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Shadows of another dimension: a bridge between mathematician and artist

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Shadows of another dimension: A bridge between mathematician and artist

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CERTIFICATION

I, Janelle Robyn Humphreys, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Creative Arts, in the Faculty of Creative Arts, School of Art and Design, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Janelle Robyn Humphreys

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ABSTRACT

The fundamental idea that provides a pathway through this exegesis is the Möbius strip. It is examined in relation to the mathematical influences on my art practice and consequently identified in the work of the Australian Modernists.

The other key link is the "bridge." The aim is to "bridge the gap" between my roles as artist and mathematician through an analysis of the making process of my painting and sculptures. Further, I establish a visual link between the Sydney Harbour Bridge, the Möbius strip and Australian modernist paintings.

The Möbius strip is introduced as a model for the paintings of William Robinson, contemporary Australian landscape painter. The Möbius strip is further established as a three-dimensional cross-section of the four-dimensional Klein bottle. It is the discussion of the similarities between shadows, cross-sections, and projections in relation to my practice which facilitates the understanding of the link between the Möbius strip and the fourth dimension.

My art practice is examined in relation to several mathematical properties including space-time sequences, systems of rules, non-Euclidean grids, transformations and the topology of the Möbius strip. Of particular importance in this analysis is the idea of the projection from one dimension to another and the associated connection to the properties of the Möbius strip.

The relationship between the Sydney Harbour Bridge imagery and the Möbius imagery is the final link forging the connection between the Australian Modernists and the Möbius strip. The Möbius strip trope is identified in several modernist Australian paintings including paintings of the Sydney Harbour Bridge. Subsequently, the influence of the fourth dimension and non-Euclidean geometry on Australian Modernism filtering through from the northern hemisphere is established.

The understanding of the relationship between the Möbius strip and the fourth dimension gleaned from my art practice was instrumental in detecting this mathematical influence on the Australian Modernists.

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For Geoff

And how will your night dances
Lose themselves. In mathematics?
Such pure leaps and spirals ----

Sylvia Plath, *Night Dances*

Shadow Waltz, the song with the stage-set winding around like a Möbius strip, from the musical film *Gold Diggers of 1933* directed by Mervyn LeRoy

1 Introduction: A bridging course

1.1 Rationalising

> **Rationalising:** Rationalising of the denominator means to get all the fractional powers out of the denominator of a fraction. After **rationalising** there should only be whole numbers on the bottom of the fraction and no surds (a number with a radical or root sign such as $\sqrt{2}$).[1]

The aim of this study is to bridge a common perception that there is a gap between the artist and the mathematician. As a mathematician this was never my experience as I have always observed a nexus between mathematics and art. In this project I affirm this through a mathematical analysis of the work of a number of artists and in particular of my own practice. The process of making projections from one dimension to another and the relationship between shadows, cross-sections and projections is examined and developed in relation to an understanding of the abstract fourth spatial dimension. Specifically, I document the conflation of my interest in both the mathematical and artistic aspects of the Möbius strip, a two-dimensional (2-D) surface that twists through three-dimensional (3-D) space, and its link to the fourth dimension and non-Euclidean geometry. The Sydney Harbour Bridge is also shown to "bridge" the gap or to provide the missing link between modern Australian art and the influence of the fourth dimension.

An impetus for this study was the book *The Fourth dimension and non-Euclidean geometry in modern art* by Linda Dalrymple Henderson, American mathematician and artist. Henderson documents in detail the intellectual influence that these geometries "which fascinated artists in the first decades of the twentieth century"[2] had on modern art. These "new" geometries formulated in the early nineteenth century were:

1. n-dimensional geometry, including four-dimensional (4-D) geometry, first discussed in 1840s

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[1] Definition adapted from: Carolyn Kennett, Liz Spielman and Janelle Humphreys, Mums the word: Macquarie University mathematical skills (Sydney: Macquarie University, 1995) 3. Teaching modules for bridging mathematics programs funded by a series of Macquarie University teaching development grants.

[2] Linda Dalrymple Henderson, The fourth dimension and non-Euclidean geometry in modern art (Princeton, N.J.: Princeton University Press, 1983) 3.

2. non-Euclidean geometries, including several different types, (see definitions in Chapter 2) initially developed in the1820s

Henderson discusses the “complex spatial possibilities suggested by a fourth dimension, as well as by the curved space of non-Euclidean geometry”[3] and their liberating effect on art from Cubism to Surrealism. Henderson was concerned only with northern hemisphere countries in which there was a strong body of literature connecting the artist to the mathematics. My study provides a link, via the Möbius strip, with contemporary and modernist Australian artists and these new geometries. Initially my search for the Australian link was precipitated by the attempts of contemporary Australian artist Imants Tillers to represent the fourth dimension in his 1970s appropriation of Marcel Duchamp (see Chapter 4, section 4.2).

Previous mathematical knowledge is not necessary for understanding this study. Mathematics relating to the Möbius strip, the fourth dimension of space and non-Euclidean geometry is introduced gently through images, cartoons, diagrams and tables rather than through mathematical notation. For example, the Möbius strip is introduced gradually through a practical example followed by the mathematical properties of the Möbius strip and how they are applied to an analysis of my artworks. At all times there is a deliberate attempt to exclude mathematical formulae apart from few highlighted definitions in “bridging course” style.

To introduce the use of the topology of the Möbius strip as a metaphor, an example of its application to the landscape of William Robinson’s painting is presented in Chapter 2. This chapter also serves as a visual introduction to the analysis of paintings using the Möbius strip properties and an introduction to the links that are made with the fourth dimension and non-Euclidean geometry. It is a common teaching device to demonstrate a practical use of a topic before presenting the mathematics involved.

In Chapter 3, as the properties of the Möbius strip are developed in greater detail, they are used to explain certain philosophical and formal applications to my artworks. In order to establish the capacity of this trope as a model for the analysis of my practice, Chapter 3 surveys an eclectic range of theorists and artists who have used the Möbius

[3] Henderson, The fourth dimension and non-Euclidean geometry in modern art xix.

strip and related ideas. In particular, the relationship between the Möbius strip and the fourth dimension of space is clearly established via the practical example of sculptures by American sculptor Tim Hawkinson and the "topodimensional" theory of American psychologist Steven Rosen. The Möbius strip is proposed and demonstrated to be the cross-section of the 4-D Klein bottle in order to clarify the relationship between the fourth spatial dimension and the Möbius strip.

In Chapter 4, formal aspects of my artistic practice are examined in relation to these and other related mathematical properties including, alternative grid systems and non-Euclidean geometry, sequences and systems of rules, chance or probability, time as a dimension, transformations and Boolean subtraction (Appendix 1). Specifically, the connection between "shadow," "cross-section" and "projection" is described with the idea of the "shadow of a shadow" being introduced and developed in relation to my practice.

Subsequently, in Chapter 5, the Möbius strip is applied to the analysis of some Modernist painters giving this study an art historical context. Works by several Australian modernist artists in which a Möbius strip can be identified are examined, adding to the literature on the influence of mathematics on modern Australian art as already firmly established for northern hemisphere art by Henderson. This completes a cycle by linking the fourth dimension to Australian Modernism via the Möbius strip, echoing the cyclical nature of the Möbius strip.

Another echo recalling the "bridging course" nature of this project is the Sydney Harbour Bridge and its architectural connection with Modernism, highlighted in Chapter 5. The arch of the bridge and its visual relationship to the twist in the Möbius strip is identified in relation to the twisted building sculptures of Australian James Angus and the arched entrance to the National Museum of Australia (NMA). Appendix 1 is a published paper in which I have examined in detail the relationship between the architecture of the NMA, the Möbius strip and the Australian Modernists adding another link between the fourth dimension and modern art.

The historical context for the project is established in Table 1.1 which identifies some important dates related to this topic and its recent relevance. In Chapter 6 the project is further rationalised by the establishing of the current position of the art / science connection and the proposing of areas of my ongoing visual arts research into the topic of dimensions inspired by areas of science.

1.2 Art and science / mathematics connection

This study was initially driven by an attempt to bridge a gap between art and science, in particular, the science of mathematics. The initial separation of science and art has been attributed by some to Aristotle, the "founding father" of different theoretical and practical disciplines, when he created disciplines and sub-disciplines for rational human thought.[4] In the West, the Renaissance continued this specialisation with art and science moving in different directions.[5] In spite of this, in the early twentieth century, science and art were more integrated, with scientists and artists speaking the same language. Henderson claims an art /science link via the fourth dimension of space.

> ... in the first two decades of the twentieth century, the idea promulgated by Hinton[6] and many others that space might possess a higher, unseen fourth dimension was the dominant intellectual influence (for both the arts and sciences) … [7]

Out of the development of n-dimensional geometry came a widespread fascination in the late nineteenth to early twentieth century with a "suprasensible fourth dimension of space of which our world might be simply a section."[8]

However, the new geometries also brought an end to this period of freedom with Albert Einstein actually using non-Euclidean geometry in developing his theories of relativity.[9] It was the widespread adoption, around 1919, of Einstein's *Theory of General Relativity* which contributed to a bifurcation[10] between the arts and sciences. Different "dialects,"

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[4] Diederik Aerts, Ernest Mathijs and Bert Mosselmans, eds., Science and art: The red book of 'Einstein meets Margritte' (Belgium: VUB University Press; Dordrecht; Boston, Mass.; Sold and distributed in North, Central and South America by Kluwer Academic Publishers, 1999) xvii.
[5] Stephen Wilson, Information arts: Intersections of art, science and technology (Cambridge, Mass.; London: MIT Press, 2002). 5.
[6] Charles Howard Hinton (1853 – 1907), British Mathematician.
[7] Henderson, The fourth dimension and non-Euclidean geometry in modern art xix.
[8] Linda Dalrymple Henderson, "Four-dimensional space or space-time? The emergence of the cubism-relativity myth in New York in the 1940s," Visual mind 2, ed. Michele Emmer (Cambridge, Mass.: MIT Press, 2005) 350.
[9] Bernard Cache, "A plea for Euclid," ANY Architecture New York 24 (1999). Cache examines the influence of non-Euclidean geometry on architecture.
[10] A England, "An artist encounters science: Dialogue and personal translations," Science and art: The red book of 'Einstein meets Margritte' eds. Diederik Aerts, Ernest Mathijs and Bert Mosselmans (Belgium:

or jargon, developed for the different disciplines making communication very difficult between scientists and artists. Henderson claims:

> … the popularization of Einstein's General theory of Relativity … brought an end to this era in which artists, writers and musicians believed they could express higher spatial dimensions.[11]

This was due to a shift in the comprehension of the fourth dimension: physicists were promoting "time" as the fourth dimension and, as a consequence, there was less interest in the possibility of a fourth dimension of space.[12]

1.3 Bridging the gap

A bridging course is designed to allay fears and to develop confidence in the subject matter. Written in simple lay terms, it addresses previous gaps in the knowledge of the participants and promotes another level of understanding allowing a re-energizing of their mathematical skills. This "bridging course" is no exception in its aim of addressing the gap in understanding concerning the fourth spatial dimension and the link between my artworks and mathematics, while at the same time aiming to demystify such links between mathematics and art. This approach via mathematics gives a new vitality to the analysis and perception of art works. The interweaving or "bridging" of this analysis with the physical making of my artworks provides not only a new interpretation of my work but also an opportunity for the unleashing of new visual imagery.

The idea of presenting in a bridging course style is attributed to Imants Tillers' Honours thesis of the 1970s, ironically titled *The Beginners' Guide to Oil Painting,* a reference to "how-to" or self help books of the 1970s, equivalent to the bridging course of today. Tillers' thesis is not about oil painting at all, but amongst other issues it questions the aesthetics of new conceptual art under such chapter headings as *What to paint*,

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VUB University Press; Dordrecht; Boston, Mass.; sold and distributed in North, Central and South America by Kluwer Academic Publishers, 1999) 168.

[11] Henderson, The fourth dimension and non-Euclidean geometry in modern art xix.

[12] Henderson, The fourth dimension and non-Euclidean geometry in modern art xix. The confusion over the fourth dimension as time is challenged in my exhibition *Sketches,* described in Chapter 4, in which I define the third dimension to be time.

Choosing the palette, *Cleaning up.*[13] Similarly, the chapters in this study have headings taken from topics in mathematics bridging course text books such as *Rationalising, Place value*, *Summing up.* A sprinkling of mathematical definitions is included to set the scene or to define certain mathematical words used in the text. In the manner of such bridging courses they are written in a popular style suited to the non-mathematician, including the "maths phobic" reader. While the scientific academic style of mathematical formulae is avoided in favour of visual explanations, certain aspects of a scientific style are deliberately retained because they are suited to the nature of this project. In particular, diagrams and tables are used as a convenient way of succinctly presenting my argument in a visual manner.

1.4 Not all numbers and geometry

My study focuses on aspects of mathematics not so frequently articulated in relation to the generating of images. Often the links between art and mathematics are assumed to be related to numbers, Euclidean geometry and the Golden Section or to sequences such as the Fibonacci numbers often found in nature. The assumed gap between the creativity of the arts and the more logical nature of mathematics is narrowed if mathematics is perceived as more than the study of such numbers and geometry, with the importance of the creative role of the mathematician being acknowledged. The nature of mathematics has changed considerably since Egyptian and Babylonian times when it was mostly about numbers (up to 500 BCE) and the Greek era when the chief concern was geometry (500 BCE to AD 300).[14] Michele Emmer, editor of art and science papers in *The Visual Mind II*, 2005, has a separate section for papers on art and mathematics from those on art and geometry, acknowledging the wider scope of mathematics.

Sometimes mathematics and artists are considered to be linked via the study of patterns. For example, mathematician G. H. Hardy claims "a mathematician, like a poet or a

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[13] Tillers' thesis is reproduced as an Appendix in: Graham Coulter-Smith, The postmodern art of Imants Tillers: Appropriation en abyme, 1971-2001 (Southampton Fine Art Research Centre, Southampton Institute, 2002).

[14] Keith J Devlin,The language of mathematics: Making the invisible visible, (New York: W. H. Freeman 1998), 15 January 2008 <http://iii.library.uow.edu.au/search~S0?/adevlin%2C+Keith/adevlin+keith/1,3,11,B/l856~b1500218&FF=adevlin+keith+j&6,,9,1,0/indexsort=->. 1.

painter is a maker of patterns."[15] Being more aware of the intuitive, aesthetic and creative aspects of mathematics, architect Robin Evans explains that "many professional mathematicians … regard intuition as essential to the performance or appreciation of mathematics of any sort."[16] This reinforces the idea of the creative nature of mathematics. A mathematician can in fact be considered a creative artist. This is reiterated in the *Foreword* to Hardy's book in which C. P. Snow says "he (Hardy) was clearly superior to Einstein or Rutherford or any other great genius … turning any work of the intellect, major or minor or sheer play, into a work of art." Snow then points out that "Graham Greene in a review wrote that along with Henry James's notebooks, this was the best account of what it was like to be a creative artist."[17] Greene wrote:

> I know no writing – except perhaps Henry James's introductory essays – which conveys so clearly and with such an absence of fuss the excitement of the creative artist.[18]

One example of this creative aspect of mathematics is seen in the process of the research mathematician who invents or "creates" new links between existing branches of abstract or "higher" mathematics.

"In Surrealism the fire of art and the ice of science have met," wrote Australian artist James Gleeson, referring to the synthesis of "the positive and negative, the light and dark, the logical and illogical."[19] This kind of perceived gap between the nature of science, including mathematics, and art is not uncommon today; to many, art and mathematics are poles apart. Mathematics is often seen as consisting of cold and rational rules while art is described as passionate and irrational.[20]

Others compare the elegance, beauty and symmetry of mathematics with art, claiming that they are innately linked. Because many do not appreciate the sense of the beauty of mathematics, artists are said to have helped bring some of that beauty out of its "cerebral closet." The idea of a "bare bones beauty" of an equation or an "elegant

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[15] G. H. Hardy, <u>A mathematician's apology</u>, Canto ed. (Cambridge England; New York: Cambridge University Press, 1992) 84-85.
[16] Robin Evans, <u>The projective cast: Architecture and its three geometries</u> (Cambridge, Mass. : MIT Press, 1995) xxix-xxx.
[17] Hardy, <u>A mathematician's apology</u> 13. In Foreword by C. P. Snow.
[18] Graham Greene, "Review: A mathematician's apology by G. H. Hardy," <u>The Spectator</u>.20 December 1940.
[19] James Gleeson, "What is Surrealism," <u>Art in Australia</u> November (1940): 28-29.
[20] Ivars Peterson, <u>Fragments of infinity: A kaleidoscope of math and art</u> (New York: Wiley, 2001) 13.

proof" is often quoted as reasons for an intrinsic connection between mathematics and art.[21] Ivars Peterson points out that the impulse among mathematicians to strip mathematics to its essence in search of an elegant proof has a counterpart among artists: those abstract painters who attempt to depict the world as it appears in its essence.[22]

Peterson also describes an artist's dialogue between material and theorems explaining the way in which a non-mathematician can share the pleasure a mathematicians takes in his work through experiencing sculpture. [23] Mathematicians feel that artists who do enjoy mathematics do not always understand its vastness. However artists and mathematicians can benefit from each other. Tony Robbins, an artist who has made use of inspiration from mathematics, insists that artists can make use of "riches that mathematicians stake out" and "introduce new viewpoints that contribute to the development of science..." [24]

This project does not enter into the debate about whether mathematics and art are linked. The assumption is that there is definitely a connection between mathematics and art, in particular through my art practice, given my previous career as a mathematician. I also leave the extolling of the artistic beauty or elegance of mathematics to others, while the aim in this project is to analyse the role of mathematics in my own art and also examine the role played by certain aspects of mathematics in the paintings of other Australian painters, particularly the Modernists.

1.5 Place value

> **Place value notation**: A system of representing numbers by an ordered sequence of digits where both the digit and its place value have to be known to determine the value. For example, the 5 in 53 indicates fifty because the place value is ten, but the 5 in 35 is just 5 units. The binary and decimal place-value systems are the two most commonly used.[25]

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[21] Peterson, Fragments of infinity: A kaleidoscope of math and art 4.
[22] Peterson, Fragments of infinity: A kaleidoscope of math and art 3.
[23] Peterson, Fragments of infinity: A kaleidoscope of math and art 18, 32. Peterson describes Helaman Ferguson's stone sculptures based on mathematical formulae.
[24] Peterson, Fragments of infinity: A kaleidoscope of math and art 134. Peterson quotes Tony Robbin.
[25] Christopher Clapham and James Nicholson,The concise Oxford dictionary of mathematics, (Oxford: Oxford reference online. Oxford University press. Sydney University, 2005), 18 March 2008 <http://www.oxfordreference.com.ezproxy2.library.usyd.edu.au/views/ENTRY.html?subview=Main&entry=t82.e2183>>.

The historical events that relate to my thesis are summarised in Table1.1 including: the discoveries of the Möbius strip and Klein bottle (rows 1-2); a competition to explain the fourth dimension of space in 1905 (row 3) and a similar competition to explain Einstein's theories in 2000 (row 11); the contribution of Marcel Duchamp and Imants Tillers to the fourth dimension (row 5-7); the revival of interest in Australian Women artists; Australian Modernist major retrospective exhibitions, since 2006, that highlight the artists discussed in Chapter 5, including Margaret Preston (row 12-13), Grace Cossington Smith (row15), Ethel Spowers, Dorrit Black and other Sydney Harbour Bridge artists (row 18, 24), Grace Crowley (row 19) and Sidney Nolan (row 25); recent uses in artworks of the Möbius / Klein motifs since they were first used in the 1940s (row 4) including Australian James Angus (row 16), American Tim Hawkinson (row 26) and Hungarian Attila Csörgõ (row 27) and contemporary Australian painter William Robinson's current (2009) exhibition of lithographs (row 28).

Table 1.1 Timeline of key mathematical and artistic events that contextualise this project

	Year	**Event**
1	1858	**Möbius strip** discovered by German mathematicians August Ferdinand Möbius(1790-1868) and Johann Benedict Listing (1808-1882)
2	1882	Klein bottle discovered by German mathematician Felix Klein (1849-1925)
3	1905	**Fourth dimension:** £500 competition to explain the fourth dimension in simple layman's terms; essays published by Henry Manning[26]
4	1930s	**Möbius strip** appears in sculptures such as Max Bill's *Endless ribbon*. 1935 – 1953[27]
5	1969	**Fourth dimension:** used by Marcel Duchamp in *Notes and projects for the Large Glass*[28]
6	1970s	**Non-Euclidean geometry**: Imants Tillers influenced by Duchamp and by reading of *Mt Analogue: A novel of symbolically authentic non-Euclidean adventures in mountain climbing*[29]
7	1972	**Fourth dimension** represented in Tillers' painting installation *Conversations with the bride*

[26] The fourth dimension simply explained: A collection of essays selected from those submitted in the Scientific American's prize competition, with an introduction and editorial notes, by Henry P. Manning, ed. Henry Parker Manning (London: Methuen & co. ltd., 1921).
[27] Max Bill, "The mathematical way of thinking in the visual art of our time," The visual mind: Art and mathematics, ed. Michele Emmer (Cambridge, Mass.: MIT Press, 1993) 5. Fig 1.
[28] Marcel Duchamp, Notes and projects for the Large Glass, trans. Arturo Schwarz, ed. Arturo Schwarz (London Thames & Hudson, 1969).
[29] Rene Daumal, Mont Analogue. English
Mount Analogue: A novel of symbolically authentic non-Euclidean adventures in mountain climbing (Harmondsworth: Penguin, 1986).

	Year	Event
8	1975	Linda Dalrymple Henderson's PhD thesis on the **fourth dimension and non-Euclidean geometry:** *The artist, the fourth dimension, and non-Euclidean geometry 1900 - 1930: A romance of many dimensions*
9	1980s	**Australian modernist** women artists: renewal of interest after feminist movement
10	1983	**Linda Dalrymple Henderson** published her historical book, *The fourth dimension and non-Euclidean geometry in modern art*[30]
11	2005	$2000 Competition to explain **Einstein's theory of relativity** in lay terms
12	2005	Rediscovery of the **Margaret Preston** rag rugs. Exhibition: *Berowra visions: Margaret Preston and beyond,* Macquarie University Art Gallery. 5 September - 14 October
13	2005	**Modernist exhibition:** ***Margaret Preston****: Art and life*, Art Gallery of NSW (AGNSW). Sydney. 29 July - 23 October 2005
14	2005	*Leonardo* journal announces a three year call for papers on the intersection of **Science and Art**
15	2006	**Modernist exhibition:** ***Grace Cossington Smith****: A retrospective,* AGNSW. 29 October 2005 - 15 January 2006
16	2006	**James Angus'** Möbius sculptures at the Museum of Contemporary Art (MCA), Sydney. 13 September - 26 November 2006
17	2006	Tony Robbin's new book on projections and cross-sections of fourth dimension called *Shadows of reality*[31]
18	2007	**Ethel Spowers,** *The works Yallourn*, 1933 exhibited in Joseph Brown Collection; permanent display from 6 October 2004 at The Ian Potter Centre: National Gallery of Victoria (NGV), Melbourne
19	2007	**Modernist exhibition:** ***Grace Crowley: Being modern****,* National Gallery of Australia (NGA), Canberra, on tour until February 2008
20	2007	Linda Dalrymple Henderson discusses the fate of the **fourth dimension** in reprint of her book
21	2007	75th anniversary of the opening of the **Sydney Harbour Bridge** which opened on 19 March 1932
22	2007	**William Robinson** painting sells under the hammer at $540,000 at a Sotheby's auction, Sydney
23	2007	**Möbius strip:** Margaret Preston rag rug *Hakea* under the hammer for $50,000 at Sotheby's
24	2007	**Sydney Harbour Bridge** Print exhibitions AGNSW and NGA including Dorrit Black, Ethel Spowers, Jessie Traill
25	2007-8	**Modernist exhibition:** ***Sidney Nolan*** exhibition at AGNSW. 2 November 2007 - 3 February 2008

[30] Henderson, The fourth dimension and non-Euclidean geometry in modern art.
[31] Tony Robbin, Shadows of reality: The fourth dimension in relativity, cubism, and modern thought (New Haven, Conn.; London: Yale University Press, 2006).

	Year	Event
26	2007-8	**Klein bottle sculpture:** *Tim Hawkinson: Mapping the marvelous*, MCA, December 2007 - 5 March 2009, including a Klein bottle; mathematical analysis of Hawkinson's sculptures by Clio Cresswell[32]
27	2008	**Möbius strip:** Hungarian artist, Attila Csörgõ, wins Nam June Paik Award 2008, the International Media Award of the Arts Foundation North-Rhine, Westphalia with *Orange space*
28	2009	**William Robinson** exhibition: *A life in lithograph.* Tweed River Art Gallery. Queensland **.** 4 December 2008 - 3 May 2009

Though discoveries of the Möbius strip and Klein bottle were first recorded in the 1800s (see Table 1.1, Rows 3-4) they are still of interest to visual artists this century. For example, Hawkinson's sculpture *Gimbled Klein Basket*, 2007 (Chapter 3, Figure 3.8) was exhibited at the Museum of Contemporary Art, Sydney, and was a subject of Clio Cresswell's mathematical analysis in a lecture on mathematics in art (Table 1.1, Row 26). In 2008 Atilla Csörgõ (Table 1.1, Row 28) won a major prize with *Orange Space*, in which the judging panel quoted:

> … a visual…apparatus record traces of light that in the form of a Möbius strip or an orange peel create entirely new visual experiences which escape the biological determinacy of human perception."[33]

This work aptly makes an art /science connection in the fields of biology, mathematics and visual art.

Table 1.1 is neither an historically complete timeline nor a comprehensive list of relevant artists and exhibitions. Rather, its purpose is to contextualise my project and establish its current relevance. In particular, rows 22 and row 28 show the current status of William Robinson, an artist whose landscape paintings were originally popular in the 1980s and will now be analysed in relation to the Möbius strip in Chapter 2.

[32] Clio Cresswell lectures in mathematics at The University of Sydney and is author of the popular mathematics book: Clio Cresswell, Mathematics and sex (Crowsnest: N.S.W: Allen & Unwin, 2003).
[33] Attila Csorgo awarded Nam June Paik Award 2008 posted 25 October 2008, Available: http://artipedia.org/artsnews/exhibitions/2008/10/25/, 15 January 2008.

2 Topology: Reinterpreting Australian landscape paintings: A Möbius model

Möbius band (or Möbius strip): A continuous flat loop with one twist in it. Between any two points on it, a continuous line can be drawn on the surface without crossing an edge. Thus the band has only one surface and likewise only one edge.

Please see print copy for image

2.1 Introduction: Bridging topic

In the spirit of a bridging course, keeping a visual arts audience in mind, this chapter acts as a bridge or introduction to the mathematical ideas of this project. Keeping in mind that the reader may not have a mathematical background, I will use a minimum of mathematical jargon in my explanation of the application of the Möbius model to William Robinson's paintings.[35]

Robinson is a contemporary Australian landscape painter who abandons the traditional representation of the landscape with its fixed viewpoint and linear perspective, taking his viewer on a pathway through the turning sphere of his painting. He has been variously labeled as religious, romantic, naïve, comic, monumental or sublime[36]. Trees and figures appear to sprout from impossible angles as the earth "twists" on this journey. [37] By comparison with the concepts of the Möbius strip and ideas gleaned

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[34] Christopher Clapham and James Nicholson,The concise Oxford dictionary of mathematics, (Oxford: Oxford reference online. Oxford University Press. Sydney University, 2005), <http://www.oxfordreference.com.ezproxy2.library.usyd.edu.au/views/ENTRY.html?subview=Main&entry=t82.e1848>.
[35] Wilson, Information arts: Intersections of art, science and technology 334. Wilson covers this issue of audience literacy in this comprehensive text on the cultural convergence of art, science and technology.
[36] Hannah Fink, "Light years: William Robinson and the creation story," Artlink 21.4 (2001): 13.
[37] Lynne Seear, "Landscape and meaning: The art of William Robinson," William Robinson: Paintings and sculptures: 2003-2005
eds. Lynne Seear and Ltd Australian Galleries Pty (Collingwood, Vic: Australian Galleries, 2005) 13. Robinson describes his painting in a handwritten essay in this catalogue.

from topology, string theory and projections from one dimension to another, I will introduce a model for the analysis of the space, multiple viewpoints and unusual tree angles in Robinson's paintings. The model will be developed in Chapters 3 and 4 in relation to my practice. In this chapter, the model will be applied to one of Robinson's paintings in particular. The application of the model will be compared and contrasted with what Robinson himself and others say about the structure of his painting. The Möbius model will also be proposed as a tool to re-examine the works of some Australian modernist landscape painters and this will be developed in detail in Chapter 5. A comparison of Robinson with the Modernists has the added advantage of shedding a different light on the work of a painter who has been difficult to locate "within the context of Australian art" [38] and difficult to classify in the "orbit of contemporary practice." [39]

The model was developed after certain similarities were noticed between my Möbius strip ceramics and the topography of Robinson's paintings. Möbius strip topology has been used widely in the visual arts. For example, it has been used in sculptural forms by American artist Brent Collins[40] and in topological modelling in conjunction with computer design in architecture.[41] Jean Baudrillard, as discussed further in Chapter 3, refers to the Möbius strip as an analogy for the exchange of information between a computer operator and the screen of the computer.[42] Three-dimensional (3-D) modelling of a painting has been used previously by Earle Loran who constructed models in order to analyse the paintings of Cezanne.[43] However, my 3-D model based on the Möbius strip topology has not previously been used to model spatial composition of landscape painting.

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[38] Fink, "Light years: William Robinson and the creation story," 13.
[39] Fink, "Light years: William Robinson and the creation story," 13.
[40] Brent Collins, "Geometries of curvature and their aesthetics," The visual mind 2, ed. Michele Emmer (M. Cambridge, Mass.: MIT Press, 2005) 77.
[41] Brian Massumi, Parables for the virtual: Movement, affect, sensation (Durham, N.C.: Duke University Press, 2002).
[42] Jean Baudrillard, Transparence du mal. English: The transparency of evil: Essays on extreme phenomena
trans. James Benedict, ed. James Benedict (London: New York: Verso, 1993).
[43] Erle Loran, Cezanne's composition: Analysis of his form with diagrams and photographs of his motifs (Berkeley Los Angeles University of California Press, 1946) 57-58.

2.2 The features of the Möbius strip

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Figure 2.1 Möbius strip with vector arrows at right angles to the surface[44]

While the properties of the Möbius strip are discussed in more detail in Chapter 3, they are introduced here in order to examine William Robinson's paintings. In addition, this analysis serves as a means of understanding or demystifying the properties via practical visual examples before tackling the more formal definitions.

Figure 2.1 shows a Möbius twist with vector arrows at right angles to the surface. The Möbius strip has exactly one continuous surface and exactly one edge. It can be made by taking a strip of paper and twisting it 180 ° before joining the ends. Because of its infinite continuous surface, it is sometimes taken as a symbol for infinity. The surface also has the property that outside becomes inside and vice versa. This is illustrated by the well known woodcut, *Möbius Strip II*, (1963), by Maurits C. Escher (Figure 2.2), of ants moving from inside to outside as they crawl around the endless surface of the Möbius twist.[45]

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[44] Konrad Polthier, Imaging maths - Inside the Klein bottle, Available: http://plus.maths.org/issue26/features/mathart/index-gifd.html, 10 February 2009. Image available as animation at this site.
[45] The mathematical art of M.C. Escher
Image: M.C. Escher, Möbius strip II (woodcut, 1963), Available: http://www.mathacademy.com/pr/minitext/escher/index.asp, 30 May 2006.

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Figure 2.2 Maurits C. Escher. *Möbius strip* II. 1963

Another feature of the Möbius model is that it conjures up an uneasy, mysterious sense of another dimension. This is discussed further in Chapter 3 and 4 in relation to notions of the fourth dimension of space. According to Nakahara Yūsuke:

> The reason that a Möbius strip gives one a strange sensation is that, conceptually, the distinction between "front and back" which ought to be clear has become ambiguous and vague. This phenomenon can also occur with other dualities such as "inside and outside," "up and down," "light and dark." [46]

This dilemma is illustrated in a cartoon by Japanese artist Mitsumasa Anno, *I am a prisoner of my thoughts* (Figure 2.3), in which a small devil, who is both inside a double glazed bottle with no base, yet outside of the double glazing, is wondering whether he is inside or outside of the bottle.[47] The bottle happens to be similar to a Klein bottle in which inside and outside become indistinct. The Klein bottle is the "3- dimensional equivalent"[48] to the Möbius strip and this is explained in detail in Chapter 3 through Figures 3.10 and 3.11.

[46] Mitsumasa Anno, The unique world of Mitsumasa Anno: Selected illustrations 1968-1977, trans. Samuel Crowell Morse, ed. Samuel Crowell Morse (London Bodley Head, 1980) 17.
[47] Anno, The unique world of Mitsumasa Anno: Selected illustrations 1968-1977 17. Plate 11.
[48] Steven M. Rosen, "What is radical recursion," SEED 4, electronic, 24 January 2009 <http://www.library.utoronto.ca/see/SEED/Vol4-1/Rosen.htm>.

Klein bottle: a closed surface with only one side, formed by passing one end of a tube through the side of the tube and joining it to the other end.[49]

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Figure 2.3 Mitsumasa Anno, *I am a prisoner of my thoughts*

2.3 Ceramic Möbius strips: An introduction to the Möbius properties

Features of the Möbius strip can be readily demonstrated using my ceramics. Because a Möbius strip is made by joining the two ends of a twisted ribbon-like surface, it is easy to make one in clay from a single twisted surface or slab. This provides a good

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[49] The Oxford dictionary of English (revised edition). ed. Catherine Soanes and Angus Stevenson (Sydney Oxford reference online. Oxford University Press. Sydney University, 2005), 17 January 2009 <http://www.oxfordreference.com.ezproxy1.library.usyd.edu.au/views/ENTRY.html?subview=Main&entry=t140.e41686>.
[50] Rosen, "What is radical recursion."

illustration of the continuous single surface property. Utilizing the property of one edge, a Möbius strip can also be made from one continuous clay coil emphasizing the continuous nature of the strip. Figure 2.4 is a ceramic double Möbius strip (two 180 degree twists) which will be used to model the multiple viewpoints in Robinson's painting.

Figure 2.4 Janelle Humphreys. *Double twist.* 1970-1990. Ceramic. 8 x15 x 6 cm

In my career as a mathematician I used tactile materials such as my ceramic Möbius strips to teach geometry (see another in Appendix 1, Figure 4). These same ceramic forms are now used as the basis of interpreting paintings with multiple viewpoints. With the intention of explaining the ideas using as little mathematical jargon as possible, I have taken a cue from Anno. He feels that if one tries to avoid mathematical terms by using non-technical verbal explanations, "the words seem to become trite."[51] To get around the problem he uses images or cartoons instead of words placed alongside quotes from famous authors to explain the mathematics. Following this lead, I present the mathematics in this chapter in a visual manner through my ceramics and diagrams superimposed over paintings.

[51] Anno, The unique world of Mitsumasa Anno: Selected illustrations 1968-1977..

2.4 Möbius model and William Robinson

Please see print copy for image

Figure 2.5 William Robinson. *Moonlight landscape*. 1987. Oil on linen. 147 x 193 cm. Private collection, Sydney[52]

Robinson's paintings of landscapes from the 1980s to the present depict trees at various seemingly impossible angles (Figure 2.5).[53] There is no single viewpoint from which to observe his landscapes as is often the case in landscape paintings based on linear perspective. The multiple or shifting viewpoints give a sense of a topography that is twisting and turning, like the rotating Earth. The similarity noticed between this topography and the topology of the Möbius strip was the catalyst for choosing a Möbius twist ceramic pot (Figure 2.4) upon which to model Robinson's landscape *Moonlight landscape*, 1987 (Figure 2.5). By sticking twigs at right angles onto the surface of the Möbius strip, I mapped the corresponding positions of the trees at right angles to the ground. Compare Figure 2.1 which has the vector arrows orthogonal, or at right angles, to the surface of the Möbius strip. In Figure 2.6, the model on the right has been superimposed on the painting on the left. The positions of a selection of trees have been mapped from the two-dimensional (2-D) painting onto the convex and concave surfaces

[52] Lynn Fern, William Robinson (Roseville East, N.S.W. : Craftsman House in association with G+B Arts International, 1995) 35. Plate 133.
[53] Robinson exhibited landscape paintings at Australian Galleries, Paddington, Sydney in 2005.

of the three-dimensional (3-D) model. In this diagram, the mapping on the right is shown using lines, rather than matchsticks, which are to be imagined as perpendicular to the surface, corresponding to the various angles of the trees.[54]

Figure 2.6 Mapping of Robinson's 2-D painting *Moonlight landscape*, 1987 (left), onto the 3-D ceramic Möbius strip *Double twist* (right) with outline of the model also superimposed over the painting.

2.5 A mathematics lesson: The fourth dimension and topology

> **Fourth Dimension: 1**. a postulated spatial dimension additional to those determining length, area, and volume. **2.** time regarded as analogous to linear dimensions.[55]

Before proceeding with further discussion of the model a mathematics lesson is presented, again through images. Another of Anno's drawings can help explain the fourth dimension of space. It illustrates the projection from one dimension to another by way of the shadow of a planet being cast onto the floor of some surreal world. The

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[54] This idea of modelling a painting in 3-D had its origin in a drawing class exercise in the Advanced Diploma of Fine Arts, Sydney Institute of Technical and Further Education, Meadowbank Campus, 2003.

[55] The Oxford dictionary of English (revised edition), ed. Catherine Soanes and Angus Stevenson (Oxford reference online. Oxford University Press. Sydney University, 2005), 16 January 2009 <http://www.oxfordreference.com.ezproxy1.library.usyd.edu.au/views/ENTRY.html?subview=Main&entry=t140.e29244>.

shadow, or projection, of the 3-D planet onto the plane is an ellipse of two dimensions. This demonstrates how, after projection, an object can lose a dimension.

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Figure 2.7 Mitsumasa Anno. The *shadow of the earth*

When an object is illuminated by the sun or by a light, it creates a shadow on the earth's surface or on the floor. What is important in this case is that though the object possesses three-dimensional mass, the shadow transferred to the surface becomes a two-dimensional outline. This is obvious; but the fact that "as an object becomes a shadow, one- dimension of the object disappears" will be important for the development of our discussion.

Tsuzuki Takuji, The world of the fourth dimension. (Kōdansha) [56]

Marcel Duchamp (after mathematician, Elié Jouffret) states that if the shadow (or projection) of a 3-D object is 2-D, by analogy, this means that the shadow of a 4-D object would be 3-D[57]. The link between shadows and projections and Jouffrett's statement is examined in more detail in Chapter 4. We can picture what a 3-D object looks like from its 2-D projections or shadows. For example, we can easily recognize a 3-D chair from its 2-D shadow. Tony Robbins explains this fully showing the ease of recognizing images from their shadows, even when distorted, compared with the

[56] Anno, The unique world of Mitsumasa Anno: Selected illustrations 1968-1977 45. Plate 39.
[57] Duchamp cited Jouffret: 'The shadow cast by a 4-dim'l figure on our space is a 3-dim'l shadow.' Henderson, The fourth dimension and non-Euclidean geometry in modern art 120.

difficulty of recognizing objects from their 2-D cross-sections or slices.[58] What would a 4-D object look like? Can we picture this from its 3-D projections?

Visually representing the fourth dimension was of interest to me in my previous role as a mathematics lecturer. I was making ceramic forms based on the Möbius strip at the time and felt there was something about the twist in its surface that represents a different dimension. If two flexible knitted Möbius strips are stretched and joined together along their single edges, a 4-D Klein bottle is formed, not unlike the bottle in Anno's cartoon (see Figure 2.3 or Chapter 3, Figure 3.8). It is not physically possible, in our 3-D world, to join the edges of the Möbius strips without making a hole in one of the strips. What we see in the 3-D Klein bottle is the projection into our 3-D world of a 4-D Klein bottle. Performing the inverse of joining, if we cut a Klein bottle in half, or in other words take a cross-section of a Klein bottle, we get a Möbius strip (see Chapter 3, Figure 3.9). Details of this cross-section are explained in depth in Chapter 3 through the work of sculptor Tim Hawkinson. Can we visualize a 4-D object (Klein bottle) from its 3-D cross-sections (Möbius strips)?

In order to visualize the fourth dimension we are challenged in that we must go outside of our usual 3-D space into 4-D space. It is this extra fourth dimension of space that gives one a strange sense of another world. This may account for the vague sensation of another space or spiritual world in Robinson's paintings. However, my application of the Möbius strip and the fourth dimension is in a spatial context, not in a spiritual context, even though the fourth dimension has often been considered as linked to the spiritual and the occult.[59] In my geometrical approach, I am visualizing the surface across which the viewer travels as he moves through the 3-D space of the essentially 2-D painting. The viewer moves from inside to outside, concave to convex, and from darkness to light. These binary opposites are discussed further in Chapter 3.

Why does the representation a fourth dimension of space cause so much concern? The definition of three dimensions involves axes taken at right angles to each other. Artists are familiar with the two dimensions of width and height of a painting. These measurements can be represented on axes at right angles to each other. Width can be

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[58] Tony Robbin, Fourfield: Computers, art & the 4th dimension (Boston: Little Brown, 1992) 64-65.
[59] The spiritual aspects of the fourth dimension is discussed at length by Linda Dalrymple Henderson in Henderson, The fourth dimension and non-Euclidean geometry in modern art.

represented on the horizontal axis with height on the vertical axis. In order to measure a piece of sculpture we need three dimensions. The axis for representing depth is added at right angles to both the width and height axes. However, it is impossible to add another axis at right angles to all three of these axes for height, width and depth in our 3-D world. This means it is impossible to represent the fourth dimension using this axis model of dimensions. It proved so difficult to visualize the fourth dimension of space that, in 1909, there was an essay competition run by *Scientific American* for a popular or layman's explanation of the fourth dimension of space.[60] While the existence of the fourth dimension can be explained, it is still difficult to represent in our 3-D world.

The desire to represent visually four spatial dimensions led me to investigate the model for string theory which physicists claim deals with up to twenty-six dimensions.[61] While this did not help with representing the fourth dimension, it did suggest a way of redefining dimensions based on curves as follows: "strings" are one-dimensional (1-D) curves or lines; "pathways" are formed by moving strings through space to define 2-D "membranes" and "tunnels," which are 3-D, are formed by twisting these membranes through space. This "curved" definition of dimensions was a visual trigger for the development of the Möbius model and the recognition of the Möbius strip in the work of the Modernists (Chapter 5).

> **Topology:** the study of geometric properties that are unchanged when we twist or stretch an object. It is sometimes said that to a topologist a teacup and a doughnut are indistinguishable. They are both solid objects with one hole in them![62]

Topology has been called "rubber sheet" geometry by John Willats in his topological analysis of images.[63] Imagine a figure printed on a rubber sheet which can be stretched and twisted so that basic spatial proximity and enclosure of the figure are unchanged, but lines do not remain straight, and distances between marks can change. Shapes are topologically equivalent if they can be made from each other by stretching as if on a

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[60] The fourth dimension simply explained: A collection of essays selected from those submitted in the Scientific American's prize competition, with an introduction and editorial notes, by Henry P. Manning.

[61] Ian Stewart, Flatterland: Like flatland but more so (London: Pan Books, Pan Macmillan Ltd 2003) 280-85. For a popular treatment, Stewart presents string theory in a non-threatening, non-technical manner in this humorous book.

[62] Peter Petocz, Introductory mathematics / Peter Petocz, Dubravka Petocz, Leigh N. Wood, trans. Dubravka Petocz and Leigh N. Wood, eds. Dubravka Petocz and Leigh N. Wood (South Melbourne :: Nelson, 1992) 11.

[63] John Willats, Art and representation: New principles in the analysis of pictures (Princeton, N.J.: Princeton University Press, 1997). Chapter 3 is on topological representation systems.

rubber sheet. For example, strings as described above are topologically equivalent to straight lines; imagine a rubber line that can twist and curve. Similarly, curved membranes are topologically equivalent to 2-D or flat planes. Möbius strips have convex and concave areas that can be shaped by twisting the membranes or pathways described above.[64] My Möbius ceramics are topologically equivalent to a Möbius strip made by twisting a strip of paper.

The combination of string theory and Möbius strips has been used in collaborative work between physicist, Lars Bergström, and sculptor, Cheryl Akner Koler. Using the artist's skills, they produced transparent diaphanous images of Möbius strips that were scanned using a 3-D point-cloud scanner. In turn, these became models to enrich the scientific research of the physicist.[65]

Marcel Duchamp uses the idea of the 3-D shadow of a 4-D object in his 2-D image *The large glass*, 1912.[66] For example, he includes an image of a series of "sieves" or twisting cones which depict 3-D projections of an imagined 4-D sieve (see Figure 2.8). Contemporary Australian painter Imants Tillers, who was influenced by his reading of Duchamp, also explores the possibilities of representing the fourth dimension in his *Conversations with the bride*, 1974-5. In one of the panels of this work he has appropriated the image of Duchamp's sieves (see also Chapter 5, Table 5.2).

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[64] Stewart, Flatterland: Like flatland but more so 281.
Stewart, who has been recognized for his outstanding contribution to public understanding of science, describes strings, membranes and the Möbius strip or "Moobius"(a cow character!) in this way.
[65] C Akner Koler and L Bergström, "Complex curvatures in form theory and string theory," Leonardo 38 (2005): 226-31.
[66] Henderson, The fourth dimension and non-Euclidean geometry in modern art 120.
Henderson cites Duchamp's notes on *The large glass.*

Please see print copy for image

Figure 2.8 Detail (right) of the sieves from Marcel Duchamp. *The bride stripped bare by her bachelors, even* (*The large glass*). 1915-23. Oil, varnish, lead foil, lead wire, and dust on two glass panels. 277 x 176 cm (left)

2.6 Robinson's view: Topology or topography?

It is also Marcel Duchamp who says, "It is the spectator who creates the museum."[67] He sees a work of art as being somewhere in the middle of the artist and the viewer and requiring both the viewer's response and the artist's action. While the mathematician may bring a new approach to the interpretation of painting, this may or may not have been the intention of the artist. With my background in mathematics I am "bringing" a model for the multiple viewpoints in Robinson's paintings using the Möbius strip. However, Robinson, by immersing himself in the landscape, also arrives at the multiple viewpoint model, probably subconsciously as a result of his experience of walking and living in the landscape. The experience of viewing Robinson's painting has been described by Lynne Seear:

> The multiple perspectives created by planes which recede, tilt and plunge, reinforce the feeling of a vastness in nature which is impossible to express or experience from a fixed viewpoint.[68]

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[67] Jeremy Bugler, "A masterpiece in your front room," New Statesman: 40.
[68] Lynne Seear, "The problem of interpretation," Darkness & light: The art of William Robinson ed. Lynne Seear (South Brisbane, Qld.: Queensland Art Gallery, 2001) 22.

While I have modelled Robinson's painting using an analytical approach based on the convex "outside" and concave "inside" surfaces of the Möbius strip, Robinson explains his own approach in his catalogue for his recent exhibition.[69] He hints that he did "construct" his paintings and interestingly refers to the duality of inside and outside.

> I have endeavoured to show the revolution of the earth through space and time. In order to achieve this I wanted to include the observer both inside and outside the picture.
>
> The picture implies an on-going existence apart from what is seen, i.e. the twists of the earth can be implied outside the painting from what is seen inside the frame…
>
> …The construction of the painting implies a helix-like twisting of space.[70]

Robinson included a diagram of his painting, showing the curve of the horizon and a linear helix which maps out a pathway through the image and out of the frame of his painting.[71] The diagram is further evidence that there was some mathematical "construction" involved in his painting which he describes as "showing what is above, in front and behind simultaneously, like the many images we take in at once when we are walking in the landscape."[72] This description also suggests Robinson may have been influenced by the Eastern tradition of landscape painting with its "shifting perspective" or "mobile focal point" which "break(s) away from the restrictions of time and space"[73] allowing the viewer to experience in one image everything that happens on a walk.

Table 2.1 provides a summary of the analyses of Robinson and others compared with my analysis of Robinson's landscapes via the Möbius model. Five different features are described in Table 2.1:

1. The multiple viewpoints, as indicated by trees at various angles, can be explained by vectors, which represent the trees positioned at right angles to the surface

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[69] William Robinson, "Creation landscape-the dome of space and time," William Robinson: Paintings and sculpture: 2003-2005 ed. Lynne Seear (Collingwood, Vic.: Australian Galleries, 2005).
[70] Robinson, "Creation landscape-the dome of space and time," 13-14.
[71] Seear, "Landscape and meaning: The art of William Robinson," 8.
[72] Robinson, "Creation landscape-the dome of space and time," 14-15.
[73] Chinavoc.com, Traditional Chinese Painting: introduction, 2001-2007, Available: http://www.chinavoc.com/arts/trpainting.htm, 20 January 2009.

of the Möbius (row 1 column 3). Others have described the earth as a turning sphere with planes which tilt and plunge as it turns.[74] Hence we are experiencing this change in time in one moment in Robinson's paintings and this explains the various angles of the trees. The wide-angle views that one experiences when immersed in landscape, could also account for the distorted angles of the trees (Table 2.1: row 1 column 2).

2. While the Möbius model (Figure 2.6) accounts for all possible angles of trees on the concave and convex sides of the Möbius surface (Table 2.1: row 2 , column 3), the wide-angle perspective does not account for the upside down trees. Robinson uses reflections on dams and other reflective surfaces as in *Creation night Beechmont*, 1988 (Figure 2.9), to account for these inverted trees (Table 2.1: row2 column 2).

Please see print copy for image

Figure 2.9 William Robinson. *Creation night Beechmont*. 1988. Oil on canvas. 143.5 x 193 cm. Private collection, Sydney [75]

3. The continuous pathway through the landscape can be explained by the continuous 3-D surface of the Möbius strip (Table 2.1: row 3, column 3). Robinson himself showed the pathway through his canvas or landscape using a continuous 2-D helical line (Table 2.1: row 3, column 2).

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[74] Seear, "Landscape and meaning: The art of William Robinson," 8. 8.
[75] Robert Tilley, Australian E Journal of Theology: Inaugural issue - August 2003: William Robinson and Nature, 2003, Available: http://dlibrary.acu.edu.au/research/theology/ejournal/aet_1/Tilley.htm, 19 January 2009.

4. The Möbius model provides an alternative pathway through the canvas to the usual linear perspective in which the viewer has one fixed view-point (Table 2.1: row 4 column 2). The critics account for the fact that there is no fixed viewpoint by comparing Robinson's perspective to Eastern perspective in which the viewer moves across the picture plane as though on a walk (Table 2.1: row 4 column 1).

5. Robinson takes the viewer both inside and outside the frame of the painting by extending his helix beyond the edge (Table 2.1: row 5 column 2). The Möbius model fits partly inside and partly outside the picture (Figure 2.6) in keeping with this intention. The Möbius model succinctly explains Robinson's unusual and unique depiction of space and the associated feelings that this arouses in the viewer.

Table 2.1 Features of William Robinson's paintings: Robinson compared with the Möbius model

Feature	**Robinson or other critic**	**Möbius model**
1. Multiple viewpoints with trees and figures at various angles	A result of the wide-angle views when viewer is immersed in landscape; the planes "plunge" and "tilt;" earth as a turning sphere	Various angles of the trees are modelled by placing trees orthogonal to the undulating surface of the Möbius strip
2. Inverted trees; "upside-down" effect	Mirror reflections in dams account for inverted trees[76]	Trees orthogonal to both the convex and concave sides of the Möbius strip
3. Continuous pathway through the landscape	Diagram of underlying structure shows a continuous helical line	Continuous surface of Möbius strip (recall Escher's ants)
4. Viewer has no fixed position	More in common with Eastern perspective; the observer moves across the picture plane as though on a walk through the landscape	Möbius model of perspective has no fixed view-point in contrast to the fixed view-point of linear perspective
5. Viewer inside and outside	Helix model crosses inside and outside of picture. Robinson states that he wants to include viewer both inside and outside of the picture	Möbius model extends beyond the edges of the painting Also, in the Möbius strip inside becomes outside

The Möbius strip accounts for the strange sensations one feels in a Robinson landscape. It allows for the dualities of up and down, inside and outside, night and day, light and dark, which are sensations that become blurred in Robinson's paintings. Compare the devil, in Anno's drawing of a Klein bottle (Figure 2.3), who felt a strange sensation

[76] Coulter-Smith, The postmodern art of Imants Tillers: Appropriation en abyme, 1971-2001 123. Imants Tillers used mirror reflections in depicting the fourth spatial dimension in *Conversations with the bride.*

wondering whether he was inside or outside of the bottle. In *Moonlight landscape*, 1987 (Figure 2.5) which I modelled on the double twist ceramic Möbius (Figure 2.6), the directions of the trees correspond to whether they are on the inside concave surface or on the outside convex surface of the Möbius strip. The patterns of light and dark are not easy to analyse in terms of convex and concave areas because the light, from the beams emanating from the top left hand corner, is catching all surfaces of the Möbius strip both inside and outside (Figure 2.5).

The variations in light can be seen more clearly in another of Robinson's paintings, *Creation landscape: Darkness and light v. Lost world landscape* (Figure 2.10).

Please see print copy for image

Figure 2.10 William Robinson. *Creation landscape: Darkness and light v. Lost world landscape*. 1988. Oil on linen. 147.2 x 193 cm. Art Gallery of Western Australia, Perth[77]

The light from the moon reaches the concave or inside of the curved surface and the convex side in the bottom left hand side is in darkness, yet the rocks are lit by the stars. These rocks are upside down on the convex side of the Möbius in the bottom left hand corner. Again, the Möbius model can explain the directions of the objects or figures at right angles to the ground. In my painting *Darkness and light* (Figure 2.11), after Robinson's *Creation landscape: Darkness and light v. Lost world landscape*,1988

[77] Fern, William Robinson 153. Plate 53.

(Figure 2.10), I used the Möbius model to organize the areas of lighter and darker tones in relation to convex and concave areas of the imagined surface of a Möbius strip. The use of the Möbius strip properties in my artworks is discussed in more detail in Chapters 3 and 4.

Figure 2.11 Janelle Humphreys. *Darkness and light* (after Robinson). 2006. Acrylic, ink & tape on canvas. 35 x 45 cm

2.7 Other artists and the Möbius strip

The Möbius model for William Robinson can be applied to other Australian landscape paintings. One can imagine a Möbius strip in the dynamic twists and turns of Roy de Maistre's painting, *Rhythmic composition in yellow green minor*, 1919 (See Chapter 5, Table 5.2.d).[78] Grace Cossington Smith's painting of the Sydney Harbour Bridge, *The curve of the bridge*, 1928-9 (Chapter 5 Table 5.2.c),[79] shows a hint of a twist of a Möbius strip in the sky, in the curved sweep of the bridge and in other parts of the landscape. These artists are discussed further, with reference to the significance of the Möbius strip trope in Australian modernist painting, in Chapter 5. Landscapes by Brett

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[78] Heather Johnson, Roy De Maistre: The Australian years, 1894-1930 (Roseville, N.S.W. : Craftsman House, 1988) Plate 8.
[79] Grace Cossington Smith, Deborah Hart and National Gallery of Australia, Grace Cossington Smith (Canberra: National Gallery of Australia, 2005) 41.

Whiteley (*Butcher bird with Baudelaire's eyes*, 1972), [80] John Perceval (*Diamond bay*, 1956),[81] Lloyd Rees (*The road to Berry*, 1946)[82] and Margaret Preston (*Flying over the Shoalhaven River*, 1942)[83] all of which display curved and undulating surfaces can also be mapped onto a Möbius strip model. The design of Margaret Preston's rag rug shows the twists and turns of a Möbius strip, thought to be the influence of the winding roads to Berowra Waters, where she worked and lived[84] (Chapter 5 Table 5.2.a).

In terms of topology, John Brack's paintings are of interest. The figures in the form of pens and pencils, cutlery or tiny children (*The playground*, 1959) [85] can be considered as figures in landscape. If the figures, like Robinson's trees, are considered orthogonal to the ground, the surfaces where their bases meet the ground can be imagined to map out a "Möbius-like" curved surface or sometimes a flat plane. In Robinson's painting *Grassy painting with William and Shirley looking at a Regency bower bird*, 1985 (Figure 2.12) the arrangement of the figures at right angles to the ground - animals trees and humans - defines the 3-D topography.

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[80] Barry Pearce, Brett Whiteley: Art & life (London: Thames and Hudson in association with the Art Gallery of New South Wales, 1995) Plate 140.
[81] Margaret Plant, John Perceval (Melbourne: Lansdowne, 1971) Plate 14.
[82] Lloyd Frederic Rees, Lloyd Rees, an artist remembers / Lloyd Rees with Renée Free, trans. Renée Free., ed. Renée Free. (Seaforth, N.S.W. : Craftsman House, 1987) 52.
[83] Margaret Preston, The art of Margaret Preston eds. Ian North, Humphrey McQueen, Isobel Seivl and Board Art Gallery of South Australia (Adelaide Art Gallery Board of South Australia, 1980) 50.
[84] Preston lived in Berowra Waters from 1932-1939. The rag rugs from that period were only recently discovered and shown at "Berowra visions exhibition: Margaret Preston & beyond," Macquarie University Gallery, 5 Sept - 31October 2005 in conjunction with her exhibition at the Art Gallery of New South Wales.
[85] John Brack, John Brack, a retrospective exhibition / Robert Lindsay; with essays by Ursula Hoff and Patrick McCaughey, eds. Ursula Hoff, Patrick McCaughey, Robert Lindsay and Victoria National Gallery of (Melbourne: National Gallery of Victoria, 1987) Plate 43.

Please see print copy for image

Figure 2.12 William Robinson: *Grassy painting with William and Shirley looking at a Regency bower bird*. 1985. Oil on canvas. 98 x 109.5 cm

There are also several artists working in three dimensions who have utilized the single surface property of the Möbius strip. For example, Max Bill began making sculptures, *Endless ribbons* in 1935, without realising they were Möbius strips.[86] Another ceramicist, contemporary New Zealand artist Rick Rudd, who has been making ceramics based on the Möbius since the 1970s was similarly unaware of the mathematics of the Möbius strip.[87] More recently, American sculptor Brent Collins based his forms on "constantly varying curvatures" (*Music of the spheres*, 1999)[88] and collaborated with mathematician Professor Carlo H. Sequin in a series called *Trefoil* sculptures.[89] Australian sculptor, Richard Goodwin used the Möbius idea in *Möbius Sea*, 1985, a spiraling white concrete sculpture with figures entwined in a spiraling twist.[90]

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[86] Collins, "Geometries of curvature and their aesthetics," 77.
[87] Rick Rudd, True to form: A survey exhibition of works 1968-1996 (Wanganui: Sarjeant Gallery, Te Whare O Rehua, 20 April – 3 June,1996). I visited Rudd in New Zealand in 1998 and he claimed he was not aware of the mathematics behind his work.
[88] Collins, "Geometries of curvature and their aesthetics," 141-57.
[89] Sculpture: Brent Collins - abstract forms, Available: http://www.hardwoodgallery.com/, 17 January 2009.
[90] Goodwin's sculpture, *Möbius sea* is located in the gardens surrounding the Art Gallery of New South Wales.

non-Euclidean geometry: A type of geometry that does not comply with the basic postulates of Euclidean geometry, particularly a form of geometry that does not accept Euclid's postulate that **only one straight line** can be drawn through a point in space parallel to a given straight line. Several types of non-Euclidean geometry exist. [91]

In Euclidean geometry due to Euclid's fifth postulate, parallel lines never meet and the angle sum of a triangle is 180° (see the plane in the diagram below).

In non-Euclidean geometry the parallel postulate does not hold and **no line** may be drawn through a point parallel to another line. They may be parallel for a while but eventually meet at the poles as in the diagram of the sphere below. Note the angle sum of the triangle is greater than 180° indicating that the surface is indeed convex (see the sphere below).

In another type of non-Euclidean geometry **more than one line** can be drawn through a point parallel to a given line, shown by the lines intersecting at a point in the diagram of the saddle below neither of which ever meets the other line. The angle sum of the triangle is less than180° as shown in the saddle below:

Please see print copy for image

[92]

The interest in these curved surfaces, in the first half of the twentieth century, is contemporaneous with the popularization of "new" mathematical developments of the curved non-Euclidean geometries.[93] The effect of the interest in non-Euclidean

[91] A dictionary of physics, ed. John Daintith (Sydney: Oxford reference online. Oxford University Press. Sydney University, 2000), 16 January 2009 <http://www.oxfordreference.com.ezproxy1.library.usyd.edu.au/views/ENTRY.html?subview=Main&entry=t83.e2074>.

[92] Figure from John F. Hawley, Organization of the Universe, 1999, Available: http://www.astro.bas.bg/~petrov/hawley99.html 2 February 2009. Linda Dalrymple Henderson includes two illustrations of different types of non-Euclidean geometry in Henderson, The fourth dimension and non-Euclidean geometry in modern art Plate 1 & 2. These are the Lobachevsky-Bolyai geometry represented on the concave Beltrami's Pseudosphere and Riemannian geometry represented on a sphere.

[93] Henderson, The fourth dimension and non-Euclidean geometry in modern art pasim. Henderson looks at the effect of these Non-Euclidean or curved geometries on painting movements from Cubism to Surrealism. The mathematics of the so called "new" geometries was actually developed earlier in the nineteenth century.

geometries and the fourth dimension has been documented in great detail for European art by Linda Dalrymple Henderson. However, the influence of the new geometries on Australian landscape painting has not been analysed. The Australian story will be the subject of further investigation in Chapter 5.

2.8 Möbius curves "out there"

Theorists interested in the formal analysis of pictorial composition such as Fred Dubery and Willats describe a curved picture plane as the basic structure of paintings in which there is a wide-angle view. One painting, which they analyse in this way, is *Vincent's room*, 1888, by Vincent van Gogh.[94] While Dubery and Willats use 2-D diagrams in their analyses of perspective, Erle Loran uses "picture box" models to describe the movement of planes and volumes in his intricate analysis of Cezanne's paintings.[95] Loran's models, like mine, involve a 3-D model to interpret the space in a 2-D painting.

While my interest is in the intrinsic aesthetic layer of a painting in relation to the curved motifs and their possible links with geometry / mathematics, the concern with organic curves need not necessarily bear a relation to a concern with geometry. Terence Maloon questions whether Richard Dunn was parodying the formal analysis of images in Dunn's *Attempting "Ten geometries from nature" (no. 1a & b),* 1978 (Figure 2.13). The diagram, which Dunn pairs with each photograph, might be a representation of the perspective in the photograph. However on closer examination it appears that while the image pairs are connected, they do not correspond exactly. Maloon writes:

> As the paired images reveal, the same regime of geometry used to construct perspectival space (as shown in the diagrams) is *already out there* in the world (as depicted in the photographs) in the parallel lines and grids apportioning the countryside into parcels of private property.[96]

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[94] Fred Dubery, Perspective and other drawing systems, trans. John Willats, ed. John Willats, Rev. ed. ed. (London Herbert, 1983).
This formal analysis and classification of perspective systems includes curved planes used to draw wide angle perspectives.
[95] Loran, Cezanne's composition: Analysis of his form with diagrams and photographs of his motifs.
[96]Terence Maloon, "The dialectical image," Richard Dunn: The dialectical image: selected work 1964-1992
(Sydney Art Gallery of New South Wales, 1992) 22. Maloon suggested that Dunn was parodying the pedagogical exercises of, say, Earle Loran's formal analysis of Cezanne's paintings.

Please see print copy for image

Figure 2.13 Richard Dunn. *Attempting "Ten geometries from nature" (no. 1a & b).* 1978. b/w photographs, graphite and red pencil on paper. 112 x 76 cm each[97]

Similarly, the curves with which I have analysed formal features of landscape paintings via the Möbius strip are also "already out there" in the curves of the beaches, the twist and turns of bush and coastal walks, the curves of the Sydney Harbour Bridge (see Chapter 5), the organic forms of nature or in the rotation of the earth. This could explain how Robinson, as artist in landscape, may have constructed intuitively what I, as viewer, established analytically: he was observing what was "out there" around him from the wide-angle views which naturally occur when the observer is immersed in the landscape.

2.9 Conclusion: Mathematics and art

In fifteenth century Florence linear perspective, with its fixed viewpoint, was discovered and used as "a means of symbolically promoting the individual, of placing the human subject at the centre of space."[98] My Möbius strip analysis is not meant to replace one form of formal prescriptive analysis with another. Rather, the aim is to suggest, through the example of Robinson's painting, how issues of representation and perception can be enhanced by an understanding of mathematics. Hence the concerns with spatial representation in Robinson's work, that viewers and critics discern, and the disruption to conventional notions of perspective and viewpoints in his work, can be more fully explored by bringing an understanding of mathematics to the reception of the work.

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[97] Maloon, "The dialectical image," 46.
[98] Maloon, "The dialectical image," 21.

While Robinson likes to draw our attention to the differences between his statistician brother and himself as an artist, perhaps he is more of a mathematician than he would have us think! In Robinson's lithograph, the placing of his brother John, the mathematician in academic robes, next to Robinson, the artist, dressed in more humble pyjama robes, could be interpreted as a symbol for the coming together of the arts and sciences.[99]

The model of the Möbius strip with vectors at right angles representing the different angles of the trees in the topography of William Robinson's painting has been presented as an example of the convergence of ideas from mathematics and art in developing new ways of seeing. There is a strong suggestion from William Robinson's own descriptions of his work that he may have also used some ideas from mathematics. The details of the fourth dimension, string theory and topology have been presented in order to explain the influencing factors behind the development of the Möbius model. Details have been deliberately simplified to avoid jargon as much as possible. Of importance in my work is the demystifying of mathematics and making the convergence of art and mathematics available to a wider audience.

The link with the Australian modernist painters of the first half of the twentieth century has been introduced in this chapter. This is developed in Chapter 5 which examines the connection between the Australian landscape which is "out there" and the underlying geometrical structure of the paintings. Chapter 3 examines some theoretical aspects in relation to six physical properties of the Möbius strip.

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[99] William Robinson, William Robinson: Self-portraits 2004, trans. Galleries Philip Bacon, ed. Galleries Philip Bacon (Fortitude Valley, Qld: Philip Bacon Galleries, 2004) 27.
The lithograph is *Professor John and Brother William*, 2004.

3 A twisted model

Je me surprends à définir le seuil
Comme étant le lieu géométrique
Des arrivées et des departs
Dans la Maison du Pere[100]

(I find myself defining the threshold
As being the **geometrical place**
Of the comings and goings
In my Father's House)

Please see print copy for image

Figure 3.1 Tim Hawkinson. *Möbius ship*. 2006. Wood, plastic plexiglass, rope, staples, string, twist ties, glue. 264.2 x 309.9 x 129.5 cm. Photograph by Steve Olivier [101]

3.1 Introduction: "The geometrical place"

The Möbius strip, or twist, is an impetus for ideas and often the physical grid, or as in the words of the prefacing poem by Jean Pellerin, "the geometrical place," used in the making process of my art practice (Chapter 4). It is also the mathematical model through which to interpret or analyse my paintings and, I argue, the work of several other artists (Chapters 2, 4, 5 and Appendix 1). In Chapter 2, the Möbius strip was used

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[100] Quoted from Jean Pellerin, La romance du retour (N,R,F. 1921) 18 in Gaston Bachelard, Poetique de l'espace. English: The poetics of space (Boston: Beacon Press, 1994) 213.
[101] Rachel Kent and John C. Welchman, Tim Hawkinson (Sydney: Museum of Contemporary Art, 2008) 122.

to model William Robinson's unusual angles of trees. These angles are also demonstrated in the masts of Tim Hawkinson's *Möbius Ship*, 2006 (Figure 3.1). In this chapter the mathematical properties of the Möbius strip are outlined (Section 3.2) and its connection to the Klein bottle is firmly established empirically, rather than mathematically, in keeping with the visual bridging course style (Section 3.11).

In order to illuminate properties of the Möbius strip, I explore eclectic yet related possible metaphorical uses of the Möbius strip and Klein bottle in contexts other than the visual arts (Sections 3.3 – 3.9). The disparate sources cross over various historical periods including philosophy, psychology, poetry, geomorphology and feminist theory. In some cases (Jean Baudrillard and Elizabeth Grosz) the theorist refers explicitly to the Möbius strip. This survey of the possible Möbius models is included to indicate the capacity of the strip as a model for nuances of dualities as applied to the collapsing of binary oppositions, an important movement in the late twentieth century. The implication for my painting practice is that, while the Möbius strip provides me with a means of physically traversing the two-dimensional (2-D) space of the canvas, it also has other significant applications. In particular, I apply the Möbius model in describing the compression of time (Section 3.8) and the merging of the nuances of binary opposites in my paintings (Section 3.12). Thus I will demonstrate how the features of the Möbius strip, can be the inspiration for the process and imagery in my creative practice as well as a tool for the interpretation of the finished works.

3.2 Properties of the Möbius strip

The Möbius strip has the following properties which are the basis of the model or metaphor:

1. It has a single surface changing from concave to convex or from inside to outside as the continuous pathway is traversed. While it seems to have two sides, paradoxically it has only one.
2. The Möbius surface has a line of stationary points, also called the line of inflection, on either side of which the concavity changes from concave to convex.
3. The one single edge is also a continuous pathway around which an object makes two revolutions before returning to the starting point.
4. It can be considered a symbol for infinity in that the pathway goes on ad infinitum.

5. The surface itself can move relative to a fixed point, as in a Möbius conveyor belt passing a fixed point.
6. It is regarded as the cross-section of the Klein bottle. In fact, if two Möbius strips could be joined along their continuous edges, a Klein bottle would result.[102]

The listed properties will be expanded upon throughout this chapter.

3.3 Nuances of binaries: Gaston Bachelard

In order to explain the Möbius model and my geometrical use of it, I will firstly refer to Gaston Bachelard's attempt to avoid geometry in *Dialectics of outside and inside* in the *Poetics of space*. Bachelard uses the house as a metaphor for humanness and "being." Here is a philosopher with knowledge of both the sciences and the arts affirming that "inhabited space transforms geometrical space."[103] While Bachelard himself might be critical of the "geometrization" of philosophy and hence avoiding it, I will show how his discussion of outside and inside can on the other hand be modelled geometrically. Referring to the reappearance of geometry in the words "spiraled being," he concedes that, "if we banish geometry from philosophical intuitions, it reappears almost immediately." [104]

In the *Dialectics of outside and inside* Bachelard veers away from the geometric discussion of outside and inside in favour of a literary discussion of these dualities, which are listed in Table 3.1. He further calls on mathematics in reference to set diagrams used by logicians for overlapping and exclusion (Table 3.1, row 2). When Bachelard mentions geometry he confirms his attempts to escape from it. He gives it a negative connotation by teaming it with the word "cancerisation."[105] However, I consider that Bachelard, while attempting to deny a link with mathematics and geometry, in fact could return to it in his search for a surface, a geometrical structure, to separate inside from outside.

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[102] Joining two Möbius strip in this way would require the fourth dimension of space. It has been tried with knitted Möbius strips of opposite orientation but there is always the need to make a tear in one of the surfaces in 3-D space. The Klein bottle as we see it is a 3-D projection of a 4-D Klein bottle.
[103] Bachelard, Poetique de l'espace. English: The poetics of space vii.
[104] Bachelard, Poetique de l'espace. English: The poetics of space 214.
[105] Bachelard, Poetique de l'espace. English: The poetics of space 213.

In my practice, I propose such a geometrical surface, the Möbius strip, as a model for these changes from inside to outside. The Möbius surface models both the inversion or the reciprocal of inside and outside and the gradual change from one to the other. For example, consider two stationary objects directly opposite each other separated only by the surface of the strip which also separates inside from outside. As one object travels around the surface, the Möbius strip, unlike a cylinder, also allows for the gradual change from inside to outside and vice versa (see property 1, 2). Bachelard describes the "countless diversified nuances" of inside and outside that can be realized by removing the idea of the reciprocal, or opposite, nature of inside and outside. I have modelled these same nuances on the geometrical model of the Möbius strip. Bachelard, however in keeping with the metaphor of the house, models the nuances of "half-way" on a door half-open or ajar.

In another example, Bachelard considers an inversion where the outside, freedom, becomes the inside, prison (see Table 3.1, row 3). Here the Möbius strip provides an appropriate model in that, as one travels around the surface, it is unclear whether one is on the inside or the outside. In fact, as the Möbius strip twists, the outside can gradually become the inside in moving very short distances across an imaginary line of points called the "line of inflection" (property 2). Concavity reverses on either side of this line of inflection. This means that on one side of this line of inflection the Möbius strip is concave (inside) and on the other side it is convex (outside). I see Bachelard referring to this change in concavity when he states that inside and outside are "always ready to be reversed."[106]

The words listed in Table 3.1 are for the purpose of summary and emphasis. The aim is to draw attention to the reciprocal nature of Bachelard's words, especially in relation to the headings "inside" and "outside" which can be modelled on the apparent inside and outside of Möbius strip. In some cases the column chosen for the words is arbitrary. For example, in row 10, "same" is on the column headed "inside" while "other" is on the outside. Irrespective of the column in which these words are listed, it is the nuances between these reciprocals or dualities that are of importance in this Möbius model. The Möbius strip in this way lends itself as a metaphor for depiction of imagery and analysis

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[106] Bachelard, Poetique de l'espace. English: The poetics of space 218.

of elements such as tone (light to dark) and direction (up or down) in my painting as described in this chapter (Section 3.9) and further in Chapter 4.

Table 3.1 Summary of Bachelard's dualities whose nuances can be modelled on a Möbius strip

	Inside	**Outside**
Bachelard: Door Half Open	being	non-being
	overlap	exclude (sets)
	security	freedom
	closed	open
	this side	beyond
	here	there
	interior	exterior
	concrete	vast
	positive	negative
	same	other

3.4 "Extreme" model: Jean Baudrillard

> Since the world is on a delusional course, we must adopt a delusional standpoint towards the world. Better to die from extremes than starting from the extremities [107]

It is quite natural that with a background in mathematics I would use a mathematical model - the Möbius strip - as a metaphor. However, this Möbius metaphor could be skimmed over by "maths phobics" as difficult jargon. On the other hand, mathematicians may feel the model is an over simplification of the geometry especially regarding property 6 in which the term "cross-section" is used rather loosely. Therefore, it is of some consolation to discover that there are others, non-mathematicians who have also used this metaphor. Jean Baudrillard is one of them, though he confesses he may be "delusional."

Baudrillard, in describing the Möbius topology, states there is "no better model of the way in which the computer screen and the mental screen of our own brain are interwoven." He mentions dualities such as "subject and object," "within and without," "question and answer," and "event and image." I have presented the Möbius strip firstly

[107] Jean Baudrillard, Transparence du mal. English The transparency of evil: essays on extreme phenomena, trans. James Benedict (London New York: Verso, 1993) 1.

as a model for dualities (property 1) and secondly as a model that provides a surface which can be traversed continuously (property 3). Baudrillard, recalling property 3, directly refers to the constant movement of information and communication around the surface of the Möbius or as he calls it the "twisted ring." He makes the connection between the infinity symbol (property 4) and the Möbius strip, also referred to in his title *Xerox and Infinity*.[108] He also uses property 5 in describing the information on the surface that moves relative to the two fixed points - the computer screen and the operator. Based on Baudrillard's ideas more words, that can be modelled on the Möbius strip, can be added to a table of dualities (Table 3.2).

Table 3.2 Summary of dualities from Baudrillard

	Inside	**Outside**
Baudrillard: Computer	subject (operator)	object (screen)
	within	without
	answer	question
	good	evil

3.5 Stationary points: TS Eliot on the still point

> At the still point of the turning world. Neither flesh nor fleshless;
> Neither from nor towards; at **the still point**, there the dance is,
> But neither arrest nor movement. And do not call it fixity,
> Where past and future are gathered. Neither movement from nor towards,
> Neither ascent nor decline. Except for the point, **the still point**,
> There would be no dance, and there is only the dance. [109.]

TS Eliot's poem is included to illuminate the point of inflection (property 2). After walking up a hill we reach a certain point at which the direction changes and we find ourselves walking downhill. This point at the summit is called the "stationary point" in mathematical terms or in the poem, the "still point." It is the point at which we are neither ascending nor descending. On a 2-D graph of a parabola this would be the point at which the slope is neither positive nor negative. In Eliot's poem it is where "past and future are gathered." Extracted from Eliot's poem the word "dance" is on either side of

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[108] Baudrillard, Transparence du mal. English The transparency of evil: essays on extreme phenomena 51-59.
[109] From *Burt Norton* in T. S. Eliot, Four quartets (London: Faber & Faber, 2001).

the still point and is therefore in both columns in Table 3.3, row 7. This hints that on the surface of the Möbius strip the dualities are breaking down; we cross the still point yet we are still on the same side – the single surface.

On the surface of the Möbius strip this changeover point, or line of points, marks the change in concavity of the Möbius strip. This is where the 3-D form[110] of the strip is neither concave nor convex. It is called the line of inflection in mathematics. In my practice, this takes on a practical significance in the process of attempting to glaze only the inside of my ceramic Möbius strips. I define this line of inflection with masking tape in order to define or demarcate the concave area to be glazed. Bachelard, in fact, calls it the "line of demarcation," while the poet Jean Pellerin in the poem prefacing this chapter refers to it as the "threshold." Philosopher Brian Massumi, taking a cue from Gilles Deleuze,[111] refers to this line of inflection as the "fold" upon which the Möbius strip doubles back or folds back on itself.[112]

The point of inflection of the Möbius strip matches the twist in the strip. It is the cross-over point where the gradual changes from one quality to its reciprocal (or binary opposite) occur. However, the Möbius strip has the capacity to model the deconstruction of these binary opposites which become one and the same on the single surface of the Möbius strip. Editor Adrian Parr's description of Deleuze's fold highlights that there is no simple inside or outside:

> On one level the fold is a critique of typical accounts of subjectivity that presume a simple interiority and exteriority (appearance and essence, or surface and depth).[113]

More dualities that can be modelled (or "critiqued") on either side of the point of inflection of the Möbius strip are listed in Table 3.3.

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[110] While the Möbius strip is a 2-D surface, it twists through and exists in 3-D space

[111] For Deleuze "the inside is nothing more than a fold of the outside." The Deleuze dictionary trans. Adrian Parr, ed. Adrian Parr (Edinburgh: Edinburgh University Press, 2005). 103

[112] Massumi, Parables for the virtual: Movement, affect, sensation 181.

[113] The Deleuze dictionary 103.

Table 3.3 Summary of dualities from Pellerin, Eliot and Deleuze

	Inside	**Outside**
Pellerin: Threshold	comings	goings
TS Eliot: Still Point	arrest	movement
	towards	from
	past	future
	ascent	decline
	flesh	fleshless
	dance	dance
Parr on Deleuze	depth	surface
	interiority	exteriority
	essence	appearance

3.6 Compressing time: Geomorphology and Kern

I often refer to the compression of time in interpretations of my paintings and this can be related to the Möbius strip. "Compressing of time" is a phrase I first heard used by a geomorphologist[114] in describing a woodcut image that depicted several events around a tsunami after a volcanic eruption in Lisbon in 1755. This natural course of events would have been in linear sequence: the earthquake, the tsunami, the fire. Here they are depicted simultaneously in the one image (see Figure 3.2). This non-linear arrangement of events is an example of the "compressing of time."

Please see print copy for image

Figure 3.2 Wood engraving. 1887 (Lisbon, Portugal) [115]

[114] Conversations with the late Geoffrey Steel Humphreys from Macquarie University, Department of physical geography

[115] Jan Kozak collection: Historical earthquakes, 2005, image, the Regents of the University of California, Available: http://nisee.berkeley.edu/elibrary/browse/kozak?eq=5234, 23 June 2008.

Geomorphologists often look at linear sequences of strata in cross-sections of the layers of the Earth. In describing the evolution of the landscape they refer to the transition from older layers compressed at the bottom of the soil profile to the younger, more recently deposited layers at the top. In a soil section one can see a sequence of events exposed at one moment in time. Imagine the Möbius strip made up of strata laid out like a pathway around the strip as seen in the changing coloured strips in Figure 3.3. The strata continue *ad infinitum* as one traverses the pathway as described in property 4 of the Möbius model. Unlike the strata laid out vertically in the soil profile, we cannot say which are younger or older and hence there is a sense of timelessness or a compressing of time modelled by the Möbius strip.

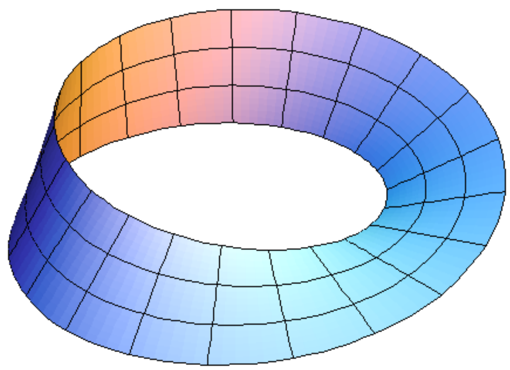

Figure 3.3 Möbius strip

Stephen Kern also uses the expression "compressing of time" in describing the "first simultaneous book" by Cendrars, 1912. This was "printed on a sheet two metres long … to be seen all at once so that the spatial limitations of one page after another would not chop up its wholeness."

> Time is compressed and reversed to break down the divisiveness of sequence, and space is ignored to undo the divisiveness of distance and bring together separate places in a single vision of his train. [116]

Kern describes the effect of the inventions of wireless telegraphy on the arts of the early twentieth century. Although the telegraph had been in operation since the 1830s, work

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Source: Georg Ludwig Hartwig, "Volcanoes and earthquakes: a popular description in the movements in the Earth's crust," The Subterranean World (Michigan: University of Michigan Library 1887).

[116] Stephen Kern, The culture of time and space 1880-1918 (Cambridge, Mass.: Harvard University Press, 1983) 72-3.

on the wireless telegraph began in the 1860s with a transmitter devised by Guglielmo Marconi in 1894. Telephone dates from 1876 and cinema was developed between 1893 and 1896. These inventions made it possible to experience, simultaneously, many different events in different places all over the world - another example of the compression of time.[117]

Kern describes simultaneity as "extending" the present spatially and discusses attempts that were made to extend the present in time as well. As an example he refers to Edmund Husserl's theory of melody retention with the experiencing of sounds that happen at different times. [118] Husserl explains how, in listening to a melody, the past sounds are retained and the melody taken in as a whole. [119] He states: "there is a perception of temporally successive unities just as of coexisting ones … also a direct apprehension of identity, similarity and difference."[120]

Another two words can be added to the table (Table 3.4, row 2) of dualities that can be collapsed by modeling them on the Möbius strip: the bringing together of "separate" events into a "single" event by compression of time.

3.7 Contracting time: Henri Bergson

In *Matter and Memory* Henri Bergson explores the reality of spirit and the reality of matter and how they can be related by memory.[121] Bergson describes how memory brings the past into the present and contracts many moments of time into a single intuition and thus compels us to see matter in ourselves.

> Memory, inseparable in practice from perception, imports the past into the present, contracts into a single intuition many moments of duration, and thus by a twofold operation compels us, de facto, to perceive matter in ourselves, whereas we, de jure, perceive matter within matter. [122]

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[117] Kern, The culture of time and space 1880-1918 67.
[118] Kern, The culture of time and space 1880-1918 81-83.
[119] Edmund Husserl, The phenomenology of internal time-consciousness / Edited by Martin Heidegger. Translated by James S. Churchill. Introd. by Calvin O. Schrag (Bloomington :: Indiana University Press, 1964) 40-4.
[120] Husserl, The phenomenology of internal time-consciousness / Edited by Martin Heidegger. Translated by James S. Churchill. Introd. by Calvin O. Schrag 41.
[121] Henri Bergson, Matière et mémoire. English: Matter and memory
trans. Nancy Margaret Paul and W. Scott Palmer (New York: Zone Books, 1988).
[122] Bergson, Matière et mémoire. English: Matter and memory
73.

Using the analogy of the Möbius strip we can represent Bergson's model of past imported to the present through memory. The memory is the surface of the Möbius strip. The single surface allows for a model of dualism but also a model for the bringing of apparent dualisms together (non-dualism). Just as we are wondering whether we are inside or outside of the Möbius strip the inside becomes the outside by either the strip moving relative to a fixed point, or by one's traversing of the surface, the continuous single surface. This single surface, now considered memory, can be seen as importing "the past into the present" [123] (Table 3.4, row 3).

Table 3.4 Summary of time related dualities to be collapsed on the Möbius strip by compression of time

Humphreys: Earth strata	younger	older
Kern: Time	single (event)	separate
Husserl: Music Memory	retained	forgotten
Bergson: Memory	single (moment)	many
	spirit	matter
	past	present

3.8 Compressing time in painting

In my practice I make use of techniques which compress time. Time can be compressed through the use of vertical layers of paint representing layers of memory. For example in a series of paintings of Kirkbride, the buildings of Sydney College of the Arts, there are layers representing the personal, geographical, archaeological and historical memories of Kirkbride, now an art school, previously an asylum. Through imagined memory, the past use of the building is brought into the present, thus compressing time. For example, in Figure 3.4, the shadows literally cast by present art students looking at the paintings are traced in blue lines over previous spiraling layers representing the past.

[123] Bergson, Matière et mémoire. English: Matter and memory 73.

Figure 3.4 Janelle Humphreys. *Friends at Kirkbride*. 2004. Acrylic and ink on canvas. 200 x 250 cm

The New Zealand beach tracings (Figure 3.5) also compress several events that occurred at different times and in different places along the beach into one image. The sequence of tidemarks visible in any particular "quadrat" (rectangular sample) maps several different time events in that particular space. Each tidemark represents the level that successive waves reached as they broke on the beach. As such they are already a naturally occurring, simultaneous image. By mapping these tidemarks from different quadrats of the beach onto one image, I am also compressing space, as well as time, by representing the information from all the quadrants in one image.

Figure 3.5 Tracing tide lines at Cable Bay, New Zealand

3.6 a

3.6 b

Figure 3.6 3.6 a: Janelle Humphreys *90 Mile Beach*. 2007. Acrylic on canvas.100 x 60cm. 3.6 b: Colin McCahon. *Six days in Nelson and Canterbury*. 1950. Oil on canvas. 88.5 x 116.5 cm. Auckland Art Gallery Toi o Tamaki[124]

In my travel diary series (Figure 3.6) I am collapsing time into the space of one canvas. The painting, *90 Mile Beach* consists of a series of images of sea and sand, originally drawn quickly from the passenger seat of a bus moving at speed along the beach (Figure 3.6a). Layers of paint link them in a way that interrupts the linearity of the sequence allowing the diary to be read along the curves as well as down the columns or across the rows of the grid of eight images. Compare this with the compression of time in New Zealander Colin McCahon's *Six days in Nelson and Canterbury*, 1950 (Figure 3.6 b) which is described as journey in time and also a spiritual journey.

> The fragmentary landscapes suggest glimpses flashing past the window of a bus or train, essentially similar, yet with varying moods…The 'six days' in the title echoes the Old Testament six days of creation.[125]

Consider also David Hockney's 36 paintings of Yorkshire, exhibited in six rows of six (Figure 3.7). It is intended that the viewer can choose to enter the whole image from

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[124] N Z Museums, Available: www.nzmuseums.co.nz/index.php?option=com_nstp&task=, 6 February 2009.
[125] N Z Museums. Citing extract from The Guide 2001

many (36) different viewpoints. The charm of the painting is not in the individual images, which are in the style of “Sunday painters,” but in the overall compression of time-in-space at the place of Hockney’s childhood home.

Please see print copy for image

Figure 3.7 David Hockney. *Midsummer: East Yorkshire*. 2004. 36-part watercolour on paper. 37.5 x 55cms each. Gilbert Collection Somerset House, London[126]

3.9 Depth-in-space and the Möbius model

A Möbius strip can be used to model depth. Consider that, in moving from outside to inside of a Möbius strip, the movement is from shallower (outside) to deeper (inside) layers. Successive deeper layers can be considered as a sequence in space along the surface of the Möbius strip. This deepening pathway around the surface would begin from a convex section (outside) to concave section (inside).

Feminist writer Elizabeth Grosz uses this notion of depth. She describes a corresponding movement on the female body from the exogenous surface to the endogenous zones of a body. Using such a Möbius metaphor, Grosz considers how signs or tracings on the surface of the female body, its corporeal exterior, are related to what is happening deep inside the body, its psychical interior. In her book, *Volatile*

[126] Gilbert Collection: A unique collection of English and Continental treasures, Available: www.gilbert-collection.org.uk/.../hockney550.jpg, 28 June 2008. Exhibition dates: 17 November 2005 – 5 March 2006.

Bodies: Towards a Corporeal Feminism the physical organization of chapters of the book is in fact also modelled on a Möbius strip.[127] This structure has the effect of reinforcing her thoughts on the relationship between inside and outside of the female body. Arguing for the "inflection of mind into body, and body into mind,"[128] Grosz is using the Möbius strip properties, in particular property 2 on inflection, to collapse Rene Descartes' mind/body dualism (see Table 3.5).

Table 3.5 More dualities that can be modelled on a Möbius strip

Grosz: Female body	deeper	shallower
	endogenous	exogenous
Gleeson: Art/science	fire	ice
	art	science
Robinson: paintings	concave	convex
	up	down

3.10 Science / art dualism and the Möbius model

Descartes established, in Western philosophy, the separation of the soul from nature. Known as Cartesian dualism, it is also responsible for the positioning of the mind as superior in relation to nature, including the nature of the body. Because the mind has no part in the natural world, knowledge of science was positioned as objective or having nothing to do with the subject. The mind / body opposition affected the foundations of knowledge itself in that science was seen as objective and impersonal in contrast to art.[129] When James Gleeson, the Surrealist artist, contrasts the ice of science (mathematics) with the fire of art, he is endorsing this (see Chapter 1, Section 1.3).

The mode of thinking behind Cartesian dualism could contribute to the still often perceived gap between mathematics and art that denies a whole range of interactions between the two. The Möbius strip model allows for their separation, yet also their interactions. If we position art and mathematics on different sides of the Möbius strip

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[127] E. A. Grosz, Volatile bodies: Toward a corporeal feminism (St. Leonards, N.S.W.: Allen & Unwin, 1994).
[128] Lynda Hall, "Review: Volatile bodies: Toward a corporeal feminism by Elisabeth Grosz," Sex Roles 31, book review, 27 January 2009 <http://findarticles.com/p/articles/mi_m2294/is_11-12_31/ai_114530026>. Interesting use of the language associated with Möbius strip in choice of the word "inflection."
[129] Grosz, Volatile bodies: Toward a corporeal feminism 6-7.

opposite each other they appear to be separated but paradoxically they are also linked by what is actually a single surface of the strip. The Möbius strip has been used in this way many times. An example is Jacques Lacan's use of the Möbius model in developing his theory of psychoanalysis. Lacan was influenced by Derrida's theory of binaries which are not defined as reciprocal or opposites of each other but actually exhibit a range of nuances between them. Derrida shows how "each term, rather than being polar opposite of its paired term, is actually part of it."[130]

Tables 3.1 to 3.5 presents a list of binaries that have been discussed in this chapter in relation to the collapsing of the dualism via the Möbius strip. While the Möbius strip trope is not a new one, I have chosen it for this discussion of art and mathematics because of its occurrence in visual imagery especially in the paintings of the Australian Modernists (see Chapter 5) and its connection with the fourth dimension of space.

3.11 The Klein factor: Four-dimensional space

Please see print copy for image

Figure 3.8 Tim Hawkinson. *Gimbled Klein basket*. 2007. Bamboo, motor, pulley, drive belt. 279.4 x 355.6 x 137.2 cm. Photograph by Joshua White[131]

The relationship between the Möbius strip and the Klein bottle is vital to the understanding of this study. Steven Rosen, philosopher and psychologist, considers the

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[130] Mary Klages, Literary theory: A guide for the perplexed (London Continuum, 2006) Chapter 4: Deconstruction. See also: Mary Klages, Structuralism / poststructuralism, 2008, University of Colorado, Available: http://www.colorado.edu/English/courses/ENGL2012Klages/1derrida.html, 1 July 2008.
[131] Kent and Welchman, Tim Hawkinson 143.

Möbius strip as the 3-D counterpart of the higher dimensional or 4-D Klein bottle [132] (see Figure 3.8). The Klein bottle is a continuous surface in 4-D space in which, like the 3-D Möbius strip, the outside becomes the inside and vice versa. In Rosen's theory, called "creative evolution," he uses the model of an n-dimensional being giving birth to its lower (n-1)-dimensional child in a "topodimensional family."[133] For example, consider the 4-D Klein bottle giving birth to the (4 minus 1)-D, that is, 3-D Möbius strip. [134] It can be demonstrated that if a Klein bottle is bisected then two Möbius strips result. The idea of "one dimension lower" is also an important part of this study in which a shadow or cross-section has one less dimension than the original object.

Empirically it can be shown that by knitting two Möbius strips of opposite orientation[135] then joining them along their single edge, a Klein bottle results.[136] The inverse suggests that the cross-section of a Klein bottle is in fact a Möbius strip, a fact reaffirmed by the observation of a Möbius strip in Tim Hawkinson's sculpture of a cross-section (or bisection) of a Klein bottle (Figure 3.9).

Please see print copy for image

Figure 3.9 Tim Hawkinson. *Fresnel Klein bottle*. Aluminium foil, urethane foam, toothpicks. 160 x 322.6 x 20.3 cm. Photograph by Joshua White [137]

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[132] Steven M. Rosen, Topologies of the Flesh: A multi-dimensional exploration of the lifeworld, 1st ed. (Athens: Ohio University Press, 2006) 68.
[133] Rosen, Topologies of the Flesh: A multi-dimensional exploration of the lifeworld 59.
[134] The Klein bottle is a 2-D surface in a 4-D space. Similarly the Möbius strip is a 2-D surface twisting through 3-D space.
[135] A Möbius strip can have left or right orientation according to the direction of the 180º twist.
[136] There is a problem with a tangled mess when trying to join these two edges. A hole must be made in one of the Möbius strips to complete the joining process. This hole corresponding to the break seen in the surface of theKlen bottle when made in 3-D space by Hawkinson in Figure 8.
[137] Kent and Welchman, Tim Hawkinson 140-41.

However, to the mathematician, there may seem to be a problem here in that the Klein bottle we observe as a 3-D object is really the projection of 4-D object into our 3-D space.[138] Rosen acknowledges that in developing his "creative evolution" theory he is using geometry in a rather non-rigorous manner. He is not deterred by the "correctness" of his mathematics and uses artistic freedom in his interpretation of geometry for his own purpose. Rosen points out some similar criticism Lacan received by mathematicians for his inaccurate use of mathematics in developing his theories.[139] While in my research, there may be a perception of a similar lack of mathematical rigour in relation to the space in which the Klein bottle exists, it is of no consequence to this project whether we are looking at the 4-D Klein bottle or the projection of it in 3-D space. Rather, what is important here is the inspiration from the geometry of the Klein bottle which I use as a geometrical model, or investigative tool, to trigger new ideas. It is through this sort of analogy rather than from strictly correct mathematics that my ideas have emerged.

> Analogy is a form of argument that gives you a poetic understanding of the mysteries of the world rather than a definitive one which depends on a branch of knowledge always being correct.[140]

Rosen explains the fourth dimension via Rucker's diagram of an alternative method for constructing a Klein bottle using a cylinder (Figure 3.11). Rucker compares the construction of a 4-D Klein bottle in a 3-D world with the construction of a 3-D Möbius strip in 2-D space (Figure 3.10) in the spirit of Edwin A. Abbot's *Flatland: A romance of many dimensions*.[141] Abbot writes about a 2-D world whose inhabitants try to envisage a 3-D world by taking 2-D cross-sections. In the same manner inhabitants of a 3-D space can envisage 4-D by taking 3-D cross-sections. *Flatland* was preceded by

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[138] Projections are discussed in greater detail in Chapter 4.
[139] Physicists Alan Sokal and Jean Bricmont were critical of Lacan's use of topology and mathematics in general. Rosen, Topologies of the Flesh: A multi-dimensional exploration of the lifeworld 6. Citing Alan D Sokal and Jean Bricmont, Fashionable nonsense: Postmodern intellectuals' abuse of science (New York: Picador 1999).
[140] Ann McCullock, author, in conversation on: "Poetry special: *The Death of the bird* by AD Hope." The book show. ABC Radio National. AM 576, Sydney. 16 May 2008.
[141] Edwin Abbott Abbott, Flatland: A romance of many dimensions, trans. Rosemary Jann, ed. Rosemary Jann (Oxford: Oxford University Press, 2008).

Plato's allegory of the cave in which those imprisoned could only see 2-D shadows (or cross-sections) of 3-D humans (see Figure 3.10). [142]

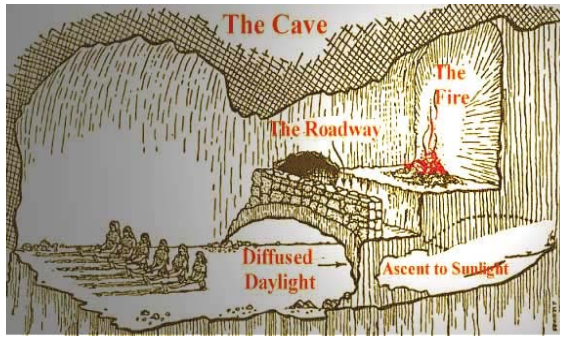

Figure 3.10 Plato's allegory: *The cave*

> "In the seventh book of "The Republic" the Greek philosopher Plato discusses our situation of the understanding of the world. In an allegoric view we live in a cave having our legs and necks chained so that we cannot turn around our heads and can see only before us. Above and behind us a fire is blazing at a distance, and between the fire and us there is a raised way; and we see a low wall built along the way, like the screen which marionette players have in front of them, over which they show their puppets. The situation is like in a movie theatre where we observe the shadow of objects on a wall using as a projector the light of a blazing fire. From these limitations we try our best to understand the world from the shadows of the objects." [143]

In a 2-D world one would have to intersect the strip in order to make the Möbius strip as there is no third dimension in which to twist. The Möbius strip thus constructed is actually the projection of the Möbius strip in a 2-D plane or space (see Figure 3.11).

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[142] Plato preceded Abbot with his allegory of the cave in which those imprisoned could only see 2-D shadows or cross-sections of 3-D humans projected onto the wall.
[143] Michael Lahanas, Plato's cave and inverse problems
Available: http://www.mlahanas.de/Greeks/PlatosCave.htm., 28 January 2009.

Please see print copy for image

Figure 3.11 Construction of a Möbius strip in 2-D requiring self intersection to join the ends of opposite orientation[144]

Similarly, with a Klein bottle, a hole must be made in the surface in order to construct a Klein bottle. Compare the knitted Klein bottle in which the joining of the two edges of the Möbius strip required a hole in one surface in order to join the edges to complete the Klein bottle. The Klein bottle in 3 dimensions must have its surface intersected, as in Figure 3.8 or 3.12, because it is actually the projection of a 4-D Klein bottle in 3-D space. In 4-D space a Klein bottle could be constructed without intersecting the surface just as it is possible to form the Möbius strip without self –intersection by twisting through 3-D space.

Please see print copy for image

Figure 3.12 Construction of a Klein bottle in 3-D space by joining two ends, of opposite orientation shown by the arrows, of a cylinder[145]

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[144] Rudolf v. B Rucker, Geometry, relativity and the fourth dimension (New York: Dover Publications, Inc., 1977) 54. Fig 76.

[145] Rucker, Geometry, relativity and the fourth dimension 54. Fig 74 & 75.

The understanding of the link between the Möbius strip and the Klein bottle serves as an introduction to:

1. the link between the Möbius strip and the fourth dimension as explained further in Chapter 4 in relation to my practice
2. a new examination of the role of the fourth dimension in Australian modernist painting in Chapter 5.

3.12 Application: Painting in the twilight zones of London

As an example of how theory and practice develop together, I will discuss my paintings in the London twilight zones around the Regent's Canal in terms of the Möbius model. This body of work shows how the model explains the dualities and the nuances of the in-between regions and how the Möbius strip also serves as a grid to position myself in the space in which I am painting and in the space of the canvas.

> **twilight zone**: (*a*) *spec.*, an urban area in which housing is becoming decrepit; (*b*) *gen.*, an indistinct boundary area combining some of the characteristics of the two areas between which it falls (*c*) occas., a dimly illuminated region [146]
>
> **twilight world:** (*a*) a shadowy region; (*b*) a world characterised by uncertainty, obscurity, or decline; (*c*) the world which comes to life after sunset, characterized by merry-making or criminal activities [147]

The words "decrepit," "dimly illuminated" and "indistinct boundary" in the definition of "twilight zone," and the words "shadowy," "uncertainty," "obscurity" and "decline." from "twilight world" aptly describe the less affluent area of North-East London in the Shoreditch and Hackney shires in which I spent six weeks painting. Descending the stairs took me to the canal walk, under the bridges, below the city, with its houseboats in murky waters, makeshift wharfs, and derelict factories and warehouses, but also with contrasting recently renovated residences and studios - a true twilight zone. I was in a twilight world in another sense too. London in winter could be said to be in perpetual twilight given the brief period of light. The sun, if it appears, is late to rise and sets early around 3 p.m. - 4 p.m.

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[146] Oxford English dictionary (O E D online), (Oxford: Oxford University Press 2008), 27 January 2009 <http://dictionary.oed.com.ezproxy.uow.edu.au/cgi/entry/50260594/50260594se17?single=1&query_type=word&queryword=twilight+zone&first=1&max_to_show=10&hilite=50260594se17>.
[147] Oxford English dictionary (O E D online).

twilight: *n.* 1. The light diffused by the reflection of the sun's rays from the atmosphere before sunrise, and after sunset; the period during which this prevails between daylight and darkness[148]

Figure 3.13 a

Figure 3.13 b

Figure 3.13 Janelle Humphreys. *London watercolours*. 2006. Oil pastel & watercolour on paper. 21 x 30cm

The Möbius strip with its continuous single infinite surface (property 4) in which outside gradually becomes inside (property 1), is a model for variation from light to dark, inside to outside, for the in-between, uncertain zones. There is a certain uncanny feeling if one moves around in a Möbius strip. For example, moving around in the image of Figure 3.13 b there is strange ambiguity: are we looking from the inside out

[148] Oxford English dictionary (O E D online).

from the arch of the bridge or outside in to the longboat on the canal ? Is the space concave or convex in Figure 3.13 b? Are we up or down, over or under the bridge? Is the image reflected or real in Figure 3.13 a? There are also the points of inflection, where concave changes to convex just as concavity changes on the surface of a Möbius strip.

While these paintings might suggest Möbius images in the curved pathways and arches of bridges, this is not the connection with the Möbius model of prime interest here. Möbius imagery will be a topic of prime consideration in Chapter 5, in the examination of the subject matter of the Australian Modernists. Though aware of Möbius-like shapes, in choosing my sites on the Regent's Canal, I was mainly conscious of uncanny regions and their variations between darkness and light, up and down, inside and outside, habitable and non-habitable spaces (Figure 3.13 b), and places of imprisonment, or security, and freedom – nuances that can be modelled on the changing Möbius surface. Note that the paintings of Kirkbride, *Friends at Kirkbride*, 2004 (Figure 3.4), now an art school, but formerly a "lunatic asylum" called Callan Park, also have a layer of meaning addressing the variations in security, imprisonment and freedom.

This interweaving of my practice and theory will be discussed in relation to further bodies of work in Chapter 4. For example, the "evolving" series of leaf sculptures in the exhibition *Evolve* have layers of meaning referencing fear of stagnation and imprisonment versus evolution and freedom. The gradual changes in the form of the sculptures reflect the underlying "evolving" sentiments that were the impetus for the works.

3.13 Conclusion: Möbius common threads

This chapter illustrates the six properties of the Möbius model through a range of sources, thus describing the essential features of the Möbius strip required for this study with as little mathematical jargon as possible. Various uses of the Möbius strip in other disciplines are apparent from this approach.

Property 1, the inside-outside property of the Möbius strip was discussed using Bachelard's *Dialectics of outside and inside.* This also provided an introduction to the

Möbius strip as a model for the deconstruction of binaries in my paintings. Depth was also related to property 1, in terms of movement from outside to inside in Grosz's model of laying out depth in space using the surface of the Möbius strip.

The continuous infinite pathway properties 3 to 5 were involved in Baudrillard's use of the Möbius metaphor for the exchange of information between computer operator and the screen.

Using property 2, the points of inflection of the Möbius strip were related to the still point in the TS Eliot poem *Four Quartets*.

Property 6 was presented through Rosen's "topodimensional" approach and Rucker's diagrams both defining the Möbius strip as a lower dimensional cross-section of a Klein bottle. This will be an important part of the discussion of projections and dimensions in my practice in Chapter 4.

Several references were made to compression of time and its use in my painting (Figures 3.4 to 3.6). The compressing of time, and the laying out of time-in-space by the strata on the continuous surface of a Möbius strip, was discussed in relation to geomorphology and compared with Kern's ideas of simultaneity of events. Bergson's theory of memory was modelled on a Möbius strip which provides a surface, representing memory, as a mechanism for the transporting of the past into the present.

The Möbius strip, an important tool in my research, is a connecting thread throughout the chapters. Interestingly, it can be used to model the art / science (mathematics) connection (Section 3.12). The non-linear Möbius model, in contrast to the well-established linear perspective model, allows for an explanation of the unusual angles of trees and multiple viewpoints in William Robinson's landscapes in Chapter 2. In Chapter 5, the Möbius strip will also be used to examine the influence of the fourth dimension on a number of Australian Modernists. Further, I present an interpretation of the National Museum of Australia via the Möbius strip in the paper in Appendix 1.

More mathematical aspects of my art practice will be described using the Möbius strip in Chapter 4. For example, the interplay between choice and chance in relation to my masking technique is mathematics related. The concave and convex areas of the surface that correlate with dark and light, inside and outside, and the gradual nuances of these, are the features of which I am intuitively aware when I am embedded in my surroundings. This has already been described with reference to the watercolour paintings in London's twilight zone (Figure 3.13). In Chapter 4, the Möbius strip will feature in the discussion of the process for the projection of the n-dimensional image onto the 2-D picture plane in my paintings.

4 The shadow of a shadow

Figure 4.1 Janelle Humphreys. *Eucalypt shadow of a shadow*. 2006. Natural materials. 10x 30 x 1 cm. Photograph by Janelle Humphreys. Nattai, NSW

4.1 Introduction: Möbius Strip and projections

In Chapter 3, the Möbius strip was proposed as a cross-section of the fourth dimension. Chapter 4 is focused also on shadows or projections of another dimension, including the fourth dimension, with the mathematical connections explained through descriptions of artworks from seven exhibitions of my work between 2005 and 2009. While up to this point the main focus of this study has been the Möbius strip, in this chapter the scope of the study is extended to cover other mathematical aspects of my practice as I survey the interweaving of my practice and research. Because of the Möbius strip's link with projections, it is once again identified as a recurring element in these artworks.

Interestingly, there is an association between the Möbius strip and projections by way of the projective plane at infinity. Since Leonardo da Vinci's time, the projective plane has been established as the plane where the parallel lines used in linear perspective in painting and drawing are said to meet at infinity. More advanced mathematics demonstrates how the projective plane can be made in the fourth dimension by joining the edge of a disc to the single edge of a Möbius strip.[149] However, because the Möbius strip has just one edge and the disc has one edge, this cannot be executed in our 3-D space without resulting in a tangled mess, reminiscent of the problem of joining the edges of two Möbius strips to make a Klein bottle. The projective plane, like the Klein bottle, needs the fourth dimension for its construction and thus is said to "live in the fourth Dimension."[150] For further reading on the mathematical details, see Tony Robbin who presents a short course on projective geometry in his book, *Shadows of reality*.[151] The technical details of the mathematics are beyond the scope of my study. However it is the fact that there is a link between the Möbius strip and projective plane that is important and exciting. It provides the "missing" mathematical link that reinforces the connection between the Möbius strip and the fourth dimension. Further, in Chapter 5, the Möbius strip will be shown to link the work of modernist painters with the fourth dimension, thus completing the cycle of connections: Möbius strip → Fourth dimension → Modernist painters → Möbius strip.

4.2 (n-1)-Dimensional projections

> **Projection:** A mapping from one coordinate space to another, possibly of a lower dimension. It takes the points of an object onto the points of a fixed plane (the view plane) in such a way that each pair of points is collinear with a fixed point, the centre of projection or eyepoint, which lies neither on the object nor the view plane. The main types of projection are parallel and perspective projections.[152]

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[149] Sculpture maths: The Mobius band and the projective plane, 2004 2002, University of Wales, Available: http://www.popmath.org.uk/sculpmath/pagesm/plane.html, 11 July 2008.
[150] From correspondence with Prof Ross Street, department of Mathematics, Macquarie University
[151] Tony Robbin, "Entr'acte: Chapter 5: A very short course in projective geometry," Shadows of reality: The fourth dimension in relativity, cubism, and modern thought (New Haven, Conn.; London: Yale University Press, 2006) 53-61.
[152] A dictionary of computing, (Oxford: Oxford reference online. Oxford University Press. Sydney University
2004), 20 March 2008
<http://www.oxfordreference.com.ezproxy1.library.usyd.edu.au/views/ENTRY.html?subview=Main&entry=t11.e4177>.

Orthogonal projection: A projection of a figure onto a line or plane so that each element of the figure is mapped onto the closest point on the line or plane. If X is the point and X' its image, this means that XX' will be orthogonal (or at right angles) to the line or plane.[153]

In the description of my process I will often refer to the projection of an n-dimensional object into a space that is one dimension lower or (n-1)-dimensional. The notation may be challenging and for the sake of clarity some abbreviations are explained here:

(n-1) is pronounced “n minus one”

n-D is the abbreviation for “n-dimensional”

(n-1)-D is the abbreviation for (n-1)-Dimensional

In Figure 4.1 the shadow cast (or projected) from the 3-D leaf sculpture has one dimension fewer than the original object. We could say the shadow is the 2-D projection (or shadow), of the 3-D leaf sculpture, interchanging the words “shadow” and “projection” in the manner of Robbin, who as well as being a mathematician (Section 4.2) is also an artist.[154] If we consider the 3-D leaf sculpture to be the shadow (or projection) of a higher-dimensional 4-D object, then the leaf sculpture can be described as the 3-D shadow of the 4-D object. Thus the 2-D shadow in Figure 4.1 is in fact the shadow of the leaf sculpture which is the shadow of another shadow (see Table 4.1). This idea of the shadow of the fourth dimension and visualizing what the fourth dimension might “look” like by examining 3-D cross sections, has already been introduced in Chapter 3 in relation to the Möbius strip as a cross-section of the 4-D Klein bottle. Also recall Anno’s cartoon, in Chapter 2, which introduced the idea of the loss of a dimension after projecting the shadow of the Earth onto a plane.

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[153] Christopher Clapham and James Nicholson., The concise Oxford dictionary of mathematics, (Oxford reference online. Oxford University Press. Sydney University), 20 March 2008 <http://www.oxfordreference.com.ezproxy1.library.usyd.edu.au/views/ENTRY.html?subview=Main&entry=t82.e2070>.
[154] Robbin, Fourfield: Computers, art & the 4th dimension pasim.

Table 4.1 The sequence of the progressive loss of a dimension from a 4-D object to its "3-D shadow" to its 2-D "shadow of a shadow"

	4-D*	**3-D**	**2-D**
Object in row 1	4-D object* (unknown shape)	3-D object Leaf sculpture (in Figure 4.1)	2-D shadow of 3-D object Shadow of leaf sculpture (in Figure 4.1)
Row 2 equivalence of row 1		3-D shadow of the 4-D* object	"Shadow of the shadow" of the 4-D* object
*This is the unknown object in the fourth dimension of which the leaf sculpture is considered a "cross-section" or "shadow" or "projection"			

Marcel Duchamp considered any 3-D form to be the projection, in our world, from a 4-D world. In his masterpiece, *The bride stripped bare by her bachelors, even*, 1915-1923, also known as the *Large glass*, he describes a 3-D projection of a 4-D bride depicted on the flat plane of the 2-D glass.[155] Imants Tillers was also interested in the fourth dimension and responded to this work of Duchamp's with a series of paintings, *Conversations with the bride*, 1975, in which he used reflective mirrored surfaces as a ground in his attempt to evoke the fourth dimension.[156] Duchamp states that the shadow, or projection, of a 3-D object is 2-D, and by analogy, in his notes on the *Large glass*, he writes, "The shadow cast by a 4-Dimensional figure on our space is a 3-dimensional shadow."[157] Duchamp, moreover, considered all 3-D objects to be projections of the fourth dimension into our 3-D world.[158] Visualizing the fourth spatial dimension from its 3-D projections is difficult, but translating this into art practice, we can more easily imagine the 3-D object from its 2-D projections. For example, consider the shadows of Bert Flugelman's sculpture and what they can tell of the3-D object which casts the shadows onto the 2-D ground (Figure 4.2) or the canvas in Figure 4.5).

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155 Dalia Judovitz, Unpacking Duchamp: art in transit (Berkeley: University of California Press, 1995) 64.
156 Wystan Curnow, Imants Tillers and the 'Book of power' (North Ryde, N.S.W.: Distributed in Australia by Craftsman House in association with G+B Arts International, 1998) 13.
157 Marcel Duchamp and Arturo Schwarz, Notes and projects for the Large Glass (London: Thames & Hudson, 1969) 36.
158 Duchamp quoting mathematician, Elié Jouffret, Geom à 4 dim. Page 86., in Curnow, Imants Tillers and the 'Book of power' 12-13.

Figure 4.2 left: Bert Flugelman. *Gateway to Mt Keira*. 1985. Stainless steel. 4 x 8m
right: The shadows of *Gateway to Mt Keira*. Photographs by Janelle Humphreys, 2007

"The shadow of a shadow," words taken from a collage by William Kentridge (Figure 4.3), is an apt title to describe the way in which my practice involves these shadows of other dimensions. *Shadow of a shadow* will also be the title of my graduation show (see Section 4.4)

Please see print copy for image

Figure 4.3 William Kentridge. Drawing for *Telegrams from the nose*. 2008. Indian ink, watercolour, coloured pencil, found pages and collage on paper. 25.2 x 23.5 cm[159]

Like David Hockney, Kentridge is interested in experimentation with "perspective and the aesthetic form."[160] His work exhibited at Cockatoo Island, Sydney, as part of the

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[159] Jane Taylor, "William Kentridge: Spherical and without exits: Thoughts on William Kentridge's anamorphic film *What will come (has already come)*," Art and Australia 45.4 (2008): 116-23.

16th Biennale of Sydney in 2008, demonstrates experimentation with anamorphic projections which are reconstructed into 3-D images through reflections in a steel cylinder. Because the reflected image appears to transform itself as one walks around the cylinder, there is a strange sense of another dimension of space.[161] This playfulness with dimensions is not uncommon in Kentridge's imagery. Another example of the interplay of dimensions in Kentridge's work is shown in Figure 4.3 in which a 3-D man steps through a chalk drawing of a man on a blackboard thus adding another dimension to the 2-D chalk drawing now floating in 3-D space.

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Figure 4.4 William Kentridge. *Dancing man*. 1998.
Gouache chalk paint on paper. [162]

Robbin, author of *Shadows of reality* (see Section 4.1)and *Fourfield*,[163] explains how all three words - "shadow", "projection" and "cross-section" - can be interchanged when referring to the lower-dimensional counterpart of a higher dimension. He contrasts the projection or shadow method and the cross-section method for visualizing a higher dimension. For example, the 2-D shadow of a 3-D chair, though distorted, tells us more

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[160] Taylor, "William Kentridge: Spherical and without exits: Thoughts on William Kentridge's anamorphic film *What will come (has already come)*," 611. Also see Chapter 2 for discussion of Hockney's multiple viewpoints.

[161] Kentridge's exhibition: *Telegrams from The Nose*. Annandale Galleries. Sydney. 11 June - 19 July 2008

[162] William Kentridge, Dancing man, image, Available: http://www.artic.edu/webspaces/fnews/2001-december/decfeatures3.html, 7 July 2008.

[163] Robbin, Fourfield: Computers, art & the 4th dimension.

about the appearance of the 3-D chair than a cross section of a chair would provide. However, were several cross-sections taken in sequence, a picture of the chair could be assembled in the same way that an ultrasound image reassembles a series of 2-D images taken at various sections through the body.

4.3 Mathematics in practice

> A portrait, a painting? You cannot paint today as you painted yesterday. You cannot paint tomorrow as you paint today. A portrait, a painting? Do not paint it of yesterday's rapt and rigid formula or of yesterday's day-after-tomorrow's crisscross ─ jagged, geometric, prismatic. Do not paint yesterday's day-after-tomorrow destructiveness nor yesterday's fair convention. But how and as you will ─ paint it today.
>
> HD, *Paint it today*[164]

In this section I will firstly explain where my imagery comes from and then in the following Sections 4.3.1 to 4.3.6, I will expand on how mathematics is involved in the bodies of work from my seven exhibitions between 2005 and 2009. Table 4.2 presents a summary of the mathematical properties in each exhibition.

When painting, my images are influenced by how I happen to be embedded in my surroundings. By this I mean I paint today what is happening around me today emotionally, spiritually, geographically, socially or intellectually. My reaction to this environment together with a ritualistic, systematic approach to painting my current surroundings results in a wide range of images. While I discuss the paintings analytically or mathematically, this usually comes after the making. The making processes, while based on systems or sets of rules for taping, unfolding, layering or pinning, does not necessarily produce works with a rigid, formulaic appearance. However, often the works are pictorially linked by a segmented appearance associated with these rules, giving them both organic and geometric qualities as a result of this construction and layering process.

While I have been researching the links between art and mathematics, this research has also influenced my painting. For example, in the exhibition *Sketches*, FCA Gallery,

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[164] (Hilda Doolittle) H. D., Paint it today, ed. Cassandra Laity (New York and London: New York University Press, 1992) 3.

University of Wollongong, 2008, I concentrated on painting in two spatial dimensions with time as a third dimension. This relates to my explanations of dimensions, especially the fourth dimension which physicists regard as time.

Often the spontaneous and raw application of paint, with the resulting "non-geometric" appearance of my images, contradicts one's expectation of a "mathematical" appearance. This may be due to the anticipation of hard edges or geometric straight lines commonly seen in other work based on mathematics. For example, all but a few of the 115 images in the appendix of *The fourth dimension and non-Euclidean geometry in modem art* by mathematician and art historian Linda Dalrymple Henderson have a predominance of straight lines giving the commonly expected geometric appearance.[165] However, many of the modern geometries are based on curved space of topological surfaces of non-Euclidean geometry.[166] Experimentation with such spaces is predominant in my art works and this results in the curving, organic appearance of my images. Henderson explains that it was the development of the non-Euclidean geometries in the nineteenth century that allowed for the flourishing of these curved perspectives. Rules of linear perspective in painting and drawing had previously been dominant since the Renaissance.[167] Two types of non-Euclidean geometry are described in Chapter 2 in regard to convex or concave curvature of space. In another type of non-Euclidean geometry there is the possibility of the curvature of the space varying and when a figure moves about in this space its shape can change. In Henderson's words:

> … figures may 'squirm' when they are moved about … It was this latter type of non-Euclidean geometry that would be of greatest interest to artists of the early twentieth century, such as the Cubists and Marcel Duchamp.[168]

Similar curved spaces observed in the Australian modernist paintings are discussed in Chapter 5.

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[165] Henderson, The fourth dimension and non-Euclidean geometry in modern art.
[166] Non-Euclidean spaces. See diagrams and description of some Non-Euclidean surfaces in Chapter 2
[167] Henderson, The fourth dimension and non-Euclidean geometry in modern art 5-6.
[168] Henderson, The fourth dimension and non-Euclidean geometry in modern art 6.

All of my processes involve a system or set of rules or "axioms" which is a mathematical idea in itself. In addition, the following mathematical ideas referred to as "properties 1-8" will be discussed.

The mathematical properties:

1. Projections from one dimension to another: mathematical, natural and using optical devices such as the epidiascope or over-head projector

2. The fourth spatial dimension: space rather than time as the fourth dimension

3. Alternative grid systems: linear and non-linear perspective, the curved grids of non-Euclidean geometry

4. Time as a dimension: compression of time; time as the 3rd dimension; space-time sequences; spatial representation of time, history, memory

5. Topology: topological surfaces such as the Möbius strip for exploration of nuances of reciprocal elements

6. Transformations and matrices: reflection (flip), translation (slide) and rotation (turn), (also in relation to Grace Crowley in Chapter 5)

7. Sequences and Boolean subtraction: addition and subtraction of layers (also Boolean Subtraction in relation to architecture in Appendix 1)

8. Probability and Chance: the interplay of choice and chance

Six exhibitions from 2005 to 2008, together with the proposed graduation show *Shadow of a shadow*, reflect successive stages in my research during this period into dimensions and projections and thus demonstrate how research and practice have been interwoven. Key works from each of the following exhibitions will now be examined in relation to these mathematical ideas.

The exhibitions:

1. *Translation*. Long Gallery, University of Wollongong. 2005

2. *Dimensions and projections*. University of Newcastle Gallery. 2006

3. *London watercolours.* Long Gallery, University of Wollongong. 2006

4. *Unfolding*. Adam House, Edinburgh, Scotland. 2006

5. *Evolve*. Glass Cabinets, Long Gallery, University of Wollongong. 2007

6. *Sketches*. FCA Gallery, University of Wollongong. 2008

7. *Shadow of a shadow*. Long Gallery and Glass Cabinets, University of Wollongong. Proposed show. 2009

The works exhibited show a diversity of imagery, media, style and size. However the common thread is in the analysis of the artworks based on the mathematical ideas which are involved. Particular common threads are the Möbius strip and the projection from one dimension to another. As already explained, a process governed by a system or set of rules is another commonality. The common threads often lead to some notable similarities in imagery. Compare the piece-wise segmented appearance of the taped watercolour sketches of the shadows of the National Museum of Australia (Figure 4.5) with the segmented appearance of the leaf sculptures (Figures 4.1, 4.14 and 4.17). The use of masking tape also gives a constructed or sculptural appearance to the Flugelman paintings (Figures 4.5 and 4. 7 a & b).

4.3.1 Translation

The mathematics in this exhibition included the compression of time in tracing shadows at different times of the day of Bert Flugelman's sculpture, *Gateway to Mt Keira*, 1985 (Figure 4.2). The sculpture, a gigantic steel construction, resembling a toaster element, frames Mt Keira and casts ever-changing sinuous shadows on the lawns of the Western campus.

"Translation" (or slide) is used in mathematics, alongside words like "rotation" (turn) and "reflection" (flip), to indicate the particular quality of a transformation or change. My studio changed location in 2005 and this exhibition documents that "slide" in my personal journey from Sydney to Wollongong. *Translation to Wollongong* (Figure 4.5), represents my first visual impression of the University of Wollongong. Painted in 2005, this painting was the initial inspiration for both my practice and research into dimensions and their projections.

Figure 4.5 Janelle Humphreys. *Translation to Wollongong*. 2005. Acrylic and ink on unstretched canvas. 120 x 400 cm

Painted on 10 pieces of un-stretched canvases that were laid under the shadow of the sculpture, it records the moving shadows traced with masking tape. An ongoing theme in my painting has been the interplay between choice and chance. The purpose of using masking tape is to follow a set of chosen rules in making the image and further removing a degree of choice in creating chance effects when the tape is peeled off while the paint is still wet. The use of roughly torn tape is in deliberate contrast to the geometric abstractionists' precise use of tape for hard straight edges in the1960s. Together with the skewed grid of the un-stretched torn canvases, this results in a raw, organic quality which provides a counter-play to the formal geometric qualities of the steel object casting the shadows. Natural greens of the Illawarra escarpment and the blues of the seaside city contrast with the rusty, metallic colours of the nearby steelworks and the silver greys of Flugelman's sculpture.

Mathematical properties discussed in relation to this exhibition, as summarized in Table 4.2 include: property 1 in the depiction of shadows as projections; property 3, 4 & 7 in the non-linear imagery due to the compression of time in the sequence of shadow tracings at different times of the day; property 5 in the topological skewing of the image of the sculpture; property 6 in the transformation of "slide" and property 8 in the chance effects from the use of tape.

4.3.2 Dimensions and projections

The paintings in the exhibition *Dimensions and projections* refer to several properties, in particular to mathematical property 1 on projections from one dimension to another as the title suggests. One of the problems when tracing shadows is their elusiveness, dependent on weather and seasons. The absence of shadows is also a consideration of my paper on the National Museum of Australia in Appendix 1. The shadows seen in Figure 4.6 b & c only occur at certain times of the year.

4.6 a

4.6 b

4.6 c

Figure 4.6 a: Janelle Humphreys. *Shadow and light* (from series of 4). 2006. Watercolour oil pastel and tape on paper. 30 x 21 cm. b & c: Tracing the shadows and light on the floor of the NMA in preparation for a painting *Trace of a trace.*

The lack of sunlight was also a problem when tracing shadows of the Flugelman sculpture. On overcast days, while waiting for the shadows of the sculpture, the works on paper in Figure 4.7 were painted with a focus on the changing scale and proportion at different distances from the sculpture. When these paintings are viewed in a series of eight, there is a variation in scale (another mathematical idea) in the zooming in from distant view to close up. In each individual image there is also the predetermined taped pathway of the process in which the size of the painting is gradually increased in a particular sequence across the canvas as successive layers of paint are added (property 7). Once again the interplay of the organic and the geometric is evident. Unexpectedly the garden plants have a hard-edge, geometric quality, while the geometric sculpture has a more organic curvilinear appearance. Drawing with tape has the effect of flattening the image giving the 3-D sculpture the appearance of a 2-D shadow. The marks on the lawns, actually lawn mower tracks, also could be confused with shadows (property 1). Are they shadows of a shadow? This ambiguity adds an eerie sense of another dimension to *Waiting for the shadows* (Figure 4.7 a, b).

4.7 a

4.7 b

Figure 4.7 a & b: Janelle Humphreys. *Waiting for the shadows* (2 of series of 8). 2006. Acrylic and ink on canvas. Each 56 x 65 cm

4.3.3 London watercolours revisited

As described in Chapter 3, this series, of 15 watercolours, expressing nuances of the binaries that can be modelled on a Möbius strip (property 5), was painted on site, in winter, during walks along the Regent's Canal, London. Many of the paintings exhibit property 3 in their non - linear grids and curvilinear appearance (see Figure 3.13, Chapter 3). The paintings from this "twilight" region also evoke a sense of another dimension (property 2). In Figure 4.8, there is an eerie feeling created by the ambiguity between inside and outside and the dark tones in the view from the window of the old school building at twilight. This mystic, occult and "otherworldliness" aspect of the fourth dimension, as discussed by Charles Howard Hinton and Claude Bragdon from America and the Russian mystic Peter Demianovich Ouspensky, is documented in detail by Henderson.[169]

Figure 4.8 Janelle Humphreys. *Twilight, Thomas Fairchild school*, 2006. Watercolour, graphite and oil pastel on paper, 30 x 21 cm

[169] Henderson, The fourth dimension and non-Euclidean geometry in modern art 186-99.

4.3.4 Unfolding

The paintings in *Unfolding* project the shape and texture of 3-D objects onto the 2-D plane of the canvas, resulting from wrapping the objects in folded canvas then rubbing with brush and ink (property 1). The canvas was initially folded into a precise sequence of folds (property 7) and then expanded in surface area as it was unfolded to accumulate subsequent layers of ink. On paper, this translated to increasing the paper size gradually by unfolding it as the graphite rubbings were in progress. This process of projection of objects by wrapping and frottage recalls Australian artist, Guy Warren's human body rubbings, *Figure in bronze*, 1975 (Figure 4.9). [170]

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Figure 4.9 Guy Warren. *Figure in bronze*. 1975. Acrylic on linen. 196 x 122 cm

Warren's rubbings suggest landscape and are part of an exploration of the connection between figure and landscape seen in his more recent work.[171] My paintings in *Unfolding* similarly became landscapes - landscapes under construction - as they gathered layers of shadows or projections on their travels from place to place for exhibitions. These paintings, while mathematical in construction, also refer to the geomorphology of Sydney sandstone, its layered history and its evolution including

[170] Geoffrey De-Groen, "Conversation with the Australian painter Guy Warren," Art International 23.March 1980 (1980): 64.
[171] *Guy Warren-still flowing: watercolour and sketchbook installation*. Annandale Galleries. Sydney. September 2007.

folded structures and eventual mining for architectural construction. However in my description, I concentrate on the mathematics of the set of rules used in the process. Sydney sandstone blocks, mined for building construction, were wrapped in canvas. After rubbing with ink, a landscape was recreated from the chance effects of black ink on the unfolding canvas as in Figure 4.10.

Figure 4.10   *Unfolding Sydney sandstone*. 2006. Acrylic and ink on canvas. 214 x 155cm

The resulting images resemble landscapes with trees at unusual angles recalling the multiple viewpoints and non-linear perspectives in William Robinson's paintings (see Chapter 2).

The process of this series of works involved the addition of layers to the sandstone rubbing. The canvas in Figure 4.11 is in the process of gaining its second layer, which I refer to as the Sydney human layer. The outline of a human figure is projected onto the canvas by tracing around the figure lying on the canvas in a similar way to the recording of the position of a figure in a crime scene. The taped spiral from inside to outer edge in Figure 4.11 defines the direction of the pattern or order of the unfolding grid (spiral grid property 3) and hence increasing size of the canvas. The only stipulation was that the people whose bodies were traced were directed to position themselves anywhere at right angles across this taped spiral, thus combining a given rule with chance effects independent of the artist's choice.

Figure 4.11 Projecting the human figure (Kerry Macaulay) onto an "unfolding landscape" at Manly Dam, Sydney

After receiving its Sydney layers the paintings travelled to Edinburgh for the Edinburgh Festival Fringe, August 2008. They were hung in the foyer of a theatre lit by coloured lights. Children and their parents, queuing for a show, were invited to have their shadows traced or to add their own drawings (2-D) to the paintings in oil pastels. Thus, the personal or human Edinburgh layer was projected onto the canvas (property 1). The result of this process is revealed in Figure 4.12 a and 4.12 b which are before and after Edinburgh layers.

4.12 a

4.12 b

Figure 4.12 *Unfolding*. 2006, a: with Sydney sandstone layer and b: final Edinburgh Festival layer. Both acrylic binder medium, oil pastel and ink on canvas, 215x 155cm. Lit by pink theatre lights (b).

There is choice and chance in these *Unfolding* paintings (property 8): choice in the planning of the sequence of folds and chance in the tracings of the environment and the human elements. The geometric grid, remnants of the folds in the canvas, contrasts with the organic projections of the natural environment suggesting a moving ambiguous viewpoint in a twisting and turning topography, similar to the topology of a Möbius strip. These mathematical links to properties 1 and properties 3 to 8 are summarized in Table 4.2.

The same physical and mathematical processes of rubbing natural material and folding in a predetermined sequence were used in a series I refer to as burnt charcoal prints (Figure 4.13). Using paper that was folded in a sequence, these were printed directly from the charcoal branches of trees burnt after bushfires in the Blue Mountains area west of Sydney. They were rubbed with sticks and seed pods from Banksia plants on their reverse side and then turned over to reveal the imprint of marks of charcoal. These paintings while mathematically planned and analyzed were inspired by my reaction to the massive destruction of the Blue Mountains National Park bushland. They will be exhibited in the exhibition *Shadow of a shadow*.

Figure 4.13 *Burnt print*. 2007. Natural materials and charcoal on paper. 60 x 42 cm

4.3.5 Evolve

Evolve was an exhibition of 3-D sculptures (Fig 4.1, 4.14 & 4.17), important in the discussion of 3-D shadows of the fourth dimension. The display of these sculptures in glass cabinets like biological specimens in a museum emphasized the art / science connection of this exhibition. *Evolve* consists of a sequence ranging from organic leaf and twig constructions (Figure 4.17) to leaves sutured together with pins (Figure 4.14) to inorganic metal and plastic sculptures (Figure 4.15 a & b) representing cross-sections, shadows or projections in 3-D space of the fourth dimension (property1 & 2).

The leaf sculptures, while organic in form and materials, were geometric in their construction process and were made on location at a series of geographical field sites in NSW, between 2003 and 2007. They were made in the Australian bushland pinning leaves in a ritualistic, repetitive process, similar to knitting, while waiting for my soil scientist husband to collect soil samples. Like the surprise of putting together a knitted garment after the monotony of knitting row after row, the resulting structures were always a surprise as they took on unique unexpected shapes according to the non-linear pattern of joining (property 3). The leaf sculptures also recall my childhood pastimes of pinning things together in craftwork and sewing with my mother and grandmother.

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Figure 4.14 *Möbius sutures*. 2007. Banksia leaves and metal staples. Photograph in the glass cabinets by Narelle Wilson

The inorganic sculptures were made in the studio using gutter guard, pins and cable ties and some found natural materials embedded in wire. *Möbius vines* (Figure 4.15 a) resembling sections of the curves of a Möbius strip (property 5), completed the "evolutionary" sequence from leaf with metal pins to metal fence with natural vines. The work with found metal wire (Figure 4.15 a and 4.15 b) was directly inspired by the delicately crafted metal bilums (string bags) by Aboriginal artist Lorraine Connelly-Northey (Figure 4.15 c). This kind of homage to an artist or artwork is a common thread in my practice, as already seen in my homage to Robinson's landscapes and homage to Flugelman paintings. The Möbius sculptures sutured with pins are an homage to David Lynch's film *Lost highway*, 1997, which has been described as a Möbius strip film in the twisting and "suturing" together of the subject into the narrative.[172]

[172] Bernd Herzogenrath, On the lost highway: Lynch and Lacan, cinema and cultural pathology, 1999 Available: http://www.geocities.com/~mikehartmann/papers/herzogenrath3.html, 6 January 2009.

Please see print copy for image

4.15 a

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4.15 b

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4.15 c

Figure 4.15 a: *Möbius vines*. Wire entwined with natural vines. 45 x 150 x 30cm
b: *Möbius mesh*. Wire. 31 x 36 x 24 cm c: Lorraine Connelly-Northey.
Narrbongs. Wire, metal[173]

Constructing the leaf sculptures evolved from my exploration of the dialogue between choice and chance (property 8). A system of rules was devised and followed with regard to pinning the leaves together in a particular sequence. This approach resulted in a chance form due to natural variation depending on factors such as the particular species of leaf, the size of the leaves and the joining pattern in relation to the veins of the leaf. The angle of the join resulted in the form twisting in a spiral in two planes compared with the twist in one plane of the spiral leaf sculpture of British artist, Andy Goldsworthy (Figure 4.16 a & b). Questions are prompted: are they animal or plant, man-made or natural, living or dead, finished or still evolving? (see Figure 4.17). In the spirit of Goldsworthy's leaf sculptures, mine are also ephemeral with their original shape existing only in the photographs.

[173] Image from invitation to exhibition: Lorraine Connelly-Northey. *Narrbongs (string bags).* Aboriginal and Pacific Art. Danks Street Waterloo NSW. 7 February – 1 March 2008

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4.16 a

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4.16 b

Figure 4.16 a: Andy Goldsworthy. *Drumlanrig sweet chestnut*. Natural materials. 32.5cm tall[174] b: Andy Goldsworthy. *Sweet chestnut green horn*. 1987. Leaves and thorns. Yorkshire Sculpture Park, West Briton[175]

4.17 a

4.17 b

Figure 4.17 Janelle Humphreys. Insect-like leaf sculptures. Natural materials.
a: 10 x 20 x 6 cm b: 10 x 30 x 10 cm

[174] This is one of a series of images in Andy Goldsworthy and Paul Nesbitt, Leaves (London: British Museum: Common Ground, 1989).

[175] Marly Youmans, "Hidden messages: Self-portrait as dryad, No. 5," qarrtsiluni online literary magazine (2008), <http://qarrtsiluni.com/2008/02/08/self-portrait-as-dryad-no-5/>. Image accompanying poem by Youmans

Some of my leaf sculptures continue to evolve or transform as they twist and change in succumbing to unpredictable events such as drying out or even total desiccation and decay (property 4, 6 & 8 – time, transformation & chance). In some cases the insects have consumed parts of the leaves contributing to the ongoing and uncontrollable evolution of the leaf sculpture to a skeletal state (see Figure 4.18).

Figure 4.18 An evolved stage of the leaf sculpture in Figure 4.1. Natural insect-eaten materials. 10 x 30 x 10 cm

In response to this exhibition, I made a companion series of paintings based on these sculptures and their glass cabinets by literally projecting images of these sculptures onto a 2-D board using an overhead projector. The paintings thus represent 2-D projections of the 3-D projections or sculptures of the invisible 4-D objects (properties 1 & 2).

Figure 4.19 Janelle Humphreys. *Spiral Möbius*. 2008. Whiteboard marker, ink & acrylic binder medium on plastic. 49.5 x 58.5 cm. Photograph by Narelle Whitson

The discussion of this exhibition *Evolve* makes reference to all eight properties as summarized in table 4.2.

4.3.6 Sketches

As a result of the tradition of three dimensions of space and one dimension of time, commonly used in physics since the time of Einstein's *Theory of general relativity*, I am often asked, "Isn't the fourth dimension time?" Responding to this, the paintings for the exhibition *Sketches* were painted spontaneously and flatly, with no deliberate attempt to create an illusion of depth. Paint is spread like icing on the surface of a cake in thick buttery strokes, thin glazes (Figure 4.21, 4.22 and 4.23) or piped lines (Figure 4.22 a). Each painting is projected from a quick sketch of a rapidly changing scene. Time is thus compressed within each image (see the 8 sections of Figure 4. 20 and Figure 3.6 a in Chapter 3) or through moving from one image to the next in a series of paintings as in *Sunrise over Lennox* (Figure 4.21) or *Walk in Little Bay* (Figure 4.23). There are two dimensions of space and the third dimension is time.

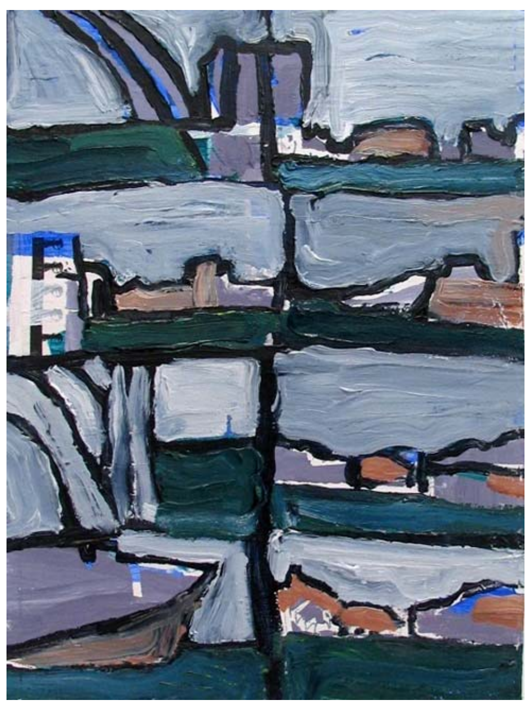

Figure 4.20 Janelle Humphreys. *Circular Quay to Woolwich*. 2006.
Acrylic, ink & paper on canvas. 80 x 60 cm

Figure 4.21 Janelle Humphreys. *Sunrise over Lennox Head* (no i and iv of series of 4). 2008. Acrylic, whiteboard marker & binder medium on board. 108 x 67.5 cm

Paul Carter, using a metaphor of the underground, alludes to depth in painting with a notion of the hidden dimension of depth underneath the physical layers of paint rather than depth implied by perspective.

> … an assumption that the meaning of a painting lies behind its surface. The painting is enigmatic because it hides what it intends. … our discourse about the painting has conventionally had the function of supplying a missing underground dimension. … This vertical dimension (not to be confused with the horizontal third dimension or depth recuperated by linear perspective)[176]

Carter's "missing underground dimension" is essentially in regard to the dimension of hidden meaning as referred to by Rosalind Williams' excavation "metaphor for truth-seeking" in *Notes on the underground*, in which she describes the "quest for knowledge … as the ancient quest for buried secrets."[177]

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[176] Paul Carter, The lie of the land (London; Boston: Faber and Faber, 1996) 116. Citing Rosalind Williams reference to the hidden strata of meaning preoccupying the structuralists and post-structuralists: Rosalind H. Williams, Notes on the underground: An essay on technology, society, and the imagination (Cambridge, Mass.: MIT Press, 1990) 46.

[177] Rosalind H. Williams, Notes on the underground: An essay on technology, society, and the imagination New ed. (Cambridge, Mass.: The MIT Press, 2008) 49. Also on page 46 in the 1990 edition.

In my works in the exhibition *Sketches*, paint was applied on the horizontal surface with no consideration of depth either through perspective or by layering, with the result that there was no deliberate attempt to create a third dimension of space. This time the emphasis in the process was on time as the third dimension rather than depth. The images were projected using an overhead projector from a series of small sketches as space and time changed on a journey on a moving vehicle (Figure 4.22 a & b and Figure 3.6 Chapter 3) or on a walk around Little Bay (Figure 4.23).

4.22 a

4.22 b

Figure 4.22 a & b: Janelle Humphreys. *Route 76 to Waterloo* (from series of 15 sketches of journey through London). 2006-7. Acrylic & ink on plastic. 58.5 x 49.5 cm

In the images of the rocks in *Walk in Little Bay* (Figure 4.23 a & b) the 2-D topological surface is receiving more attention in my process of thin glazing than the depth or 3rd dimension of the rock strata in the topography of the subject matter. This is an example of how the mathematical analysis of my artworks could be regarded as superficial in that it is only describing one level of the many layers of possible “missing” layers of interpretations.

4.23 a

4.23 b

Figure 4.23 a & b: Janelle Humphreys: *Walk in Little Bay (*from a series of 8). 2007. Acrylic & ink on plastic board. 49.5 x 58.5 cm

The idea of "missing underground dimension" also can also be applied to the idea of hidden dimensions in my paintings described in my paper on the absent or virtual string of the National Museum of Australia (Appendix 1). Ironically in these non-existent, yet to be executed "absent paintings," all three dimensions of space are absent. Figure 4. 6 a (Chapter 4) is one of a series of preliminary sketches for these paintings. In Figure 4.2 there is also a sense of a hidden inner dimension - maybe the fourth - created by the making process resulting in a spiraling in towards the focal point.

4.4 Summing up: Shadow of a shadow

Shadow of a Shadow is the proposed title of my next exhibition summing up the research project. Works from the previous exhibitions will be included in this survey exhibition and it will present new works such as *Outside In*, inspired by Elisabeth Grosz's Möbius metaphor for the journey in depth from outside to inside of the body (Chapter 3, Section 3.9).

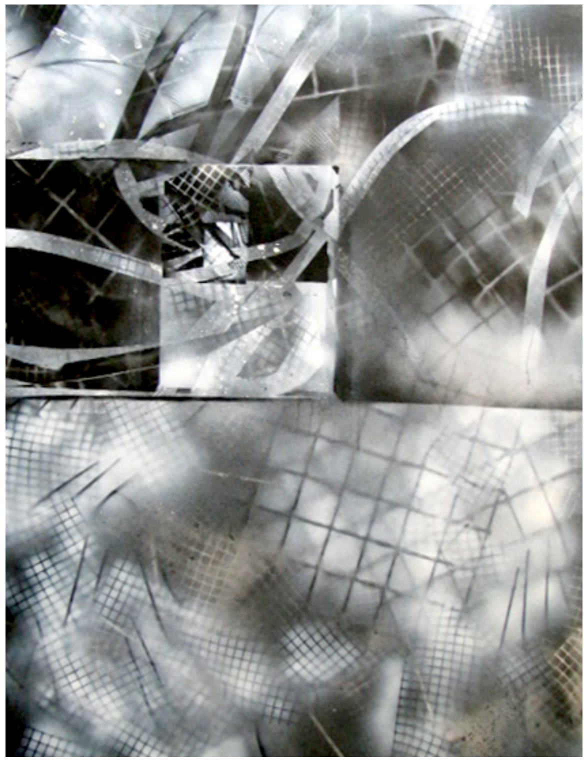

Figure 4.24 Janelle Humphreys. *Outside in*. 2008. Acrylic, ink & enamel paint on canvas. 110 x 90 cm

Outside In (Figure 4. 24) has resulted from a similar process to that used in the unfolding paintings. However, in this case, the canvas size is gradually being reduced from the outside in rather than unfolding from the inside out. In order to explain the process I will define the "active canvas" as the section of the canvas receiving a particular layer of masking tape and paint. For the first layer the entire canvas was used. The next layer used only the top half of the canvas. This half was then divided vertically and the left hand quarter became the active canvas. In subsequent layers, the active canvas was halved in size each time, forming a spiraling grid from inside to outside. The innermost smaller or "deeper" rectangular sections received progressively more layers of paint. The paint was applied by spraying through Möbius strips, made from gutter guard, resulting in the projection of their images onto the canvas. This could be considered as casting the shadows of the Möbius strips in spray paint. In describing the process of this painting, all eight mathematical properties listed in Section 4.3 are included: the projection by spraying from 3-D object to 2-D plane of canvas; the fourth dimension suggested by 3-D cross-section in the form of the Möbius strip; the spiral grid which is non-linear; a space-time sequence with depth of layers increasing toward the centre in time and space as the spiral journey is followed; the Möbius strip topology; transformation in the rotation of the grid and the chance effects in the use of tape. *Outside In* represents a culmination or summary of the mathematics in the earlier exhibitions (see Table 4.1).

Other new works proposed for the exhibition *Shadow of a shadow* include the "back-to-front" paintings (Figure 4.25 & 4.26) with images inspired by the *Evolve* sculptures, painted on the reverse side of transparent perspex. This process developed in an accidental manner, from a chance viewing of the paintings which, with the aid of back lighting, reversed the order of the layers with those applied first becoming the top layers when viewed back to front.

Figure 4.25 Janelle Humphreys: *Back-to- front*. 2008. Ink, acrylic & binder medium on perspex. 38.5 x 29 cm

Figure 4.26 Janelle Humphreys: *Inside out Möbius.* 2008. Ink acrylic & enamel on perspex. 153 x 97 cm

Table 4.2 presents a summary of the mathematical properties that have been discussed in relation to each exhibition.[178] An asterisk indicates a mathematical property relevant to that body of work, with a double asterisk indicating the main property. From Table 4.2, row 1, note that *Translation* is mainly concerned with the projections, shadows or cross-sections of another dimension. In the exhibitions *Dimensions and projections* (row 2) and *Unfolding* (row 4) this idea continues with the added property of the sequence of the depth of paint layers across the paper in the series *Waiting for the shadows* (Figure 4.7) and the unfolding paintings (Figure 4.10 & 4.12) respectively. The works in *London watercolours* are primarily concerned with the metaphor of the Möbius strip topology (row 3). In *Evolve* (row 5) the leaf sculptures address the Möbius as a 3-D cross-section of the fourth dimension. While *Evolve* refers to time as a dimension in the evolutionary sequences of the sculptures, *Sketches* (row 6) is concerned primarily with "time as the 3rd dimension." The proposed final exhibition, *Shadow of a shadow* (row 7) incorporates all previous shows and hence makes reference to all of the mathematical properties.

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[178] The idea for this table comes from a table used by American architect Peter Eisenman in explanations of the mathematics behind his buildings in: Peter Eisenman, Diagram diaries (London: Thames & Hudson, 1999) 238-9.

Table 4.2 Mathematical properties behind the seven exhibitions

	1. Projection	2. Fourth dimension	3. Non-linear	4. Time	5. Topology	6. Trans-formation	7. Sequences	8. Chance
1. ***Translation***	** shadows		* non-linear space –time	* compressed time	* skewing	* slide	* space-time	* masking tape
2. ***Dimensions and projections***	** shadow / projection	*sense of another dimension	* grid			* slide across canvas	* across canvas / zooming in	* masking tape
3 ***London watercolours***		* sense of another dimension	*non- linear perspective		** Möbius strip nuances			
4. ***Unfolding***	* of objects		* spiral grid	* space-time	Möbius topography	* rotating spiral	** in unfolding	*from tape & in unfolding patterns
5. ***Evolve***	* of fourth dimension	**3-D project-ions of fourth dimension	spiraling	* change with time	* Möbius strip	* evolution	* in materials	* in diversity of form
6. ***Sketches***		* time as 4th dimension	* grid in series	**compressed time / time 3rd dimension			* space-time	* projection form tiny sketches
7. ***Shadow of a shadow***	*	*	*	*	*	*	*	*

*relevant property ** main property

In Chapter 5 an application of the relationship between the Möbius strip and the fourth dimension is examined in the context of the Australian modernist painters. This gives my project an art historical context while providing a fresh interpretation of the Modernists in terms of the influence of the mathematics of the fourth dimension filtering through from the northern hemisphere to Australia.

5 The Sydney Harbour Bridge and the Möbius strip: The missing link to the fourth dimension in Australian painting

5.1 Introduction: Bridging the gap

In 2007, the 75th anniversary year of the opening of the Sydney Harbour Bridge images of this Australian icon became prolific in the media, books, museums and art galleries. The bridge did not always enjoy this popularity. In the early years following its construction it was felt in certain circles that Australia needed a national style of architecture, not another imitation of the international style imported from the northern hemisphere. However, the Harbour Bridge proved to be linked to the development of an Australian style in an unexpected way. Paradoxically, rather than a mere copy of international realism, it is presented in this chapter as an influencing factor on the development of a national style of modernism.

In this chapter, via the Möbius strip, another prolific image this time in Australian painting, the Bridge will be linked to the geometries that have influenced modern painting. Margaret Preston, Australian modernist painter, describes the bridge as a "towering structure… (that) sends everything around it out of perspective."[179] Ironically it is the illusion of twisting "out of perspective" of this same arch that is shown here to be associated with Möbius-like geometric images which appear in Australian paintings of the1920s-1930s. The connection between the Möbius strip and its association with the fourth spatial dimension provides the missing "Australian link" to the research of Linda Dalrymple Henderson who documents the influence of the geometry of fourth dimension and non-Euclidean geometries on modern art in the northern hemisphere.[180] It was the complex nature of the reception of modernist art in

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[179] Margaret Preston, "Meccano as an Ideal," Manuscripts 2 (1932): 91.
[180] Henderson, The fourth dimension and non-Euclidean geometry in modern art pasim. Henderson examines the influence of the fourth dimension in the northern hemisphere: France, Holland, America and Russia but not in Australia.

Australia that prompted, and allowed for, this re-evaluation of mathematical influences on modern painting gleaned from the northern hemisphere,.

5.2 Bridging Sydney: Meccano art

Margaret Preston (1875-1963) criticised the Harbour Bridge as "Meccano" art. The Bridge is in fact held together, like a Meccano set, by rivets rather than welded joints. However, this was not the basis of Preston's claim. She saw it as another example of art imported from Europe, arriving in Australia like a child's Meccano building set or "art out of a box." She expressed these ideas in her "vitriolic"[181] essay in the journal *Manuscripts* in 1932. She felt that what Australia needed was a national art form and the bridge was just another copy of internationally inspired "ironbound realism that has ruled the art of Australia generally" and present in other works such as the fountain in Hyde Park, Sydney, a replica of "all public fountains in the world."[182]

However, The Harbour Bridge, a "symbol for the modern city"[183] was received with mixed feelings.[184] Leon Gellert, joint editor with Sydney Ure Smith of *Art in Australia*, described it as a "perfect object of art and as such will be recognised by critics of the future."[185] Julian Ashton, artist and teacher in Sydney, felt the "beastly thing" interfered with the natural beauty of the harbour.[186] Preston at least referred to it as "art" even if

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[181] Humphrey McQueen, The black swan of trespass: The emergence of Modernist painting in Australia to 1944 (Sydney Alternative Publishing, 1979) 148.
[182] Preston, "Meccano as an Ideal," 91.
[183] Ursula Prunster, The Sydney Harbour Bridge 1932-1982: A golden anniversary celebration (Sydney Angus & Robertson in association with the Art Gallery of N.S.W., 1982) 15.
[184] John Slater, Through artists' eyes: Australian suburbs and their cities, 1919-1945 (Carlton, Vic.: Miegunyah Press, 2004) 54-6.
[185] Slater, Through artists' eyes: Australian suburbs and their cities, 1919-1945 55. Note 78. Quoting Gellert in foreword to Harold Casneauz (ed.) *The Bridge Book*
[186] Slater, Through artists' eyes: Australian suburbs and their cities, 1919-1945 54. Note 76. Quoting from a lecture to Haymarket-Central Square-George Street Association. Sydney Morning Herald. 4 October, 1933

"art out of a box," and the Bridge appears in one painting, contrary to myth,[187] several of her linocuts and in a rag rug depicting the arches before they met.[188]

By 1982, the 50th anniversary of the opening of the Bridge, it had become a symbol of modern society and contemporary critics considered it "representative of thirties modernism."[189] The 75th anniversary celebrations have rekindled an interest in the Harbour Bridge and "the progressive tempo of Australian life of the time."[190] This provides an opportunity for a review of paintings, drawings, etchings and photos depicting the bridge or the bridge under construction many of which were brought together for an exhibition called *Bridging Sydney* at the Museum of Sydney in 2007. According to the hymn of praise by C J Dennis, it was the "arch that cut the skies!"[191] It attracted the attention of artists including Dorrit Black, Roland Wakelin, Grace Cossington Smith and Harold Casneaux (Tables 5.1 & 5 2).

Grace Cossington Smith's painting *The bridge in-curve*, 1930, was not considered good enough to be included in the 1930 exhibition of the Society of artists.[192] Not only was the society a very traditional body, resisting change at the time, but this was also an era when women artists were being overlooked.[193] The complexities of the reception of modernist art in Australia are such that it is now considered a major modernist painting, owned by the Art Gallery of New South Wales. This fulfilled the prediction of Mary Turner, former director of Macquarie Galleries Sydney, that "Gracie's" work was ahead

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[187] Oral source, quoting Eric Riddler, archivist with the Art Gallery of NSW: "The reference to Preston not painting the bridge was made by Susannah de Vries in one of her *Great Australian Women* books… The contrary was found in the catalogue for the *Sydney Harbour Bridge celebrations: exhibition of paintings & drawings of Sydney & environs organised by the Sydney Harbour Bridge Celebrations Arts Committee and etching exhibition by the Australian Painter-Etchers Society*, Sydney, NSW: Sydney Harbour Bridge Celebrations Arts Committee, 1932."

[188] Oral Source, Rhonda Davis: This rug, which is missing, depicts an aerial view of the bridge under construction. Davis, curator, Macquarie University Art Gallery, cites an oral source via Mick Joffe, owner of the two known rugs from 1973-2007, via notes of Myra Worrell, Preston's maid. These two rugs were purchased in 2007 by the National Gallery, Canberra, and one, the Hakea rug, was included in the exhibition, *Art Deco 1910-1939*. National Gallery of Victoria. 28 June - 5 October 2008.

[189] Prunster, The Sydney Harbour Bridge 1932-1982: A golden anniversary celebration 15.

[190] Eileen Chanin, Degenerate and perverts: The 1939 Herald exhibition of French and British contemporary art (Carlton, Vic.: Miegunyah Press, 2005) 39.

[191] Peter Spearritt, The Sydney Harbour Bridge (Sydney: George Allen & Unwin Pty Ltd, 1982) 39.

[192] Deborah Hart, Grace Cossington Smith (Canberra: National Gallery of Australia, 2005) 40.

[193] Ambrus describes the prejudice against professional women between the wars in spite of two decades of Feminism in: Caroline Ambrus, Australian women artists: First Fleet to 1945: History hearsay and her say (Woden, A.C.T.: Irrepessible press, 1992) 127.

of its time and "would wait with its face against the wall, until the world caught up with it."[194]

5.3 Multiple perspectives

The Harbour Bridge is one of seven bridges in a complete circuit surrounding the Sydney Harbour. This gives motorists and pedestrians a means of viewing it from a range of vantage points. For example, approaching the Gladesville Bridge south over the Tarban Creek Bridge, it seems to creep slowly from behind a headland, while seen from a distance, it appears to be a giant two-dimensional coathanger spanning the bushland. Viewed up close, or from underneath, the distorted perspectives of the "coathanger" give credence to Preston's view that it throws everything around it out of perspective. From certain vantage points, such as Lilyfield in Sydney's Inner West, the arch appears to begin to twist into a spiral and continues twisting and turning as one observes it while traveling across the Anzac Bridge. Given the small scale of Sydney at the time the bridge was being built, the distorted inner-city views would have been the most common.

It is the apparent twist which is of interest. Harold Casneaux's photograph, *A study in curves*, 1931, (Table 5.1b) presents a popular view of the bridge in which the four curved edges of the arch suggest such an optical illusion of a twist. Consider the four curved lines which we can trace, as they intersect and criss-cross along the length of the arch. Also examine the four surfaces of the bridge considering it as an arched rectangular prism. The illusion of a twist occurs because we are unsure whether we are looking at the upper- or the under-side of the bottom plane of the arch on the right hand side of the bridge. There is added confusion from the triangular struts, that appear to intersect, and the connections between these points of intersection, giving the illusion of extra curved lines as seen in Casneaux's second photo in Table 5.1 c. It is the resultant twisting in the arch seen from such points of view that suggests the link between the Bridge and the Möbius strip. Indeed, this optical illusion of twisting during construction, as depicted in the painting of Roland Wakelin, *The bridge under construction*, 1928, created interest in whether the arches, which seem to have rotated

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[194] Mary Turner, "Recollections on the art and life of Margaret Preston, Thea Proctor and Grace Cossington Smith: A personal memoir," Art Monthly Australia 179 (2005): 7.

out of alignment, would actually meet (Table 5.2 e). This twisting of the arch is also apparent in Cossington Smith's *The bridge in-curve,* 1930, in which the sweeping curves of the arch and the approaching expressway appear to map out the beginning of a Möbius strip (Table 5.2 c).

Table 5.1, though presenting images chronologically, is not presenting an historical sequence. Rather, it highlights a series of images that depict a visual sequence from an initial twist to a full Möbius strip. The twist is taken to the extreme in a humorous postcard by Neil Curtis from the 1980s (Table 5.1 d) in which a giant squid wraps its tentacles about the arch, twisting it apart like the beginning of a James Angus Möbius loop sculpture.[195] Angus has constructed models of buildings distorted into a 3-dimensional (3-D) Möbius twist. Examples include the pair *Lakeshore Drive Möbius loop*, 2001, which depict two Möbius strips, one left-oriented and the other right-oriented (Table 5.1 f). *Palazzo della Civilta Italiana*, 2001, an Italian Fascist style building, is elongated and twisted into a complete Möbius strip (Table 5.1 g). The loop at the entrance of the National Museum of Australia is another example of a partial Möbius twist (Table 5.1 e) which is given more attention in Appendix 1.[196]

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[195] Prunster, The Sydney Harbour Bridge 1932-1982: A golden anniversary celebration 130.
[196] Janelle Humphreys, "Art and the mathematics of the National Museum of Australia," The International Journal of the Arts in Society 1.4 (2007): 69.

Table 5.1 The evolution of the Möbius strip

a: John Bradfield 1867-1943 *Graceful curves of Sydney Harbour Bridge and nature's arches* [197]		The appearance of a twisting out of alignment in this historic photo prompts the question: will the arches meet?
b: Harold Casneaux 1878 – 1953 *A study in curves*. 1931 Photograph b/w. 26.9 x 37.3 cm [198]		The beginning of a twist can be seen on the right hand side.
c: Harold Casneaux [199]		The optical illusion of a twist: five curved lines, instead of the expected four, counted in the arch on the top left hand quarter of this photograph[200]

[197] J. J. C. Bradfield, Sydney Harbour Bridge, and City railway (Willoughby, N.S.W.: Printed and published by H. Phillips). Image: Bradfield's Bridge, Available: http://www.library.usyd.edu.au/libraries/rare/bridge/bridge.html 6 February 2007.

[198] Historic Houses Trust: Museums, Available: http://www.hht.net.au/museums/mos/exhibitions/past_exhibitions, 15 June 2007.

[199] Image on the cover of Bridging Sydney, ed. Caroline Mackaness (Sydney: Historic Houses Trust of New South Wales, 2006). Also at: Historic Houses Trust: Museums, Available: http://www.hht.net.au/museums/mos/exhibitions/past_exhibitions, 15 June 2007.

d: Neil Curtis *Revenge of the Calamari*. 1981 [201]	Please see print copy for image	Literally twisted: comical postcard showing the twist which breaks the arch
e: Howard Raggart architect *National Museum of Australia* [202]		Partial Möbius strip in the canopy of the National Museum of Australia symbolically takes visitors from the outside to the inside
f: James Angus *Lakeshore Drive Möbius loop*. 2001. Basswood aircraft plywood. 150 x 110 x 110 cm [203]		The 3-dimensional Möbius strip is almost complete. Angus made two of these one with a left-oriented twist and the other right-oriented
g: James Angus *Palazzo della Civiltà Italiana*. 2001.Laser cut cardboard. 45 x 95 x 95 cm [204]		The Möbius strip is complete

[201] Prunster, The Sydney Harbour Bridge 1932-1982: A golden anniversary celebration 130.
[202] Photograph by Janelle Humphreys
[203] Artists: James Angus, Available: http://www.roslynoxley9.com.au/artists/5/James_Angus/120/33639/, 12 May 2007. Also in James Angus, James Angus (Sydney: Museum of Contemporary Art, 2006) 32-6.
[204] Artists: James Angus, Available: http://www.roslynoxley9.com.au/artists/5/James_Angus/48/33614/, 12 May 2007.

5.4 Revisiting the Möbius strip: Cross-section of the fourth dimension

The detailed consideration in Chapter 4 of the Möbius strip as a 3-dimenisonal (3-D) cross-section of a 4-D object, provides the mathematical basis for this examination of the influence of the fourth dimension on Australian painting. Particular reference will be made to the influence of new geometries developed in Europe in the early to mid-nineteenth century and reaching artistic circles in London and Paris by the first quarter of the twentieth century.

To understand this connection we begin with Marcel Duchamp's ideas on the fourth dimension. Revisiting ideas developed in Chapter 4 and summing up, it was Duchamp who stated, after mathematician Elié Jouffret, that the "shadow cast by a 4- dimensional figure in our space is 3-dimensional," using the analogy that the shadow of a 3-dimensional object would be 2-dimensional.[205] Further descriptions by Tony Robbin's of the link between shadows, projections and cross-sections prompted me to restate Duchamp's claim by replacing the word "shadow " with "cross-section":

> the cross-section of a 3D object would be 2-D and therefore by analogy
> the cross-section of a 4-D object would be 3D.[206]

The physical connection between the Möbius strip and the fourth dimension is revealed when the Möbius strip is shown to be the cross-section of a Klein bottle, a 4-dimensional object.[207] In fact, if two Möbius strips, one left-oriented and the other right-oriented are joined together the result is a Klein bottle which reinforces this idea of the Möbius strip as a cross-section of a 4-dimensional object.[208]

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[205] Note 3 in Duchamp, Notes and projects for the Large Glass 36.
[206] The distinction between projection, shadow and cross-section is explained fully in both of Robbin's books: Tony Robbin, Shadows of reality: the fourth dimension in relativity, cubism, and modern thought (New Haven, Conn. ; London: Yale University Press, 2006) pasim. Robbin, Fourfield: Computers, art & the 4th dimension pasim.
[207] The Klein bottle, as we see it in 3 dimensions, is in fact a 3-D projection of a 4- D object. The bisecting of a Klein bottle reveals two Möbius strips which are thus cross-sections of the projection of the fourth dimension.
[208] Rosen uses the Möbius strip as a cross-section of the higher dimensional Klein bottle as a philosophical model in Steven M. Rosen, "What is Radical Recursion?," SEED 4.1.See also Rosen, Topologies of the Flesh: A multi-dimensional exploration of the lifeworld.

5.5 Fourth dimension: Unseen dimension

While the fourth dimension of space aroused much interest at the beginning of the twentieth century it is also of current interest with Henderson, Steven Rosen (see Chapter 3) and Robbin each publishing new volumes on the subject in 2006-7. The fourth dimension is still often assumed to be time.[209] In the 1900s, and today, those who actually consider the fourth dimension as a spatial dimension, often associate it with the spiritual or the mystical. It is an "unseen" dimension, the dimension that cannot be realised in our 3-D world. Bernard Smith briefly outlines the scientific basis of the fourth dimension but also refers to the "predominantly occult belief in the existence of the fourth dimension."[210]

However, as outlined in Chapter 1, there are simple mathematical explanations of the fourth dimension of space available including Henry Manning's book of essays, *The fourth dimension simply explained,* which documents entries in a world-wide competition in 1905 to explain the fourth dimension in lay terms.[211] Robbins, who makes art works based on the fourth spatial dimension, has updated his study in the area of the fourth dimension in a new book published in 2006. In Henderson's study of the influence of "new"[212] geometries in *The fourth dimension and non-Euclidean geometry in modern art*, she examines countries that have a strong body of literature on the fourth dimension of space in order to support her claim for the strong influence of the fourth dimension on modern art.[213]

5.6 Maggie, the two Graces and mathematics

Through their travels and studies in the northern hemisphere, several Australian artists were also influenced by the new geometries. In order to examine this claim, I have

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[209] After the acceptance of Einstein's theories of relativity in the early 1900s, time was generally considered by physicists to be the fourth dimension.
[210] Bernard Smith, Modernism's history: A study in twentieth-century art and ideas (Sydney: UNSW Press, 1998) 77-79.
[211] The fourth dimension simply explained, ed. Henry P Manning (London: Methuen & co. ltd., 1921) pasim.
[212] Actually not "new" at the time as the geometry of the fourth dimension and non-Euclidean geometries were developed by the mid-nineteenth century.
[213] Henderson has also recently updated these findings in a new edition of her text, intended for publication in in 2007, with an introductory essay addressing the "fate" of the fourth dimension.

chosen to discuss three Australian modernist painters - Margaret Preston, Grace Cossington Smith and Grace Crowley - each of whom has been recognised as a major Australian artist. There is a regeneration of interest in and an increasingly positive reception of these women artists, indicated by the fact that each has had a major retrospective exhibition in Australia between 2005 and 2007. There is also strong evidence that they were interested in mathematics and not merely mimicking the superficial elements of art they saw overseas.

However, being female, and at the time considered as mimics and dabblers, meant their contribution to Modernism was overlooked until the feminist revival of interest in Australian women artists in the 1980s and 1990s by authors such as Caroline Ambrus and Helen Topliss.[214] There is another allusion to the intellectual mathematical basis of women's art in what was meant as a derogatory comment against women. The claim was they can "talk Art, using freely terms such as 'third dimension.'"[215] It is of interest to this study on the influence of the fourth dimension, that dimensions, though the third, were actually being discussed even if only amongst women and "pansies," both of whom were considered responsible for and interestingly, in fact, "blamed" for, the development of Modernism in Australia.[216]

Stronger evidence of an interest in mathematics can be gleaned from letters, teaching notes, the ideas and teachings of their colleagues and in Preston's case, from her handwritten notes tucked away inside her own copy of Theodore Andrea Cook's *Spirals in nature and art*. [217] Here are three women clearly recognised for their forward thinking, modern ideas and fiery enthusiasm. Red-haired Preston was called "mad Maggie," and Crowley was said to have come back from Paris with "red hair, red nails and red ideas."[218] Though "modest and unassuming," Cossington Smith was also

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[214] Ambrus, Australian women artists: First Fleet to 1945: History hearsay and her say. Helen Topliss, Modernism and feminism: Australian women artists, 1900-1940 (Roseville East, NSW Australia ; U.S.A.: Craftsman House ; G+B Arts International, 1996).
[215] Ambrus, Australian women artists: First Fleet to 1945: History hearsay and her say. Ambrus quotes James Stewart MacDonald from an article in the *Bulletin*
[216] Ambrus, Australian women artists: First Fleet to 1945: History hearsay and her say 140.
[217] Theodore Andrea Cook, Spirals in nature and art: A study of spiral formations based on the manuscripts of Leonardo da Vinci, with special reference to the architecture of the open staircase at Blois, in Touraine, now for the first time shown to be from his designs (London: John Murray, 1903). This book is in the archives of the AGNSW in the Margaret Preston bequest.
[218] Oral source: Dianne Ottley, M phil presentation on Grace Crowley's contribution to Australian Modernism and Geometric Abstraction, the Power Institute, University of Sydney, 19 April 2007.

described as a "wild woman" who pushed "ceaselessly at the limits of her vision."[219] They were intelligent women in a position to be aware of mathematics and the influences affecting the art in the northern hemisphere.

Margaret Preston has been described as Australia's foremost woman painter of the interwar period.[220] Her extensive annotations which can be seen in the margins of Cook's *Spirals in nature and art* are direct evidence of her interest and attempt to understand mathematics. In this book, Cook examines naturally occurring spirals in horns, tusks shells, arrangements of petals and leaves, palm trunks, seed pods, tendrils and vines. He includes the spirals in water and bird flight as described in Leonardo da Vinci's manuscripts. The logarithmic spiral curve of the nautilus shell is also presented. Preston added notes and diagrams in the margins of the text and inserted pages of mathematical notation into the front cover. The nature of these additions indicate Preston's attempt at a geometrical understanding of the spiral and a familiarity with the Fibonacci sequence, the mathematical basis of a spiral. She notes "a definite relation with the laws of mechanical construction" on pages inside the cover of the book. This provides primary evidence of what Ambrus described as Preston's "rigorous intellectual approach to the geometric reconstruction of nature" while adding another dimension to her work which otherwise might appear simply decorative and figurative.[221] Further evidence of her scientific awareness is in her statement that "an artist may work with a knowledge of science but he seldom works scientifically."[222] In Preston's *Hakea* rag rug, the abstract geometric image recalls the cubist inspired designs of Anne Dangar's pottery. The spiraling hakea leaves suggest a Möbius strip giving the rug a 3-dimensional appearance (see Table 5.2 a).[223] Preston has been linked with De Maistre in her use of "sweeping swirling symphonies of colour…curvilinear labyrinths of form."[224]

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[219] Turner, "Recollections on the art and life of Margaret Preston, Thea Proctor and Grace Cossington Smith: A personal memoir," 6-9.
[220] Elizabeth Butel, Margaret Preston (Sydney: ETT Imprint, 1995) 1.
[221] Ambrus, Australian women artists: First Fleet to 1945: History hearsay and her say 128.
[222] Preston, The art of Margaret Preston 92.
[223] Hakea is a native Australian plant growing in bushland in Berowra where Preston lived at the time.
[224] Leonard Janiszewski, ed., Berowra visions: Margaret Preston and beyond (Sydney, NSW: Macquarie University, 2005) 35.

For Grace Crowley, there is also primary evidence of an interest in mathematics. It is in her handwritten teaching notes that Crowley makes direct reference to mathematics and spatial dimensions: "Frankly it seems to me in painting to be a desire to suggest the dimensions of space and still retain the surface design."[225] In a notebook (c1928), that Ann Dangar gave Crowley, there are diagrams of the geometric transformations and geometrical analysis that both Dangar and Crowley had learned from studying with Albert Gleizes and Jean Metzinger.[226] Included are diagrams of transformations of rectangles and the *Section d'Or* or Golden Section. Crowley was in France from 1926-1930 while Dangar served an apprenticeship for nine years then taught for another nine with Gleizes. Her letters to Crowley kept her directly informed about what was happening in France in the 1930s and 40s. Because of Crowley's thorough understanding of geometry and her subsequent teaching of this mathematics to her colleagues, including Ralph Balson, there is strong evidence that it was Crowley, rather than Balson, who made the greater contribution to geometric abstraction and hence Modernism in Australia.[227]

Further evidence that Crowley's knowledge of geometry is recognised is indicated by the inclusion in *Grace Crowley: Being modern*, a retrospective exhibition at National Gallery of Australia,[228] of a book of writings by Gleizes and Metzinger, with diagrams depicting translations and rotations of rectangles.[229] The curator placed this book alongside Crowley's paintings that implement these transformations of geometrical figures. For example, Crowley's, *Abstract painting*, 1947 depicts a thin line weaving in and out of the translated and rotated abstract shapes giving a 3-D appearance to this otherwise flat 2-D geometric composition. Together with the shifting planes, this inter-weaving suggests the movement from inside to outside which can be modelled on the continuous surface of a Möbius strip (Table 5.2 b).

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[225] This was in two pages of Crowley's handwriting on "Space Painting" in the archives of the Art Gallery of NSW (AGNSW).
[226] This notebook is in the Grace Crowley boxes in the Archives of AGNSW. Crowley was also in France from 1926-1930.
[227] Balson has often been credited with the introduction of geometric abstraction to Australia making the first big break with the pastoral landscape tradition in his exhibition of 1919. Oral Source: Dianne Ottley. See footnote 218.
[228] Exhibition dates for *Grace Crowley: Being Modern*. National Gallery of Australia. 23 December 2006 – 6 May 2007
[229] Peter Brooke, <u>Albert Gleizes: For against the twentieth century</u> (New Haven, Conn.: Yale University Press, 2001) 96-9. Fig 52-5.

While there is less evidence of a mathematical basis to Grace Cossington Smith's work, the strong architectural elements in her work suggest a good grasp of geometry. This is evidenced by her skilful draughtsmanship in the preliminary sketch for *The bridge in-curve,* 1930.[230] The dynamic curves together with the reinforcing concentric lines of the vortex of the sky in this painting suggest the beginning of the twisting of a Möbius strip (Table 5.2 c).

Cossington Smith's colleagues were interested in the connection between mathematics and art. For example, she knew Roy De Maistre and Roland Wakelin and shared their fascination for experimenting with modern theories of colour and music.[231] De Maistre had been influenced by Willard Huntington Wright's Synchromism,[232] a movement, with a small following at the time, that linked colour and music.[233] It was a forerunner of the now well established link between colour, music and mathematics. Artist friend of Cossington Smith, Thea Proctor, aware of the mathematical basis of images, stated: "Composition is something that is quite mathematical." She described the geometric tension between lines in an image.[234] Cossington Smith, as a student of Antonio Salvatore Dattilo-Rubbo was also influenced by Preston's lecture on randomness in the choice of colour at his art school.[235] Randomness is a topic in mathematics, in particular in the study of probability and statistics, thus illustrating another link between mathematics and art.

Just as Henderson assumes that the northern hemisphere artists were familiar with the literature on the new geometries, it is fair to make a similar assumption that the Australian artists travelling to Europe would have been aware of this literature indirectly through their studies with overseas artists. In fact, through the notes of Preston and Crowley, we have concrete evidence of their familiarity with, and interest in, mathematics. This mathematical evidence is summarised in Table 5.2 through reference to specific artworks. There is certainly more than a superficial connection with the art

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[230] Hart, Grace Cossington Smith 40.
[231] Ann Stephen, Modernism and Australia: Documents on art, design and architecture 1917-1967 (Carlton, Vic.: Miegunyah Press (Melbourne University Publishing), 2006).
[232] "Synchromism" has also been spelt without an "h" as "Syncromism"
[233] Willard Huntington Wright, Modern painting, its tendency and meaning (New York: John Lane; London: John Lane, 1915).
[234] Stephen, Modernism and Australia: Documents on art, design and architecture 1917-1967.
[235] Stephen, Modernism and Australia: Documents on art, design and architecture 1917-1967 759-60.

of Europe filtering through from the north to the south from the travels of these women. It is true, according to Humphrey McQueen's analogy in *The black swan of trespass*,[236] that the mathematics influencing modernist painting in Europe had "trespassed" upon the shores of the 'Antipodes.'

5.7 Möbius trope

The paintings and prints in Table 5.2 a to g have been chosen initially for their demonstration of curved Möbius-like imagery. Ethel Spowers shows the use of spiraling curves in her linocuts and paintings. For example, in *The plough*, 1928, the pathway of the flight of the birds traces a partial Möbius strip also seen in her black and white linocut of the same name (Table 5.2 g).[237] Dorrit Black's painting *The bridge*, 1930 is included for its geometric abstraction which, while depicting sweeping curves, makes use of diagonals and flat planes to define form (Table 5.2 f).[238] Black had learnt these cubist principles from her teachers Gleizes and André Lhote in France who were influenced by the fourth dimension and new geometries.[239] Black and Spowers also show the influence of the curved compositions of London teacher Claude Flight.[240] Black's *The olive plantation*, 1946 suggests the curved grid of non-Euclidean geometry in the curved topography of the landscape (Table 5.2 f). De Maistre's *Rhythmic composition in yellow green minor,* a painting linking music and colour is another painting with a strong image of a Möbius strip (Table 5.2 d). This painting recalls works by Stanton MacDonald Wright such as *An organisation on blue-green* and the influence of the writing on Syncromism by his brother Wright.[241]

In this chapter, an argument for the influence of the fourth dimension on Australian painting is proposed through the connection with the Möbius strip. Imants Tillers' connection with the fourth dimension and non-Euclidean geometry is undisputed. In

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[236] McQueen, The black swan of trespass: The emergence of Modernist painting in Australia to 1944
[237]On loan from Hazelhurst Regional Gallery and Arts Centre to the Art Gallery of NSW for *Australian Etchings and Engravings.* Art Gallery of NSW. 5 May – 22 July 2007.
[238] Jane Hylton, South Australian women artists: paintings from the 1890s to the 1940s (Adelaide: Art Gallery Board of South Australia, 1994) 26 -7.
[239] Henderson discusses the influence on French artists in Henderson, The fourth dimension and non-Euclidean geometry in modern art.
[240] Claude Flight lectured on lino-cutting at the Grosvenor School of Modern Art in London. Spowers, Black and Eve line Syme were amongst his pupils.
[241] Wright, Modern painting, its tendency and meaning. Colour plate by SM Wright inserted between pages 300-301

Conversations with the bride, Tillers investigates different means of representing the fourth dimension and appropriates Duchamp's image of the sieves representing 3-D cross-sections of the fourth dimension. He also shows an awareness of non-Euclidean geometry in citing René Daumal's, *Mt Analogue: a novel of symbolically authentic non-Euclidean adventures in mountain climbing,* as a favourite influencing book.[242] It was the writings of Henderson on Duchamp combined with Tillers' subsequent appropriation in *Conversations with the Bride* of Duchamp's *The bride stripped bare by her bachelors, even,* 1915-23, that provided the original impetus for this study. This led me to the modelling of William Robinson's *Moonlight landscape*, 1987 on a 3-dimensional ceramic Möbius strip (Chapter 2) and the subsequent observation of the Möbius strip in the works of the Australian Modernists (Table 5.2).

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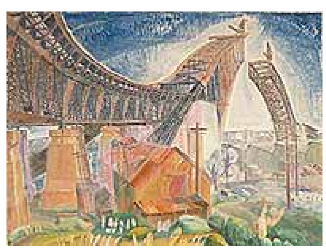
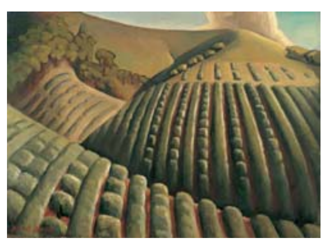
[242] Daumal, Mont Analogue. English
Mount Analogue: A novel of symbolically authentic non-Euclidean adventures in mountain climbing.

Table 5.2 Summary of mathematical links in some Australian artworks

Artist	Image	Mathematical Links
a: Margaret Preston 1875-1963 Hooked rag rug *Hakea*. c1933. Mixed cotton and woollen fabric on hessian. 140 x 90 cm. National gallery of Australia [243]		Möbius strip design Preston's handwritten mathematical additions to her personal copy of T.A. Cook, *Spirals in art and nature* Pictorial imagery linked with De Maistre
b: Grace Crowley 1890 - 1979 *Abstract painting*. 1947. Oil on board. 63.2 x 79.0 cm. Private Collection, Sydney [244]		Crowley's handwritten teaching notes on geometry Anne Dangar's geometrical diagrams in notebook and letters to Crowley Gleizes notes on translation and rotation influenced Crowley's compositions
c: Grace Cossington Smith 1892 - 1984 *The bridge in-curve*.1930. Tempera on cardboard. 83.6 x 111.8 cm. National Gallery of Victoria [245]		Möbius- like curves in the Bridge and the sky Smith knew De Maistre and Wakelin and had an interest in colour theory Knew of Preston's work on colour theory.

[243] Janiszewski, ed., Berowra visions: Margaret Preston and beyond 33.
[244] Elena Taylor, "Grace Crowley: Being modern," 31 January 2009 <http://nga.gov.au/Crowley/>.
[245] Slater, Through artists' eyes: Australian suburbs and their cities, 1919-1945 59. Plate 41.

d: Roy De Maistre 1894 - 1968 *Rhythmic composition in yellow green-minor*. 1919. Oil on paperboard 85.3 x 115.3cm. Art Gallery of NSW [246]		Influenced by Wright's chapter on Synchromism and Stanton McDonald Wright's paintings based the link between colour, music and mathematics
e: Roland Wakelin 1887 - 1971 *The bridge under construction*. 1928. Oil. 101.0 x 121.6 cm [247]		Interest in colour and music Friend of De Maistre: a colour, music, mathematics link The arch of the Bridge appears to twist out of the page as a counterbalance to the curve of the road suggesting a partial Möbius loop
f: Dorrit Black 1891 - 1951 *The bridge*. 1930. Oil. 60 x 81 cm [248] *The olive plantation*. 1946. Oil. 63.5 x 86.5 cm [249]	 	Curved Möbius strip-like geometry influenced by teacher, Claude Flight top left: Cubist influence from teachers Gleizes and Lhote in France bottom left: Curves of the topography recall the curved space of non-Euclidean geometry

[246] Johnson, Roy De Maistre: The Australian years, 1894-1930 36.
[247] Slater, Through artists' eyes: Australian suburbs and their cities, 1919-1945 62. Plate 45.
[248] Slater, Through artists' eyes: Australian suburbs and their cities, 1919-1945 57. Plate 39.
[249] Hylton, South Australian women artists: paintings from the 1890s to the 1940s 42. Fig 40. Image at: Art gallery of South Australia: The learning foundation, 2005, Available: http://www.artgallery.sa.gov.au/TLF/01482/, 13 March 2009.

g: Ethel Spowers 1890 - 1947 *The works, Yallourn*. 1933. Linocut. 15.7 x 34.8 cm [250] *The plough*. 1929, wood engraving, black ink on thin ivory laid paper. 10.1 x 15.7 cm [251]	 	Influence of the curved Möbius imagery of Claude Flight's School Birds flying in a Möbius-like swirl
h: William Robinson 1936- *Moonlight landscape*. 1987 oil on linen, 147 x 193 cm. private collection, Sydney [252]	Please see print copy for image	Topography of Robinson's landscapes, with trees twisting in all directions, is modelled by topology of the Möbius strip to account for the directions of the trees (see Chapter 2, Figure 2.5)
i. Imants Tillers detail of Marcel Duchamp's rotating sieves from *The large glass* (see Chapter 2, Figure 2.9)	Please see print copy for image	Tillers depicted 4-D space in *Conversations with the bride*, (1974-5) [253] appropriating the image of Duchamp's sieves: 3-D cross-sections of a 4-D object Tillers read René Daumal's *Mt Analogue* [254]- non-Euclidean adventures[255]

[250] National Gallery of Victoria, The Joseph Brown Collection at NGV Australia (Melbourne: National Gallery of Victoria, 2004) 116.
[251] Online catalogue for the exhibition Australian Etchings & Engravings 1880s-1930s. 81. Plate 122. PDF link http://www.artgallery.nsw.gov.au/collection/catalogues/australian_etchings_engravings. available 2 February 2009.
[252] Fern, William Robinson 133. Plate35.
[253] Graham Coulter-Smith, "Imants Tillers. Inventing post-modern appropriation ", 2 June 2008 <http://www.shermangalleries.com.au/artists_exhib/artists/tillers/nature.html >.
[254] Coulter-Smith, The postmodern art of Imants Tillers: Appropriation en abyme, 1971-2001 195.
[255] Coulter-Smith, The postmodern art of Imants Tillers: Appropriation en abyme, 1971-2001 128-31.

5.8 Preston, the spiral and the Möbius twist: Cook's books

Preston's application and understanding of the spiral and Fibonacci sequence is an important link in this analysis of Australian painting. While Cook wrote *The curves of life* in 1914, before the mathematics of the Möbius surface was developed, he makes an indirect reference to the Möbius strip.[256] Cook describes the horns of an animal in section called "Twists and curves."[257] He contrasts the twist around the axis parallel to the horn and an axis perpendicular to the horn "if the horn were a flat spiral." The idea of "the flat spiral" refers to the horn, a 3-D object, being projected (flattened) into a 2-D plane. This directly refers to the projection from one dimension to another which is vital to the understanding of the Möbius strip and the Klein bottle (see Chapter 3, Figure 3.11).

Another example is Cook's diagram of the pathway of a bird's wing in flight. He notes Leonardo Da Vinci's observation that "As the tips of the bird's wing, in flight, go up and down as well as onwards, they make a spiral in the air."[258] Though it is called a spiral, it resembles the looping pathway of several Möbius strips. Cook also discusses "shadow spirals" which are shell-like forms with a strong resemblance to a Möbius strip.

While Cook's work predates the mathematical development of the Möbius surface, he correctly predicts that "in capable hands" there could be further development of this "shadow spiral."[259] While there is no inference intended that Preston was aware of the geometry of the Möbius strip, it is of interest that this was the literature that she was annotating at the time. Thus we have a link between Preston, the spiral and the Möbius strip.

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[256] Theodore Andrea Cook, The curves of life: Being an account of spiral formations and their application to growth in nature, to science and to art, with special reference to the manuscripts of Leonardo da Vinci (London: Constable, 1914).
[257] Cook, Spirals in nature and art: A study of spiral formations based on the manuscripts of Leonardo da Vinci, with special reference to the architecture of the open staircase at Blois, in Touraine, now for the first time shown to be from his designs 77.
[258] Cook, Spirals in nature and art: A study of spiral formations based on the manuscripts of Leonardo da Vinci, with special reference to the architecture of the open staircase at Blois, in Touraine, now for the first time shown to be from his designs Fig 45.
[259] Cook, The curves of life: Being an account of spiral formations and their application to growth in nature, to science and to art, with special reference to the manuscripts of Leonardo da Vinci 460. Figs 413-5.

5.9 Conclusion

This chapter connects the Australian modernist painters, the Sydney Harbour Bridge and the Möbius strip. The popular perception was that all three of these were "ahead of their time." However, the Modernists and the Harbour Bridge are now historicised as modernist and hence "of their time." The early modernist paintings were not considered good enough by the traditionalists for exhibition at their time of painting, yet were predicted to gain recognition later. As well, the Harbour Bridge was criticised as international in style and out of place in Australia and also predicted to be appreciated at a later date. The Möbius strip or band had already been invented in 1858 by August Möbius (1790 - 1868) and while the mathematics had not been developed at the time, it had been foreseen by Cook.

The Bridge and the Möbius strip are linked to provide a new interpretation of the influence of mathematics on modern art in Australia. The Möbius connection to the Modernists is made through the twisting Möbius-like imagery occurring in the paintings. It is the connection between the Möbius strip and the fourth dimension that links the Australian artists to Henderson's study of the influence of the fourth dimension on Modern art in the northern hemisphere. Recognition of the similarities between the Möbius strip and the Harbour Bridge led to the development of the visual sequence in Table 5.1 linking the bridge to the Möbius strip via the work of sculptor James Angus. The relationship between the Bridge imagery and the Möbius imagery was the final link forging the connection between the Australian Modernists and the Möbius strip.

In summary the links are: Modernists to fourth dimension (via Henderson's work), fourth dimension to Möbius strip (via the Klein bottle), Möbius strip to Harbour Bridge (Table5.1) and finally, completing the loop, Harbour Bridge to Modernists.

6 Rounding up: Conclusion

> **Rounding up, down**: make a number round by omitting units, by adding or subtracting a small amount.

6.1 Summing up: Mathematics and meaning

> Though a straight line appears to be the shortest distance between two points, life has a way of confounding geometry. Often it is the dalliances and the detours that define us. There are no maps to guide our most important searches. We must rely on hope, chance, intuition, and a willingness to be surprised.
>
> Gordon Livingston. *Too soon old, too late smart*[260]

In the broad theme of the art /science / mathematics connection, topical in contemporary art, I am focusing on aspects of mathematics not so frequently articulated in terms of the perception of art works and the generating of images. Topics include: the role of sequences and systems of rules; probability an the interplay of choice and chance; projections from one dimension to another in particular from the third dimension to the second and, more unusually, projections from the fourth dimension to the third; and the curved space and non-linear perspective of non-Euclidean geometry.

I acknowledge that, while in my descriptions I have concentrated on the mathematical analysis of artworks and their making process, this mathematical description is only one of many possible interpretations. Though an artist makes use of geometry, it may be without any intention or realisation of a connection with mathematics as in Tim Hawkinson's Klein bottles and baskets (Chapter 3, Figure 3.8 & 3.9). An art work has many hidden layers of meaning as described by Paul Carter in Chapter 3. A painting can be compared to a music score as expressed in the words of Australian conductor, Simone Young, describing the controlling of an orchestra:

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[260] Cited in: Pete Takeda, An eye at the top of the world (Thunders Mouth Press, an imprint of Avalon publishing group, 2006).

> You are moving … a weight of sound, something that almost has a physical, vertical shape and density, and you're moving that through the horizontal line of time and space[261]

She could be describing the process of the artist laying out the various layers of paint and levels of meaning through time and space across the canvas. Möbius strip topology is used to model the twisting and tilting planes of William Robinson's canvases (Chapter 2). However, while I describe William Robinson's work in terms of the movement through a twisting of space and time, there is no denying the personal, spiritual, hidden layers intended by Robinson and also conveyed to the viewer by his images.

A similar use of curved space of non-Euclidean geometry and non-linear perspective is demonstrated in the paintings of a selection of Australian Modernists (Chapter 5). A link between the Möbius strip, the fourth dimension and the Modernists is established providing a new perception of Australian painting. Through this mathematical analysis, Australian art is linked to intellectual influences of the northern hemisphere which prompted the break with linear perspective.

Each body of my work analysed in Chapter 3 and 4, has several levels of meaning and was made in response to a significant personal driving force and a ritualistic approach often unrelated to the mathematics. The analysis in terms of mathematics "bridges the gap" between my mathematics background and my paintings in the following different ways:

1. Sometimes the mathematics is intentionally built into the making process through a system of rules and sequences (Chapter 4: *Unfolding*, *Evolve, Sketches*)
2. Other times mathematics presents as a topological awareness of space in terms of binary opposites modelled on the Möbius strip (Chapter 3 and 4: *London watercolours*).

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[261] "Simone Young, orchestral, opera musicals, composers." The music show. Radio National, Australia. 15 November 2003.

3. However, the analysis of the art work is often retrospective (Chapter 4: *Dimensions and projections*) as I investigate the links between my finished art works and my previous role as a mathematician.

6.2 Cyclical exegesis: Interconnections

Two recurring and interconnecting elements - the “bridge” and the Möbius strip - are presented in this exegesis. The bridging of the perceived gap between mathematics and art is emphasised through chapter headings taken from mathematics bridging courses, the inclusion of mathematical definitions, the mathematical references in the titles of the paintings and exhibitions, and the bridging course style of presentation using a predominantly visual style.

The physicality of the architecture of the Sydney Harbour Bridge which throws things out of perspective, serves as a symbol of the changing perspectives in modernist painting in Australia - the break with linear perspective. A connection is made between the twist in the arch of the Sydney Harbour Bridge and the twist in the Möbius strip. There is also the conceptual idea of the Möbius strip, as a projection or cross-section of the fourth dimension, being the “missing link” to the fourth dimension and thus “bridging the gap” between the modernist art of the northern and southern hemispheres.

The Möbius strip model, clearly the strongest recurring and interconnecting thread throughout the exegesis, is developed in the following ways:

1. through the interweaving of a series of exhibitions of my own bodies of work inspired by the progressive research into the Möbius model
2. from the mathematical interpretation of my art works
3. through the subsequent research into the influence of mathematics on modernist artists

There are also echoes of the Möbius strip in the cyclical nature of the presentation of mathematical ideas - a strategy often practiced in the teaching or explaining of mathematics. For example, the Möbius strip, the idea of the projection from one dimension to another and the fourth spatial dimension were introduced initially in relation to a specific modelling of on the ceramic Möbius strip surface of a William

Robinson painting. This allowed for a practical understanding of these ideas before a more conceptual treatment of the properties of the Möbius strip in Chapter 3 followed by a more detailed examination of projections and cross-sections of the fourth dimension in Chapter 3 and Chapter 4. The Möbius strip was also used in Chapter 4 to discuss several exhibitions of my work and, subsequently, in Chapter 5 to forge a link to the fourth dimension with some modernist painters. The idea is that each time the concept is repeated the reader feels more comfortable with the mathematics. It is not accidental, that the continuous cycle of the Möbius strip is echoed in the cyclical nature of the process of this exegesis. Nor is it a unique idea: the Möbius strip was also used by Elizabeth Grosz for the physical structure of her book *Volatile Bodies*.[262]

Interest in the relationship of the Möbius strip to the fourth dimension is still current, as is evidenced by the publication between 2006 - 2008 of several new books on the fourth dimension by two major authors in the field, Linda Dalrymple Henderson and Tony Robbin, (see Table 1.1 in Chapter 1). However, what is new in my exegesis is the use of the Möbius strip as a trope to detect and establish the influence of the "new" geometries filtering through from the northern hemisphere on the Australian modernist painters. Instrumental in detecting this mathematical influence on the Australian Modernists was the establishing of the link between the Möbius strip and the fourth dimension, gleaned from the analysis of the mathematics in my art practice.

6.3 Projections for the future: Art / science connection

This century the link between science / mathematics and art is being actively re-established through the discourse and practice of artists and scientist collaborating with each other and again mutually informing each other's discipline.[263] This is evidenced by the art and science sections in recent issues of two major journals: *Nature* V 434 17 March 2005, the international weekly journal of science and *Leonardo* V 38 June 2005, the leading international journal for the arts, sciences and technology. *Leonardo* is currently seeking to publish papers in *ArtScience: The essential connection*[264] which

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[262] Grosz, Volatile bodies: Toward a corporeal feminism.
[263] Wilson, Information arts: Intersections of art, science and technology 5.
[264] "ArtScience: The essential connection," Leonardo: journal of the International Society for the Arts, Sciences and Technology 38 (2005): 223.

investigate the boundaries and intersections of art and science. Perhaps in the future the links between art and science will be even stronger.

A recent example is an artwork designed by professor of mathematics at Penn State, Adrian Ocneanu, in 2005. It is an artwork described as a "teaching tool" [265] that can be used to help visualize several structures in areas of mathematics and physics. The words used to describe it in terms of "a three-dimensional 'shadow' of a four-dimensional solid object,"[266] recall my descriptions of the fourth dimension and its projection as discussed in Chapters 2, 3 and 4.

Please see print copy for image

Figure 6.1 Adrian Ocneanu. Octacube. 2005. Stainless steel and granite. 201 x 200 x 200cm. McAllister Building headquarters of the Penn State Department of Mathematics

My research into dimensionality in this project has prompted my interest in the areas of:

1. the increasing number of dimensions of string theory (see Chapter 2) that physicists describe in relation to small particles of matter and the associated unusual visual imagery emanating from diagrams and videos of these investigations.[267]

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[265] Physorg.com: Science: Physics: Tech: Nano: News, 2005, Available: http://www.physorg.com/news7409.html, 31 January 2009.
[266] Physorg.com: Science: Physics: Tech: Nano: News.
[267] v. Extra dimensions, 2007, Available: http://tena4.vub.ac.be/beyondstringtheory/extradimensions.html, 9 February 2009.

2. the concept of “half dimensions,” from semiotics / psychology, as described by Steven Rosen in his theory of creative evolution of dimensions, or “topodimensionality” (see Chapter 4) , which is a natural progression in the notion of the projecting of images onto a space of an even lower dimension. Rosalind Williams’ investigation of the “underworld” in her long essay *Notes on the underground*[268] also hints at the concept of a lower dimension of space.

3. further links between art and mathematics, especially dimensionality. For example, I have interpreted Margaret Roberts’ drawing *TURN*, 2008 (Figure 6.2)[269] in which a drawing of the room is projected back onto the space of that room, in terms of the mathematics of projections, transformations such as rotation, and topological equivalence.[270]

Please see print copy for image

Figure 6.2 Margaret Roberts. *TURN*. 2008. Masking tape 80 mm. Dimensions variable. Photograph by Sue Blackburn

New research and imagery inspired from a mathematical point of view in these areas from quantum physics, psychology and art, respectively, will contribute to the rapidly growing interconnection between arts practice and scientific knowledge.

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[268] Williams, Notes on the underground: An essay on technology, society, and the imagination

[269] Margaret Roberts, *TURN,* 2008. Factory 49, 49 Shepherd Street, Marrickville. December 2008.

[270] Janelle Humphreys’ review of *TURN* to *Eyeline* magazine currently in progress.

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Appendix 1: Art and the mathematics of the National Museum of Australia

This appendix is the following paper which is referred to in my thesis:

Humphreys, Janelle. "Art and the mathematics of the National Museum of Australia." The International Journal of the Arts in Society 1.4 (2007): 69-76.