Discovery processes in designing

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Paul Murty
Ph.D. candidate
paul@arch.usyd.edu.au

Associate Professor Terry Purcell
Supervisor
terry@arch.usyd.edu.au

Key Centre of Design Computing and Cognition
Faculty of Architecture, University of Sydney
NSW, 2006, Australia

SUMMARY

This thesis describes an interview study of forty five professionally accomplished male and female designers and architects. The study considers how each respondent designs and makes discoveries throughout conceptual design. How they start designing, what they attempt to achieve, the means they employ, how they cope with getting stuck, their breakthroughs and discoveries and the circumstances of these experiences, are the main ingredients of the study.

The aim of the research is to estimate the extent to which designing may be regarded as an insightful activity, by investigating experiences of discoveries as reported by the respondents. Throughout the thesis, discoveries or ideas occurring to respondents when they are not actively designing, an apparent outcome of a latent designing or preparation activity, are referred to as *cold* discoveries. This label is used to distinguish these discoveries from discoveries that emerge in the run of play, when individuals are actively designing. The latter are referred to as *hot* discoveries. The relative insightfulness of *hot* and *cold* discoveries is also investigated.

In general, the evidence from the research suggests that designing is significantly insightful. Most respondents (39:45) reported experiences of insights that have contributed to their designing. In addition there is strong evidence that *cold* discoveries are considerably more important, both quantitatively and qualitatively, than is currently recognized. More than half of the respondents (25:45) reported the experience of *cold* discoveries, many after disengaging from designing, when they had been stuck. Being stuck means they were experiencing frustration, or had recognised they were not making satisfactory progress in attempts to resolve some aspect of conceptual design. Typically these respondents reported experiencing discoveries while doing other work, performing some physical activity, resting, or very soon after resuming work. They had elected to let ideas come to them, rather than persist in searching and this strategy was successful. Moreover, many respondents (10:45) described positive attributes of *cold* discoveries using terms such as *stronger*, more *potent*, or *pushes boundaries*, which suggest their cold discoveries are more insightful than their *hot* discoveries.

Many respondents associated their cold discoveries with mental activities such as *incubation*, a concept identified by Gestalt theorists nearly a century ago. They used a range of informal terms, such as ideas *ticking over*, or *percolating away*. These apparently uncontrolled mental experiences, which I refer to generically as *latent preparation*, varied from one respondent to another in when, where and how they occurred. Latent preparation or its outcomes, in the form of interruptive thoughts, apparently takes place at any time and during different states of consciousness and attentiveness. It appears to be, at different times, unplanned, unintentional, undirected, unnoticed, or unconscious, in combinations, not necessarily all at once. It is clearly not only an unconscious process. This suggests one, or more of the following; 1) that incubation is only a component of latent preparation, or 2) that the conventional view of incubation, as an unconscious process, does not adequately account for the range of insightful experiences of mentally productive people, such as designers, or 3) that the old issue of whether incubation is a conscious, or an unconscious process, is not vital to a systematic investigation of insightful discovery.

The thesis concludes by considering prospects for further research and how the research outcomes could influence education. Apart from the findings already described, statements by the respondents about personal attributes, designing, coping with being stuck and discoveries, were wide ranging, resourceful and down-to-earth, suggesting there are many ways for individuals to become proficient, creative designers at the high end of their profession. A major implication for future research is that latent preparation may be found as readily among highly motivated and skilled individuals in other occupations unrelated to architecture or designing. The evidence of the research so far suggests there is much to be learned about latent preparation that can be usefully applied, for the benefit of individuals aiming to be designers, or simply wanting to become more adept at intervening, transforming and managing unexpected and novel situations of any kind.

ACKNOWLEDGEMENTS

I owe many thanks to the following people and no doubt many others, for countless indirect and direct contributions to my personal development, the undertakings of this research and finally the thesis.

The University of Sydney, the Faculty of Architecture and its illustrious staff and students, accepted me as a sixteen year old Leaving Certificate holder in the 1960s, taught me the basics of my chosen field and provided a convivial learning environment. The Faculty has enabled me to continue learning throughout my life. In fact it made it compulsory. The work in this thesis began as a Master of Architecture thesis on the attributes of designers. In 1971 after finishing the Masters thesis I went off to be an architect, with no thought of returning to academic life. I think I left with a sense of unfinished business, feeling that maybe there was more to designing than attributes, but I needed to experience professional practice if I was contribute from a position of strength.

Few of the colleagues from my architectural practice years directly participated in this research, but many contributed to my thinking and my own latent preparation. The diverse partners and other workmates at Jackson Teece Chesterman Willis, where I worked for several years early in my career and occasionally later, were brilliant in their own completely different ways. My professional colleagues in what was the Electricity Commission of NSW were equally influential. Through being in the right place at the right time, I was fortunate to spend several years helping expedite two massive power station projects, side by side with a small group of brilliant individuals, who could hardly have been more different mentally if I had picked them myself. The combination of these experiences certainly helped prompt me to transfer my 1970s curiosity from (in simple terms) what people were, to what people thought and did.

Professors John Gero and Mary Lou Maher gave me my second chance to look at the big questions of design. John was my Masters Degree research supervisor, but coincidentally in 1994 Mary Lou hired me to teach AutoCAD and she and John welcomed me into the Key Centre of Design Computing, as a contractor. By an unexpected but welcome quirk of fate, a few contracts later, I became a staff member who needed a PhD. The unfinished business was then back on the table and my guide in unravelling it and ever since, has been my supervisor and unfailing supporter Terry Purcell. Terry has introduced me to both cognitive and design research, provided insightful nudges in productive directions, displayed a wonderful ability to encapsulate ideas and has been constantly encouraging when I needed cheering up, which was often.

Present and past colleagues of the Key Centre for Design Computing and Cognition and elsewhere in the Faculty have made many contributions in the form of ideas and encouragement. Direct assistance came from Michael Tang in the form of guidance on my thesis proposal structure, Gerard Gabriel for assistance with qualitative analysis software. Kate Butler, Katrina and others in the informal qualitative research discussion group have also contributed with tips and encouragement. Those winter nights outdoors at the Duck and Swan were certainly stimulating.

Five good friends, who participated in the preliminary study, let me interview them and responded enthusiastically and openly, helped and influenced the study in many ways. They were followed by the forty architects who participated in the main study, generously giving me hours of their attention at no charge, nearly always during billable time. Several have been very helpful in providing names and contact details. They gave me confidence and made it much easier for me to arrange interviews with architects I didn't know. The leads, enabling me to reach less well known, accomplished female practitioners, were invaluable. As the terms of the ethical consent for my research requires all respondents to remain anonymous, my thanks to these individuals must be general.

A whole chapter could be written about transcribing. Many different people started and completed parts of interviews. A few completed one or two. But the bulk of the work was done by three wonderful mothers of young children, Rachael Titovs, Kellie O'Malley and Cathy O'Malley, all equipped with professional typing skills, time at home and a genuine interest in what I was doing. My daughter Jessica found Rachael, who found Kellie, who found Cathy and so the task was sustained right to the end.

There are more than one thousand pages of transcript, which added up to a substantial cost. Most of this was met from my research funding provided by the Architecture Faculty. But to acquire such

money from the University you need expert help and for this I greatly admire and appreciate the good efforts of Suzanne Roberts in particular. Suzanne and her colleague Megan Haig have also been unfailingly patient in guiding me through the labyrinthine procedures of acquiring travel funding, which change every year, and in organising various forms of leave, especially during 2005.

None of my requests would have made it to first base without the support of individuals higher up the Faculty food chain who have maintained their faith in me, this includes John, Mary Lou and Terry, already mentioned and also Peter Phibbs, Bruce Forward, Warren Julian, Gary Moore and the General Staff. All have facilitated my requests and given personal encouragement as fellow colleagues. I really can't think of anything that I needed that has been refused, which must be a record of some sort.

Contributions by many other friends in Australia and elsewhere and my family have also been crucial to me in many ways. Occasional assistance, willingness to listen, intelligent responses and encouragement, forgiving my inadequate behaviour, being nice to me, all helped. To Sue, my wife and best friend for nearly forty years I owe the most of all. Without her good will I couldn't have taken this on. Others have helped without knowing. Jack Smith, Michael Bennett and Adrian Buzo who have been good friends forever almost, have each contributed to my developing interest in things of the mind, in totally different ways. Sioned Fay encouraged me to work full time on the thesis in 2005. Oh Seung Min (Minnie), her family and especially her father Oh Hyun-Guen. I have a sentimental reason for my thanks, in that the cold discovery idea came to me while preparing my presentation to the ADC 2001 Conference in Seoul while Minnie and her family were looking after me. There was no hint of it in the conference paper. Hyun-Guen invited me to speak to students and Faculty at Pukyong National University in Pusan. Addressing hundreds in a foreign country, with the aid of a translator, then meeting and dining with the professors was a great thrill and gave me tremendous encouragement to get on with my project.

This work has been an investment that I hope will contribute to my life and to others. I feel very pleased at the prospect that I may succeed in adding something of value to the state of human knowledge and thereby contributing to a better world. In my view that seems to be a good way of expressing thanks for the privilege of living.

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APPENDIX CONTENTS

Due to its size and composition, all Appendix items are contained in the CD placed inside the thesis back cover. The Appendix CD includes the complete thesis and three folders containing supplementary information about key aspects of the study, including Methodology, Respondents and Other Documents, as described below.

Note: The Appendix is not included in the digital version of the thesis. Access to parts of the Appendix, for the purposes of an approved program of research, may be provided on request to the author.

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Human Ethics documents folder	Applications and reports, 2002 to 2007
Interview files folder	Developing versions of interviews
Worksheets folder	Project spreadsheets and worksheet images
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Wksheet1_ Activity schedule.gif	Project management tool
Wksheet2_ Completion schedule.gif	Completion management tool
Wksheet3_Q-R-Summary.pdf	Question-response summary
Wksheet4_ResponseAnalysis.pdf	Response analysis
Wksheet5_RespondentDiscSum.pdf	Respondent discovery summary
Wksheet6_DiscoveryExpAnalysis.pdf	Respondent discovery experience analysis
Wksheet7_Graphs.pdf	Respondent graphs
Appendix 2 - Respondents	
Interview transcripts folder	Transcripts of all interviews 9 files, each of 5 interview transcripts
Respondent tables folder	Coded interview data, all respondents 9 files, each of 5 interview tables
Appendix 3 - Other Documents	
Earlier work folder	Papers and other items prior to thesis submission
Recent work folder	Papers following thesis submission
Murty.2007.DiscProc.Designing.PDF	Complete thesis

CHAPTER 1

INTRODUCTION

1.1 AIMS

The general aim of this thesis is to contribute to the understanding of design, designing, design cognition and creative thinking generally. The more specific aim and method, is to attempt to measure the extent to which designing is an insightful activity, by investigating *latent* preparation among accomplished conceptual design practitioners. Concepts drawn from *Gestalt* theory are utilised to identify insightfulness and to provide a consistent and coherent working terminology for the purposes of the research. The term *latent* preparation is meant to describe the acquisition of design ideas and concepts from discoveries, realisations, revelations, or insights that occur *unexpectedly* when individuals are not actively designing. Preparation is a term commonly used to describe the first stage of problem solving. The concept of *latent* preparation is intended to include Gestalt *incubation,* but the expression *latent* preparation is intended to accommodate *incubation-like* mental activities that need not conform to a strict Gestalt definition of being unconscious active work.

Three senses of what is meant by *unexpectedly* need clarification. A capable designer may expect to make a discovery (sense 1) that will lead to a useful concept, before knowing what the discovery will be (sense 2), or when or how it will come (sense 3). The discovery experiences associated with latent preparation are unexpected in the second and third senses. They are unexpected conceptually, in being unrelated or only partly related to current thoughts or activities. They are unexpected in their timing and mode of arrival. Statements from some respondents in this study affirm that discoveries sometimes interrupt current thoughts, or originate thoughts, rather than occurring as a continuation, or destination of intentional designerly thoughts. It is clear that the experience of latent preparation may occur at any time, or place, whether an individual is designing, or not.

In this study the main focus of concern is on conceptual design, or designing that leads to the realisation, testing and acceptance of design concepts. Typically that may be the preliminary design of a whole building, but it might also be the design of a part, like a sun hood, or a stair in the atrium of a high rise building. All of the respondents in this study are conceptual designers, in the sense that they spend a significant amount of their professional lives engaged in conceptual design. More specifically, they start projects and generate the main design concepts, either alone, or in collaboration with others, through a variety of methods. It is well known that architectural practices vary in how they manage designs after the conceptual stage. Some designers hand jobs on to a production team, after reaching a particular milestone, (eg. client or council approval) while others maintain active involvement until construction is completed. This is reflected in design philosophies. Some in the first category would say a 'strong idea can withstand a bit of battering along the way', while some in the second category would declare, 'God is in the details'. No attention is paid to evaluating any design discovery or decision. The focus is on the processes of reaching discoveries and the designers stated experiences.

Although the respondents in this study are mostly architects, it is not assumed that study findings will only be applicable to architects, or designers. It is intended that professional practitioners in other disciplines will also be studied in the future and that the findings of this and later studies will be applicable to all individuals who need to plan and make intelligent, strategic decisions in their work.

1.2 HYPOTHESES

The specific aims of the research are to evaluate the following three experimental hypotheses.

1. Unexpected discoveries during the conceptual phase of a design project include both;

   i) insightful discoveries, which resemble Gestalt insights, and therefore may involve what Gestalt theorists have described as productive thinking and,

   ii) non-insightful discoveries which can be attributed to normal cognition, or reproductive thinking.

2. Among some designers, unexpected discoveries when they are not actually working on their design, described as *cold* discoveries, are important in their designing.

3. Unexpected discoveries made during active design sessions, described as *hot* discoveries, are more likely to be the outcome of normal cognition, or appear to be that way, while *cold* discoveries made when the designer is not actively thinking about the problem, are more likely to show signs of being insightful.

1.3 THESIS IN BRIEF

The body of the thesis, which follows, consists of five chapters

CHAPTER 2 REVIEW OF RESEARCH CONTEXT

This chapter, which gets the business of the thesis underway, has two parts.

2.1 Investigations: is a synopsis of the events and ideas that have contributed to the formation of design research in its present form. Three main sources of development are described and discussed: 2.1.1 Mapping design, was very much an exploratory stage of design research during the 1960s. 2.1.2 Observing designers, was a logical progression, as the limitations of mapping based on conjecture rather than evidence of how designers actually worked became apparent. 2.1.3 Cognitive research, a parallel and vigorous area of enquiry, sometimes involving design research, has also generated new ideas and resurrected earlier concepts and techniques initiated by Gestalt researchers.

2.2 Applying the Gestalt Legacy, sets the course of the thesis leading to the decision to apply ideas drawn from Gestalt theory to the study of design discovery, by interviewing designers at work. This part commences with a review of criticisms of Gestalt theory. Targets include its theoretical limitations, absence of agreement on the nature of insight, shortcomings in Gestalt research methodology and skepticism of the need for the concept of insight. The review concludes that in spite of its shortcomings Gestalt theory is a rich source of clues and tools for the study of human intelligence and of the insightful discoveries of designers in their everyday working environment. Five components of discovery, from the body of existing research on insight and creative problem solving, are identified and described. They are: 1) Preparation, 2) Fixation, 3) Incubation, 4) Restructuring and 5) "Aha!" experience. They form the structure of a review of alternative theoretical views of discovery, forming the remainder of Chapter 2 and providing the base for the proposed method of analysis of insightful discovery presented in Chapter 3.

In 2.3 Research issues and options, attention is directed towards research variables, collection methods and organisation, to be elaborated in Chapter 3.

CHAPTER 3 INTERVIEW STUDIES METHODOLOGY

This chapter, describing the development and design of the research, has three main parts, aims and objectives, the interview study procedure and the treatment of the information data.

3.1 Studies, Aims and Objectives, describes the development and aims of the interview studies, in three parts. 3.1.1 Preliminary study aims, describes the initial aims of the preliminary study, as a "pilot" study. 3.1.2 Extended role of Preliminary study, describes the reasons why an initial decision to treat the preliminary study as no more than a "pilot" was reconsidered and a decision was subsequently made to consolidate the data from both studies. 3.1.3 Study Aims generally, sets out the broader aims of the combined studies

3.2 Interviews, addresses the interview design. Four aspects are described. 3.2.1 Respondent selection, focuses on the respondents and how they were selected. 3.2.2 Interview setting and recording, describes the physical and technical components of the interview study, including the interview setting and methods of recording, sound-editing and copying, and transcription of the interviews. 3.2.3 Semi-structured Interview Procedure - provides details of the initial interview planning, communications with respondents and the interview structure. Finally, 3.2.4 presents the interview questions, with comments on each question and allowances for variations in responses. The preliminary and main study questions are displayed together, to facilitate comparisons.

3.3 Interview Data, describes both the data and its organisation. Respondents are identified by a coded ID so that their identities will not become a distraction. The main function of data organisation is to facilitate the finding and presentation of responses, or statements that are relevant to one of the three research hypotheses. Coding of the interview data is described in three parts: 3.3.1 Coding Method, reviews method development and explains the methods of analysis and interpretation

employed in the production of the thesis. Data items retained and studied include the interview recordings, transcripts and subsequent coded interview text and database files, containing abbreviated or coded responses to all questions by all respondents. 3.3.2 Respondent Table Coding, sets out and explains the method of coding interview data based on the use of individual respondent tables. Testing the three research hypotheses involves assessing insightfulness and importance of both, *hot* discoveries and *cold* discoveries, based on respondent statements. Hypothesis 1: evaluation of insightfulness is based on the proposition that descriptions of insightful discoveries will reflect associations with components of discovery described in 2.2 above; ie. *preparation, fixation, incubation, restructuring* and *'aha!'* experience. Hypothesis 2: evaluation of the significance of cold discoveries is based on frequency, value and confirmation that they are cold discoveries. Hypothesis 3: evaluation of the insightfulness of cold discoveries in comparison with hot discoveries is based on observations made by the respondents.

CHAPTER 4 INTERVIEW RESPONDENTS

Statements the respondents made about themselves and their designing are the focus of this chapter. Many of the early interview questions in particular, prompted a wide range of statements of different experiences, traits, beliefs and priorities. These indicated that, from the outset of conceptual design, the respondents consistently attempt to do different things. They proceed in different directions, adopt different strategies and use different methods of handling the *stuff* of the design. They experience different ways and means of progressing and of making discoveries, all of which extend the limits of their understanding differently.

The first part of this chapter, 4.1 General Attributes, provides a brief overview of the respondents, considering the distribution of attributes such as years of practice, gender, RAIA award status, partnerships, development history and formative characteristics.

The next three parts describe how the respondents design, employing three categories, which all have a cognitive side, 4.2 Design focusing, describes respondent values and aims. Three main concepts described here include: Focus Orientation, Scope and Framing, 4.3 Design processes provides an indication of the conscious aspects of designing, combining the design generating approaches and what the respondents actually do, when they design. Key concepts and issues include: Idea Driven design, Emergent Understanding versus Understanding Led design, Magazine browsers versus Originators, Inside-out versus Outside-in, General to particular versus Particular to General, Plan versus Section or 3D representations and Intuitive versus Rational design. 4.4 Design Action Styles describes patterns, or idiosyncrasies, in the way individuals design, that have developed and stabilised over time. Action styles include Progression Mode, Incessancy, Quick versus Reflective, Creative Catalysts, Reactivation and Representation Preferences

CHAPTER 5 DESIGN DISCOVERIES

This chapter describes the key results of the interviews relating to the research hypotheses. Briefly, more than 85% (39/45) of all respondents confirmed Hypothesis 1. Among this group, more than 50% of all respondents (25/45) confirmed Hypothesis 2. Then among the latter, more than 20% of all respondents (10/45) confirmed Hypothesis 3. A fourth and separate group of respondents, less than 15% (6:45) of all respondents, are categorised as incremental designers.

The first three sub-chapters describe the design experiences of respondents whose statements best fit them to one of the three hypotheses. A fourth sub-chapter describes Incremental designers or respondents whose discovery experiences were minor, unidentifiable or forgotten. It is noted that the three hypotheses can be equated with levels, in the sense that a positive result in Hypothesis 3 depends on a positive result in Hypothesis 2, which similarly depends on Hypothesis 1. Therefore respondents can be viewed as having different levels of insight experiences.

To avoid repetition, in the description of the results that follows, respondents have been grouped by Level and are described in the sub-chapter that corresponds to their Insight Level. A selection of the most informative and different respondents are reviewed in detail. The remainder are summarised. 5.1 Insight Experience - Hypothesis 1 - reports insight and discovery experiences of 12 Insight level 1 designers. The respondents are ordered according to the qualitative characterisation of their experience, based on the key terms, *clarity, fluency, recognition* and *idea*. 5.2 Cold discovery experience - Hypothesis 2 reports insight and discovery experiences of 15 Insight level 2 designers. These respondents are ordered in a similar manner to the Level 1 designers. 5.3 Cold discovery insightfulness - Hypothesis 3 continues, describing 10 Insight level 3 designers. Finally, 5.4 Incremental Design - describes respondents with few or no insight recollections

CHAPTER 6 DISCUSSION

The purpose of this chapter is to review the information provided by each respondent, to return the focus of consideration to the research findings and to consider what they mean.

6.1 Review of discovery findings, considers the findings of insightfulness in relation to the respondent population. Levels of insightfulness have been graphed in relation to key respondent variables, gender, years of professional practice and RAIA award status. No dramatic surprises are evident. The visible trends are not very pronounced and are obscured by interference between the variables, as the female respondents are younger than the males and proportionally fewer have won awards. In general, males, more experienced designers and award winners were more frequently associated with Insight Level 2 than other levels of insightfulness, while females and less experienced designers were more evenly distributed across Levels 1, 2 and 3. Further minor trends are also evident. Part 6.1.1 Insight Experience - Hypothesis 1, reviews the findings of relevance to this hypothesis in relation to insight components. This section refers to all 45 respondents, not just the Insight Level 1 group. Parts, 6.1.2 and 6.1.3, which follow, are specific to Hypotheses 2 and 3 and focus on the distinguishing characteristic of the Insight Level 2 and the Insight Level 3 respondents. The fourth part 6.1.4 is a summary of observations about the remaining respondents, categorised as Level 0 or Incremental Designers. In spite of small numbers this is a varied group which comprises three distinct types.

6.2 The Respondents, compares the Chapter 4 findings, associated with respondent attributes and their designing, with the Chapter 5 findings of insightfulness. In 6.2.1 Ways of designing, respondent variables including Design Focusing, Intuitive versus Rational design and three Design Action Styles (Progressions, Incessancy and Reactivation) are compared with Insight Levels and Discovery Experiences. This analysis suggests, among other things, that variations in Design Focusing and Action Styles are more strongly associated with Levels of Insightfulness and Discovery Experiences than whether respondents are Rational or Intuitive designers. It is proposed that this unexpected finding could be related to evidence that some of the most accomplished respondents appear to have combined rational procedures with their intuitive designing

6.3 Future Research, describes three directions of enquiry. 6.3.1 Replication and extension studies outlines options to replicate and extend the study by interviewing small groups of respondents, of a wide range of distinct types, including systematically different architects, designers from different disciplines and non-designers in occupations with a significant strategic, cognitive, or creative component. It is proposed, by this approach, to approximately double the current population and widen the scope of investigations into latent preparation. 6.3.2 Deeper exploration of available data is proposed, to enrich the current qualitative analysis, by more thorough coding, and to further develop the basic existing quantitative study, by applying more advanced statistical methods. This approach can be applied to research questions associated with issues of: discovery hotness and coldness, distinctions between problem solving and creativity, perceptions of discovery and intuitive designing, early formative experiences and collaborative partnerships.

6.3.3 Bridging or collaborative studies. Possible utilisation of the extensive data collected for this study, in other research, is also foreshadowed. Examples could include investigations of relationships between theories of creative cognition and design thinking, studies of the role of working memory and long-term memory in designing, particularly in relation to hot and cold discovery. Studies of design reasoning and visualisation, including blindfold design studies.

CHAPTER 7 STUDY CONCLUSIONS

Concluding remarks begin with a summary of the main findings of insightfulness confirming the three research hypotheses. This is followed by a summary of concepts that have been developed after listening to the respondents describe themselves and their designing, and the subsequent discovery of significant insightfulness in their work. These include action styles, levels of insightfulness, discovery experiences and latent preparation. The thesis is completed with a few last words on the broader context of the research including thanks to the late Herb Simon for insightfully reapplying long neglected concepts and methods from early Gestalt research in his own totally different ground breaking research.

APPENDIX

The Appendix items of this study, being extensive and of varying forms are in a CD attached inside the back cover of the thesis hard copies. The CD includes the complete thesis, interview transcripts and coding, conference papers and other documents. Refer to p.9 Appendix Contents, for details.