: n: a loss of blue colour intensity (Dictionary.com Unabridged (v.11), 2010).</td>
</tr>
<tr>
<td>Three</td>
<td>blue, lighter blue</td>
<td></td>
</tr>
<tr>
<td>Five</td>
<td>Blue</td>
<td></td>
</tr>
</tbody>
</table>
Stage one results revealed differences in interviewees’ naming of the colours they saw when observing a live bird, and inconsistencies between the colour descriptions of the same bird in the field guides. Similar results emerged in the data for the other three birds, the Eclectus Parrot, Torres Strait Pigeon and Barking Owl.

Although there was evidence that some consistencies in colour naming did occur between interviewees and field guides, often these were based on common colour names that were vague rather than descriptive, such as brown, blue, and red. There were also instances where descriptive colour names were used such as buff, cream, scarlet, and pillar box red. However, these were not used frequently enough for the one bird to validate them as a known colour for that bird. The results show that most of the time the interviewees and field guide descriptions were inconsistent when communicating colour. As noted earlier in this

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<tr>
<td>Seven</td>
<td>Turquoise blue</td>
<td>Turquoise blue: n: a bright blue with a greenish tinge or a bright green with a bluish tinge (Dictionary.com Unabridged (v.11), 2010).</td>
</tr>
<tr>
<td>Eight</td>
<td>Blue</td>
<td></td>
</tr>
<tr>
<td>Nine</td>
<td>Turquoise blue, sky blue</td>
<td></td>
</tr>
<tr>
<td>Eleven</td>
<td>Pale turquoise</td>
<td></td>
</tr>
<tr>
<td>Twelve</td>
<td>Blue black</td>
<td>Blue-black: n: black with bluish highlights (Dictionary.com Unabridged (v.11) 2010).</td>
</tr>
<tr>
<td>Field guides</td>
<td>Colour Names</td>
<td>Colour naming for Blue-winged Kookaburra: lesser and medium covert sections of the wings</td>
</tr>
<tr>
<td>Pizzey &amp; Knight (2003)</td>
<td>Blue</td>
<td></td>
</tr>
</tbody>
</table>
chapter, colour is significant for the bird watching community as it is one of the four main field marks for identifying a bird. This finding therefore demonstrates the need for colour standardisation systems for bird illustrations across field guides, which will enable birders to accurately name the colour of a bird and to be confident that they will be understood when communicating that colour to others.

4.5.2 Stage two: colour differentiation

In stage two, a visual display of the colour differentiation results from stage one was developed. This information was collated with the addition of a Red Green Blue (RGB) code and RGB colour swatch and the Hue in which the colour name falls.

Colour, whether printed in a book or projected onto a computer screen has three dimensions, hue, value and chromacity. The ‘hue’ of a colour refers to the fundamental colours of ‘red, orange, yellow, green, blue, violet, brown, black, grey and white’ that all colours can be traced back to (Fluck, 2006, para.3). For example, the hue for the colour ‘Cobalt Blue’ is blue, and the hue for the colour ‘Burgundy’ is red (Fluck, 2006). The ‘value’ of a ‘colour (also called brightness or luminosity)’ refers to the tint or shade of a colour as it ‘corresponds to a scale of grays from black to white’. Finally, chromacity (also called intensity) refers to the ‘purity’ the colour (Bloomer, 1990, p.90).

There are two types of colours: there are the colours that you can touch, for example those printed on the surface of a book; there are colours that you cannot touch that are produced by a beam of light, for example the ‘colour produced by your computer monitor’ (Morton, 2008, para.2). The RGB system is the latter. The RGB system was developed in the 1940’s as a result of the invention of the colour television (Reiman, n.d). The scientific premise is simple; the surfaces of a television and computer screen are covered by tiny dots of ‘phosphorescent materials (molecules)’ and minute amounts of red, green and blue light are projected onto the phosphorous dots (Fischer, 1999, para.1). It is the arrangement of the coloured dots that determines the image that is projected on the screen. The human eye is not capable of seeing each point of colour but rather ‘can only register the mixing effect’ of the RGB combination (Fischer, 1999, para.3).

The visual display was organized in chart series B as B1, B2 and B3. Chart B1 is given below as the exemplar for this series. As in all charts, the exemplar is for the Blue-winged Kookaburra. Chart B1 contains six columns. Column 1 displays each colour name as extracted from stage one of the data analysis. Column 2 shows how many times it was used by the interviewees, and column 3 how many times it was referred to in the field guides. Column 4 displays the RGB code. Column 5 displays the RGB colour swatch that clearly illustrates similarities and
Design for nature and the nature of design ability: Chapter 4 | Colour Standardisation

differences, and column 6 where that colour is positioned in terms of hue.

The reference sources for the RGB colour swatches used to represent the colours named by the interviewees and used by bird field guides are Cloford.com (2000), Walsh (2008), and Microsoft Development Network (2000). The reference sources are online databases that offer the RGB digital code information for more than fourteen hundred colour names.

Chart B 1 shows that the colour names used were based on three hues, namely blue, grey and violet. The process to determine the hue for each colour swatch involved an online tool called Colblinder (2006). Daniel Flück (2006, para.2) developed Colblinder as a tool that enables the user to type in an RGB code ‘to find its closest match of a named color and its corresponding hue’ (2006, para.2). Further analysis involved establishing the chroma values (also known as intensity) and the tints and shades for each hue. Chroma values and tints and shades are determined by human perception and the colour samples in Chart B 1 include the chroma values of high (blue, electric blue, blue-violet and bright blue), medium (cerulean blue and royal blue), and low chroma values (azure and blue-black). There were also shade and tint differences in these samples. To elaborate, baby blue and pale blue tend more towards white than black, making them tints of blue. In contrast, blue-black and navy blue are closer to black, making them shades of blue.

<table>
<thead>
<tr>
<th>COLOUR NAME</th>
<th>Interviewee Frequency of use</th>
<th>Field Guide Frequency of Use</th>
<th>RGB CODE</th>
<th>Colour Swatch*</th>
<th>Hue**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azure blue</td>
<td>1</td>
<td>-</td>
<td>193 – 205 – 205</td>
<td>Grey</td>
<td></td>
</tr>
<tr>
<td>Baby blue</td>
<td>1</td>
<td>-</td>
<td>176 – 224 – 230</td>
<td>Blue</td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>3</td>
<td>2</td>
<td>0 – 0 – 255</td>
<td>Blue</td>
<td></td>
</tr>
<tr>
<td>Bright blue</td>
<td>1</td>
<td>-</td>
<td>0 – 0 – 205</td>
<td>Blue</td>
<td></td>
</tr>
<tr>
<td>Blue-black</td>
<td>1</td>
<td>-</td>
<td>32 – 31 – 64</td>
<td>Violet</td>
<td></td>
</tr>
<tr>
<td>Cerulean blue</td>
<td>1</td>
<td>-</td>
<td>42 – 82 – 190</td>
<td>Blue</td>
<td></td>
</tr>
<tr>
<td>Electric blue</td>
<td>1</td>
<td>-</td>
<td>0 – 0 – 238</td>
<td>Blue</td>
<td></td>
</tr>
<tr>
<td>Navy blue</td>
<td>1</td>
<td>-</td>
<td>0 – 0 – 128</td>
<td>Blue</td>
<td></td>
</tr>
<tr>
<td>Pale blue</td>
<td>1</td>
<td>-</td>
<td>176 – 224 – 230</td>
<td>Blue</td>
<td></td>
</tr>
</tbody>
</table>
The results shown in chart B1 reveal very significant discrepancies between the colour names generated by interviewees and field guides and the colour swatches. As the chart demonstrates, the hues ranged from grey through to violet, and in the case of blue, from pale to almost black. The most frequently used colour name was ‘blue’, which was used five times out of a total of a possible seventeen. However, although the name blue was popular for identifying the colour of the prominent field mark for the Blue-winged Kookaburra, the visualisation of the results in chart B1 demonstrates the inaccuracy of such a generalized colour terminology. To further illustrate, Fig.4_1 is a colour swatch that is equivalent to the definition for ‘blue’ given across a range of dictionaries. For example, ‘Colour of a cloudless sky, the primary colour between green and violet in the visible spectrum, an effect of light with a wavelength between 450 and 500 nanometers’ (Dictionary.com, 2010); ‘The name of one of the colours of the spectrum; of the colour of the sky and the deep sea; cerulean.’ (Oxford English Dictionary, 2012); ‘any of a group of colours, such as that of a clear unclouded sky, that have wavelengths in the range 490-445 nanometres’ (Collins English Dictionary, 2000). Fig.4_2 is a photograph of the Blue-winged Kookaburra. A comparison of the colour swatch of Fig.4_1 with the colour on the Kookaburra’s wings in Fig.4_2 shows that the name ‘Blue’ does not accurately represent the colour. As noted above, the same process was also used to analyse the colouration of breast and crown colour for all four bird species.

<table>
<thead>
<tr>
<th>Colour Name</th>
<th>Hue Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Royal blue</td>
<td>1</td>
<td>65 – 105 – 225</td>
</tr>
<tr>
<td>Bue-violet</td>
<td>–</td>
<td>138 – 44 – 226</td>
</tr>
<tr>
<td>Sky blue</td>
<td>–</td>
<td>135 – 206 – 235</td>
</tr>
<tr>
<td>Turquoise blue</td>
<td>1</td>
<td>64 – 224 – 208</td>
</tr>
</tbody>
</table>

4.5.3 Stage Three: Comparison of bird colour descriptions with bird illustrations in field guides

The discrepancies identified in the hues meant that a more detailed analysis of the field guides had to be carried out. Stage 3 was that analysis. The objective of Stage three was to determine whether the colour names used in field guides to describe the field marks of a specific bird species matched the colours used in that guide to illustrate that same bird. The method used was to record the colours used in each field guide for each bird and identify any consistencies and inconsistencies. Rather than analyzing colours for just the Blue-winged Kookaburra, all four birds from the Perth Zoo case study were selected for visual comparison for each of the four bird field guides. The four guides were Simpson & Day (2004), Pizzey & Knight (2003), Storr & Johnstone (1995), Morcombe (2004). As with chart series A and B, only one exemplar is given (Chart C1 below).

In all four charts, column 1 lists the colour names used in the guide for the individual field marks for each bird. The field guide list therefore varied slightly according to the marks assigned to each bird, but in all cases eight field marks were used. Column 2 lists the colour names identified in the field guide illustration. Column 3 gives an analysis of comparisons between the colour names in the field guides with the colour names identified in the bird illustration.

<table>
<thead>
<tr>
<th>Bird field marks: Field guide colour names</th>
<th>Bird field marks: Field guide illustration colours</th>
<th>Comparison and analysis of field guide colour names and field guide illustrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head: streaked brown (some brown-headed)</td>
<td>Female: streaked brown, buff and white, heavier between eyes and crown. Male: lightly streaked with brown, cream and white.</td>
<td>Streaked brown is consistent with illustration but there is no indication of the Buff and white that were present.</td>
</tr>
<tr>
<td>Eye: pale eye</td>
<td>Female: Dark brownish-black. There is a dark brown patch of feathers that frame the eye. The patch extends from one corner of eye, then under the eye and to back corner. Male: Pale cream iris with black pupil.</td>
<td>Pale. is generalised and vague for identification purposes. No note of the dark brown-black in female eye and not mention of the dark feathers that frame the lower half of the eye.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wings: blue</th>
<th>Female: Mantle, median coverts, greater coverts, combination of white, light blue edges of feathers with dark chocolate brown in centre. Male: majority mid sky blue with flecks of white and mid brown on some feathers.</th>
<th>Blue is generalised, open to interpretation. Blue alone suggests a flat overall colour with no notation of other colours including dark chocolate brown, light blue and white.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Tail: deep blue, white tip</td>
<td>Primary blue, small flecks of black and white tip.</td>
<td>Description consistent with illustration.</td>
</tr>
<tr>
<td>Female Tail: Rufous brown, barred dark blue</td>
<td>Mid brownish-orange barred with black, and white tips with black flecks</td>
<td>Description accurate but Rufous indeterminate can cause confusion as descriptor of orange/brown colour. Rufous can cause confusion as descriptor of orange/brown colour.</td>
</tr>
<tr>
<td>Back: Brown</td>
<td>Female: Highly saturated dark brown with buff tips. Male: Mid brown, with dark brown flecks and buff tips.</td>
<td>The use of brown is accurate but too generalised a description of both male and female backs for identification purposes.</td>
</tr>
<tr>
<td>Underparts and neck: Fine barring</td>
<td>Female and Male: White, with some flecks of mid to light brownish-orange in a barred pattern.</td>
<td>Unclear what barring refers to. Description does not accurately support illustration and assumes expert knowledge of the meaning of ‘barring’.</td>
</tr>
<tr>
<td>Shoulders and rump: Light blue</td>
<td>Female: Highly saturated dark brown with buff tips. Rump not illustrated Male: Mid brown with dark brown flecks and buff tips. Rump majority mid sky blue with tiny flecks of white.</td>
<td>Light blue is insufficient to describe the blue of illustrations, particularly for female. There was insufficient illustration for the female and therefore inaccurate.</td>
</tr>
</tbody>
</table>

The information from chart series C series was then translated into a visual form, but this time, instead of an RGB code, the Pantone MS system was used. The reason for the change was the nature of the colour data. The chart B series was created from colour names as used by the interviewees, and the most effective way to translate language-based data i.e. colour names, was to use the online colour reference sources described earlier. Visual analysis of printed field guides generated the chart C series, which are colours that can be touched (described earlier in this chapter). Colours that can be touched in a field guide and other
printed material are generated using one of two colour systems Pantone MS or Process (CMYK).

The Pantone MS system has already been described earlier in this chapter, however, the Process (CMYK) requires introduction. CMYK stands for cyan, magenta, yellow and black and this colour system is generally used to print highly complex and detailed images like photographs and illustrations. Briefly, an original colour illustration, for example of a bird in a field guide, is subjected to the process of scanning whereby the colouration of the image is deconstructed using a scanner and transformed into a series of four films, one for each colour of cyan, magenta, yellow and black. Scanners are digital devices that analyse and process images and text (OCR – optical character recognition), with the objective of transferring the information according to the needs of the user (Tyson 2001). There are four types of scanners, the flatbed, sheet-fed, hand-held and drum scanner (discussed later in this chapter) (Tyson 2001). The drum scanner is commonly used to scan an image for the purpose of printing original artwork such as the illustrations for bird field guides. Drum scanners, as the name suggests, consist of a cylindrical or drum shaped form that rotates the document past the scanner head. It is a sophisticated instrument used by the print industry to capture minute detail (Tyson 2001).

Each colour film is comprised of tiny dots that are similar to the dots described for the computer screen, but instead of phosphorous material these dots are for each of the CMYK coloured inks. If a magnifying glass was used to look closely at a printed page, it would show individual dots cyan, magenta, yellow and black. Finally, each film is made into a print plate that is placed onto an Offset printing machine. When it comes to printing, for example a page for a field guide, the sheet of paper is fed into the Offset printer and passes through each colour plate and when the sheet of paper leaves the printer the information is printed.

The Pantone MS colour system follows a similar process to that described above, but rather than a combination of coloured dots, one specific colour is used that creates what is referred to as a ‘solid’ colour. In this instance, if a magnifying glass was used to look closely at a printed Pantone MS colour, it would not reveal any dots but rather solid colour.

The final choice to use Pantone MS over CMYK to convert the colours seen in the field guide to a colour swatch was based on the extreme difficulty of viewing a colour in a field guide and converting that to the four colour coding of CMYK. Therefore it was a logical choice to use the preferred system of all VC designers, Pantone MS. The complex process of converting the printed colour as seen in a bird field guide to a Pantone MS colour swatch is described in the following section.
**Colour capture process**

According to Geoffrey Hill (2006), a well-known writer and authority on bird colouration, one of the dilemmas facing self-funded researchers such as myself is the financial constraints which prevent them from accessing expensive equipment for research purposes. This applied in my case. For the purposes of this research, a reflectance spectrometer (RS) would have been the best option, but at more than AU$5,000, the cost of an RS for translating the printed colour in the field guides was prohibitive. Hill in particular notes that the cost of an RS means many visual and colour researchers are unable to use this equipment. However, Hill urges researchers to proceed with their research, replacing the RS with their own visual judgment. Hill (2006, p. 44) argues, ‘based on standard observers (CIE 1971, 1978, and humans without UB-blindness and yellow-biased sensitivity) human colour psychometrics are spectrally and mathematically formulated in such detail that in some respects, our colour vision can be used as a physically calibrated instrument’. Therefore, the colour matching process proceeded using my own visual capabilities, as determined by Hill. These capabilities were informed and supported by my twenty-five years of experience in colour matching involving the Pantone colour matching system to visually determine colour matches.

**VC design expertise in colour perception and colour matching**

The ability to accurately perceive, select and match colours is a primary expertise of the experienced VC designer. This skill is developed over many years and is called into play in every printed design project. In some projects the VC designer uses individual perception to imagine a specific colour for a project and then searches through the Pantone colour system to take the idea of a colour and make it a reality. In others, the VC designer is required to match an existing colour, and this involves using visual perception expertise to study the colour and then refer to the Pantone colour system until a perceptual match is identified. For the analysis in this thesis, the latter process was used to match the colours in the field guide with the Pantone system in order to derive a swatch for each colour.

Perceptual colour matching requires certain environmental conditions. Natural light is the most stringent of these, and for this reason the perceptual analysis was carried out solely between 12 noon and 2pm across three consecutive days in summer in Perth, Western Australia, when the light was strong and clear. The process involved selecting a colour displayed in the bird, then studying the Pantone MS swatch guide until a swatch was identified that perceptually matched the colour on that bird. The Pantone colour swatch was then converted to RGB colour coding so that the colours could be displayed accurately on the computer and later printed digitally. The process to convert the Pantone colour swatch
to RGB involved using the computer and Adobe Illustrator software. Adobe Illustrator is an industry standard program used to produce digital illustrations and documents in preparation for either digital or printed outcomes. Adobe Illustrator has the Pantone MS system built into the program, which meant using the program to construct a square shape in the specified Pantone MS colour that was developed for the Blue-winged Kookaburra. Once the square patch of Pantone MS colour was created, Adobe Illustrator provided the facility to translate that colour into numerous codes, and one of those codes was RGB.

The colour analysis focused on the Illustrations of the four birds in each of the four Australian bird field guides to determine the printed colours used in the illustration of the same bird. The tail of the male bird was also included for the Blue-winged Kookaburra, as this is the only colour difference between the male and female. The results of the analysis were then noted in chart series D, which mapped the colours used to illustrate each of the four birds across the four guides. Again, only one chart is presented as an example, and that is for the Blue-winged Kookaburra.

From the descriptions listed in all four of the field guides, seventeen field marks were established for the male and female Blue-winged Kookaburra, Eclectus Parrot, Torres Strait Pigeon and Barking Owl: upper bill, lower bill, throat, breast, belly, wings-coverts, scapulars, secondaries, and primaries, crown, nape mantel, back rump, and tail.

<table>
<thead>
<tr>
<th>Chart Series D: Colour Comparison Chart across four Australian Field guides.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chart D 1</strong></td>
</tr>
<tr>
<td>Colour Comparison chart for the Blue-winged Kookaburra across four Australian bird field guides.</td>
</tr>
<tr>
<td><strong>Chart D 2</strong></td>
</tr>
<tr>
<td>Colour Comparison chart for the Eclectus Parrot across four Australian field guides</td>
</tr>
<tr>
<td><strong>Chart D 3</strong></td>
</tr>
<tr>
<td>Colour Comparison chart for the Torres Strait Pigeon across four Australian field guides</td>
</tr>
<tr>
<td><strong>Chart D 4</strong></td>
</tr>
<tr>
<td>Colour Comparison chart for the Barking Owl across four Australian field guides</td>
</tr>
</tbody>
</table>

The chart series D has five columns. The first column is designated for the name of the field mark under analysis. Columns two to five present the Pantone MS colour for each field mark in one of the field guides.

Design for nature and the nature of design ability: Chapter 4 | Colour Standardisation


The process to perceptually match the colours in each field guide with a swatch in the Pantone MS guide involved studying the designated field mark, say the dark brown on the upper bill of the Blue-winged Kookaburra, then examining the Pantone MS colour chart for a similar brown and placing the Pantone MS colour swatch on the page beside the colour to be matched until a perceptual match was found. Once the match was established, that Pantone MS code was translated into a Swatch using Adobe Illustrator. The results of the colour matching process are presented in chart series D1 which focuses on the Blue-winged Kookaburra. This process was then applied for the remaining three birds and generated chart series D2, D3, and D4.

Chart series D provided complex and visually rich data which demonstrate that there are colour discrepancies between field guides. For example, the Upper bill for the Blue-winged Kookaburra was represented as Pantone 405 (grayish-brown) in field guide one, Pantone 460 (pale yellow with orange tinge) in field guide two, Pantone 534 (Blue grey colour) in field guide three and Pantone 433 (light grey) in field guide four. The next step was to establish whether any colour standardisation existed across the four field guides, i.e. to identify same or perceptually similar colours to represent any of the seventeen field marks that are listed in column one for the Blue-winged Kookaburra. To simplify the comparison, the information in Chart D was separated into three smaller charts D 1a, D 1b, and D 1c.

| Chart series D1: Colour Comparison Chart of seventeen field marks for the Blue-winged Kookaburra across four Australian bird field guides. |
|---------------------------------|-------------------------------------------------------------------------------------------------|
| Chart D1 (a)                   | Instances of different colours used to represent the seventeen field marks of the Blue-winged Kookaburra across four Australian field guides. |
| Chart D1 (b)                   | Instances of the same colours used to represent the field marks of the Blue-winged Kookaburra across four Australian field guides. |
| Chart D1 (c)                   | Instances of perceptually similar colours used to represent the field marks of the Blue-winged Kookaburra across the four field guides. |
|-------------------------------------|----------------|-----------------|-------------------|-----------------|
| Bill: Upper                         | 405            | 460             | 534               | 433             |
| Bill: Lower                         | 162            | 712             | 722               | 415 4545        |
| Throat                              | 406            | 148             | Warm g 1          | 5305            |
| Breast                              | Warm grey1     | Cool grey1      | Warm grey 10      | 468             |
| Belly                               | 164            | 149             | Warm grey 10      | 468             |
| Wings: coverts                      | 3105           | 290             | 2995              | 290 292         |
| Wings: scapulars                    | 411            | 147             | 435               | 1395 1545       |
| Wings: tertiaries                   | 415            | 1405            | 295               | 1395 1545       |
| Wings: secondaries                  | 3105           | 2925            | 295               | 325 1395        |
| Wings: primaries                    | Black          | Black           | 433               | 325 1395        |
| Crown                               | 406 411        | Cool grey 1     | Black Warm grey 10| Black 1575     |
| Nape                                | Warm g 1       | Cool grey 1     | Warm grey 10      | white 1575     |
| Mantle                              | 411            | 147             | 433               | 1395 1545       |
| Back                                | 3105           | 147             | 433               | 1395 1545c      |
| Rump                                | 2925           | 290             | 2995              | 292 white       |
| Female: tail                        | 139 Black      | 139 2925        | 167 Warm grey 10  | 1525 Black      |
| Male: tail                          | 292            | 300             | 2935              | 285             |
Chart D.1 (a) highlights the number of instances where different colours were used across the four field guides to depict the same part of the Blue-winged Kookaburra. The chart reveals that twelve out of the seventeen field marks for the Blue-winged Kookaburra were illustrated using significantly different colours.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bill: Upper</td>
<td>405</td>
<td>460</td>
<td>534</td>
<td>433</td>
</tr>
<tr>
<td>Throat</td>
<td>406</td>
<td>148</td>
<td>Warm g 1</td>
<td>5305</td>
</tr>
<tr>
<td>Breast</td>
<td>Warm grey 1</td>
<td>Cool grey 1</td>
<td>Warm grey 10</td>
<td>468</td>
</tr>
<tr>
<td>Belly</td>
<td>164</td>
<td>149</td>
<td>Warm grey 10</td>
<td>468</td>
</tr>
<tr>
<td>Wings: coverts</td>
<td>3105</td>
<td>290</td>
<td>2995</td>
<td>290 292</td>
</tr>
<tr>
<td>Wings: tertiaries</td>
<td>415</td>
<td>1405</td>
<td>295</td>
<td>1395 1545</td>
</tr>
<tr>
<td>Wings: secondaries</td>
<td>3105</td>
<td>2925</td>
<td>295</td>
<td>325 1395</td>
</tr>
<tr>
<td>Wings: primaries</td>
<td>Black</td>
<td>Black</td>
<td>433</td>
<td>325 1395</td>
</tr>
<tr>
<td>Crown</td>
<td>406 411</td>
<td>Cool grey 1</td>
<td>Warm grey 10</td>
<td>Black 1575</td>
</tr>
<tr>
<td>Mantle</td>
<td>411</td>
<td>147</td>
<td>433</td>
<td>1395 1545</td>
</tr>
<tr>
<td>Back</td>
<td>3105</td>
<td>147</td>
<td>433</td>
<td>1395 1545c</td>
</tr>
<tr>
<td>Female: tail</td>
<td>139 Black</td>
<td>139 2925</td>
<td>167</td>
<td>1525 Black</td>
</tr>
</tbody>
</table>
Chart D.1 (b) highlights the fact that although four field marks, the wing coverts, wing primaries, crown and the female tail were illustrated using the same colour, they were not standardized across the four field guides. For example, the field mark ‘Wings: coverts’ was illustrated using Pantone 290 in field guides two and four but not for the remaining two field guides. In addition, the ‘Female tail’ was illustrated using Pantone 139 in field guide one and two, but not in three and four. These results further substantiate the lack of colour standardisation.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wings: coverts</td>
<td></td>
<td>290</td>
<td></td>
<td>290</td>
</tr>
<tr>
<td>Wings: primaries</td>
<td>Black</td>
<td>Black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crown</td>
<td>Black</td>
<td>Black</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Female: tail</td>
<td>139</td>
<td>Black</td>
<td>139</td>
<td>Black</td>
</tr>
</tbody>
</table>

Chart D.1 (c) (to follow) reveals that the colour for eight field marks out of a possible seventeen for the Blue-winged Kookaburra was perceptually similar but not across all four field guides. For example, for the Wings tertiary, two field guides used a similar golden brown, and for the Wings primaries field guides one and two used black, which is similar to the dark grey colour used by field guide three. Even though chart D.1c provides evidence for eight perceptual similarities, technically these do not meet the requirements for colour standardisation discussed earlier in this chapter.
Results from chart series D.1, which includes D.1a, and D.1b and D.1c for the Blue-winged Kookaburra, substantiate a lack of colour standardisation across the four Australian field guides. These results were consistent for the remaining three birds the Eclectus Parrot, Torres Strait Pigeon and Barking Owl, which demonstrate that colour standardisation is not practised by bird illustrators to illustrate birds for field guides. This substantial colour differentiation is a cause of confusion when the novice birder is referring to more than one field guide in an attempt to learn colour-based field marks in order to identify a bird in the field.

This section has confirmed the absence of colour standardisation in the visual representation of birds in the most commonly used Australian field guides as a design problem requiring a solution. In order to arrive at a solution, a design brief for this problem had to be established. The following sections of this chapter define the brief, establish the parameters of the problem and then discuss the design process to arrive at a result that meets the brief.
4.6 Ridgway meets the 21st Century: the process from design brief to design result

The absence of colour standardisation in the visual representation of birds in field guides is a VC design problem and not a design brief. To arrive at an appropriate resolution to the problem, it must be thought of in terms of a brief with a clear aim, objectives and parameters, all of which are defined in order to maintain focus throughout the design process of research, ideation, testing, development, reflection, refinement and result. In most cases the client approaches the designer with a brief and together they negotiate the details of the brief and then the designer works within those parameters. However, in this instance the brief was designer-led. This allowed the knowledge gained from the case studies to be factored into the brief, and also gave the designer the rare freedom to take creative risks and include experimentation that, in general, a paying client would not agree to. As a result the brief not only focuses on defining the parameters of a VC design outcome for colour standardisation for the bird illustrations and colour nomenclature in Australian bird field guides, but also includes reflection on the full implications of the colour system and how it could be applied to the illustrations of birds for field guides across the world.

The design brief

Given the above parameters, the design brief was, first, to design a visual system that captured the perceptual colours on a live bird and then match those colours to Ridgway’s colour system and nomenclature. Second, the brief was to design a digital illustration technique that supported Ridgway’s (1912) colour palette. The resultant visual system and digital illustration technique were then to be tested through their application to one Australian bird, the Blue-winged Kookaburra.

As discussed earlier in this chapter, Ridgway’s colour system with colour nomenclature was chosen over other potential systems because it was developed specifically for the natural sciences, and it is still in use today by bird illustrators. In addition, Ridgway’s colour nomenclature, for example, amber brown and amethyst violet, have relevance for the birder and ornithologist, whereas other systems, for example Pantone MS and Process CMYK, are numerically based, which holds no meaning or relevance to the birding world.

The first concern was to determine the technologies needed to sample the colours as seen on a live bird, and then the technologies required to match that colour data to Ridgway’s digital colour palette. Research was carried out into digital cameras and scanners as digital devices that can sample colour, in order to determine the value of these devices as tools. Current colour systems used by printers, RGB, and CMYK (Cyan, Magenta, Yellow, Black)
were also examined. The exploration of each technology is given in the following sections with technical specifications and explanations.

4.6.1 Technologies: digital cameras and flat bed scanners

Digital cameras

A digital camera has the capacity to photograph a live bird and then use the digital photograph as a primary source to analyse the colouration on the bird. Digital cameras are designed around the process of converting analogue conventions, represented by a fluctuating wave, into the ones and zeros (or bits) of digital information. Digital cameras have a built-in computer and record images electronically, removing the need for analogue film and development processes (Nice 2000). The printed version of a digital image is accessible through a variety of devices. For example, a home computer and printer, a printer that connects directly to the camera, or a print and editing system offered in photo-processing stores. The transfer of images from the camera to printers, computers and mobile phones is achieved through the use of the removable and reusable digital Flash card or a Universal Serial Bus (USB) device that comes with the camera. The Flash card and USB store images, allow the transfer of images, and are reusable upon deletion of outdated images.

Control of digital camera resolution is essential to photographing birds and analysing colour because the resolution relates to the amount of detail that the camera captures. Camera resolution is measured in pixels, and the more pixels, (also known as Megapixels in the camera world) the camera has the more detail it captures. For example, digital cameras begin at .03 Megapixels and up to 10 Megapixels. Pixels are comprised of a red, green and blue (RGB) phosphor and each colour phosphor is arranged as a dot or a stripe. A camera with a high-resolution or high Megapixel no smaller than 6 Megapixels rating is necessary for capturing colour detail in birds (Tyson, 2001; Nice, 2006; x-rite, 2004).

In addition to a high-resolution capability, digital cameras offer the facility to select an appropriate editing colour space that is determined by the end use of the images. The literature and professional design, photography and printing online forums reveal debate regarding the ideal colour space for consistent colour sampling, viewing on digital monitors and printing. In essence, the debate examines the two main colour spaces, Adobe RGB and sRGB, and compares the benefits and limitations of each (Ballard 2004; DryCreekPhoto, 2009; Harris 2005; Johnson 2006; McHugh, 2009; Pantone 2009; Rockwell, 2006; The SheridanGroup, 2005; Cooper, 2009).

After comparing the differences between sRGB and Adobe RGB colour spaces, Adobe RGB
was chosen as the most appropriate colour space for this test case. Although Adobe RGB is a large colour space, meaning the resulting files would be large, Adobe RGB offers the flexibility of saving the original scan directly to CMYK conversion in preparation for offset printing, or saving down to sRGB for digital device viewing, lab and home printing.

**Testing and evaluation of the digital camera**

Testing and evaluation began with the digital camera, a Canon EOS 350D digital SLR camera, which offered the high resolution value (8 megapixels) required for taking detailed images of birds. That information was transferred into the computer in order to calculate RGB breakdown (Askey, 2005; Sahpiro, 2006; Canon, c2005).

In the initial process of photographing the birds at the Perth Zoo, a number of potential limitations with this method of colour sampling became apparent. Firstly, the birds were constantly moving between shade and sun, altering the perceptual colour with each shot. Although the movement of birds is natural behaviour and the birder must deal with the influence of shade and sun, it impedes the objective of capturing colour based on one lighting source. This potential limitation was resolved by transferring the images into Photoshop, where they could be adjusted to simulate one lighting source and thus ensure viable data.

In addition, during the initial photographing process the bird feathers lying on the aviary floor offered another data source. Collecting individual bird feathers and photographing them in a controlled environment offered a second method for solving the bird movement issues and non-standard lighting source, and provided an alternative to using Photoshop. Although not all the prominent feathers for each bird were available on the aviary floor, and feathers alone could not provide colour information for the bird’s beak, legs, and talons, nevertheless the direct contact of a feather to the scanner, with the controlled lighting source, offered a potential depth of colour that added to the colour samples available from the digital camera. Therefore, over a process of two weeks a selection of feathers that displayed the dominant colouration of each bird was collected under the direction of Dr Wen Haur at the Perth Zoo.

The second stage of bird photography entailed the process of following the movements of an individual Blue-winged Kookaburra and photographing numerous detailed images of the feathers and other features. These images were transferred from the camera to the computer and then opened in Photoshop. Photoshop had been preset to Adobe RGB colour space and 300dpi (dots per inch), which is the same resolution as the camera i.e. 8 Megapixels. To clarify, Photoshop and digital cameras do not use the same terminology when discussing resolution. Photoshop refers to resolution as pixels whereas the camera
as dots per inch (dpi) but in fact they are the same. The decision to set the image at 300 dpi (8 Megapixel) resolution was based on the fact that it supported the highest colour range available in preparation for possible printing (offset printing, digital lab printing, ink-jet printing) and computer viewing scenarios (computer monitors and iPhones).

The images were opened and evaluated for the amount of detail and quality of the image, in particular the sharpness of the colour and textures, which resulted in the selection of one image as the best for the colour ‘sampling’ process (Fig.4_3). The only limitation in the photo was the amount of shadow that was cast by clouds at the time of the ‘shoot’. The limitation was resolved in Photoshop by reducing the amount of shadow from 50% to 25%. The impact of the adjustment was that now the photo was perceptually accurate to a day without cloud, which is the perfect lighting for the clarity of colour. For the requirements of this study, the image was saved in multiple Photoshop formats including sRGB, .psd and jpeg files. These files are best for digital lab printing, home ink-jet printing, and on screen viewing. However, the image was also saved as an Adobe RGB Photoshop file (.psd) format and set aside for future offset printing purposes.

![Fig.4_3 Image of Blue-winged Kookaburra used for the colour ‘sampling’ process.](image)

The strategy for capturing the colour samples of the Blue-winged Kookaburra called for opening a copy of the master Photoshop sRGB file, selecting the colour sample tool, setting it to 11x11 pixels and proceeding to determine areas of primary colour on the bird. The colour sample tool collects colour data according to the number of square pixels selected, calculating a numerical colour average such as RGB and CMYK. The choice of 11x11 was determined by two factors. Firstly, the areas of colour that required sampling averaged between 15 and 30 pixels, and secondly, the minimal perceptual and numerical colour difference between 11 and 31 pixels, resulting in 11x11 pixels being suitable for this study. The colour sample tool offers four colour selections per Photoshop file; accordingly
four samples were selected and those four colours translated into a solid rectangular sample (swatch), with each swatch being assigned a temporary name and a numerical RGB and CMYK code (Fig.4.4). Photoshop file was saved as a jpeg for web and other digital devices ready to incorporate into the thesis as examples. In order to represent the range of colours seen on the Blue-winged Kookaburra, nine Photoshop files were created of the same Kookaburra image with four samples per file, totaling 36 swatches.

Theoretically and technically the digital camera provided reliable data required for the production of a colour palette for the Blue-winged Kookaburra, however, before making a final decision as to the validity of this tool, comparative data were needed from a different instrument. The flatbed scanner was selected as a comparative source in order to determine whether the two pieces of equipment worked best together or alone to create the colour palette.

**Testing and evaluation of the flat bed scanner**

Scanners are versatile digital instruments designed to analyse and process images and text (OCR – optical character recognition), with the objective of transferring the information to a computer. Once transferred the text and image can be altered, enhanced, and or printed according to the needs of the user (Tyson 2001).

There are four types of scanners, the flatbed, sheet-fed, hand-held and drum scanner (Tyson 2001). The flatbed scanner is the most versatile and accessible, making it the most used scanner on the market. The document is positioned information side down on a flat sheet of glass and remains stationary as the scanner head moves down the document to capture the information (Tyson 2001). The sheet-fed scanner is similar to the flatbed except the document moves rather than the scanner head (Tyson 2001). Drum scanners, as the name suggests, consist of a cylindrical or drum shaped form that rotates the document past the
scanner head. The drum scanner is a sophisticated instrument used by the print industry to capture minute detail (Tyson 2001). Finally, the handheld scanner is based on the same technology as the flatbed scanner but without the image quality, so is typically used for scanning text rather than image. Held by hand, this scanning instrument is carefully moved over the document to capture the text (Tyson 2001). Out of the four scanners on the market, the flatbed scanner was selected for further investigation based on its accessibility, affordability, and versatility.

In the same way as for a digital camera, resolution is vital to the image quality produced by a flatbed scanner. Tyson (2001) makes it clear that scanners vary in resolution and sharpness; most have a true hardware resolution of at least 300x300 dots per inch (dpi). This means that if the true resolution is 300x300 dpi and the scanner is capable of scanning a letter-sized document, then the CCD has 2,500 sensors arranged in each horizontal row, and a single-pass scanner has three of these rows for a total of 7,560 sensors and moves in increments equal to 1/300ths of an inch.

The light source in a flatbed scanner is white light, produced by a Cold Cathode Fluorescent Lamp (CCFL) that emits a smooth broadband optical spectrum, which is excellent for capturing natural colour representation (Maxim 2009).

The flatbed scanner used for this study met the resolution specification requirements as described in the technology section above. It was an Epson Perfection 1660 Photo flatbed scanner, and offered a true hardware resolution of 1600dpi x 3200dpi, which far exceeds the 300dpi x 300dpi resolution required for high quality offset printing. This scanner offered one lighting source, white light, and had a high resolution facility, which meant it could capture intricate detail. The scanner was therefore a viable technical tool for capturing a perceptual match of the natural colours of bird feathers and making the scanned result useable for digital or print outcomes.

The next stage of planning involved determining the colour and resolution setting on the scanner that would best facilitate colour sampling for three-dimensional objects. In this instance, the three-dimensional objects were feathers from the Blue-winged Kookaburra. The scanner glass was cleaned and prepared following Hewlett-Packard's instructions for scanning three-dimensional objects. The scanner was set to a resolution of 300dpi (dots per inch for high quality image), then the object was scanned and saved in TIFF format (Hewlett-Packard, 2009). TIFF is an image format that is ideal for archiving photos as it is editable in Adobe Photoshop (or other editing software) and can be re-saved without compression loss. When the image was transferred from the scanner to the computer monitor, the recommended configuration for colour accuracy of both the scanner and the computer to the same editing colour space, Adobe RGB (1998) was followed (Hewlett-Packard, 2009; Nice 2006).
Adobe Photoshop (Photoshop) is a professional computer software program used by design experts for image editing. Photoshop editing facilities allow colour calculations, resolution manipulation and jpeg format saving, all of essential for the development of the desired colour palette. Photoshop was therefore selected as the computer software program most suitable for editing and colour measurement.

Health regulations had stipulated that feathers collected on the Perth Zoo grounds were not allowed beyond the boundaries of the Zoo. Accordingly, scanning procedures for the feathers were carried out in office space provided by the Zoo. The office was set up with the Epson Perfection 1660 Photo scanner connected to a Macintosh laptop computer. The scanner and computer were configured to the Adobe RGB colour space, with 300dpi resolution and 24-bit colour, which provided the flexibility to convert into CMYK (required for offset printing), as well as the ability to save in sRGB for digital monitor viewing.

Consistency in the scanning process was maintained by the placement of four feathers on the pre-cleaned scanner glass, closing the lid and selecting preview mode on the scanner (Fig.4_5). Preview mode allowed for position correction before selecting the scan mode. The feathers were scanned and saved as TIFF files, which were then automatically transferred to the computer desktop. Adobe Photoshop preferences were adjusted in preparation for opening the feather TIFFs with rulers set to pixels, the print resolution set to 300 pixels/inch, the screen resolution to 72 pixels/inch and the grid-line at every 30 pixels. Upon launching Photoshop the document was calibrated to A4, resolution: 300 pixels/inch, colour mode: RGB colour, 16 bit, colour profile: Adobe RGB (1998) and pixel aspect ratio:

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Fig.4_5 Four primary wing feathers from the Blue-winged Kookaburra placed on the flat bed scanner and scanned.
Design for nature and the nature of design ability: Chapter 4 | Colour Standardisation

With Photoshop preferences correct, the 22Mb (megabyte) TIFF file was opened to reveal four primary wing feathers from the Blue-winged Kookaburra (Fig. 4_5). Rather than working with one 22Mb document, which can slow the computer down, the document was duplicated four times, with each feather now saved as a single 6Mb (average size) document. Following the standards set for the digital colour images, the colour sample tool was set to 11x11 pixel average, four samples of dominant colours were identified in each feather, captured, and the RGB and CMYK code transcribed, totaling 24 colour samples (Fig. 4_6).

4.6.2 Data comparison between swatches created using digital photos and flatbed scanning

The flatbed scanner was used to scan feathers fallen from the Blue-winged Kookaburra. The collection of six feathers covered colours seen in the bird’s wings, back and breast (Fig. 4_7), but excluded the dominant light blue, for which the Blue-winged Kookaburra is known (Fig. 4_8). At the same time, a digital camera was used to take close up images of live Kookaburras, the same bird family that supplied the feathers for scanning. Digital photography enabled the image capture of the bird’s back, tail, wings, head, breast, beak, legs and talons (Fig. 4_9).

The scanning process produced 24 colour swatches, including blue, brown, cream and grey, and tints and shades including dark blue, dark to mid-brown, light cream to mid-cream and mid-grey (Fig. 4_10). On the other hand the digital camera, because of its ability to capture colour details across multiple parts of the bird, generated 51 swatches representing hues including blue, brown, cream and grey, and tints and shades from light to dark for each hue (Fig. 4_11).

Fig. 4_6 Samples of dominant colours captured using RGB and CMYK codes.
Fig. 4.7 Collection of 6 feathers from the Blue-winged Kookaburra displaying the colours seen in the bird’s wings, black and breast.

Fig. 4.8 Colour samples of the light blue the Blue-winged Kookaburra not captured when collecting the fallen feathers.
Fig 4.9 Colour sampling of the bird's back, tail, wings, head, breast, beak, legs and talons.
A colour comparison between the 24 swatches generated from the feather scans and the 51 swatches from the digital camera that represented the colours seen in the bird’s wings, back and breast, revealed 19 out of 24 instances where the colours were perceptually and RGB numerically close, as illustrated in (Fig.4.12). These similarities in swatches between the flatbed scanner and digital camera substantiated that both are viable sources for colour capture. However, it also demonstrates that the digital camera is more versatile and reliable because it can capture images of the entire bird, whereas the flatbed scanner is limited to the feathers available.

4.7 Perceptual colour palette for the Blue-winged Kookaburra conversion to Ridgway’s (1912) colour standards and nomenclature

The final stage in the research process was to name each colour according to Robert Ridgway’s (1912) colour palette and nomenclature, which translated to devising a method of matching the swatches with Ridgway’s to define the appropriate name. One method to achieve this was to perceptually match the swatch colour with Ridgway’s. Another method was to match them by comparing the RGB codes. The latter method was selected as more accurate and meeting the requirements of colour standardisation and consistency.

The first issue with using RGB colour codes was to identify if Ridgway’s hand-rendered colour
### Chapter 4 | Colour Standardisation

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**Fig. 4.10** 24 Colour swatches from the Scanning process

**Fig. 4.11** 51 Colour swatches from the Digital Camera process
Fig. 4.12 19 out of 24 instances where the colours generated from the scanned feathers were perceptually and RGB numerically close to those generated from the digital camera.
swatches had already been converted to RGB code. This had been done by John C. Foster
for the philatelic Texas Precancel Club in 2006. The RGB conversion by Foster conforms to
the American Inter-Society Color Council - National Bureau of Standards (ISCC-NBS) as a
formal system for expressing colour, with standard symbols for hue, qualified for lightness
and saturation. Foster digitised both Ridgway’s colour palette and also all ‘5411 color names
in the NBS/ISCC Dictionary of Color’ (Jaffer, 2011, para.7).

The Blue-winged Kookaburra colour palette was matched to the closest RGB code
designated by Foster’s ISSC-NBS conversion (Fig.4.13). If an identical match was not possible
then a colour that was perceptually similar was selected. This process identified the colours
from the Blue-winged Kookaburra colour palette that were similar in hue, tint or shade, to
Foster’s conversion, which reduced the palette from the original 17 colours to a workable
The final ten colours were Black, Bluish-slate Black, Chaetura Black, Amber brown, Seashell Pink, Mars Yellow, Olympic Blue, Lumiere Blue, Bluish Black, and Acetin Blue. These colours formed the basis for selection when applying colour to the digital illustration of the Blue-winged Kookaburra and the Identicon (bird icon) which is the subject of the chapter to follow.

4.8 Conclusion

This chapter has investigated and analysed colour comparisons across four Australian bird field guides focusing on five native Western Australian birds to reveal a lack of standardisation in both the nomenclature used to describe the colour of field marks and the printed colours used in the illustration to represent the bird. The chapter has explored how expert approaches to VC design and print reproduction technologies, colour theories, and formal visual analysis were used to resolve the lack of colour standardisation in the visual representation of birds in the field guides. Next, chapter 5 presents design-led experiments devised to test ideas relating to colour, colour reproduction and advances in print technology towards a response that could transform the way colour is created for bird species and represented in bird field guides.
5. Digital Scientific Illustration & Identicons

5.1 Introduction

This chapter takes Ridgway’s digitised colour pallet, developed for the Blue-winged Kookaburra in chapter 4, and applies it to two design-led projects. The first project develops a digital scientific illustration technique with the specific purpose of applying the palette from chapter 4. The second project develops a bird icon that this thesis names Identicon that also applies the palette from chapter 4. Together the results of these advanced visual systems support colour standardisation in printed bird field guides.

5.2 Time for change: traditional versus digital bird illustration

Based on the level of colour accuracy available to the bird illustrator through digital technologies, authors and publishers of bird field guides can now expect digital illustrations of birds that are superior in their scientific accuracy to the less accurate traditional/artistic, hand-rendered representations.

There are a series of critical differences between a traditional bird illustration and a digital bird illustration. The first uses traditional media of oil paints, watercolour and colour pencil applied to materials such as watercolour paper and stretched canvas. The latter uses a desktop computer, a computer pen and drawing tablet and computer software such as Adobe Illustrator, and rather than the final illustration instantly being a part of our 3D world, it remains in the virtual world of the computer until it is finally printed onto for example, smooth, textured or coloured paper.

Another critical difference is that the traditional illustrator applies colour by using pure pre-mixed pigments or by hand mixing colour pigments. As established in the previous chapter hand mixing colour is reliant on the illustrator’s perception and therefore no two
illustrations of the same bird would have the same colouration. Then once the illustration is complete, it is scanned in preparation for printing. It is common knowledge in the VC designer discipline and the print industry that the current scanning technologies for the Offset printing process (described in chapter 4) cannot accurately reproduce the hand painted colours of an original artwork. Furthermore, the CMYK offset printing process that is used to print bird field guides can further alter the colouration of the illustration, with the end result being an inaccurate colour representation of the bird.

Digitally produced illustration on the other hand supports the illustrator to select and apply colours from a digital colour palette that is equivalent to the colours used in the printing process. This means that the illustrator can select colours with the knowledge and confidence that if the print process is supervised, the printed colours will be exact to the colours originally selected and constant on paper stocks, whether gloss, matt, uncoated or satin.

5.3 Vector fills the gap

As discussed in chapter 2 this study recognises the value of detailed bird illustrations as a way of introducing bird species to the novice birder as well as the aesthetic value for those interested in learning about birds but not identifying them. Current visual systems of representation in bird field guides include detailed artistic renderings (Fig.5_1), silhouettes (Fig.5_2) and line drawings (Fig.5_3), accompanied by descriptive text to highlight the key features of the bird. However, formal visual analysis carried out on four Australian field guides (Chapter 3) revealed a gap in the current approaches to visual systems of representation. In particular this analysis demonstrated the lack of visual systems of representation for birds that capitalise on contemporary approaches to design and print technologies and an understanding of the human perceptual-motor system.

With the Ridgway (1912) colour palette established for the Blue-winged Kookaburra in chapter 4, the next stage was to develop a digital illustration technique with the technical capacity to incorporate the colour palette that would scientifically represent the bird and support colour standardisation in and across different field guides.
The potential of vector graphic drawing software that allows for the integration of contemporary approaches to design and in particular embedding digital colour palettes was investigated as a possible digital tool for this process. Vector-produced graphic images are typically created using illustration software programs, such as Adobe Illustrator, which make use of mathematically defined geometric shapes constituted of lines, objects, and fills to produce images (TSG, 2004). The important feature of the vector graphic technique for this study is the ability to create outlined shapes that can be filled with a specified colour, providing the facility to use the digital colour palette developed for this study. For example, Fig.5_4a & b displays an outline of a feather shape filled with Ridgway’s Bradley’s Blue (a) and the exact same shape filled with Ridgway’s Ivory Yellow (b).

Part of the VC designer’s practice is to keep up-to-date with computer software technologies and how other practitioners are using them. With this in mind, a global level internet search for current examples of vector images used for illustrating representations of birds was carried out. The search revealed only four digital illustrators who offered representations of birds, namely Jennifer Fairman (2010) (Fig.5_5), Frank Ippolito (2009) (Fig.5_6), Paul Mirocha (2009) (Fig.5_7), and Chris Vest (2009) (Fig.5_8). This was in comparison to the 69 digital scientific medical illustrators, such as Gary Carlson (2011) (Fig.5_9), Eric Olson (2011) (Fig.5_10) and Gale Mueller (2011) (Fig.5_11). This result suggested that illustration for the likes of bird field guides was still grounded in a traditional illustration system with roots in an early combination of art, aesthetics and science, and further validated the need for the investigation and creation of advanced visual systems of representation for ornithological illustration.

The examples from the search provided some insight into technical and aesthetic approaches to vector based illustration. For example, Fairman (2010) uses a graphic approach to the technique (Fig.5_5): the lines are smooth, shapes crisp and clear, and the surfaces are rendered in gradating colour from dark to light, with the darker shades on the under part of the bird and around the eye and on the webbing between the bird toes. The use of gradating colours in this way produces three effects; firstly, a three dimensional illusion of the breast; secondly, the mid grey to white gradation creates the soft downy look of the feathers; thirdly, a darker more defined gradation creates the transition from toe to webbing on the feet.
The establishment of the brief to guide the development of the digital illustration technique was founded on the formal visual analysis of the work of Fairman (2010) and other digital illustrators combined with the extensive collection of information about bird field guides, their purpose, the design paradigms and iconography used since the inception of the bird guide, then the role, attitudes, and expectations of the scientific illustrators for bird field guides and the people who use them (audience). In addition, information on the people and technology responsible for the production of bird field guides, such as authors, publishers, and printers, was applied to the brief.

The specifics of the brief entailed the following parameters: the technique must involve the use of simple shapes that can be filled with the already defined colour palette; the use of gradients is acceptable to define form; the representation must be accurate and more realistic/scientific than artistic for the bird’s colouration, field marks and physiology.

Although the key criteria for the brief were strong and supported by extensive data collection and analysis, there were other important theoretical issues and ideas that required consideration throughout the design process. They included dual coding, colour and shape constancy, colour standardisation, as well as spatial knowledge, gestalt laws of visual organisation and icon design.

Although these theories are fundamental to design and with practice become tacit within the design process, they are rarely discussed amongst designers or shared with clients or audiences. However, the premise for each theory is transferable, meaning if taught it can become useful knowledge to disciplines beyond design. For example, how humans perceive, interact, and negotiate environments and objects is relevant to ornithology and birding as humans draw on spatial knowledge and skills inherent to the human cognitive system that can augment the learning process of how to identify birds. Subsequently, spatial knowledge theories are not only integrated into the brief to develop visual systems of representation for field guides but are also auditioned as a potential bird identification strategy.
5.4 Traditional to digital illustration and Icon to Identicon: attending to the design process from brief to result

The design-led project brief was composed of two related design-oriented problems. The first was to resolve the colour standardisation issue in the visual representation of bird species in field guides. This involved the development of a digital design technique that incorporated simple shapes that could be filled with the already defined RGB colour palette, the use of gradients to define form, to test the techniques including traditional to digital, photograph to digital and digital alone and to select the technique that supports accurate representation that is more realistic/scientific than artistic of the bird’s colouration and physiology which worked to ‘communicate in support of the text, emphasising’ the bird’s field marks (Frascara, 2004, p.112).

The first round of technique development was driven by the specifics of the brief. This was a 60-hour process that produced two test illustrations (prototypes one and two) of the Blue-winged Kookaburra, discussed in detail later in this chapter.

5.5 Digital illustration: An advanced visual system of representation to support colour standardization

The nature of ‘design process’ is that it can be used for both illustration and design related briefs and as such it underpins the development of the two test cases of digital illustration and icon to Identicon. That is a design action research cycle comprised of visual research, sketching, illustration/icon development, illustration/icon prototype, critical reflection, evaluation and amendment (Burns, 2000).

The design action research cycle in both test cases generated a number of prototypes before the final selection of the ‘best’ prototype for each. Prototypes were numerically categorised using ‘Prototype 1, through to Prototype 6 for the development of the digital illustration and Prototype 1 through to Prototype 3 for the development of the Identicon.’
5.5.1 Prototype one: combination of traditional and digital illustration

The first prototype to develop a digital illustration technique relevant to the brief was based on the concept of combining traditional and digital illustration. This concept was derived from the combined understanding of field guide iconography and the technical capabilities of illustration computer software such as Adobe Illustrator. It offered a logical solution for the meeting of traditional and digital techniques. Adobe Illustrator has the facility to convert a traditional artistic illustration to digital code, so was used to test this concept.

As with all design and illustration projects, the process began with visual research that involved gathering visual information about the Blue-winged Kookaburra, including illustrations and photos printed in the four Australian bird field guides (Fig.5.12), photographs of the bird from the Perth Zoo case study, (Fig.5.13), and images found on the internet (Fig.5.14). It also included time spent observing the live birds at Perth Zoo, because it is important for an illustrator to have a mental reference of the live bird as well as photographic references; without the live reference it is more difficult to illustrate the three dimensionality of the bird.

The visual research assisted in determining the pose of the bird. Current field guides offered profile views (Fig.5.14), which appeared to be most appropriate for capturing the prominent features for the ultimate use of identification. Based on this understanding, a profile image of the Blue-winged Kookaburra was selected that offered enough clarity of detail to support accurate representation (Fig.5.15).

With the establishment of a final visual reference (Fig.5.15) and supportive visual references (Figs.5.12-15), preliminary sketches of the bird were produced (Fig.5.16). Making preliminary sketches provided the time needed to attain the visual focus required to produce an accurate representation of the bird, the time required going beyond a superficial observation to engaging with the details. The sketching process involved setting up a location with the visual references, pencil, eraser, layout paper, coloured pencils, and architectural drafting film, which was preferred over illustration paper. The preference for drafting film was because it is translucent and therefore the illustrator can illustrate on both sides, which has the result of
enhancing the depth of colour beyond the capabilities of paper. From the completed sketch, the three-stage process of illustrating the bird began with setting up a location with the final sketch, visual references, coloured pencils and architectural drafting film. Next was to illustrate the bird through the layering of colour pencil onto the drafting film. This illustration process began with positioning a clean piece of drafting film over the final sketch; drafting film is translucent, making it easy to see the sketch below. A set of colour pencils that closely matched the colours of the Blue-winged Kookaburra palette was selected. The illustration technique was based on laying down strokes of colour where the strokes followed the texture and form of the Blue-winged Kookaburra. Illustration began with the palest colour (Fig.5_17) then a shade darker (Fig.5_18) continuing until the darkest colour was used. This technique enables depth of colour and tone to be created while capturing detail (Fig.5_19) and creates the illusion of three dimensions. This process continued until the illustration met the requirements of the brief, which at this stage was to capture the bird’s field marks and physiology in preparation for later digitization (Fig.5_20)
The completed illustration (Fig.5_20) was scanned with a digital flatbed scanner as an RGB at 300dpi (dots per inch) as this illustration would be used in Adobe Illustrator and converted to digital code. This resolution provided enough image detail for the conversion to digital. The illustration was opened in Adobe Illustrator and four conversion tests were carried out (Fig.5_21). Adobe Illustrator offers the facility to convert an image into vector code by scanning and converting it to a specified number of colours, black and white or greyscale between 1 and 256. The conversion turned the original illustration into patches of colour, very similar to the ‘paint-by-numbers’ concept. The program also offered predetermined selections such as ‘high fidelity photo’, ‘low fidelity photo’, cartoon and line work. For this test, 25 colours, 256 colours, high fidelity photo, and low fidelity photo were selected. This choice was based on the need for enough detail to ensure accurate representation of the Blue-winged Kookaburra.
The digital conversion results (Fig.5_21) aligned with predictions that the lack of refinement of shape and line in the original illustration would be reflected in the digital conversion. However, this test provided the opportunity to explore the potential of the program to apply the colour palette developed for the Blue-winged Kookaburra. The procedure involved highlighting one of the colour patches (see Fig.5_22) and then converting that colour to an appropriate match from the colour palette developed (Fig.5_23). The critical reflection process confirmed that there was no need to proceed with prototype one (Fig.5_21) but rather to draw on what was learned during the process and apply that knowledge to prototype two.

5.5.2 Prototype two (Illustration): combination of traditional and digital illustration

The visual research for sample two involved re-evaluation of the images sourced from Internet searches, the field guides and case study photos, based on the new criteria to find a pose that revealed more information about the bird’s back and tail. The result was the image displayed as Figure (5_24).

In comparison to prototype one the new Kookaburra image was then traced rather than sketched to ensure the accuracy of overall form and internal shapes of the bird (Fig.5_25). Although based on the same technique as the first sample, the technique for this illustration applied more controlled line work and formulation of clear shapes to indicate feathers, beak, eye, and claws as shown in Figure (5_26).
The result was similar to sample one in that it was still reminiscent of a traditional artistic illustration, although attention to line and shape is evident in comparison to Prototype one (Fig.5_20). The pose met the criteria of revealing a partial view of the back and tail while offering a profile view of the head and beak. This illustration was transferred into Adobe Illustrator and the same digital conversion as for prototype one was carried out, then the result evaluated to determine whether the combination of traditional and digital satisfied the objectives of the design brief.

Fig.5_27 Live trace conversions of Prototype 2
The identical procedure was applied to this illustration as for Prototype one, with the addition of three more Live Trace conversions, 100, 16 and 6 (Fig.5_27). The purpose for the extra conversions was to establish if the reduction of colours would maintain the necessary details required for an illustration to communicate essential visual information for identification while at the same time making easier the task of colour conversion to the Blue-winged Kookaburra palette. With these criteria in mind, evaluation of the different Live Trace conversions (Fig.5_28) showed that only High Fidelity, 256 and 100 were suitable for colour conversions. Subsequently a comparison between the High Fidelity and 256 revealed they were the same, leaving the 256 and 100 colours for further experimentation (Fig.5_28).

The overall results of the two experiments revealed that, regardless of the number of colours used to convert the traditional illustration to digital code, applying the digital colour palette was not made easier. More importantly, the digital trace resulted in line work converted into unsatisfactory patches of colour determined by Adobe Illustrator, meaning the illustrator has no control over their size, shape, or position. This automated facility and the results did not support the level of accuracy necessary to meet the requirements of the brief. The conclusion was that making the concept combine traditional and digital illustration techniques was not an appropriate solution for this brief. Therefore the amendment to the design-research cycle was to develop a digital technique that did not incorporate traditional mediums.

5.5.3 Prototype three (Illustration): digital photograph to digital vector illustration

The concept for the third sample illustration was investigated next. It involved using the Adobe Illustrator Live Trace command to convert a digital photograph of a bird into a digital vector illustration. This concept was tested to determine whether the Live Trace of the photograph and the subsequent conversion to the Blue-winged Kookaburra colour palette achieved the requirements of the brief. If it did so, this would remove the need for an illustration first, which would in turn eliminate issues of accuracy regarding bird shape and form. However, the direct conversion (Fig.5_29) from digital photograph to digital vector illustration resulted in similar issues identified in the earlier samples noted above. Therefore the
technical concept of transforming a digital photograph of a bird to a digital illustration using Adobe Illustrator’s Live Trace command did not fulfill the requirements of the design brief.

Fig.5_29 Prototype Three: Digital photograph to digital vector illustration. Top: Digital photograph Bottom: Vector live trace
5.5.4 Prototype four (Illustration): digital vector illustration.

The investigations demonstrated that Adobe Illustrator software supported the technical concept of developing a digital vector illustration using preliminary sketches and photographs of the Blue-winged Kookaburra as reference, but not as the technical foundation for digital conversion. Therefore prototype four was developed using Adobe Illustrator alone. The key reference photograph used for this prototype was the same as that used for Prototype two (Fig. 5.24), however this time the photograph was used as a visual reference only.

The photograph of the Blue-winged Kookaburra (Fig. 5.24) was transferred into an Adobe Illustrator document and positioned on a single layer. A layer in Adobe Illustrator is similar to a sheet of transparent paper, which provides the means to place one layer on top of another and still see images/text/graphics on the previous layer. It enables the illustrator to illustrate sections of an image on separate layers rather than having to create the image as a whole on one plane, as in the case when traditionally drawing using paper.

Another layer was then created and traced around the photograph to ensure the accuracy of the bird’s shape. This shape was then filled with a neutral colour from the Blue-winged Kookaburra colour palette to act as a colour base for the bird image (Fig. 5.30). The outline shapes of the beak, eye and head feathers were then filled with palette colours. The reference photo was used as a guide for correct placement of shadow, tint and texture areas (Fig. 5.31). The colour fills are gradients rather than flat colours, meaning two palette colours, such as mid tan and white, were blended to create the tonal/tint shift from dark tan to light (Fig. 5.32). The same technique was applied to the shape outlines for each feather of back, wing and tail feathers, which were filled with gradient mixes from the palette. A brush tool was then used to draw white lines on top of each feather shape to create the illusion of feathers. However, although the final illustration was visually attractive, it needed further development to achieve the level of accuracy required to fulfill the requirements of the design brief (Fig. 5.29).
5.5.5 Prototype five (Illustration): digital illustration

The visual research for prototype five involved the re-evaluation of the images already sourced from the Internet, the field guides, and my own photos based on the same criteria as prototype four, however a change of bird image was required due to the fatigue that I developed with the accumulated hours spent to develop prototype four.

The traditional sketching process was not required for this prototype due to the fact that this technique is driven within the digital environment. Instead the reference image was placed in the Adobe Illustrator document and digital rendering applied on a layer positioned directly above the image (Fig.5_34).

The technique for prototype five was derived from the work carried out to produce prototype four with extra attention to line work and formulation of clear shapes to indicate feathers, beak eye, and claws as shown in Figure (5_35). Prototype five was simple to produce; the prior prototypes provided a wealth of knowledge that informed the process. The feathered shape of each feather had a naturalistic effect that I was hoping for and the line work added depth of colour and texture (Fig.5_36). In addition, I used the
symbol command in Adobe Illustrator to create a set of duplicate feathers, meaning once a feather was drawn and saved as a symbol it can be repeated as often as required without further drawing required. An additional benefit of using symbols was that it reduced the final file size by 14.7 Megabytes (MB). The reduction in MB is important because the greater the file size the slower the program works and the more difficult files become to save onto the hard-drive.

The comparison of prototype five (Fig.5_37) with prototype four (Fig.5_33) confirmed that prototype five was less ‘artistic’, that it applied the digital colour palette and that the representation was accurate to the bird’s colouration and field marks. However, the representation of the physiology was still more artistic than realistic/scientific. Therefore, further development of Prototype six was required in order to meet all of the requirements of the brief.
5.5.6 Prototype six (Illustration): digital illustration

The increased experience and knowledge gained from the accumulative work for the previous five prototypes and reflective practice process provided the skill and knowledge to develop Prototype Six.

The visual research for prototype six involved the re-evaluation of the images already sourced from the Internet, the field guides, and my own photos as well as another search based on the same criteria as prototypes four and five. During this process a new image was discovered that offered an extensive view of the bird’s beak, head, eye, primary and secondary wings, back and tail, which carry the essential field marks on a Blue-winged Kookaburra, for example the prominent beak shape, predator eye, the blue markings on its primary wings and the colouration of its tail feathers. Therefore a new reference image was selected for prototype six (Fig. 5_38).

The visual research on the Internet also identified the work of wildlife artist Chris Pope (2010) (Fig. 5_39). Pope’s work, although acrylic paintings and not digital artwork, exemplified the level of realistic/scientific representation required for the brief. The level of accuracy and detail provided a visual benchmark from which to work towards an accurate scientific illustration of the bird, as scientific is defined in terms of this thesis. As a result, images of Pope’s work became a valuable resource for refining the illustration (Pope, 2010).
Similar to prototypes four and five the traditional sketching process was not required for this prototype due to the fact that this technique is driven purely within the digital environment. Instead, the reference image was placed in the Adobe Illustrator document and digital rendering applied on a layer positioned directly above the image.

The technique for prototype six was derived from the work carried out to produce prototypes four and five. As for all prototypes, attention to the requirements of the brief was a high priority in order to produce an advanced representation of the Blue-winged Kookaburra. Figure (5_40) is a photo of the computer screen whilst engaged in developing the technique. Figure (5_41) displays the development of a set of individual feathers that were eventually converted to a symbol and used to create the feathers for the final prototype six (Fig.5_44). Figure (5_42) shows the digital swatches devised for the Blue-winged Kookaburra that had to be applied to prototype six. Figure (5_43) displays the illustration technique applied to the bird’s bill.

Fig.5_41 Individual feathers converted to a symbol in Adobe Illustrator

Fig.5_42 Final digital Colour palette for the Blue-winged Kookaburra based on Robert Ridgway’s 1912 Colour standards and nomenclature.

Fig.5_43 Illustration technique applied to the Blue-winged Kookaburra beak

Fig.5_44 Prototype Six
The difference in this technique was the increased skill applied to represent the individual feathers, beak, claws and other features to a more advanced level of realistic/scientific representation. As a result, Prototype six (Fig.5.44) fulfilled the requirement of the brief. The next section of this chapter will describe the process and prototype development from icon to Identicon.

5.6 Icon to Identicon: an advanced graphic system of representation for bird field guides

The second test case investigated the concept of creating icons of birds for identification purposes. The concept emerged from my own design-led knowledge, meaning my extensive professional experience and knowledge of visual communication design. This gave rise to questions as to whether the icon visual language systems developed by modern VC designers could be applied to bird identification and field guide illustration. The result of this questioning was the research for this study, to investigate whether icon representation of a bird that was simplified to highlight the primary form, shapes, features and colour would assist in the learning process of how to identify a bird. However, as with all designer-led ideas, research and prototype development and testing were required. The research component has been described throughout the previous chapters of this thesis. In the following sections the process from Identicon development to solution is described.

The design brief was to create an icon device (Identicon) of the Blue-winged Kookaburra. Like the digital scientific illustration brief, the iconic device had to incorporate simple shapes that could embed the already established RGB Ridgway colour palette, the form and coloration had to be accurate to the bird species, and when viewed alongside the digital illustration it had to emphasise the bird's field marks required to identify the Blue-winged Kookaburra in the field.

An icon device is based on a reductive communication code, and is the result of capturing the abstracted essence of physical objects (Lupton 1993; Hollosi 2000). The creation of an icon involves analytical skill to break down the complexity of nature into its constituent forms, to identify and 'elementarise' the underlying geometry, arriving at a 'schematic sign that describes the most salient attributes of an object or scene that makes it instantly recognizable' (Lupton 1993, p.6).

Associated with symbolic visual communication design, graphic icon language is extensively used for visual identification systems and more specifically, business identity and corporate branding. Simplification to an icon device that is an instantly recognisable form is also
central to information designing systems such as those used by Tufte (1990) to display, for example, the different colour arrangements on one style of T-shirt. Icon design development from idea to solution is part of the VC design educative process and is practiced by the majority of VC designers throughout their career. It is the practice of icon design process that builds skill. As stated in chapter 1 of this thesis, my own extensive practice as a professional VC designer, which includes peer recognition of that skill base through the VC design award system, informs the icon design for this study. The following section presents the development process for each of the three Identicon prototypes and the critical and analytical thinking applied to the process.

5.6.1 Icon to Identicon: a design action research cycle

The design of an Identicon involves the same design action research cycle that was used for the design brief ‘traditional to digital illustration’, that is, visual research, sketching, development, prototype, critical reflection, evaluation and amendment (Burns, 2000). Due to the repetitive nature of design development for an icon, the process used to develop each prototype will be described only once. Similarly, the critical reflection and evaluation of the first prototype will be discussed in detail and then for later prototypes only the individual differences will be discussed.

As per the illustration test case and resultant prototypes, visual research was carried out to find a photograph that captured a profile view of the Blue-winged Kookaburra. However, the photograph used to create the final Prototype Six illustration, (Fig.5_38), did not provide the visual information required for an icon representation of the bird. Although this photograph did give a comprehensive view of the whole bird, with an entire side profile of the head, the pose was too complex for developing a strong visual icon. A different photograph was needed which gave a side view that offered the essential and most prominent features of the bird without distortion. Therefore the photograph for the icon (Fig.5_45) was selected specifically for its pose as it displayed the profile of the bird’s head and beak wing and tail. Together, the more comprehensive view of the bird in (Fig.5_38) and the profile view in (Fig.5_45) provided all the essential field mark features for a birder wanting to learn how to identify the male and female Blue-winged Kookaburra.
Design for nature and the nature of design ability

The icon to Identicon development process focused on the female Blue-winged kookaburra, differentiated only by the orange-brown striping on its tail, which the male does not have.

The sketching process began with preparing the workspace with all necessary tools, such as layout paper, tracing paper, pencil, eraser, photo references of a Blue-Winged Kookaburra, (and iPod digital mp3 recorder/player to capture reflection-in-action, which will be discussed in detail in the next chapter 6). Tracing paper was placed on the photo and the prominent features of the bird were traced (Fig.5_46), ensuring that the overall shape of the bird was accurate. The completed sketch was labeled as the 'master sketch', which is the sketch referred to during the refinement process (Fig.5_47).

The master sketch was positioned under a sheet of layout paper and the original photo of the bird was positioned on the table in full view as a reference while the initial sketch of the icon was developed and refined. The refinement process involved the reduction and elimination of all unnecessary detail to ensure only the form; the primary shapes and the prominent features (field marks) remained (Fig.5_48). The conscious application of Gestalt principles was essential at this stage; continuance, similarity, simplicity, proximity, unity, and closure, while at the same time maintaining discipline regarding the accuracy of the bird’s form, shape and features.

This process was followed until the sketch of a simple, iconic form was resolved (Fig.5_48). This sketch was scanned as a jpeg format on a flatbed scanner, transferred onto the computer and the jpeg opened in Adobe Illustrator. In line with the second aim of this thesis, which is to investigate the cognition processes of the designer in the act of design creation, the steps that followed during the digital icon development process were recorded as part of the reflective practice.

The digital icon development process involved tracing the original sketch using the Pen tool in Adobe Illustrator. However, because the aim of this icon was to fill sections with a pre-determined colour palette, each section of the bird had to be drawn on a separate layer. This simplified the fill process in comparison to that used with a single layer image and attempting to manually isolate colour fill areas. Each section of the bird was drawn using a .25 line weight black rule because a fine line weight
Design for nature and the nature of design ability: Chapter 5 | Illustration & Identicons

reduced any expansion issues when filling the section with colour. It was essential at this stage not to lose any of the Gestalt principles already established and to maintain the accuracy of the form and of each shape and feature. Figure (5_49) shows the first digital drawing of the icon, and each colour represents a layer in Adobe Illustrator.

The colours for the icon were then selected from the Ridgway colour pallet developed for the Blue-winged Kookaburra. The colours were determined by the most prominent colours of the bird as established in the interviews carried out within the Perth Zoo Case study. Specifically, black, blue, light blue, cream, buff and grey-brown for the male and then black, blue, light blue, cream, buff, grey-brown and orange-brown for the female. These colours were then translated into the Ridgway digital colour palette and nomenclature developed for the Blue-winged Kookaburra of Black, Olympic Blue, Lumiere Blue, Mars Yellow, Seashell Pink, Chaetura Black, and Amber Brown (Fig.5_50).

This stage was concerned with the accuracy of colour placement signifying the bird’s family and species. At this stage also colour standardisation was applied to the icon by using the specially designed colour palette for this bird species (Fig.5_50), which would ultimately support the objective of colour constancy for bird representation in printed field guides and on digital devices. The process was continued until an accurate representation of the bird’s colour, form, shape and features was resolved.

The next section provides an overview of the principles and processes involved in the creation of an Identicon. Then each prototype, three in total, are discussed and analysed against the requirements of the brief. Finally, the Identicon that met the brief requirements is presented and reasons why it was the best solution are discussed.

5.6.2 Design principles and processes in the creation of an Identicon

The Identicon is a VC design device based on icon design theories that include spatial knowledge, spatial visualization and gestalt laws of visual organization. As discussed in chapter 2 these theories are recognised in the ‘dynamic interplay of parts and wholes’ (Behrens 2004, para.15) and ‘contextual cues’ (Bower et al 1975, p.216) that support learning. Learning
is supported because the visual language of icons and Identicons works directly with the human perceptual-motor system, which is key to how humans learn, process, store and retrieve visual and linguistic information (Paivo, 1975; Swartz, 2006; Ryu et al., 2000; Ware, 2008).

Gestalt laws of visual organisation combined with VC design principles of figure-ground, closure, uniform connectedness, good continuation, economy, proximity, similarity and unity work together to create an icon, and therefore the same principles apply to Identicons (Behrens, 2004; McClurg-Genevese, 2005; Thiel, 1983; Pedroza, 2000; Verstegen, 2006). To follow is a brief introduction to each icon/Identicon principle.

- Figure-ground explains the principle separating two or more elements within a field, one will take prominence (figure) over the other, which will recede into the background (ground) (Behrens, 2004; Soegarrd, 2010).
- Closure is a principle that applies when humans ‘see complete figures even when parts of the information are missing’ (Skaalid, 1999, para.3). Closure results in the organisation of elements to make a whole (Behrens, 2004).
- Uniform connectedness explains the Gestalt law to perceive elements as being more related if they ‘share uniform visual characteristics’ (Rutledge, 2008, para.6).
- Good Continuation represents peoples perception that elements are more related if they are arranged to form a curve or a line (Behrens, 2004; Rutledge, 2008).
- Economy is a principle that reinforces simplicity and emphasises the minimal use of elements to convey the whole (Behrens, 2004).
- Proximity refers to the idea that elements that are positioned closely are ‘perceived to be more related than’ elements that are positioned further apart (Rutledge, 2008, para.11).
- Similarity works on humans ‘innate tendencies to’ group elements that ‘look alike’ (Behrens, 2004, para.10)
- Unity refers to the way all of the elements of a design work together as a whole (Skaalid, 1999).

Because the principles and processes for an icon and Identicon are the same, from this point on the reference will be to Identicon.

Figure-ground is displayed in the economy of the overall shape of the Identicon, which has been sent visually to the back ‘ground’, and the identification colours of the wings are addressed to come forward as the ‘figure’ as displayed in (Fig.5_51). Understanding closure validates the simplicity of the form and elements of the Identicon. The theory of closure
Design for nature and the nature of design ability: Chapter 5 | Illustration & Identicons

asserts that human perception can close simple shapes, fill in missing information and organise elements to perceptually make a whole (Behrens, 2004; Soegarrd, 2010).

In order to give emphasis to the prominent field marks and overall shape of the bird, deliberate attention was given to **proximity and good continuing** when creating each *Identicon*. **Proximity and good continuing** are evident in the overall form of the bird, which emphasises the oversized beak, large head and prominent feathers as shown in (Fig.5_52). In addition, concerted attention to *economy*, of line, shape, and colour is essential to *Identicon* design and is evident when a detailed illustration is compared to an *Identicon*, see (Fig.5_53) (McClurg-Genevese, 2005).

In order for the *Identicon* to be complete it has to meet the stringent requirements of *unity*, which is a sense of wholeness in the design, where all the elements in the *Identicon* unite to create a whole (McClurg-Genevese, 2005; Soegarrd, 2010).

As discussed in Chapter 2 spatial awareness theory acknowledges the human ability to visually scan an environment and take in essential information. Part of that process, according to Colin Ware (2008), is to seek out the most useful visual patterns to assist in what the viewer is doing. For example, when engaged in the activity of bird identification, people look for contextual-cues derived from the bird’s overall shape, in this case the shape of the beak, the head and the colours highlighted on the wings and tail. Although spatial awareness is inherent, it can become more sophisticated through education such as that offered by the *Identicon*. Case in point, an *Identicon* is designed around ‘contextual cues’.

The function of the *Identicon* is for the person to learn the visual cues

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Fig.5_51 Figure-ground

Fig.5_52 Proximity and Good Continuing

Fig.5_53 Detailed illustration positioned next to an *Identicon* to display the effectiveness of Economy in *Identicon* design
displayed, put them in memory and draw on that information when out in
the field. An Identicon uses VC design expertise to determine visual cues
and offers them in a device that works directly with the perceptual-motor
system.

In developing the Identicon the visual communication principles of form,
function and significance were applied. Form was applied in terms of the
contention that iconic representation would support the function, which is
to assist in simplifying and facilitating the learning of bird field marks. The
significance is that the Identicon delivers a design outcome that fulfills the
need of a visual strategy that supports the sustainability and preservation of
birds in their natural environment (McClurg-Genevese, 2005). Finally, each
Identicon prototype applied the essential identification colours from the
Ridgway standardised digital colour palette devised for the Blue-winged
Kookaburra.

5.6.3 Prototype One (Identicon): Visual analysis
and discussion

Once the digital version of the Blue-Winged Kookaburra Identicon was
complete, the shapes were filled with the relevant colours from the Blue-
Winged Kookaburra Ridgway digital palette to produce the first Identicon
prototype (Fig.5_54 Identicon Prototype test 1). With the colours in place
it became clear that the brown that surrounded the eye was a field mark,
but not the patch that extended to the right. This patch captured a subtle
darkening of the feathers on the photograph of the bird that was used as
the master reference (Fig.5_55). However, careful analysis of other photos
of this bird showed that this was not a prominent field mark, and therefore
it was removed from test prototype 1 and also removed when creating
prototype two.

Prototype one used black as a partial silhouette with the prominent colours
of Ridgway’s Chetura black, Amber brown, Olympic blue, and Lumiere Blue
95% tint positioned in the foreground of the silhouette. The use of the
black silhouette visually reinforced the form of the bird. For example, this
colour scheme emphasises the shape of the beak, head and stocky posture
of the bird, which are essential physical features when identifying the bird
in the field. Another identifying feature of this bird is its predator eye, which
Design for nature and the nature of design ability:

has a white band around the pupil. The dominant use of black on the head and beak emphasised this feature. Finally, the black silhouette represented those times in the field where the bird is in shadow and therefore the only colors that are seen are the brightest and most prominent.

Analysis of prototype one demonstrated that it could provide the principles for the creation of the Identicon. However, before a final decision was made, and in order to test different possibilities other colour alternatives were tried and the extended eye patch was removed.

Prototype Two (Identicon): Visual analysis and Discussion

Prototype two removed the black silhouette and replaced the overall form of the bird with Mars yellow (Fig.5_52). The design thinking behind this strategy was the figure-ground principle, whereby the neutral colour (Mars yellow 45% tint) provided a background layer to highlight the lighter brighter colours in the foreground. The black was used to emphasise the top of the beak and the far back of the bird. The Chaetura black highlighted the eye, tail and the streaks that occur on the top of the head. Removing the extended eye patch further emphasised the visually striking eye of a predator. The streaks on the top of the head were introduced because they are a prominent visual feature on this bird, however, including them meant this prototype went beyond the principle of economy. A comparison of the two Identicons shows that the inclusion of the streaks and small areas of black constitutes twenty colour elements that had to be learned for Identicon prototype two (Fig.5_56) in comparison to the eight that made up prototype one (Fig.5_54). Another extra element initially included in icon prototype 2 was the top of the beak, which was accentuated through applying black (Fig.5_57). Although the top of the beak is not the most important aspect of the overall beak, this element was selected based on a design aesthetic logic that highlighting this part of the beak would produce unity in the overall Identicon. In addition, the gestalt principle of closure would support the birder to complete the entire beak, even though the base of the beak was not in brown. However, re-visiting the design function of the Identicon determined that scientific accuracy outweighed design aesthetic and this element was removed for prototype 3.

Amendment for prototype 3 involved removing the brown streaks on the head and replacing the black with the Chaetura black except for the pupil.
In addition, comparison of photographs of the Blue-winged Kookaburra showed that the full Mars yellow tint was too dark for the overall visual appearance of the bird. A 25% tint of Mars yellow was applied to the body and development options for the beak that supported accuracy were explored.

**Prototype Three (Identicon): Visual analysis and Discussion**

In Prototype three (Fig.5_58) the 25% tint of Mars yellow used for the body reflected the principle of layer and separation as described for prototype one, i.e. the body was set to the background and prominent feather colours were brought to the foreground. However the light colour of the body did not reinforce the overall form of the bird as strongly as the black used in prototype one. The body form is also an important field mark for this bird.

Highlighting the top of the beak was also problematic. Three development options were explored for the beak, as displayed in (Fig.5_59 a, b and c). Development option a) highlighted the top of the beak in the brown colour, b) accentuated the bottom half of the beak and c) emphasised the entire beak. With the three development options displayed in what Tufte (1990, p.67) refers to as ‘small multiples’, which refers to a succession of the same graphic positioned side by side so they can be easily compared. It became apparent that option c) was the best, particularly when accuracy and the
emphasis of essential features were the primary function of the Identicon. Based on the design parameters and the extensive trials of illustrations and prototypes, Prototype three is a scientifically accurate iconic representation of the Blue-winged Kookaburra. This is demonstrated in the accuracy of the bird’s form, the simplicity of the shape of each element, and the accentuation of the prominent field marks for this bird, specifically, the oversized beak, large head, light buff colour of the body, predator eye, the orange-brown stripes on its tail and the dark and light blue on the primary wings.

The Identicon and Scientific Illustration working together as an identification strategy: Analysis and Discussion

The figures below show the proposed prototypes next to the prototype illustration as they would be placed together in a bird field guide (Fig.5_61, Fig.5_62 & Fig.5_63). Figure 5_64 shows the proposed final prototype 3 and detailed illustration in the context of a field guide. This positioning of the illustration and Identicon together provides the birding audience with the detailed visual information of the bird and offers the visual cues needed for identification purposes. Although it is part of the human perceptual motor system for every human to reduce detailed information into more manageable contextual cues, this takes concerted effort and some learning.
Design for nature and the nature of design ability: Chapter 5 | Illustration & Identicons

to determine the ‘right’ visual cues to focus on. The Identicon removes that effort and provides the visual cues most relevant to each bird species (Bower et. al., 1975, p.216).

The Identicon positioned next to the illustration provides the correct visual relationship for identifying the best Identicon for learning the prominent field marks for the Blue-winged kookaburra. Prototype 1 displayed in Figure (5_54) has visual strength through the use of black, which reinforces the overall form of the bird and has a direct relationship to the silhouettes used in bird field guides and other identification systems such as identifying airplanes. However, it is problematic when used for the identification of bird species. Silhouettes are generally used to represent birds in flight to highlight the differences in wing form and span between bird families, not the specifics required for the accentuation of differences in species. The use of black as shown above could confuse the audience,
particularly when learning to identify birds that are primarily black such as the Crow and Raven.

Prototype 2 (Fig. 5.56) removes the majority of the black and replaces the head, lower beak, breast and under parts with a 45% tint of Mars yellow. The Chaetura black that remains highlights the small amount the bird’s body that is visible beyond the wing, the circle around the eye and the top of the beak. The top of the head was also detailed with striations of Amber brown to represent the striations seen on the live bird. However, as discussed in the analysis of Prototype 2 this test Identicon incorporates too much detail, which is not in alignment with the importance of economy when designing an Identicon.

On the other hand, prototype 3 displayed in Figure (5.58) still draws attention to the species form and colouration without uncertainty about the bird family or species. Prototype 3 therefore fulfills the essential requirements of the Identicon to create an iconic representation that is scientifically accurate in form and colouration to inform the audience of the prominent field marks for the Blue-winged kookaburra.

Figure 5.64 Detailed illustration and Identicon Prototype 3 positioned in the context of a field guide
5.7 Conclusion

Identicons are the outcome of principles of icon design combined with the visual communication process, Gestalt principles and theories of the human perceptual-motor system, dual coding, spatial knowledge and colour and shape constancy and colour standardisation, resulting in an advanced system of visual representation that extends and simplifies current approaches to bird identification.

The visual system for bird field guides is composed of several factors, but it is the Identicons that carry the visual “gist” of the bird, enabling more effective and accurate bird identification. Success is achieved when Identicons are developed with attention given to minimal lines and the accurate form, shape and colour representation of the bird. Developing an Identicon requires visual communication design expertise usually assigned to symbol/branding projects. This expertise requires years of practice, an eye for detail, in-depth observation and an understanding of the visual principles of visual communication design and Gestalt laws of perception that lead to the decisions that capture the visual essence of the bird. Identicons can help to build or maintain a strong connection for humans to birds by making the learning process for bird identification more accessible to the ordinary interested person. Other fields within the natural sciences that require learning skills for accurate identification can be modeled with Identicons once an understanding of the visual essence of the bird is synthesised with the design expertise offered by visual communication designers. Once established as a new field for visual communication design expertise, Identicon have the potential for multiple uses, all of which contribute to the awareness of our native flora and fauna, supporting the sustainability and enrichment of our natural world.

Chapter Six introduces the critically contextualised discussions of design cognition and the theoretical issues and concepts that emerged from the case studies and the Identicon development.
6. Ways of knowing in Visual communication design and Scientific illustration

6.1 Introduction

This chapter advances the practical focus of the two design-led case studies described in chapter 5 by offering insight into the design thinking that was present in the practice of creating both the scientific digital illustration and the Identicon. It achieves this through discussing the reflection-in and on-action that was carried out while engaged in the illustration and designing process. The main purpose in engaging in reflective practice, analysing it and discussing the results is to build upon Nigel Cross's research focus presented in his books Designerly Ways of Knowing (2006) and Design Thinking: Understanding how designers think and work (2011, p.1), 'on building an understanding of the nature of design ability' of experienced designers. In particular this designer offers insight into design thinking based on the researchers two hats- the scientific illustrator and the VC designer.

As discussed in chapter 1, VC design and scientific illustration are two domains where there has been little research into design thinking, and therefore have received little coverage in books such as Cross's (2011) publication. This validates the importance of this chapter in building knowledge in design cognition for these two less researched domains. It also provides propositional understanding of these two domains in order to locate them within Cross's observations rather than being positioning them within a common assumption that all design domains are the same.

The chapter begins by clarifying the limitations and strengths associated with reflective practice. It then introduces the approach to reflective practice used for this study. Next it presents research into design thinking and establishes the importance of Nigel Cross in the advancement of theories of design thinking for contemporary design research, and how his work has influenced this present study.

The experiment-based reflective case study methods and procedure applied to the digital
Design for nature and the nature of design ability: Chapter 6| Ways of Knowing

scientific illustration process and the Identicon process are introduced. The Grounded theory methods that guide the analysis process are defined, and Cross’s (2006, 2011) theories of design cognition which were used in the coding process are introduced. Then the chapter discusses the insights that emerged from the Grounded theory analysis of reflection—in an on-action. It also identifies where VC design and scientific illustration practice are aligned with Cross’s theories. Finally, the chapter introduces a new insight that emerged from the Grounded theory analysis of the reflection-in and on action and that is the idea of the designer ‘wearing two hats’ and the implications associated with thinking across two domains.

The chapter concludes with observations and comparisons in terms ‘of the literature of the studies of design cognition’ with an in-depth focus on Cross’s (2006, 2011) books on this subject (Cross, 2011, p. 1).

6.2 Limitations & strengths of reflective practice

The reflective case study offered in this chapter is ‘participatory’, meaning that the person doing the research, in this case myself provides a detailed record of the design and scientific illustration processes of their own practice. The term ‘reflective’ also influences the presentation of the text in this chapter. To report and analyse the personal reflection, the researcher must be immediately present in the use of ‘I’, rather than in a more de-personalised and distant voice.

While ‘It is difficult to treat personal experiences as ‘data’, which implies a remove or distance’ (Cahill, 2007 p.6), particularly considering these experiences involve tacit-knowledge, it is an essential part of design-led research. Following Cahill, the argument of this chapter is that designers are best placed to explore and articulate what they do and how they do it.

With that in mind, although the case study is self-reflexive and ‘therefore an experimental and artificial situation there are some interesting observations that somewhat parallel those from’ Cross’s ‘case studies of expert designers’ (Cross, 2011, p.79). This chapter argues that with the right kind of circumstances and the willingness to do so designers can capture their own thoughts in action and articulate them with clarity and insight.

6.3 Capturing my design thinking

Protocol studies, as discussed in chapter one, traditionally involve a non-participatory researcher, meaning the researcher is an observer and not a participant, who asks a designer
to talk aloud the thoughts that occur while engaged in the design action (Burns, 2000). The researcher assisted by either audio or video apparatus, records the designer’s comments verbatim. The researcher then analyses the recorded comments using Protocol analysis methods (Cross, 2006, 2012; Dorst 1995; Ericsson, 1993; Lloyd et al., 1995). The limitation as highlighted in chapter one of this thesis is that in this research setting the designer is limited to ‘talking aloud’ as they work, which does not capture all of the modes of thinking the designer is experiencing at the time of the recording. The research outcomes are defined by the recorded comments, which mean that Protocol studies carried out by a non-participatory researcher are limited to ‘talking aloud’ comments (Cross, 2006, 2012; Ericsson, 1993). However, in this thesis the designer is in charge of recording and analysing his or her own thoughts and thus this becomes an opportunity for the designer to articulate the layers and modes of thinking that were present in the design action.

In this reflective case study I am both a participatory researcher and design practitioner. The recording apparatus to record reflection-in action comments consisted of an iPod and a hand written journal to record reflection-on action comments. Audio recordings were the primary source because they freed my designer’s hands allowing me to work and think aloud, (reflection-in action). The hand written journal records were secondary and only used when thoughts arose shortly after the act of designing (reflection-on-action) and also when the timing of the thought was in a circumstance such that an oral recording was not appropriate. For example, when I was out at dinner or shopping.

According to Cross (2004; 2006; 2011) and design cognition theorist Brian Lawson (2004) the preferred method for research and analysis of design activity is protocol analysis. However, as discussed in the Introduction of this thesis, due to concerns raised by Cross (2004, 2006); and Lawson (2004) that this method is weak in capturing non-verbal thought processes that are salient in design work, I investigated other methods, with the result that I employed a multiple methods approach for recording non-verbal thought processes and for the analysis process of the data. The research setting and methods are described in the following sections.

6.3.1 Setting the scene

A fundamental requirement of a research project is to establish the research setting and procedure and once established the setting and procedures are followed carefully and systematically. For example, in a traditional Protocol study the researcher establishes who will be the design exemplar, then defines the design brief for the designer to follow, a location where the study will be performed and a time frame for the study. In addition, the location, for instance a room is organized with audio recording apparatus, a table, and two
chairs. One chair is for the designer and the other for the researcher. Then on the day of the research the designer is given the design brief, paper and pencils/pens and asked to resolve the design issues that are set out in the brief. The designer is also asked to ‘talk aloud’ the thoughts that are occurring while they are in the process of designing. Concurrently, the recording apparatus is switched on and then switched off at the end of the experiment. Later the researcher translates the audio recordings to text and then analyses the text using protocol methods. The resultant analysis offers insight into the thought processes that the designer engaged in while in the action of designing (Binder et al., 2011; Cross, 2006, 2012; Dorst 1995; Ericsson, 1993; Lloyd et al., 1995).

The research setting for this study is similar but does differ because the researcher is also the design exemplar. In this study, I formulated the design brief and established the time and location for the experiment. I then organized a location, which was my personal studio space, and provided the workstation, design materials and iPod. So far my research setting and procedure aligned with the ones used by Protocol researchers. However, where it departed is that a framework was devised to support me to reveal not only ‘talking aloud’ comments but also those thoughts that existed either concurrently, or in-between what was said out loud.

To arrive at a framework that would support me to think freely while engaged in design activity called for an investigation of a multiplicity of methods as discussed in chapter one of this thesis. As discussed in chapter one the reflective practice methods of reflection-in and on action were engaged for this study because reflection can make ‘explicit the action strategies, assumptions, models of the world, or problem-settings that were implicit’ in the design action (Schön, 1995, para.38). The framework that I imposed on my reflection process was derived from two narrative systems, firstly the ‘stream-of-consciousness narrative’ (Reinharz 1992, p.227), and secondly, theories of narrative reflection/storytelling (Gubrium, 1998; Lloyd, 2000; Mc Gloin, 2008; Swann 2005). Stream-of-consciousness narrative importantly assists in releasing thoughts into words without the restrictions of English language conventions, for example allowing for clusters of words rather than formalised sentences. In other words, verbalising random thoughts and words as they occur while in the action of ‘doing’ design activity. These word clusters are then subjected to grounded methods of analysis in order to determine language patterns, concepts and theories that emerge from the word collective (Garson 2003; Gustafson 1998; Hancock c1995; Theo Van Leeuwen 2001; White 2006; Glaser 1992; Charmaz 2006, 08; Reinharz 1992). Once the patterns, concepts and theories are established using grounded theory, the practitioner/researcher can engage in ‘reflection-on-action’, through implementing ‘storytelling’ methods. According to Swann (2005), Kinsella (2007), Neil (2003), Taylor (2003), and Bal (1997), ‘storytelling’ enlists the practitioner as a narrator of the design process while at the
same time stepping back from the process to reflect on what has happened.

In essence, with the assistance of an MP3 player I recorded my thoughts and processes while in the act of designing or illustrating, recording my thoughts as an unedited stream-of-consciousness narrative. (Note-taking is not an option for the recording of thoughts while in the act of doing because the action of stopping and taking notes takes the mind away from the focus of the investigation.) This technique assisted in revealing what I was thinking while doing and what I was doing while acting. It was crucial to allow the flow of thoughts and not edit prior to revealing them. The MP3 player recordings were later transcribed from an audio recording to text.

Grounded theory coding and analysis for this case study is in keeping with the analysis procedure for all of the case studies within this thesis, with one modification, the use of ‘pre-determined codes’ as well as ‘open-coding’ process discussed in chapter 3 (Urquhart, 2001, p.2). The pre-determined codes were those creative strategies that Cross (2004, 2006, 2011) offers as potentially common across design disciplines, for example, problem formulation, goal analysis, solution focussing and problem framing to name a few. I discuss this process in detail later in this chapter.

The use of Cross’s creative strategies as pre-determined codes was imperative for the analysis process as these strategies provided direct comparative codes to establish where aspects of design thinking were concurrent in my reflective practice data (Urquhart, 2001, p.2). It is important to emphasise that the reflection-in-action which I carried out for this thesis was completed prior to my discovery of Cross’s creative strategies and prior to the idea of using them as a comparative source. It is important because when I was engaged with the reflective practice I was focussed on what was true for me in the moment of reflection, and I was not informed by or guided by Cross’s strategies. Cross’s creative strategies came into play during the reflection–on–action as part of the grounded theory analysis. The creative strategies of Cross (2006, 2011) are defined in the next section.

6.4 Nigel Cross’s creative strategies imbued in design thinking

Cross (2006 p.12) asserts that there are ‘five aspects of designerly ways of knowing: designers attend to problems that are ‘ill-defined’; their approach to problem solving is to focus on the solution; their mode of thinking is ‘constructive’; ‘they use ‘codes’ to translate abstract requirements into concrete objects; they use codes to both ‘read’ and ‘write’ in ‘object languages’. Cross (2006, pp.91-93) asserts that these ways of knowing are expressed by designers, as a set of creative strategies that he believes are common across all design
domains. These strategies include:

‘Problem formulation’, which is comprised of goal analysis, solution focussing, co-evolution of problem and solution, and problem framing.

‘Solution focussing’ that involves fixation, attachment to concepts, and generation of alternatives, creativity, and sketching.

‘Process strategy’ that integrates structured process, opportunism, modal shifts, novices, and experts.

It is these creative strategies that are compared and discussed in terms of how they reflect or do not reflect the design practice of my VC design and scientific illustration practice.

6.4.1 Problem Formulation: Problem defining / problem scoping, setting and changing goals, attachment to concepts, co-evolution of problem and solution

Problem formulation, also known as brief formulation, as offered by Cross (2006, p.78) is based on the idea that the designer is an ‘ill-behaved’ problem solver’, meaning designers do not spend concentrated time and effort on defining the problem based on formal deductive or inductive reasoning prior to launching into the design process. Rather, they engage in what Cross describes as ‘abductive’ reasoning, because designing is about ‘what may be’ not what ‘must be’ or ‘actually is’ (Cross, 2011, p.27).

Abductive reasoning, also referred to as ‘appositional reasoning’ and ‘productive reasoning’ in Cross (2011, p.27) points to the idea that there is always more than one solution to any given design problem. More than one solution means that a design solution is matched to the problem but does not ‘solve’ it in a scientific sense. According to Cross (2006) this drives the designer to engage in ‘problem scoping and framing’ throughout the design process instead of defining the problem before the design process begins.

In his latest research, Cross (2011, p.144) questions his initial thoughts on protocol studies because more recent studies have revealed that engineers and software designers are engaging in a mix of both ‘breadth-first and depth-first solution development strategies’. Breadth-first refers to beginning the process by broadly exploring the problem, and depth-first refers to the designer engaging in in-depth exploration of ‘solution concepts in order to assess their viability’ (p.144). He suggests that expert designers prefer a ‘breadth-first’ approach but will move into a ‘depth-first’ strategy if the problem is complex or if he or she are experiencing ‘design uncertainty’. Although these recent studies provide signs that some design practitioners are defining the brief, Cross nevertheless stands by the idea that expert
designers do not fully ‘define or understand the problem fully before making solution attempts’ (p.144).

Abductive reasoning plays out through the entire design process from beginning to end of what Cross (2006, p.91) refers to as ‘problem scoping/framing’. That is, to gather information about the problem, and formulate that information into goals and criteria that is then prioritised. The key to this process as expressed by experienced and renowned designers is their attention to imposing their view of the problem and using those views to direct the search for ‘solution conjectures’ (Cross, 2006, p.91). Cross argues that this approach is appropriate for designing, based on evidence from a number of studies that ‘suggested that over-concentration on problem definition does not lead to successful design outcomes’ (p.91). During the creative strategy of problem formulation the designer concurrently considers ‘ideas for their solution’ and will adjust and re-formulate the problem based on whether they can identify a possible solution (Cross, 2006, p.78). Subsequently, if criteria that emerge in the formulation of the problem do not trigger an idea for a possible solution, then that criterion is dismissed and others are formulated. In effect, the problem is formulated during the ideation process.

Abductive reasoning also establishes that designers are ‘solution focussed’ and not ‘problem focussed’. A solution-focussed approach encourages what Cross (2006, p.91) calls the activity of problem and solution ‘co-evolution’. Co-evolution is when the designer develops the problem and the solution simultaneously during the ‘conceptual stages of the design process’ (p.91). Cross contends that this approach is introduced in the design education process and then when a designer develops experience in a ‘specific problem domain’ that experience and knowledge inform their ability to ‘move quickly to identifying a problem ‘frame’ and proposing a solution conjecture’ (p.91). Once the criterion for the brief has been identified, the designer then establishes a set of goals that are adjustable and not static because, as discussed earlier, designing is about ‘what might be’ (Cross, 2011, p.27). This means the designer uses the initial set of goals to analyse their progression towards solving the design problem, with the understanding that they ‘exercise the freedom to change goals and constraints, as understanding of the problem develops and definition of the solution proceeds’ (Cross 2006, p.78).

The activity of setting and changing goals is “inherent”, meaning that the designer engages in this activity as a characteristic of the activity, not as conscious effort (Cross 2006, p.80) describes the. This study prefers “tacit” to “inherent” activity. Inherent, according to the *Encarta World English Dictionary* (1999), is defined as unable to be considered separately from the nature of something because of being innate or characteristic. The problem with using “inherent” in relationship to design activity is that if something is unable to
be considered separately from the nature of something else, then “setting and changing
goals” as a design activity is not achievable, because to do so would mean considering it
separately from goal analysis activity. On the other hand, “tacit”, according to the same
dictionary, is something that is understood or implied without being stated openly; not
spoken, which means that “goal setting and changing” can be acknowledge as separate and
therefore brought out into the open.

In sum, problem formulation appears to be based on abductive reasoning of ‘what may
be’ and not through the logical and more scientific approach of ‘propositional argument
from problem to solution’ (Cross 2006, p.91). The abductive approach involves the designer
engaging in the activity of framing/scoping the problem rather than the more disciplined
approach of defining the problem. The designer does this by developing criteria for the
problem, and key to the criteria is that the designer’s point of view is embedded into the
criteria. Once the criteria are established the designer derives a set of goals then searches
for a matching problem-solution pair. If the goals do not generate acceptable problem to
solution pairs, then the goals are re-set until a satisfactory solution is formalised.

6.4.2 Solution generation: fixation, attachment to concepts,
creativity and sketching

The design activity of ‘solution generation’ activates the creative design strategies of fixation,
attachment to concepts, generation of alternatives, creativity and sketching (Cross, 2006).
‘Fixation’ is that point where designers fixate on the features of already established design
solutions when engaged in the design process for a new problem (Cross, 2006, p.91). Cross
identifies ‘fixation’ as particular to engineers, and speculates whether Engineering education
programs highlight this activity more than others. Fixation is a ‘double-edged’ feature of
design activity in that it can lead to conservative, routine design or, when exercised by
outstanding designers, to creative, innovative design solutions. Fixation can also result in
designers becoming attached to single ideas that are conceived early in the design process
(Cross 2006, p.92). In addition, it can lead to the designer becoming ‘reluctant to abandon’
these single ideas, even when he or she recognises ‘difficulties in developing these concepts
into satisfactory solutions’ (Cross 2006, p.92).

On the one hand, the ‘attachment to concepts’ is seemingly a weakness in design behaviour,
and a better solution is the generation of an extensive variety of solution concepts. On
the other hand, this attachment could possibly be an ‘effective and productive feature
of intuitive design cognition’ (Cross 2006, p.84). The act of generating a single or multiple
ideas is often thought of as the creative stage of the design process. It calls for the designer
to engage their intuition and heroically take the leap from the problem to an innovative solution. However, Cross (2006, p.92) argues that the real creativity happens while the designer is engaged in ‘problem framing, co-evolution and conceptual bridging between problem space and solution space’.

Ideation and concept generation, while cognitive activities, also demand that the designer engage in the quintessential design act of ‘sketching’ and Cross (2006, p.92) suggests the reason for this is that ‘It seems to support and facilitate the uncertain, ambiguous, and exploratory nature of conceptual design activity’. The act of sketching works in conjunction with design thinking by realising concepts to paper and allowing the designer to ‘see’ ‘what needs to be known about the developing concept, and especially the recognition of emergent features and properties. Studies of the role of sketching have all emphasised its inherent power as a design aid’ (p.92).

To summarise, the generation of the design process solution generation incites the creative strategies of fixation, attachment to concepts, generation of alternatives, creativity and sketching. Fixation occurs when the designer, often an engineer, studies a prior solution to a similar problem and their thoughts become so preoccupied with the features of that concept they are unable to create something new. Fixation is a limitation to creativity, as is ‘attachment to concepts,’ where the designer becomes attached to an early concept and cannot be persuaded to let it go even though the concept reveals major design issues. The strategies of ‘problem formulation’ combined with ‘co-evolution of problem and solution’ are at the core of creativity in design. Sketching in the creative process supports the designer to transfer thought into something that can be seen and then worked with.

6.4.3 Process strategy: structured process, opportunism and modal shifts

All design activity is based on a process strategy and design success seems to be based on a structured design process that is flexible rather than rigid. In order to control this flexibility, a highly developed understanding of the design process is key. ‘Opportunistic’ behaviour is one of the creative strategies expressed in a flexible process. In the first instance, ‘opportunism’ built into a strategy might sound ‘like another feature of the characteristically unprincipled’, ‘ill-behaved’ activity of designers’ (Cross, 2006, p.92). However, protocol studies have resolved that opportunism is expressed as ‘modal shifts’ and is part of the approaches to design thinking that enhance the ‘quality of outcome’ (Cross, 2006, p.93). Such ‘modal shifts’ occur when the designer frequently switches ‘between concrete representations and abstract thought, between doing and thinking’ (Cross 2011, p.136). Cross
Design for nature and the nature of design ability : Chapter 6| Ways of Knowing

(2006, p.93) hypothesises that this behaviour might ‘be related to the need to make rapid explorations of problem and solution in tandem’.

In sum, design activity is engaged through following a structured process that allows for flexibility. The flexibility is observed in what is termed ‘opportunism’ and this is where the designer engages in the cognitive activity of ‘modal shifts’. Modal shifts allow the designer to move quickly between abstract thought and concrete representations that could be associated with the practice of co-evolution between problem and solution. With Cross’s creative strategies defined, the following sections present the discussions, results and recommendations that emerged from the comparative analysis of my own design activity applying Cross’s design cognition theories. The intention of this section is to identify where VC design and scientific illustration do or do not correlate with other design disciplines.

6.5 Design activity under the microscope

The two design-oriented case studies described in chapter 5 provided the source for reflective practice, and the data collection procedure involved switching on the iPod to record as soon as I engaged in the design/illustration activity of sketching, process strategy, development, and thinking. While in action, I talked aloud with the idea of simultaneously describing the activity and expressing aloud the thoughts that were ‘implicit in the action’ (Schón 1995, para.32). Reflection occurred throughout the activity of scientific illustration and design, and also in the moments where I paused, and sat back to evaluate the development of the prototypes. In all there were three hours and twenty-eight minutes of recordings.

The construction of the ‘talking aloud’ was influenced by ‘stream of consciousness’ methods. Stream-of-consciousness speaking, which is also used as a method for writing, is defined as ‘a person’s thoughts and conscious reactions to events, perceived as a continuous flow’ (Oxford English Dictionary, 2012). Stream-of-consciousness method is encouraged in grounded theory in order to capture thoughts as they occur without concerns for syntax or logical sequence (Glaser, 2008).

At the end of each day’s design activity and reflective practice, I typed the recordings into a word-processing program (Microsoft Word) in preparation for later analysis. To follow is an extract of the first reflection-in-action recorded while illustrating the Blue-winged Kookaburra, followed by the reflection-on-action. The reflection-on-action occurred after I had transcribed the recording of my reflection-in-action and I was thinking about the thought process. The timestamps for each reflection-in-action start at 00:00 and the time displayed next to the quote indicates the beginning of each talking aloud comment.
The reflection-on-action comments are not time stamped because they were hand written comments and not verbal recordings.

**Fig.6_1 Reflection—in–action 1**

(00:10) I am drawing and I notice that I am swinging between the emotions of anxiety and annoyance. Anxiety- I want to get it right, I want to ‘see clearly’.

(00:21) I am pushing my perception, forcing myself to see, to see what is in front of me and not rely on what I know or believe will make it look better.

(00:35) I am annoyed –my motor skills want to take over- my hand is making irrelevant marks based on my sub-conscious—what I have learned before, no what I have drawn before wants to do it again.

(00:57) anxiety, will it get better, will I get it right?

(01:29) still laying down colours- in a rhythm now- strokes are in the same direction

(01:44) I can see better now, I can see what is in front of me and feel better, calmer. The image is pleasing me-

(02:01) I am feeling like I am slipping into meditation state.

(02:15) My eyes are glazed my hand and pencils mix the colours- do their own thing. I can only see the colours and the texture, all sounds are gone- it is silent here.

02:36 My voice brings me out, but when I pause I go back.

03:52 Now is about colour, line- years of practice tell me how and where.

**Fig.6_2 Reflection—on–action 1**

Meditation while illustrating refers to times when I am totally absorbed with what I am doing. My eyes, thoughts and motor skills are working in unison to create the scientific illustration. This mental state only occurs when I am very confident that I will be able to achieve the aesthetic that I had pre-determined before engaging in the scientific illustration process. This level of confidence is built on years of practice and being very clear about the requirements of the brief.

Once I had transcribed the un-edited reflective praxis recordings to text, I copied and pasted them into a design based software program called Adobe InDesign document, because InDesign offered the flexibility and control I needed when working with large amounts of text and pages.

With the text in place, I next engaged in analysis based on Grounded theory protocols. I arranged the data that were generated without preconceived notions (iPod and journal
notes) by date, in chronological sequence. Then in the same manner described in the Case Study in chapter 3, I carried out steps one through three of Grounded theory analysis. First ‘open coding’ (see Fig.6.1) entailed highlighting the key words and phrases that emerged from the text using bold text. These key words and phrases were inspired by asking myself simple what, where, and how questions (Corbin & Strauss, 1990; Glaser, 1992, 2004, 2006). For example, I asked, what words and phrases relate to design process and then what stand out as ‘interesting’? This question generated the following codes: illustration, icon design, technical, layering, reduction, colour, stylise, accuracy, scientific, experimentation and meditation.

With the key words and phrases highlighted, I applied Phase Two of the grounded theory analysis process, theoretical and substantive coding and memo writing (Glaser, 2004). Phase two involved asking questions that supported making connections and identifying emerging gaps (Charmaz, 2008; Glaser, 2004, 2008.). For example, the sorts of questions I asked during this process included: ‘what are the causal conditions i.e., events or variables that lead to the occurrence? What was the context i.e. the specific conditions (brief/ technical/skills) influencing the action/strategy? Is there a consequence of the action or strategy (intended or unintended)? Phase two was where I introduced the predetermined codes from Cross’s (2006) creative strategies. Specifically these were: problem formulation, fixation, co-evolution, creativity, concepts, process strategy, opportunism, sketching, and modal shifts. I applied these codes to the text by asking the same question for each predetermined code, for example, ‘Where is ‘problem formulation’ present in the comments? Theoretical and Substantive coding are represented in Fig.6.2 as the ‘red’ coloured text under the comment.

The use of the word ‘technically’ refers to my understanding of the requirements of the brief, which falls under Cross’s ‘problem formulation’. The reference to ‘meditative state’
state’ is a phenomenon that has emerged from the comment and therefore is an emergent code.

(00:34) I get into doing the layering process - not a lot of technical, just aesthetic thinking is here. Is this the right position? Is this too uniform?

‘Layering’ is part of the illustration ‘process’ related to the particular technique I used in this illustration, therefore it falls under Cross’ ‘process strategy’.

The final stage of the grounded theory analysis was for me to make ‘conclusions and draw results’. I achieved this by comparing the codes, theories and memos across the collective ‘reflection—in and –on practice’ comments. Then I reduced the data to the key theories in order to draw conclusions from results (Charmaz, 2008; Glaser, 2004,2008.).

In the next section I discuss the creative strategies that emerged in the reflection—in and –on that I carried out while I was engaged in the scientific illustration and Identicon projects. I also discuss how they compare with Cross’s (2006, 2011) creative strategies of problem formulation, solution generation and process strategy.

6.6 Discussion: VC design and scientific illustration compared with Cross’s creative strategies embedded in design thinking

The following discussion offers a comparison from the results of my own reflective praxis with each of Cross’s (2006) eight creative strategies described above. Each strategy offers a conclusion in order to identify where my VC design and scientific illustration practice parallel or differ from his theories.

6.6.1 Problem defining / Problem scoping

The results of the reflective practice—in and—on action and grounded theory analysis do not fit neatly into Cross’s (2006) supposition that design activity is a ‘problem scoping’ rather than ‘problem defining’ discipline. However, the results do fit better with Cross’s updated insight that expert designers from engineering and software design engage in ‘breadth-first and depth-first solution development strategies’ (Cross, 2011, p.144). Both the Identicon and scientific illustration projects required a ‘depth-first’ approach because the design problems were complex and the design situations stretched my knowledge. Cross’s (2006; 2011) creative strategies of ‘problem scoping’ and ‘problem framing’ were apparent in the depth-first approach, but where my data departed from Cross is that these
Design for nature and the nature of design ability : Chapter 6| Ways of Knowing

strategies assisted in defining the brief. Cross asserts that in the protocol studies that he has cited expert designers do not 'attempt to define or understand the problem fully before making solution attempts’ (Cross, 2011, p.144). However, the reflection–in and on action comments and analysis support that a clearly defined brief for the two design-led projects was essential to me as both the VC designer and the scientific illustrator, otherwise the design work to follow could become irrelevant, inappropriate, or completely wrong for the intended audience.

The overarching design problem that informed the scientific illustration and Identicon briefs was the lack of colour standardisation and nomenclature in the representation of birds in bird field guides. This problem initiated clear accounts of Cross's (2006, p.81) creative strategies of 'problem scoping', 'problem framing' and 'co-evolution of problem and solution conjectures' that lead to two clearly defined briefs. Scoping this problem involved informal visual analysis of field guides that was recorded as part of the reflection–in–action. The results of scoping then led to formal visual analysis of field guide to substantiate any initial ideas and issues. Framing the problem involved interviews and surveys with experienced birders who were the end-users.

**Fig.6.5 Scoping the problem | Reflection-in-action Digital Scientific illustration**

(00:05) The illustrations are artistic, which is ok but not for identification. As my research said they need to be more scientific. But what does that mean to me when drawing them? ( Asking what does this mean is an example of me scoping the problem)
Accurate, the shape of the bird must be accurate, the features must be accurate they must look like the real bird. How will I do this - I will have to look closely at photos and at the live bird (How questions indicate scoping the problem)

(01:33) Looking at the illustrations I am wondering how they could carry a standardised colour pallet (How questions indicated scoping the problem). They are detailed and hand painted. Hand painted is the issue they would need to be digital so that you could use the same pms colour every time the bird is printed.

(02.03) This would mean each bird would have to be designated its own colour palette (Scoping the problem in defining implications).

(02:15) What if the bird was photographed and then turned into a digital vector? (What if? questions are indicative of scoping the problem) That would make it scientific but does not resolve the same colour. I will have to check out if there is a colour palette for birds.
Fig.6_6 Scoping the problem | Reflection-in-action: Identicon

(02:01) An icon would also support colour standardisation – you could print the same colour for each field guide (Scoping the problem by considering how the idea could work). I wonder if anyone has done this yet? I need to research this to find out (Scoping the problem involves looking at what has already been done).

(02:44) What if an icon was next to a detailed illustration? (Scoping through asking ‘what if?’ questions) That would be an idea – that would help the person to look at the details and then the icon would point out the bits they need to remember (Framing the problem in the context of the end-user). A bird flies past pretty fast and you need to remember ‘bits’ of the bird not all that detail. I need to find out more about what bird people do when identifying a bird. How do they get from one of these highly detailed illustrations to remembering enough to identify one? (Scoping the problem by sourcing market feedback)

With the design problems defined it was then a matter of engaging in the design and scientific illustration process, and checking with the brief throughout to ensure I kept on track with it. Fig.6_7 demonstrates my action of referring back to the brief while I was engaged in the design process.

Fig.6_7: Problem defining | Reflection–in–action: Sketching the icon

(00:09) The amount of blue on the primary wings varies from bird to bird, the constant is the location of the blue, which is on the lower area of the primary feathers. They are very visible because the blue is situated next to the dark greyish brown of the back and upper primary feathers.

(00:54) Now I am drawing the blue tail – ok I feel that I have captured the shaded areas where they change and the shape of the bird quite well and I will then now go back with my layout paper and trace this again and then reverse it so I am comfortable with continuing this.

The critical assessment and attention to detail expressed above are evidence of following the brief. I am addressing the goals of accurate representation that is realistic/scientific.

The analysis in this section has demonstrated that, although problem scoping and framing are present in my VC design and scientific illustration process, they are the thinking strategies applied to defining the brief. However, this approach is different to that expressed by the design domains tested by Cross (2006; 2011) because those domains do not ‘define or understand the problem fully before making solution attempts’ (Cross, 2011, p.144). The difference in approach is interesting because Cross (2011) assumed that all of the creative
strategies discussed in his book Designerly Ways of Knowing would operate in the same way across all design domains.

6.6.2 Setting and changing goals

Setting and changing goals is essential to scientific illustration technique development and icon development because these activities are experimental. Experimental means the testing of visual prototypes until a solution is created that meets the requirements of the brief, which can often lead to the setting and changing of visual goals. For example, Fig.6.8 below demonstrates that I had the goal to emphasise the bird’s field marks required to identify the bird in the field. In order to achieve this goal another goal was established. That goal was to apply black as the background colour because, based on my experience and understanding of icon design theory and application, black should work to emphasise the bird’s field marks. However, once I applied the black I realised that it was not working so I had to re-think the goal and test another colour. In essence, if issues and/or negative outcomes emerge, the immediate response is to set or change the goals. However, it must be emphasised that the goal shifting is always within the defined brief. To set and change goals that break the bounds of the brief could and more likely would generate solutions that are not appropriate to the client or the market.

Fig.6.8: Setting and Changing Goals | Reflection-in-action: Constructing the icon: Prototype One

(01:32) With that finished I look at it. My thinking is that this is how I would approach a corporate icon, using the black and a touch of colour to highlight areas. But realise this does not look right for the blue winged kookaburra (the moment where I realise the initial goal is not working), it is communicating that the blue winged kookaburra is a dark bird, which it is not.

(01:53) I find it a surprise; I really thought this would work, because it has always worked in my corporate icons. It is interesting how my head is not happy that this is not working, and it is challenging ‘what I know about icon design’-- then I think -oh well- have to try colours other than black (Here I am changing the goal from black to test other colours).

To conclude, although setting and changing goals are creative strategies used in my VC design and scientific illustration process, where they depart from Cross’s definition is that the goals are kept within the bounds of the brief. To do otherwise could lead to design decisions that were not appropriate to the brief and subsequently would not solve the problem. This is an important distinction because, according to Cross (2006, 2011), other design domains change and set goals throughout the design process.
6.6.3 Co-evolution of problem and solution

Cross’s (2006) theory of co-evolution of the problem and solution is evident in the reflective case study analysis. There is an oscillation between thoughts about the problem and solution, not only when defining the problem and defining the brief but also throughout the design process. For example Fig. 6.9 (below) captures when I am engaged in the activity of scientific illustration, while illustrating I am thinking within the ‘problem frame’ (Cross 2006, p.80), which involves the scientific parameters required for the illustration. At the same time, my thoughts draw from experience and knowledge of scientific illustration and how the application of that knowledge will have an impact on the solution.

Fig. 6.9 Co-evolution of problem and solution | Reflection—in–action: Illustration
Prototype One Sketching
(07:28) Actually, my brain moves between the problem, technical and the final aesthetic. (Co-evolution of the problem and solution, here I refer to the solution as the ‘final aesthetic’). I am looking at one singular feather at the moment, I am looking at the gradient colour (I am considering how the colour gradients will fit into the scientific parameters of the problem) and looking at Popes work and deciding that I would like to build up a few layers of the colour - so changing the colour to an opacity of 40% - hoping that if I layer them on top of each other I might begin to get some depth of colour. (The analysis of colour, and technique and critiquing the aesthetics in relationship to the appropriateness to the problem reveals evidence of co-evolution) - so I have just done that and it looks quite interesting- an aesthetic moment....When I say ‘interesting’ it is a pause in my final judgment- I am engaged in experimental phase - so very open to it working or not- (Evidence of solution focus while staying open to it not being the final solution for this problem).

To conclude, the VC design and scientific illustration reflective practice data analysis reveals incidences where I engage in the creative strategy of co-evolution of problem and solution. However, this study shows that Cross’s (2006, p.80) description of ‘co-evolution’ of problem and solution ‘spaces’ does not capture the complexity of my thought process. Metaphorically, my VC designer mind is similar to a stack of A4 paper, each sheet containing specific information related to the design problem, such as the problem statement, problem criteria and goals, images, technical information, past project solutions, potential issues, what to avoid, possible inclusions, and solution concepts. I mentally scan, filter and sub-categorise information in case it becomes important later, and make mental notes, all the while concurrently engaged in the processes of sketching, developing and refinement.
6.6.4 Fixation

Reflecting on my own career as a practising VC designer and design educator, my experience is that the ‘fixation’ (Cross, 2006, p.81) on pre-designed features, particularly conceptual, is discouraged across the field of professional VC design. Perhaps fixation in the three-dimensional world of engineering is practical and useful, particularly when involving the mechanics or structural workings of an existing solution. The creative/innovative engineer could use this knowledge as groundwork for a next generation response. However, my experience indicates that in the two-dimensional world of VC design and scientific illustration, rather than resorting to ‘fixation’, designers are encouraged to refer to past responses and concepts as inspiration towards a unique solution. ‘Fixating’ on a pre-designed solution, particularly a concept, could easily lead to plagiarism and is therefore highly discouraged.

In this discussion, I refer to a pre-designed style and a pre-designed concept as two different entities, a separation that is important to make clear. For this study, a pre-designed style refers to the stylistic approach used to communicate a design concept. For example, VC designer Seymour Chwast (cited in Cass, 2012) drew on the stylistic approach of art nouveau (Fig.6_a) to convey a concept for the Artone Studio Indian Ink. The companies name Artone and the product, which is Indian ink, drove the concept, i.e. the letter ‘A’ from the name Artone was stylized to represent a drop of Indian ink (Fig.6_b). On the other hand a pre-designed concept refers to the thinking behind the solution. For example, Figure 2 Design A illustrates an original design concept and Fig.6_c Design B is a solution derived from Design A’s pre-designed concept. In effect Design B is an example of what is referred to in the VC design field as a design ‘rip off’ (Cass, 2012, para.1).

Fixation in this sense on a predetermined style is an accepted VC design and scientific illustration education and practice activity. In fact, there are books and websites available for designers and illustrators that encourage style ‘fixation’, for example, Richard Hollis (2006) Swiss Communication Design: The Origins and Growth of an International Style, 1920-1965. It is also acceptable to explore how a VC designer or illustrator generated an idea, such as their source/s of inspiration, and then use that as a platform for ideating the current, new design/illustration problem. Examples of work that supports the notion of designers deriving inspiration from other
Design for nature and the nature of design ability: Chapter 6 | Ways of Knowing

Designers include Diana Martins (1995) Communication Design: Inspirations and Innovations and Petrula Vrontikis (2002) Inspiration=ideas: A creativity sourcebook for communication designers. Vrontikis’s (2002, p.7) book explores what inspires nineteen of the ‘world’s top designers’ to create innovative and visually engaging design solutions. The purpose of the book is to provide insight into their creative processes and for the reader to interpret whether any of the methods discussed could constitute a basis for inspiration in their own design practice. The underlying assumption and understanding behind these types of books is that these information sources are inspiration only, not plagiarism.

The two reflective design case studies offer examples of where I am ‘fixated’ with pre-designed and pre-illustrated styles but not with the conceptual basis of the response. The first quote below reveals how I used examples of another illustrator’s work as a source of stylistic inspiration. I am ‘fixated’ with Pope’s attention to detail and strive to accomplish this in my own illustration. However, the concept of applying this stylistic approach using vector-based illustration software and a standardised colour palette belongs to me.

Fig.6_10 Fixation | Reflection—in–action: Illustration Prototype Six
(07:16) I have images of Christopher Pope’s work for inspiration… Looking closely at Popes illustration, looking closely at the feathers, he has in-fact drawn each feather in great detail and repeated that approach for each feather. (Fixation to styles is evidenced in how closely I am looking at Pope’s work for technical inspiration)

The following quote supports ‘fixation’ in creating the style of a VC icon. However, the concept of using this style and the associated theories to develop a visual system for the representation of birds for the purpose of identification belongs to me.

Fig.6_11 Fixation | Reflection—in–action: Illustration Prototype Six
continued
(0:3:43) I have just noticed that I am so driven by the years of experience as a corporate designer to have the icon be standardised (to follow the rules of icon design). … the perfection of a fully resolved icon or symbol it’s consistency of line weight, shapes and form. … one shape blends or bleeds into another …(Evidence of fixation to the style of icon design)
Therefore, from my VC design and scientific illustration experience, ‘fixation’ with pre-design solutions requires some explanation, such as highlighting the difference between fixation on style and fixation on concept. This could support ‘fixation’ as a position of inspiration and not plagiarism.

6.6.5 Attachment to concepts

The Identicon design and digital scientific illustration were two concepts that were derived from scoping and framing the problem. Then, as demonstrated in chapter 5, the solutions for both of these concepts were selected after numerous prototype tests and analysis. Specifically, to arrive at a digital scientific illustration technique that met the ‘problem definition’ took six conceptual prototypes, and for the Identicon it took numerous conceptual alternatives to arrive at three prototypes and then the final solution. Therefore, the reflective case study supports the proposition that my VC Identicon design and scientific illustration do not engage in Cross’s (2006, 2011) creative model of ‘attachment to concepts’. In contrast to Cross (2006, 2011), my VC Identicon design and scientific illustration are domains where I explore a wide range of concepts before arriving at a final solution. However, from what I have seen across my VC design career through exposure to the work of my peers, this approach is not extensively supported and therefore further research is required to set any paradigm for these two domains.

6.6.6 Creativity and Sketching

The creative strategy of ‘sketching’ as described by Cross (2006, p.92) was dominant throughout the two design-led case studies. The nature of the scientific illustration and Identicon design was that they demanded sketching in order for me to make clear the ‘tentative solutions’ that were in my mind and then to explore those ideas that lie in the ‘emergent features and properties’. The comments in Fig.6_12 reveal the times when sketching was present in the design process.

Fig 6_12 Sketching | Reflection–in–action: Illustration Prototype Four

(00:05) I have decided... for this very initial sketch I will include those details, knowing -because I have done this many times before- they will be eliminated into smooth line work (sketching is used here to address properties in the illustration).

(00:57) Because it is a representation of the object, it does not have to be scientifically accurate. So I am gently sketching around the bird and if there are any specific, markings that I feel are relevant for identification (Sketching has been used here to
Due to the accuracy required for this illustration I spent time at the Zoo sketching, then later traced the bird from a photograph. Both forms of sketching supported the scientific accuracy required (Sketching used to make clear ‘tentative solutions’).

In this study, sketching was essential to my design activity when generating concepts and the development process, and therefore my reflective-practice analysis supports Cross’s argument that sketching has ‘inherent power as a design aid’ (2006, p.92).

**6.6.7 Structural process**

The two reflective case studies offer evidence that aligns with Cross’s (2006, 2011) creative strategies of a structured process that has room for flexibility. In Fig.6.13 the comments reveal the specific process applied to the scientific illustration prototype three. The basis for this process was developed when attempting the first illustration, and I modified the process according to what I learned. This modified process was used for the second attempt, and then slightly modified again to achieve the final scientific illustration. This demonstrates the use of a core process that offers the flexibility to modify aspects if they are not delivering the desired results.

**Fig.6.13 Structural Process | Reflection in action Scientific illustration Prototype three**

(00:11) Process began with photograph of a Kookaburra placed in an Adobe Illustrator document. The photo acts as a visual reference for illustration of main features of the bird. **Step one:** Determine sections of the bird to illustrate on separate layers. **Step two:** Trace the wing areas and fill with blue palette colour. Using the main photo as reference. **Step three:** Create of individual feathers, fill with gradient created from colour palette. **Step four:** Trace outline of head and beak, fill with soft background colours from the palette. **Step five:** Using the brush tool selected to colours from palette begin to draw feathers on head and nape.

**Fig.6.14 Structural Process | Reflection in action Identicon Prototype two**

(10:43) Willingness to shift from normal strategy in order to achieve the requirements for this brief. An attitude of – whatever it takes to get the job done to the highest level.

To conclude, the evidence from for the reflective practice for my VC design and scientific illustration process is that they are in alignment with Cross’s idea of processes structured
with the understanding of flexibility. In the following section I discuss how ‘opportunism’ and ‘modal shifts’ are the strategies at the core of inciting a flexible process strategy and how they developed in my own design practice.

6.6.8 Opportunism and Modal shifts

Cross (2006, 2011) asserts that ‘opportunistic behaviour’ within the design process is played out as ‘modal shifts’, and the evidence as captured in the reflective–practice demonstrates that this behaviour exists in VC design and scientific illustration cognitive activity. Modal shifts refer to the designer’s ability to ‘shift rapidly’ between concept and problem, between concrete and abstract thoughts and ‘between doing and thinking’ (Cross, 2011, p.136). The reflective case study analysis supports evidence of modal shifts in my VC design and scientific illustration cognitive activity.

The reflective practice comments above highlight the practice of shifting modes of thinking while in that activity of designing. I concur with Cross (2006, 2011) that this process works at high speed, demonstrated where I am rapidly cross-referencing what I know, past experience, and possible ideas or experiments that may enhance the design or resolve the problem. There is the sense of crossing over between both sides of the brain; the left when drawing upon systematic process or principle strategies and the right when experimenting with,
for example, a different technical approach to resolving the design problem. Sometimes modal shifting involves learning while in action, such as pushing the boundaries of design computer software in order to resolve a design issue. Therefore the analysis of the reflective practice confirms that in both my VC Identicon design and scientific illustration process I engage in Cross’s (2006, 2011) creative strategies that are associated with process strategy. The data confirm that when I am engaged in these two domains I employ a process strategy that is flexible and that the flexibility is due to the engagement of opportunistic behaviour that employs the complex cognitive strategy of modal shifts.

The following penultimate section engages with the theories that emerged from the grounded theory analysis of the reflective case studies. This section is important to this thesis because it demonstrates the strength of grounded theory to uncover insights that are difficult to uncover using Protocol analysis because they are often hidden within tacit knowledge. A number of important understandings emerged that offer a contribution to design thinking research. The following emergent theories do not provide final solutions to issues raised in this thesis, but rather offer insights that can be taken up in future research.

6.7 Emergent theories beyond Cross and into further studies

The value of the emergent grounded theories used throughout this thesis is that this method allows for insights and theories to emerge from the data. The following section offers insights into the idea of a designer who works across two domains and the kinds of thinking that operate for the designer. In addition this section offers new creative thinking strategies that emerged from the reflective praxis that were not acknowledged by Cross.

6.7.1 Two Hats: The design thinking associated with skills across two domains.

A unique characteristic of this study is that I as the researcher wear two domain ‘hats’ within my overarching domain as a VC design expert, identified in the introduction to this thesis, one for VC design and the other scientific illustration. The protocol studies presented by Cross (2006, 2011) have not introduced the types of design thinking associated with the skills and knowledge that cross over two domains. Research into the design thinking that designers must be involved in when they engage in two design disciplines would be a worthwhile endeavour, and I offer thoughts in that direction gained from this study.
The value of dual expertise

The results from analysis of the reflective praxis carried out for this thesis revealed that my cognitive processes undergo complex ‘modal shifts’ (Cross, 2011, p.136). But rather than the modal shifts being isolated to one domain, this study shows that I am constantly assessing which form of expertise is most appropriate at any given time during the design and/or scientific illustration process. The modal shifts can create internal creative conflict, for example (Fig.6_17), reveals the conflict of domain opinions that I experienced when I was assessing the value of the scientific illustration techniques.

Fig.6_17 Modal Shifts and Conflict | Reflection in action- Scientific illustration Prototype
Five

(12:22) I think as an illustrator I can come to terms with the fact that, I need to do a technique that is repeatable, that other illustrators could do this technique, and I need for the technique to not be too complex (Illustrator technical goal).

(12:29) I think at the same time breaking new ground also has to be important (Illustrators personal goal).

(12:31) But the designer in me says, ‘no make it easy so it is repeatable’ (VC designer technical goal), the illustrator striving for uniqueness and professionalism is saying no, why don’t we break new ground (Illustrators personal goal).

(12:38) I think if the illustrator in me makes the compromise that I want it to be a technique that is repeatable but breaking new ground in enabling consistency in reproduction values is important (VC designer and Illustrator defining a compromise both domains are thinking about goals and technical considerations).

(12:44) As an illustrator I can make this compromise and allow myself to be precious about these illustrations because that will enable me to strive towards breaking new ground in bird illustration (Illustrator goals), driven through the designer who is interested in reproduction consistency, reproduction values and colour standardisation (VC designer considering technical details).

The reflection–in –action comments above reveal the illustrator and VC designer in me engaging in modal shifts that engender internal conflict. The modal shifts for the illustrator include personal expression, aesthetic value, accuracy and technical repeatability. As Illustrator, my priority was personal and concerned with breaking new ground. While conversely and concurrently, as VC designer I engaged in modal shifts to do with the time efficiency of each scientific illustration, reproduction values and colour standardisation. Further, as a VC designer, my priority was not to break new ground but to be efficient and
reproducible by other illustrators.

The reflection—in action comments indicate that while developing and drawing the icon for this study, my illustrator (expertise) actively engaged with modal shifts that included perceptual and spatial considerations, focussing on the details of the bird and representing them as close to realism as possible. At the same time, the communication designer (expertise) actively engaged in modal shifts to reduce detail to a minimum with a preference for abstraction to achieve simplified forms that captured the bird. In the end, a combination of the two was required to achieve the Identicon.

Fig.6_18 One person two expertise | Reflection in action- Identicon Prototype Three

My illustrator experience brings the detail, it understands what should be where – it understands the anatomy of the bird. Then, I have to discipline my mind away from detail when involved in Identicon design. Because my ‘VC design brain’ has to determine the aesthetic and communication values. Icon design involves deconstructing an object from the three-dimensional and detailed of the illustrator world into the two-dimensional, or what Tufte (1990) calls the “flatland” of paper. It involves an abstract, disciplined and confined way of thinking and seeing, which can challenge some aspects of my illustrator approach, such as the desire to see and represent detail and to think broadly.

Dual specialised abilities in spatial representation in Identicon design

Specialised abilities in spatial representation emerged as a prominent modal shift within the duality associated with the different aspects of expertise across VC design and scientific illustration, in particular when it came to Identicon design. For example, (Fig.6_19 (a)) the scientific illustrator has specialised spatial representation abilities for dealing with the detailed information associated with, for example, a live bird. The scientific illustrator has expertise in the ability to see important details that the untrained eye does not see (Schwartz, 2006). Then, (Fig.6_19 (b)) the VC designer has specialised spatial representation abilities of reductive thinking that are associated with Gestalt theories and icon design (Behrens, 2004).

Fig.6_19 Spatial representation abilities | Reflection –in– action- Identicon Prototype One

(a) Detailed perceptual abilities based on years of concerted effort as an illustrator to ‘see’ the details, then the VC designer in me kicks in to determine what is needed and what is not in order to create the minimalist iconic representation.
(b) (19:01) **Perceptual understanding** of how to see the object that is the live bird in order to create an icon- from the 3 D world to 2D.

In sum, the modal shifts and duality of specialised abilities between domains discussed above provoked internal conflict and a new approach to design, the *Identicon*, which I argue are positive creative outcomes of the one person engaging in two domains.

**A meditative state as a creative strategy**

A phenomenon revealed in the reflective process was the presence of a ‘meditative state’ during the illustration process.

![Fig.6_20 Meditative state | Reflection –on– action- Scientific Illustration](image)

(00:11) Another phenomenon worth discussion is the illustrator propensity for retracting into a meditative state when illustrating. This ability to focus into a ‘singularity’ of mind and creation seems to be isolated to illustration process rather than VC design. Interestingly, when in this ‘meditative’ condition the outside world disappears, and it feels as though my eyes glaze over. I then become focussed on the ‘vision’ of what I am creating more than the marks that are appearing on paper or computer. In fact, I have to force myself to finish what I am doing, and focus on the image that I have created to confirm that it is progressing in alignment with my vision.

I present this phenomenon without explanation of what is happening cognitively as this is beyond the framework of this thesis, but offer it as a creative strategy used in the process of illustration that is worth further research.

**Tacit- motor activity an extension of Tacit-knowledge**

Results from the two case studies identified the potential for a new creative strategy that has not been noted by Cross, and that is tacit-motor activity. The tacit-motor activity calls attention to the tacit-motor skills in design activity and acknowledges the difference between design motor skills and design thinking activities.

Tacit-knowledge as defined earlier in this thesis is as an act of ‘indwelling’ (Polanyi cited in Howells, 2002, p.872), meaning the process of knowledge assimilation by means of cognitive processes (learning towards knowing). This study argues that tacit knowledge also includes motor activities (learning towards doing) and that tacit-motor activity (motor-action) is a stand alone creative strategy that is employed by VC designers and scientific illustrators (Howells 2002; Miller 2005; Polanyi 1958; Smith 2003; Sveiby 1997; Swann 2005; Ware 2008). Analysis of the reflection-in and on comments suggests that tacit-motor activity defines
those actions that are embedded in knowledge but performed as a motor action, such as illustrating, development sketching, working with digital design software, preparing digital artwork for print, and navigating a computer. The following quotations from reflective case studies one and two illustrate the tacit-motor activity in action and the cognition that lead to the definition.

**Fig.6_21 Tacit-motor activity | Reflection –on– action- Icon Design**

I suppose in reality it is too difficult to have motor skills, technical information, problem solving, the brief, the client, the end user, and internal dialogue in the foreground while designing. Some aspects have to become automatic- or deep in the subconscious- tacit- so it can be occurring while dealing with the visual outcome.

Quote Figure (6.21) reveals why tacit-motor activity is important when engaged in a complex activity like design, where there are many variables and design elements to consider at once. My reflective comment refers to motor skills, and at the time I was aware that Polanyi’s (1958) definition for tacit-knowledge did not seem to take into account those motor skills that become automatic with experience. At this point in time I was curious to investigate further the idea of tacit-motor activity and its relationship to activating motor skills.

**Fig.6_22 (a) Tacit-motor activity | Reflection –in– action- Icon Design Prototype One**


The above quote Figure (6.22 (a)) refers to the development stage of designing an icon and I refer to this behaviour as a tacit-response pattern. Later, after some consideration, I re-named this tacit-motor activity because it is more descriptive of the action. My conscious thoughts were focussed on the shapes appearing, not on how I was forming them – the how was occurring in autopilot mode, allowing me to concentrate on what the form was communicating. I identify the process that leads toward the tacit-motor activity, in particular how it involved knowing that I had to construct an icon, and that this thought activated knowledge relating to the design problem and theories of icon design, which in turn activated my motor skills to pick up the pencil and begin drawing.

**Fig.6_22 (b) Tacit-motor activity | Reflection –in– action- Icon Design Prototype One**

(16:43) My mind is preparing itself to have to look very carefully at the bird, so it is like a preparation for perception... I am looking at the very outer edges of the bird, the edges of the bird as opposed to the content and texture of the bird.
Figure (6.22 (b)) is an example of the way my tacit-knowledge and understanding of how to approach the initial sketches of an icon are sending a message to my visual cognitive subsystem, alerting me to see the image in a particular way, which activates my motor system to move my eyes and focus on specific features of the bird. Moving my eyes and focusing on specific elements within an object can only be achieved by activating motor skills, and where to look is activated by knowledge derived from experience.

This discussion offers the possibility of the tacit-motor activity as a design creative strategy that is activated through tacit-knowledge. However, further VC design and scientific illustration activity research is required to establish its validity.

**Tacit-activity: the silent partner**

The idea of tacit-knowledge and activity being silent partners emerged during reflective practice as something worthy of acknowledging. For example, in the following quotes:

**Fig.6.23 Tacit-activity: The silent partner | Reflection –on– action**

I then began my exercise routine and realised that problem solving, development, and task planning can occur outside of practicing design, often when engaged in menial activities such as exercise or cleaning the car. Although aware of this phenomenon, I was surprised how often my thoughts engaged with the project outside of scheduled designing time. This cognitive activity was almost like a silent partner within the design process, tacitly acting on my behalf by preparing for the next phase of designing.

I was planning what I was going to do when I sat down. Realizing I was in the process of thinking prior doing design, I stopped and grabbed the iPod to record my thinking process.

**Fig.6.24 Tacit-knowledge: The silent partner | Reflection –in– action**

(00:00) ...Thinking, planning before doing– ... it was not a planned activity, I simply engaged in the planning process without the intention of doing so.

**Fig.6.25 Tacit-knowledge: The silent partner | Reflection –on– action**

The silent partner that is tacit-knowledge seemingly works on my behalf while I am doing other things, and then when it is time to sit down and carry out the next design phase I am clear and prepared. Reflecting on my design career, I surmise that this silent tacit-ability to plan the next design phase without reference material and
with little focused attention is achievable only after accumulated knowledge and experience in the practice of design.

The idea of problem solving while engaged in menial tasks is not a new phenomenon. However, I believe that it is an area of creative thinking in design that has had little attention. My reflection-in and on action comments and when reflecting on my design career substantiates that this creative strategy is powerful and could contribute to understanding why designers often cannot recall when or how an idea came about.

These findings have implications, first for VC design. They substantiate the value of adding VC design to the continuing discussion of design cognition within the broad field of design. As this thesis has shown, in the past VC design has been a neglected field for research in creative thinking. This thesis has been an exploration of an individual case-study. Nevertheless, the results of the reflection-in and on practice study have demonstrated that complex modes of thinking exist in VC design, as have been identified in other design fields such as architecture and engineering. Further, this study has demonstrated that an individual designer can carry out reflective practice and self-analysis of their creative strategies (Cross 2006, 2011). The study has provided a model that can be used by individual designers in any design discipline to investigate these creative strategies. Second, these results have potential implications for teaching VC design. The clearer the designer/design teacher is on the processes of their own creative strategies, the more they will be able to articulate these to novice design students. When tacit knowledge can be made verbal, it no longer carries the mystique of an intuitive ability but becomes a skill that can be explained. Third, these results have implications for the practice of creative strategies in scientific illustration, another much under researched area. One major point that emerged from the survey of experienced and highly regarded scientific illustrators was their immediate desire to talk about their practice, the thought processes behind their illustration work, and the value they placed on communicating their creative strategies. This could be a fruitful area for future research. The implications of the results of this study are discussed further in chapter 7.

6.8 Conclusion

This chapter has presented the results of the reflective practice which showed that there are incidents where my VC design and scientific illustration processes did not fit neatly within Cross's description of creative strategies. The major difference was that my approach to VC design was to define a brief before starting to design. This is in contrast to Cross's
finding using Protocol Analysis, that engineers, architects and product designers do not follow this process. The grounded theory method used for the reflective practice study provided a broad range of data and a more flexible means of data analysis than protocol analysis, allowing for difference and dissonance to emerge, rather than just focussing on linguistic analysis of predetermined categories, as protocol analysis does. The final chapter of the thesis concludes the thesis by reviewing the main findings and discussing implications of the findings for VC design for bird field guides and for theories of design thinking.
7. Conclusion

This chapter concludes the thesis by reviewing the main findings. Through the connection of birding, VC design and scientific illustration this research has resolved colour standardisation and visual representation issues inherent in current Australian bird field guides. At the same time it has used the design-led projects developed for this thesis to research the nature of VC design and scientific illustration design ability.

The argument of this thesis is that designers themselves are those best placed to reflect on their own practices and determine the creative strategies tacitly embedded in their own design thinking. The premise of this research is that it is the deeply personal insights of the designer in the act of designing that are the most valuable for understanding the process of design cognition, and these can only be realised by designers themselves while in the moment of designing. The methods developed and tested to investigate these propositions are a combination of protocol analysis and emergent grounded theory, which could be applied by VC designers to reflect on and examine their own design activity in other areas of VC practice.

This thesis proposes that VC design knowledge is transferable and useful to the natural sciences where accurate identification of species is essential, whether these are birds, plants or insects. It achieves this through a combination of formal research strategies and design-led projects that draw on the expertise of the VC designer and scientific illustrator, and also engages the assistance of birders.

Chapter 2 identified that bird field guides have not significantly advanced in their approach to the visual representation of information since their introduction in the late 19th century. This chapter argues that field guides need to take advantage of advances in 21st century design and production capabilities, and recommends the following design and illustration modifications are required in order to do so.

- Vivid images, in the form of an icon device, supported by theories of dual coding whereby image and text are positioned side by side will support learning and recall for the birder.
• The bird illustrations in bird field guides need to be scientifically accurate illustrations of birds as opposed to individual artistic impressions in order to further enhance the learning experience for the birder.

Chapter 3, the Perth Zoo Case Study, explored the findings from Chapter 2 that offered insight into improvements for the performance of bird field guides. This chapter also expanded the important understanding of the world of birders and their needs as end users of the guides, including how they use field guides and their personal strategies when identifying a bird. The case study employed a number of research methods including non-participant observation, in-depth interviews and online survey. The main findings included identification of the following issues:

• Colour standardisation in bird field guides for both the colouration of bird species and the nomenclature used to describe the bird is missing in current field guides. Colour standardisation is necessary to avert confusion for the birder when learning the colouration of a single bird species. Therefore colour standardisation and nomenclature need to be investigated further and the issue resolved in order to improve the performance of bird field guides.

• Current field guides follow the established tradition of using artistic and individualistic representation of bird species. However, scientifically accurate representations of birds are more desirable. Therefore, new techniques need to be explored in order to achieve a more scientifically accurate result.

In addition, findings in this chapter were:

• Birders and VC designers demonstrate highly developed skills in spatial awareness, categorisation and Gestalt laws of visual organisation. Although these skills are inherent to all humans as part of the human perceptual motor system, they can also be developed through engaging in activities that require those skills. The link between the skills inherent in the human perceptual motor system and the birder and the VC designer is important because it demonstrates that the VC designer can advance current visual systems in bird field guides through the deliberate employment of these skills. The value of these advanced systems is the enrichment of the identification abilities of the birder.

Chapters 5 and 6 tested the link in expertise between the birder and the VC designer in the context of bird field guides. It achieved this through the use of the VC design theories that link VC design with birding i.e., spatial awareness, and categorisation and Gestalt laws of visual organisation, as well as theories of colour standardisation, dual coding and icon design in the creation and performance of bird field guides.
Chapter 5 provided a detailed explanation of the process involved to resolve the lack of colour standardisation in the design, illustration and print production of bird field guides. It introduced the work of Robert Ridgway, who in 1912 produced a book of colour standards and colour nomenclature for the natural sciences. It established that Ridgway’s colour work is still in use by some natural science illustrators but that the application is traditional through the use of hand mixing colour and therefore does not meet the demands of colour standardisation for the 21st century. In response in this chapter:

- A digital colour palette based on Robert Ridgway’s 1912 Colour standards and colour nomenclature was created. The colour palette was tested against the prominent field marks of the Blue-winged Kookaburra.
- The process strategy used in the creation of the colour palette was explained and can be followed to create an extensive digital colour palette for all bird species. The concept is that all bird species are assigned their own field mark colours and these field mark colours are standardised. In the event of the scientific illustrator illustrating a particular bird, they would be required to use the assigned CMYK codes for that bird.

Chapter 5 took the new digital adaptation of Ridgway’s digital colour palette and applied it to two design-led experiments to test the viability of its application. The results transformed the way colour is created for bird species and represented in bird field guides.

The first design-led project involved the creation of a digital scientific illustration technique that uses Ridgway’s digital colour palette. The new illustration technique supports:

- Colour standardisations in the creation of bird illustrations, in this test case the Blue-winged Kookaburra. Colour standardisation is supported because the technique uses specific CMYK coded colours assigned to the Blue-winged Kookaburra.
- Colour standardisation in the print and production of bird field guides because the final illustration uses the same CMYK code that is used in the printing process.
- Scientific accuracy in the depiction of bird species field marks and form.
- The digital scientific illustration resolves two design issues in bird field guides that were identified in this thesis. Firstly, the technique is scientifically accurate to the bird form and field marks, and second, colour standardisation is resolved. Together, responses to these two issues simplify the transference of bird identification knowledge from the guide to the birder.

The second design-led project was the creation of the Identicon for the Blue-winged Kookaburra. The Identicon device is a progressive visual system developed for this thesis. The Identicon device draws on the complex set of VC design theories described above.
to develop an icon for the Blue-winged Kookaburra. Identification is at the core of the Identicon and the results include:

- **Identicons** are a result of the deliberate employment by the VC designer of spatial awareness, and categorisation, Gestalt laws of visual organisation, dual coding, colour standardisation and icon design. The results work directly to enhance the birder’s skills in bird identification.

- Currently birders learn to identify birds through reading descriptions of field marks in bird field guides and relying on their inherent abilities in spatial awareness, categorisation and Gestalt laws of visual organisation. Identicons deliberately draw from the intuitive component of the birder’s identification strategy and provide a tangible designed icon that can be learned. In effect, the Identicon simplifies the identification process for the birder.

- **Identicons** support colour standardisation because the colouration of the field marks is based on the specific CMYK code developed for the Blue-winged Kookaburra.

This thesis also provides the steps associated with how to produce both of the design-led projects, that is, the digital scientific illustration and Identicon.

Chapter 6, presents the reflective case study carried out while engaged in the two design-led projects presented in chapter 5. The research methods used for the reflective praxis included oral recordings and reflective note taking to capture my own design activity and the tacit-thinking that informs it. The reflective practice tools included an iPod and journal. The iPod was used to digitally record both reflection-in and reflection-on action, and the journal was used for note taking and to record reflection-on-action only.

This study introduced new VC design and scientific illustration research methods in the data analysis process. Rather than relying on the traditional protocol study tools, it included emergent grounded theories. The introduction of grounded theory as a research method was in order to keep the research open to emergent insights and theories in the data that extended the assigned codes associated with protocol analysis. The combination of analysis theories was also used to investigate design thinking, research into design processes, and the nature of the author’s VC design and scientific illustration expertise. Concurrently, the data were compared with Cross’s (2006, 2011) theories of design cognition in order to identify where the author’s VC design and scientific illustration practice sat with his theories. Cross (2011, p.2) argues ‘that many aspects of design thinking are common across the different domains, and so I (Cross) trust that my observations and comments will be valid across them all’. However, the results from the reflective practice data carried out for this
thesis suggests that the author’s VC design and scientific illustration engage in some but not all of the creative strategies as defined by Cross (2006, 2011). The key differences are in the creative strategies of problem formulation and solution generation. Specifically:

- The author’s VC design and scientific illustration engage in problem scoping and problem framing in order to define the brief. This is in opposition to Cross’s definition whereby designers engage in problem scoping and framing throughout the design process and do not define the brief.

- Cross asserts that a well-defined brief could confine the creative process, whereas this study suggests that in the case of the author’s practice it is the well-defined brief that encourages creativity.

- Cross suggests that setting and changing goals is part of the creative process and that this flexibility occurs throughout the design process as part of the problem framing process. In contrast, this thesis reveals that, for this VC designer and scientific illustrator, setting and changing goals occurred within the bounds of the brief.

- According to Cross, fixation in the design context is a creative strategy that is used by the VC designer and scientific illustrator. However, rather than fixating on a concept, the author’s design and scientific illustration practice fixated on style only. This is an important distinction because in the experience of the author, to fixate on a concept could lead to plagiarism, which is unacceptable.

- Cross states that some design domains engage in attachment to concepts, but in contrast, the author’s approach to VC Identicon design and scientific illustration support multiple concepts. This is because limiting the design process to one or two concepts may not lead to the ‘best’ solution for the brief.

The grounded theory methods used to analyse the reflective praxis data revealed potential research ideas, insights and creative strategies that are not noted by Cross. The findings presented are important to this thesis because they provide new knowledge and insight into design thinking for VC design and scientific illustration and offer themes for future directions. These include:

- Design cognition research into the designer who wears ‘two hats’. This means the designer who works across two domains, in this case VC design and scientific illustration.

- Modal shifts in the practice of the designer who works across two domains. These thought processes are not only complex but also bring added value to the design process. The one designer offers not only two perspectives but also brings a depth of knowledge of two areas of expertise to one project. In this thesis, dual abilities in spatial representation worked together in the creation of Identicon design as an
advanced system for identification of bird species. *Identicon* design can also be applied to other areas of the natural sciences that require identification strategies, for example, plants, spiders, insects and fish.

- The phenomenon of the ‘meditative state’ that emerged in the activity of illustrating. The meditative state is described as a level of focus that has a ‘singularity’ associated with it. In other words, the concentration becomes singular to the act of ‘illustrating’, which can mean during the time when the illustrator is using a paintbrush to apply colour, or texture or detail to one area of the subject. The phenomenon only occurs once the concept has been established and the form of the subject and composition is resolved. This phenomenon has not been explored in the context of scientific illustration in this study, but is worthy of further research.

- The new term tacit-motor activity is offered as a creative strategy that is activated through tacit-knowledge. Tacit-motor activity means those physical skills that the VC designer and scientific illustrator employ. For example, illustrating, sketching, working with design software and navigating the computer. These physical skills develop over time and with deliberate practice until they become automatic in the process. This study asserts that tacit-motor activity is a creative strategy that should have equal study credence with the thinking associated with tacit-knowledge because it is those skills that support the design process, and without them design solutions cannot be achieved.

- The idea of reflective practice and protocol studies of tacit-knowledge, the silent partner, is offered. This study identified reflective practice as a powerful creative strategy that could offer reasoning as to why designers often cannot recall when or how an idea came about.

To conclude, the research methods and findings presented in this thesis have direct implications for VC design and scientific illustration research and practice. The implications include research and practice theory and practical advice to both the VC designer and scientific illustrator. This study presents a theoretical model for reflective practice that is applicable to the individual designer/illustrator and design/illustrator researcher that can be used to identify tacit-knowledge within individual practice. That knowledge can then be refined and used in the design/illustrator’s own practice, and extended to the practice of future designers.

This thesis offers the VC designer the *Identicon*, a development model that demonstrates how to offer design expertise that extends to the entertainment world and into the sciences. It also offers the scientific illustrator a model that reveals how the scientific illustrator can integrate personal aesthetics with scientific accuracy that extends to colour...
standardisation in printed material.

Finally, the scientific and Identicon model extends representation from birds to include other
fields within zoology, particularly ichthyology (fish) entomology (insects), paleontology
(fossils and extinct animals), herpetology (reptiles and amphibians) (Pike, 2010).
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