Emotion and Insight: The physiological and psychological experience of positive and negative insight through qualitative exploration of everyday experience and quantitative investigation using problem solving tasks.

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Submitted to the University of Buckingham in partial fulfilment of the requirements of the degree of Doctor of Philosophy

February 2017

Abstract

An insight moment is defined as a sudden new idea, understanding or solution to a problem accompanied by an Aha experience. Typically researchers have described this experience in terms of positive emotions, with a recent shift in focus from purely cognitive aspects to explore the phenomenology of insight. Taking such an approach, this thesis firstly identifies that the historical research focus on cognitive, experimental methods in the study of insight may have led to an incomplete definition. A series of qualitative studies were therefore undertaken to characterise everyday experience of insight.

Firstly an online questionnaire collected 76 open, qualitative descriptions of everyday insight moments. These were analysed by an adapted qualitative method, Integrative Thematic Analysis (ITA); developed within this thesis to minimise the effects of researcher subjectivity bias. Results identified a typology of insight, with themes describing the Process (Time Away, Active Search, Social Facilitation), Content (Intellectual, Practical, Personal) and Feeling (Positive and Negative) aspects of insight. These findings represent the documentation of negative insight in research for the first time. A follow up study using the same methodology was then conducted to specifically record everyday experiences of negative insight. ITA and Deductive Content Analysis were performed on the 67 insight descriptions collected. Findings suggest a functional role of everyday negative insight as a problem finding process, which is not recognized in current definitions of insight framed as a positive event. As a result, this thesis proposes the development of an updated definition of the insight moment for further experimental testing as:

> **A sudden new understanding, realisation or idea that is accompanied by a positive feeling Aha moment, or negative feeling Uh-oh moment.**

A third qualitative study was then conducted to record everyday insight moments in real-time, using a diary methodology and event contingent sampling in a focused sample of 11 participants. This aimed to explore the prevalence of insight in

in real-time in everyday life for the first time. Follow-up semi-structured interviews with participants were then conducted that intended to enable rich accounts of their insight experiences. Insight moments were shown to be rare, with few reports made during the participants' week of recording. This corresponds with researchers expectations in terms of prevalence but was shown to contrast to the participants who were surprised by how few insights they experienced. Furthermore, the de-brief interviews identified some participants who reported never experiencing insight, corroborating other recent research suggesting that the insight moment might not be a universal experience. ITA identified themes, including Individual Differences in insight, where participants suggested that differences in factors such as trait emotionality may affect how people experience insight.

The emotional aspects of insight identified from the qualitative studies were then explored in two laboratory-based experiments. Psychological and physiological aspects implicated in previous insight and emotion research were measured including: emotional expressivity (Berkeley Expressivity Questionnaire), interoceptive accuracy (Heart Beat Counting [HBC] task) and heart rate [HR]. In Study 4, 79 participants completed Compound Remote Associates, an established problem solving task that elicits positive insight and search experiences. No relationship was seen between emotional expressivity or heart beat counting accuracy and performance (proportion of insight and search reported) on the CRA. Different HR changes were shown between insight and search trials, with decreased deceleration in insight. A biphasic HR change response was seen for both solving types that was congruent to HR changes shown in previous research in response to emotional stimuli.

Study 5, then aimed to explore the same measures using a problem solving task that in addition, elicited negative insight. In order to do this, a novel paradigm was developed, using Connect 4 as a naturalistic problem solving task. This was demonstrated to elicit the full range of problem solving experiences, positive and negative, insight and search in a sample of 80 participants. No associations were seen between solving performance and emotional expressivity or heart beat counting accuracy. HR change patterns seen in Study 4 were replicated, with greater HR decreases for search compared to insight trials, although evidence was less clear in terms of the biphasic response.

The utility of Connect 4 as a naturalistic problem solving task was demonstrated by Study 5, however limitations in the computer-based version of the game developed in this thesis were also identified. As such, future research is recommended with an improved version Connect 4 to enable more robust conclusions to be drawn. In addition, the limitations of the proportion of insight, a problem solving performance measure, were also highlighted. Therefore, future work to better validate this measure in laboratory based tasks, and in relation to everyday insight experience are proposed.

The findings in this thesis are discussed in terms of wider impact, in relation to applied fields beyond academic study. For example, in Counselling Psychology where insight is seen as a central process in therapeutic change, there are implications in terms of individuals who do not report having insight. Furthermore, everyday creativity including experiencing insight has been demonstrated elsewhere to relate to flourishing and wellbeing, with this research offering corroboration in terms of the positive experiences reported in relation to insight.

This thesis contributes to our knowledge in first offering an updated and ecologically validated definition of insight. Furthermore it highlights the role of emotion in insight experience and corroborates the phenomenological approach that is now being seen in insight research. Finally, it identifies a possible somatic marker in HR, to distinguish insight and search solving. In addition, novel methods of qualitative analysis (ITA) and a naturalistic experimental problem solving (Connect 4) have been developed.

Acknowledgments

The irony of my thesis incorporating research on emotion and emotion expression, when I am adverse to any form of public expression of emotion is not lost upon me. But here I must buck this trend and express thanks, gratitude, sheer relief and happiness to those who helped me over the last three years of study. These include my husband, Richard and children, Courtney, Sam, George and Joe. Shelly, my first supervisor who has believed and encouraged (and sometimes downright forced!) me every step of the way. Philip (second supervisor) and Alan (head of department) who have developed a research environment in which I have thrived. Our PhD SOS gang who have supplied cake, cheese scones and been there for every Uh-oh moment. Also, all of the often forgotten non-academic staff around the university, in both the Hunter Street and Verney Park Library, my early morning friends in domestic services and most importantly Sharon and Jayne who are the heart of the psychology department. Finally, I have a huge appreciation to all of my participants, both online and in person who have contributed to this research. Thank you!

Declaration of Originality

I hereby declare that my thesis/dissertation entitled *Emotion and Insight: The physiological and psychological experience of positive and negative insight through qualitative exploration of everyday experience and quantitative investigation using problem solving tasks* is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text, and is not substantially the same as any that I have submitted, or, is concurrently submitted for a degree or diploma or other qualification at the University of Buckingham or any other University or similar institution except as declared in the Preface and specified in the text. I further state that no substantial part of my thesis has already been submitted, or is concurrently submitted for any such degree, diploma, or other qualification at the University of Buckingham or any other University or similar institution except as declared in the Preface and specified in the text.

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1 Literature Review

This programme of research aims to explore the naturalistic experience of insight. It will firstly focus on every day experience of insight to clarify if and how the definitions of insight used in creativity research relate to those seen in daily life. A second aim is to expand definitions that focus on insight as a positive, solution moment to incorporate negative insight experience. Finally the role of biology, drawing from problem solving and emotion research in relation to positive and negative insight will be explored.

1.1 Approaches and definitions in the study of insight..

1.1.1 Origins of research into creativity and insight.

The often cited catalyst for psychologists' interest in creativity is Guildford's1950 APA presidential address, through which he highlighted the "appalling" (p. 34) lack of research into this area at that time. Reviewing Guildford's (1950) speech provides many interesting correspondences to the contents of this thesis that will be highlighted in the following overview.

Firstly, and perhaps key is the relationship between creativity and insight. While Guildford (1950) bemoaned the general paucity of creativity research, he highlighted the close association between creativity and insight. Outlining an early stage model of creative problem solving processes (Wallas, 1926) that identifies insight as one of its four stages. Section 1.1.3.1, below charts this model and its relationship to historical and contemporary perspectives, notably early Gestalt research from which frequent reference is drawn by Guildford (1950).

A second notable reference is made by Guildford (1950) to creativity in everyday life. He highlights that empirically developed conceptions and measures of creativity would need to be related back to people's behaviour in their daily lives in order to demonstrate validity. Furthermore asserting that creativity should be considered in the full range of a population, not just eminent creatives. Section 1.1.2 below (and also 2.4.4.3) will outline how this may have been seen for creativity, but has been overlooked with respect to insight.

Throughout his address, Guildford (1950) takes an individual differences perspective reflecting his research focus on psychometrics and the argument he was making to look beyond intelligence traits towards those representing creativity.

Below, this chapter will explore how an individual differences perspective in insight has very much taken a back seat to the search for cognitive processing explanations of insight (described in section 1.1.4). In particular, the case for exploring emotion and insight will be made. This is not something that Guildford (1950) explicitly discussed, however throughout his address are echoes of concepts that are arguably related to emotion, for example discussions of motivation and temperament. "Impressionability to the environment" (p. 42) that Guildford (1950) tentatively relates to curiosity could equally relate to individual differences in emotional experience. He further highlights how feelings of "unease" or "sensitivity" (p. 42) in some individuals might promote problem finding (whilst others are oblivious); this can be seen to be congruent to ideas proposed in this thesis of the existence of negative insight, outlined below in section 1.2.

Guildford's (1950) address was before the 'cognitive revolution' and the subsequent development of neuroscience to complement psychological research and help explore the relationship between mind, body and brain. As such it is perhaps unsurprising that the final consideration of this thesis, exploring physiological (heart rate) aspects of insight, was not discussed by him. Section 1.2.5 will outline the biological basis of insight, briefly focusing on neuroscience and psychophysiological approaches.

1.1.2 Creativity and Insight

Definitions of creativity typically incorporate two aspects, that it produces something novel and useful (Kaufman and Sternberg, 2010). The novelty part of this definition is usually quite easy to determine, more debate revolves around the idea of utility that can be further expressed in terms of the quality of an idea and how useful it is. As highlighted above, Guildford (1950) advocated a research focus in psychology on creativity. Subsequent work has taken both an experimental approach, for example using laboratory based tests such as the Alternative Uses Task (1967) where scores of fluency, originality, flexibility and elaboration are given for participants' creative uses for everyday objects such as a brick. Taking on board Guildford's (1950) call for validation of creativity findings, general creativity in everyday life has also been explored. For example investigating the features and adaptive explanations for creativity in daily life and looking at the benefits of creativity at an individual and societal level (Richards, 2010). In contrast to general creative behaviour in everyday life, much less research is seen specifically in relation to insight in everyday life.

In terms of creativity theory, Wallas (1926) proposed a stage model of creative problem solving which can be seen as an early process model of creativity. He identified four stages of problem solving: preparation, incubation, illumination and evaluation. The preparation stage sees efforts to capture aspects relevant to the problem, incubation is seen as an unconscious process where the work continues on the problem while an individual is engaged in other, unrelated activities. The solution then appears back into consciousness through a moment of illumination or insight, with a final verification checking the solution is correct. This model has clear links to insight, which will be further discussed below in 1.1.3.

However, other models of creative processes have since been proposed that can also be seen to relate to insight. For example, Runco and Chand (1995) suggested that there are three aspects involved with creative problem solving, problem finding, ideation and evaluation. The role of insight in this model is less explicit than in Wallas' (1926), with insight processes forming part of ideation, in the production of different candidate solutions to the problem.

A final alternative way to compare creativity is as a developmental process. Kaufman and Beghetto (2009) expand on a distinction often made in creativity literature between eminent creative people and everyday creative acts such as painting or playing music. They highlighted that further distinctions be made, identifying a progression from one type of creativity to another. As such the final stage of this can be seen as the Big-C of eminent creativity. However not everyone reaches such recognition, but never the less engages in high levels of creativity perhaps in a professional basis where a certain level of expertise is assumed, this is categorised as Pro-C. The everyday creativity, recognised as such by others would therefore be seen as non-expert creativity, so the painters and musicians who show little-c creativity. However, in addition Kaufman and Beghetto [2009] propose a more personal level of creativity where activities are new and useful to an individual, so-called intrapersonal insight, in which the first level of creativity is seen, labelled mini-c. Further discussion regarding this model in relation to insight can be seen in section 2.4.4.3.

1.1.3 Historical Study of Insight: Gestalt Psychology

1.1.3.1 Insight solving: beyond learning explanations.

Early studies of insight were undertaken by Gestalt psychologists such as Kohler (1925), Maier (1931) and Duncker (1945). These focused on the restructuring element of insight and were seen to support the notion that perception of the Gestalt or more accurately, changes to this perception are necessary to enable an insight. This provided a challenge to the predominant American behaviourist approach that argued any behaviour could be exclusively explained through learning and conditioning processes. As such, Gestalt and neo-Gestalt (e.g. Ohlsson, 2011; Perkins, 2000) psychologists posited that insight (as part of creative thinking or problem solving) was a special process distinct from analytic thinking that relied on trial and error, learning-based processes.

This original distinction between insight and learning-based explanations was described by Wertheimer (1959) as productive versus reproductive thinking (Cunningham and MacGregor, 2016). With reproductive thinking being a problem solved by 'reproducing' previously learnt or habitual behaviour. Whilst productive thinking requires something more in its explanation than previous learnt behaviour. That 'something', the Gestalt psychologists argued was insight (Dominowski & Dallob, 1995). Recent research has adopted this distinction to propose a series of behaviours that are self-rated and give an indication of an individual's tendency to use productive or reproductive thinking (Cunningham & MacGregor, 2016, 2013). Cunningham and MacGregor's (2016) approach sees productive thinking as analogous with insight.

However, another common distinction is made in research is between insight and search (interchangeably referred to as search or non-insight solving) (Bowden and Jung-Beeman, 2003a; Jung-Beeman et al., 2004). In this paradigm, participants are typically presented with word association problems (a variation on Mednick's (1968) Remote Associates Test (RAT) called the Compound Remote Associates (CRA) task (Bowden and Jung-Beeman (2003b)) where they find a single word which forms a compound word or phrase with each of the three presented. For example the solution when presented with river, note and account, is bank. Participants then rate their solving experience indicating whether they were solved by insight or non-insight, search-type processes using what was subsequently labelled feeling-of-insight ratings (Jarosz, Colflesh and Wiley, 2012). Bowden and Jung-Beeman (2003a) used a seven point rating scale to measure the degree that their participants felt a problem was insightfully solved, while Jung-Beeman et al. (2004) presented a two alternative forced choice (2AFC) response of insight versus non-insight solution. Subsequent research has adopted both approaches dependent on the type of comparisons being made (for examples of use see Danek et al. 2014a; Jarosz, Colflesh and Wiley, 2012; Subramaniam et al., 2009).

However, CRA solutions can be seen as being novel in the sense that they are solutions to a problem that is unlikely participants have faced before, as such both types of solving (insight or search) that the task elicits are examples of productive thinking. Search in the CRA paradigm is in the main defined as an experience that is not insight. The definition of insight commonly offered being:

> A feeling of insight is a kind of ‘Aha!’ characterized by suddenness and obviousness. You may not be sure how you came up with the answer, but are relatively confident that it is correct without having to mentally check it. It is as though the answer came into mind all at once—when you first thought of the word, you simply knew it was the answer. This feeling does not have to be overwhelming, but should resemble what was just described (Jung-Beeman et al., 2004, p. 0507).

As such non-insight or search might be inferred as being a solution with no Aha, that was not sudden or obvious, with a conscious perception of the process by which it was reached. This is different from reproductive thinking where the solution is derived from habit or a purely learned response. This demonstrates how different researchers are using different definitions of insight in their work.

The word association studies described above enable with-in participant comparisons of insight to non-insight problem solving over many trials and so have the potential to provide data enabling more powerful statistical analysis of aspects related to insight (Bowden et al., 2005). Additionally these types of problems lend themselves to being used in neuro-imaging studies as they can be conducted using display screens and eliciting verbal responses and button presses from participants without the need for extensive movement or physical action (Bowden and Jung-Beeman, 2003a; Jung-Beeman et al., 2004; Subramaniam et al., 2009). Taking this approach, the definition of insight relies on the requirement for a solution to be judged sudden and unexpected and accompanied by an Aha moment. This definition focuses on the phenomenological experience of the problem solver and neglects process aspects that will now be discussed.

1.1.3.2 Re-Structuring and Fixation in Insight.

The illumination stage of Wallas (1926) model is equivalent to the insight moment on which Gestalt psychologists focused (section 1.1.3). Many of the tasks that they used to elicit this moment of illumination form part of a classic collection of insight problems still adapted and used in research today. Maier's (1931) ‘two strings’ problem is one example. Two strings are suspended in a room at a distance where one cannot be reached while holding the other. The task is to tie the strings together. Also in the room are a chair and table on which there are a variety of objects, including some pliers. The solution is to use the pliers as a pendulum weight on one string, swinging it so it can be caught while holding the other string. Maier (1931) argued that this problem was difficult for people to solve due to a fixation on using the objects for their primary purpose, so the pliers are only considered to hold or cut things, not as a pendulum weight. In order to solve the problem a mental re-structuring is necessary to imagine using the pliers in an unusual way.

Duncker (1945) also highlighted the role of fixation (also termed set) in his candle problem. Participants were provided with a candle, box of matches and drawing pins and asked to attach the candle to the wall (cork board) so that it could be burnt without spilling wax on the table or floor (version used by Isen, Daubman and Nowicki, 1987). This again elicits a functional fixation as most participants see the box (either drawing pin or match box) as a container and discount it as a resource to solve the problem. The moment of insight occurs when they overcome this fixation and mentally re-structure to see the box's potential to be used as a platform, being attached to the wall by a pin and so hold the candle.

A second insight problem proposed by Duncker (1945) was the tumour problem. In a hypothetical scenario given to a participant, a patient has an inoperable stomach tumour that needs a high dose of radiation to treat. However the dose necessary would also damage surrounding healthy tissue. Participants are asked to provide a solution to treat the patient's stomach tumour without damaging their healthy surrounding tissue. The solution is to use several lower powered radiation sources around the body enabling a concentrated higher dose to be delivered at their targeted point of intersection on the tumour. It is suggested that this is difficult to imagine as many participants falsely believe that the radiation can only be delivered from one source (Gick and Holyoak, 1980). This is an example of fixation resulting from an initial misrepresentation, in this case a single source of radiation.

These classic insight problems do not see comparisons between different types of solving, rather making the assumption that if an insight problem is solved, then insight occurred, and if it was not solved there was no insight. The characteristics of the problem, so the level of restructuring or fixation to be overcome defined it as an insight problem.

1.1.3.3 Insight and the Role of Experience

Others however have argued that the Gestalt psychologist's assertion that an individual has experienced insight by virtue of solving an insight problem is flawed (Chu and MacGregor, 2011). It has been demonstrated that classic insight problems may not necessarily be solved by insight (Danek, Wiley & Öllinger, 2016; Davidson, 1994; Webb, Little and Cropper, 2016). This suggests that insight should be defined by the individual's cognitive processes or experience rather than by the type of problem they solve. One example of this is the role of experience in solving insight problems. This has been explored in terms of it increasing an individual's likelihood of fixation and impeding problem solving and insight (for example Wiley, 1998). Conversely, experience has also been demonstrated to improve performance on insight tasks.

Enhanced solving of Duncker's (1945) tumour problem (see section 1.1.3.2) was seen when participants had previously experienced an analogous problem and solution in a different context or domain. One such example is the Attack Dispersal story (Gick and Holyoak, 1980). In this scenario a General plans to invade a fortress. There are landmines on all the approaching roads that would detonate under the weight of the General's troop. The General resolves this problem by splitting the troop into smaller groups who use different access roads, safely passing over the mines (the smaller groups weigh less than the detonation threshold) and mounting a simultaneous attack on the fortress. The underlying strategy for this is analogous to the solution for the tumour problem. Both divide the attacking agent (troop of soldiers or dose of radiation) to quantities below the trigger threshold that would cause an undesirable outcome. These converge on the target from different directions at the same time. Gick and Holyoak (1980) demonstrated that participants exposed to the Attack Dispersal Story (especially when a hint about its helpfulness were given) were more likely to solve the tumour problem. As such it was argued that experience of the fortress problem could aid insight in the tumour problem. This additionally highlights a weakness in the assumption that all insight problems are necessarily solved with insight, as experience may actually negate the need of an insight moment.

1.1.3.4 Role of Intuition in Insight Problem Solving.

Metcalfe and Wiebe identified in 1987 that while the concept of insight mapped to common sense descriptions, there was little empirical evidence to support the notion of insight. They set about providing evidence in terms of self-reported intuition as participants solved problems through insight and non-insight. Participants indicated how close to a solution they felt at regular intervals whilst solving classic insight and contrasting systematic, algebra based problems. For the algebra problems participants were generally shown to give gradual increasing 'feeling of warmth' (FOW) ratings with time as they worked towards a solution. Conversely for the insight problems, no gradual increase was shown, with low FOW ratings given up until solution when a sudden jump was seen congruent with the insight moment. Metcalfe and Wiebe (1987) suggested the participants' lack of intuition that they were close to an answer could be used to empirically identify and differentiate insightful from analytic problem solving.

However, Metcalfe and Wieble's (1987) distinction was reliant on self-reported awareness of how close participants were to a solution. Maier (1931) demonstrated in his two strings experiment outlined above that there was a difference between participants reports of their problem solving experience and what actually happened. Participants who were unable to solve the problem were given an implicit hint by an experimenter brushing past one of the ropes and so causing it to swing. This group demonstrated enhanced solving of the problem in relation to others in a no hint condition, suggesting that the cue helped them solve the problem. However, none of the participants reported that this incident (the brushing of the rope) helped them reach a solution. This presented early evidence of a disconnect between participant self-reports (such as FOW) and behavioural evidence.

Bowers, Regher, Balthazard and Parker (1990) conducted a series of experiments to explore intuition in discovery. They firstly presented participants with two lists of three words. For one of the lists (the coherent list) there was a word which associated with the three words presented, participants were asked to detect the coherent list and give the common associated word. For trials where they were unable to give a solution, participants were asked to indicate which list was the coherent one. While participants reported that they were guessing, they selected the coherent list at above chance. A second study repeated the methodology employed using Gestalt Closure Figures (partial line drawings of familiar images such as a camel, see Figure 1.1) instead of word lists, The components of the Gestalt Closure Figure (coherent image, Figure 1.1a) were rearranged by artists to produce an incoherent yet "aesthetically pleasing" (Bowers et al., 1990, p. 82) image (see Figure 1.1b). Similar to the effect seen with the word lists, for images that they could not name, participants were better (than chance) able to correctly identify which image was coherent. This again demonstrated that despite a lack of reported intuition, as participants felt they were guessing between the two images, something was enabling them to act intuitively. In a final experiment participants were presented with a list of words for which they had to identify a solution word that associated to each of those on the list. If participants did not know the solution word they were asked to guess, and give a rating of certainty. An additional word was then added to the list and the process repeated until participants indicated they were certain they had the solution. The closeness of the words given through this process for a selection of the participants was rated by assessors blind to the nature of the study. It was demonstrated that the participants' responses gradually became more associated to the actual solution. Crucially, this was much sooner than the participants' indication that they had a hunch (so an increased rating of certainty). A similar convergence on the true solution word was seen in the guesses made for trials reported as insight, where no feelings of certainty were reported before the solution moment. In sum, this research suggests that while intuition may not be consciously reported in experimental problem solving, behavioural evidence supports a role of intuition in insight problem solving.

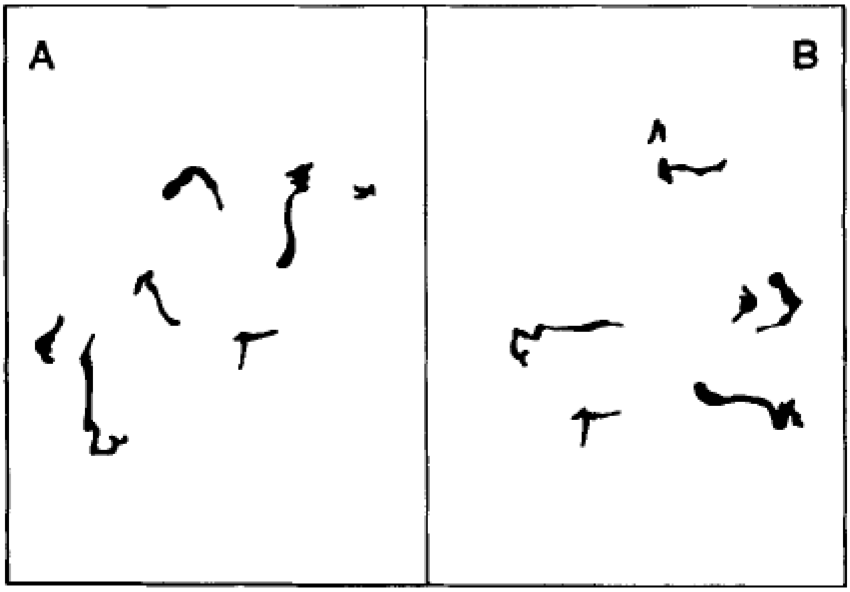


Figure 1.1 Example of coherent (A) and incoherent (B) images of a camel from Waterloo Gestalt Closure Task. Adapted from Intuition in the context of discovery by K.S. Bowers, G. Regehr, C Balthazard & K. Parker, 1990, *Cognitive Psychology*, (1), 72. Copyright 1990 by Elsevier.

1.1.4 Contemporary Theories of Insight

1.1.4.1 Representational Change Theory.

The examples above can be seen to highlight the importance of re-structuring in insight. This forms the basis of a theory of insight proposed by Ohlsson (1992), the Representational Change Theory (RCT) which was later incorporated into a wider reaching Redistribution Theory (Ohlsson, 2011). This proposes that insight is contingent upon the presence of an impasse in problem solving from which the representation of the problem is re-structured (the terminology changes to redistributed in his later theory). Representation of a problem can be restructured in a number of ways: Ohlsson (1992) proposed mechanisms including elaboration and re-encoding which both operate on the initial representation of the problem. An example being in Duncker's (1945) Candle Problem (see section 1.1.3.2) where the initial representation of the box as a container is re-encoded to see it as a platform. Constraint relaxation is another re-structuring process Ohlsson (1992) suggested, this operates on the representation of the goal rather than specific elements in the problem. An example of this can be seen in Figure 1.2 which shows the solution to the six match problem (for example, Weisberg and Alba, 1981). Participants are asked to arrange six matches to make four equilateral triangles and not given any information about the form the solution takes. Ohlsson (1992) suggests that an impasse is caused by the problem solver's representation of the solution as two dimensional. The actual solution is to construct a three dimensional pyramid from the matches where each face forms an equilateral triangle. In this instance he argues that there needs to be a relaxation of the implicit constraint that the solution is two dimensional in order to break the impasse.

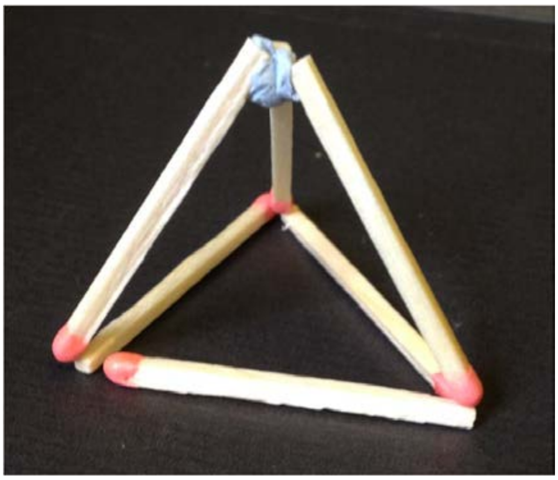


Figure 1.2 Solution to the 'Six Matches' problem

1.1.4.2 Criterion for Satisfactory Progress.

Ohlsson’s (1992) RCT can be contrasted to another theory of insight, the Criterion for Satisfactory Progress (CSP) theory (formerly Progress Monitoring Theory, MacGregor, Ormerod and Chronicle, 2001; Chu and MacGregor, 2011). The focus of this explanation of insight is conscious cognitive processes, explaining impasse and re-structuring in terms of “lookahead” (MacGregor et al., 2001, p. 176) ability, the extent a problem solver plans their forward moves which therefore determines the point at which impasse will occur, with greater lookahead abilities enabling an individual to identify a potential impasse sooner, so begin a search for alternate solving strategies. Jones (2003) compared predictions made by both theories for the car park problem, an unlimited moves computer game where the object is to clear an exit path for a taxi in a car park by moving cars. Trials could be set up requiring an insightful move (where the taxi was moved in addition to parked cars). He found support for both theories and suggested an integrated theory of insight where CSP explains the individual difference in when impasse occurs within the RCT model.

1.1.4.3 Role of Incubation in Impasse

Sio and Ormerod (2009) conducted a meta-analysis of incubation studies in the context of general problem solving, though in practice the majority of studies incorporated in the analysis used problems identified above including classic Gestalt insight problems (section 1.1.3.2), RAT/CRA (section 1.1.3.1) and rebus problems. They identified aspects of insight which seem to affect problem solving performance including the time of attempted problem solving (preparation) and incubation, the presence or absence of misleading cues and the type of problem being solved. Additionally the type of activity undertaken during incubation was also suggested to impact. Curiously, the biggest positive impact on problem solving was seen for incubation tasks of low cognitive load, preferential to either a high load task or where no task was undertaken (generally participants were required to rest or do nothing). Baird et al. (2012) directly tested this finding, investigating the effects of different types of incubation periods on repeated (tested pre and post incubation) and novel (post incubation only) alternative uses tasks. Their findings corroborated Sio and Ormerod's (2009) assertion of the enhanced effect of mundane incubation tasks over a lack of, or more complex activity. They furthermore demonstrated that this enhancement was not shown for new post incubation tasks, eliminating a general post incubation task increase in creative thinking explanation for incubation effects.

Different theories have been proposed to explain incubation effects. Gilhooly, Georgiou and Devery (2013) set out to test three prevailing theories by exploring the interactions between the types of problem solving and incubation tasks presented. One theory suggested that a break from problem solving simply helps to change the focus of the problem solver, so if they are set on an unhelpful aspect of the problem, the break gives the opportunity to change to another aspect (Segal, 2004). An alternative suggestion is that the incubation period enables the problem solver to forget unhelpful approaches, again enabling the adoption of new approaches post incubation (Simon, 1966). They finally explored Dijksterhuis and Nordgren’s (2006) Unconscious Thought Theory (UTT), which posits that attempts to problem solve persist outside of the participants' awareness during the incubation period. In the study participants' either provided solutions for a divergent spatial creative task (mental synthesis) or verbal creative task (alternative uses), with incubation breaks comprising of a verbal or spatial task. Better performance on the creative problem solving task was found subsequent to an incubation period where a less similar task was performed. This suggested support for the Unconscious Thought Theory (Dijksterhuis & Nordgren, 2006) as the similarity of tasks should make no difference to performance where it is simply the presence of a break that explains the effect. In fact forgetting should actually be maximised when the tasks are more similar, as the same cognitive resources would be deployed to the incubation task. For different tasks drawing on different cognitive resources, there would be less of a distraction effect to break the focus on the useful aspects of a problem. Conversely, and in accordance Gilhooly, Georgiou and Devery's (2013) findings, a similar incubation task competing for cognitive resources taking the UTT perspective would interfere with the unconscious processing that could take place. In a recent review of these different explanations Gilhooly (2016) concludes that the most likely explanation for incubation effects is spreading activation below the threshold of conscious awareness.

Whatever explanation is adopted for incubation effects in creative problem solving, it intuitively makes sense that reaching an impasse would cause the problem solver to put aside the task and do something different. However as highlighted, most studies in this area are experimental and so lack ecological validity. This is in terms of the problems being set, the types of incubation task employed and of constraints on natural problem solving behaviour, for example incubation periods are pre-determined rather than occurring in response to participants' reaching an impasse. Therefore it can again be seen as desirable to explore how creative problem solving occurs in daily life.

1.1.4.4 Insight without Impasse

Cranford and Moss (2010) also used CRA tasks to elicit insight and search problem solving whilst conducting verbal protocol analysis: they recorded participants "thinking aloud" to describe their thoughts as they attempted to solve the puzzles, these were transcribed and coded for different aspects of insight such as impasse. From this they identified that some trials of the CRA task were almost immediately solved (within the first 15 seconds), where the first solution word offered by participants was correct. Participants labelled these incidences as insight despite there being no preceding discussion of impasse beforehand. Cranford and Moss (2010) speculate that while there may have been an impasse that was too fast to describe, an alternative explanation might be that the solutions were not insightful, but rather labelled as such due to the speed that the participants saw the answer. As highlighted at the end of the above section (1.1.3.1), participants are instructed to focus on phenomenological aspects such as suddenness when making their FOI judgements. Yet when they respond according to these criteria, the behavioural data collected does not match other cognitive features of insight, such as the presence of impasse. This highlights a gap between cognitively focused, research based definitions of insight and the phenomenologically focused instructions that participants receive in order to identify and report it in elicitation studies.

Cranford and Moss (2011) followed up this with an fMRI study of participants undertaking CRA tasks and giving feeling-of-insight reports. They identified two different neural activity patterns for responses reported as insightful using the 2AFC feeling-of-insight paradigm. These again distinguished between immediate and delayed insight, whilst participant reports did not.

In a subsequent study Cranford and Moss (2012) again conducted verbal protocol analysis with the CRA task. As by definition immediate insight is almost instantaneous, no protocols were produced and so no analysis of this type of solution process was made. For delayed insight and non-insight solutions however, they coded for examples of impasse, fixation and re-structuring and found that occurrences of these in protocols did not predict that a solution would be reported as insightful. As discussed above, a trial is labelled as insight in this paradigm by the subjective experience of the problem solver. Taking this perspective, focusing on self-reported experience and contrary to RCT and CSP theory, the presence of impasse is not seen as an essential component of insight.

1.1.4.5 Weisberg's (2014) Stage Model of Problem Solving: Incorporating Insight without Restructuring and Impasse.

Weisberg (2014; Fleck and Weisberg 2004, 2013) also expands from the dichotomous notion of insight versus search problem solving processes and suggests a stage model of problem solving (see Figure 1.3). It proposes that in the first stage of problem solving, solutions result from the transfer of knowledge directly related to the problem. At the second stage solutions result from the application of heuristics. This incorporates the search approach outlined above, but as Fleck and Weisberg (2013) suggest also accounts for CSP, as look-ahead can be seen as a heuristic process. The third stage represents solutions elicited by conceptually driven restructuring, identified by Fleck and Weisberg (2004) as an incidence of restructuring (and as a consequence and in line with some of the wider definitions, as an incidence of insight) in the absence of an impasse, a suggested necessary component of contemporary insight theories outlined above (RCT and CSP). In the fourth stage (termed by the authors, 'pure insight') solutions occur due to restructuring prompted by impasse.

This model can therefore be seen to incorporate processes described in RCT and CSP whilst accounting for the apparently contradictoriy findings of Cranford and Moss (2010, 2011, 2012) that insight can occur without impasse. The incidence of immediate insight can also be seen to be analogous to solutions reached through Stage 1 of the model. However, Weisberg (2014; Fleck and Weisberg 2004, 2013) asserts that these will be solutions without an Aha, whilst the Aha is the defining feature of their classification as insight by CRA tasks. This again demonstrates how differences in how researchers conceptualise insight in cognitive terms, yet describe insight to participants in phenomenological terms, is problematic.

SOLUTION THROUGH ANALYTIC METHODS

STAGE 1 – SOLUTION THROUGH TRANSFER (PROBLEM-SPECIFIC KNOWLEDGE)

Problem presented ⇒ matches with knowledge ⇒ transfer solution (no solution available ⇒ Stage 2)

A. If solution transfers ⇒ problem solved (problem is familiar ⇒ no Aha!)

B. If solution fails, but new information arises ⇒ Stage 3

C. If solution fails and no new information arises ⇒ Stage 2

STAGE 2 – SOLUTION THROUGH HEURISTIC METHODS (RULES OF THUMB)

2. Apply heuristic methods to problem

A. Heuristic method successful ⇒ solution

B. If no heuristic method produced solution, but new information arises ⇒ Stage 3

C. If no heuristic method produced solution and no new information arises ⇒ Impasse ⇒ Stage 4

STAGE 3 – SOLUTION THROUGH RESTRUCTURING (IN RESPONSE TO INFORMATION ARISING DURING SOLUTION OR FROM FAILURE)

3. New information from failure ⇒ New match with knowledge ⇒ New Method (Restructuring).

A. If new method leads to solution ⇒ stop

B. If new method fails, but new information arises from the failure ⇒ recycle through Stage 3

C. If new method fails and no new information arises ⇒ Impasse ⇒ Stage 4

SOLUTION THROUGH INSIGHT

STAGE 4 – SOLUTION THROUGH INSIGHT (DATA-DRIVEN RESTRUCTURING IN RESPONSE TO IMPASSE)

4. Impasse ⇒ Redistribution of activation

A. If data-driven restructuring leads to new information ⇒ Stage 1; if no new information ⇒ stop

Figure 1.3 Model of stages in Problem Solving (Wiesberg, 2014). The solution moments have been highlighted with red boxes. Stars indicate where possible Mini Aha moments might occur. Adapted from Toward an integrated theory of insight in problem solving by R. W. Weisberg, 2014. *Thinking & Reasoning*, 21(1), 5-39. Copyright 2014 by Taylor & Francis.

The stage model additionally highlights another potential aspect perhaps overlooked. In tracking progress through this model, the potential for mini Aha moments can be seen during the problem solving process. These have been added to the original figure produced by Fleck and Weisberg (2004) shown in Figure 1.3. Effectively, each point where participants glean new information about either the problem or solution could represent a moment of insight, and may in itself elicit an Aha moment. These have been labelled mini Aha to differentiate them from the solution moment. Really this is a question of scale. In daily life, problem solving is unlikely to fall into neat episodes that can easily be divided into distinguishable problems mapping to linear problem solving models such as Wallas (1926) (see section 1.1.2). What is more, as highlighted in real life case studies of famous problem solvers (more detail in section 2.1.4.3), problems may not be solved in a matter of minutes or even days. Therefore, along the way it is possible that both moments of search and insight might contribute to the big Aha at the end.

1.1.5 Lack of a Definitive Insight Definition

To summarise, it can be seen that different research definitions for insight very much depend on the theoretical or methodological approach of the researchers. For Gestalt psychologists, restructuring was central and so problems that on face value required such changes were classified as insight problems and their solving taken to mean an experience of insight had occurred. Neo-Gestalt theorists such as Ohlsson (2011) and MacGregor et al. (2001) focused on the process causing restructuring, seeing impasse as a necessary precursor to restructuring through insight. As such, impasse was central to their working definitions for insight and theories to explain it. As highlighted above, while these theories might be seen as conflicting, Jones (2003) identified that they are complimentary explanations for how impasse might occur. Both however neglect to explain experiences of insight without impasse, some taking these experiences to not represent insight because of this (see Cranford and Moss [2010] and Weisberg [2014]). However others identify insight in relation to experiential aspects rather than processes, for example Jung-Beeman et al. (2004). Use of this definition would not exclude instances of insight without impasse. Finally, a juxtaposition can be seen between Jung-Beeman et al.'s (2004) working definition that participants use to label insight versus search focusing on experiential elements incorporating cognitive and emotional descriptors and their research focus on purely cognitive processes (this disparity will be further explored in section 1.2). Overall however this demonstrates that no single definition of insight is adopted across the literature, and furthermore sees classification of insight moments as dependent on the definition adopted.

1.1.6 Definition of Insight (for now)

As has been discussed above, there are varying definitions of insight used by different research teams using different methods to elicit insight. However, in contrast to creativity research, little has been explored in terms of everyday experience of insight making it difficult to comment on the usefulness and validity of insight definitions seen in research. The few studies that have recognised this are outlined in much greater detail in 2.1.4, but in summary this research in the main uses historical case studies (e.g. Klein and Jarosz, 2011) or focuses on Big C or Pro C creative individuals (e.g. Csikszentmihalyi and Sawyer, 1995). As such, this thesis will explore everyday insight in an attempt to validate findings made experimentally, and check assumptions and definitions adopted over the last 100 years of insight research.

For now, as a starting point two contemporary definitions taking alternate perspectives have been combined to offer a working definition for this research. Beeman, Collier and Kounios' (2008) research reflects a neuroscience approach to the study of insight, very much framing it within a problem solving paradigm. In contrast, Klein and Jarosz (2011) explored naturalistic case studies of insight encompassing a broader selection of situations in which insight might occur. Together they provide an interim definition on which to base an initial literature review and research design for Study 1.

Insight is a sudden solution to a problem, sudden recognition of a new idea, sudden understanding of a complicated situation, a change in mindset or shift in thinking accompanied by an Aha moment (Beeman et al., 2008; Klein and Jarosz, 2011).

Beeman et al.'s (2008) definition allows for the experience of insight across a wide range of situations but was interestingly originally offered not as part of an experimental research report, but rather a non-peer reviewed article directed at a business and management audience. The study of insight has long been identified as problematic as by definition it is unpredictable in its occurrence (Chu & MacGregor, 2011). As such, researchers have sought to identify situations which elicit insightful experiences in order to experimentally explore it. Efforts towards this have generally focused on the first aspect of Jung-Beeman, Collier and Kounios'

(2008) definition by creating problems which are solved through insight. In fact many working, research-based definitions of insight narrow to only consider it in respect of problem solving. Affective Aspect of Insight

As demonstrated above the foundation for insight research and its subsequent empirical exploration has focused on it as a cognitive event. In the main this has concerned the exploration of the processes that occur during insight, for example the necessity for impasse or not. Little focus has been paid to emotional aspects that contribute to the experience of insight. This is despite the definitions of insight used, on which participants' make phenomenological judgements (see above section 1.1.4.4) including emotional aspects such as the feeling of Aha.

Gruber (1995) suggested that in respect of insight the cognitive and affective elements are viewed as separate in line with current thinking about the two at the time. However, as outlined above most research before and after this assertion takes a cognitive approach. If there is reference to affect in relation to insight, it is usually in terms of phenomenological descriptions used in participant descriptions. Little attention has been paid to the affective experience itself. Gick and Lockhart (1995) identify two components of an emotional response which they suggest correspond to the two sources of emotion in insight. Firstly they identify a response to the perceived suddenness of a solution when it comes. This could explain why Cranford and Moss's (2010, 2011, 2012) immediate insight is labelled as such. The surprise of the immediate solution due to its suddenness is interpreted as an insight experience despite other commonly identified aspects of insight being absent.

A second affective aspect, again defined in terms of surprise results from the difference between the solution in comparison to the initial representation (and therefore expected solution) of the problem. Gick and Lockhart (1995) identify that this could be a positive or negative emotion, the positive response relating to the pleasure of having arrived at a solution. They discuss the negative reaction being one of "chagrin" (Gick and Lockhart, 1995, p. 202), as exemplified by the popular cartoon character Homer Simpson's 'd'oh', when he sees something that has been clear to all around him from the beginning. In this instance the negative affect results from annoyance at how obvious the solution was, and how wrong the person's initial interpretation of the problem was. Both of these emotional reactions assume that the insight relates to something positive. In fact this is implicit in the current insightful problem solving paradigm which sees insight as the moment of reaching a problem solution and as such as goal achievement.

However, others do not limit insight by explicitly defining it in terms of problem solving, For example, Klein and Jarosz (2011) described insight as a sudden, new and improved understanding to a situation. This understanding could relate to a better understanding which is negative, leading not to an Aha moment, but rather an Uh-oh or put less politely (and in more ecologically valid terminology) an oh-shit moment! An anecdotal example of this might be in a game such as chess, or Connect Four, where two players make alternate moves. In playing such games there are occasions where insight strikes with a sudden realisation that a move must be made or the game is lost, an Uh-oh moment. This meets the criteria of insight in that the individual experiences a sudden realisation which represents a better understanding of their situation (and often a realisation of something obvious) and is accompanied by an affective response.

While there are no explicit accounts of Uh-oh moments in insight literature, Glick and Lockhart (1995) do unwittingly highlight an example in their discourse. In discussing the role of insight in humour and specifically humorous cartoons they draw attention to a particular illustration by Gary Larson (The Far Side) where two pilots in an aeroplane cockpit are pictured from behind viewing a goat emerging through the cloud (see Figure 1.4). One pilot is seen to remark. "Say....what's a mountain goat doing way up here in a cloud bank?" Glick and Lockhart (1995) suggest that the humour in this story originates in the reader's insight that the goat is in fact on a mountain; this represents a restructuring of the naïve pilots' view. If the pilots had the same realisation, it would likely not be seen as funny, but be experienced as an Uh-oh moment! This example can be seen to demonstrate the fundamental constituents of that outlined above in classic insight definitions, a re-structuring of a problem accompanied by an affective aspect. An additional aspect, implicit in problem solving paradigms, and made more explicit in the context of creativity, is that insight is adaptive (Klein and Jarosz, 2011). In Larson's example, it would most certainly be adaptive for the pilots to have the negative Uh-oh moment in order to take evasive action as they speed towards the mountain!

Figure 1.4 Illustration by Gary Larson (The Far Side) discussed in Glick and Lockhart (1995) as an example of the use of insight in humour, this gives the viewer the insightful Uh-oh moment that the pilots are clearly lacking.

1.1.7 Definitions of emotions, affect and feelings

As discussed above, emotion in insight has been largely overlooked. As such, this thesis will aim to investigate the relationship between emotion and insight further. There is much confusion in the literature regarding the use and meaning of different terms in the relation to emotion, or even in terms of agreeing what an emotion is. Accordingly, it is important to clarify the descriptors to be used in relation to emotion in this thesis. Classic neo-Jamesian approaches see the use of the nouns emotion and feeling interchangeably to describe psychological manifestations of perceived bodily change. Interestingly, when used as verbs in non-academic prose, 'to feel' generally leads to an assumption of an inward psychological phenomenon shared from the first person perspective, whilst 'to emote' implies a more outward expression of emotion intended to broadcast ones inner feelings to others. Gross (2015a) does not define feelings, but does suggest that 'affect' be adopted as an umbrella term for psychological states where an evaluation is made as to whether something is 'good for me' or 'bad for me'. He further suggests that an emotion is an affective experience (helpful or harmful) which is typically in response to an event or stimulus with a subjective experience of change that is relatively short in duration (longer affective experiences being seen as moods). In contrast, Damasio (2000) separates the two: emotion being the actual bodily change; the psychological perception of these changes referred to as feelings. For the purposes of this thesis, emotion and feelings will be used in the interchangeable tradition of neo-Jamesians which is roughly akin to the way that Gross (2015a) defines emotion.

1.1.8 The Role of Emotion and Cognition in Insight.

Sternberg and Davidson's (1995) seminal focus on "The Nature of Insight" included chapters which focused on insight and affective aspects. Within this, Gruber (1995) discussed affect in terms of the "temporally extended internal milieu" (p. 422) that relate to the insight moment, suggesting that the surrounding emotional feelings should be considered in terms of the insight moment. He further highlighted that insights experienced in different emotional contexts will represent different kinds of insight. Gruber (1995) is explicit in his consideration (a reflection of thinking at the time) of cognitive and emotional processes being separate but interactive processes.

Evidence from decision making research contradicts this idea and suggests that distinctions between rational thought and emotion may not be as clear cut as assumed by insight researchers (see recent reviews by Clore & Palmer, 2009; Le Blanc, McConnell & Monteiro, 2014; Lerner, Li, Valdesolo & Kassam). In fact Ellesworth (2014) suggests that emotion and cognition are "inseparable" (p. 24). As such, taking this perspective the exploration of insight should necessarily be conducted with consideration of both cognitive and emotional aspects.

Tversky and Kahneman (1984) demonstrated that how a problem is framed determines decisions made, highlighting a number of heuristics that contradict rational cognitive responses. For example, showing problems highlighting potential gains promote more conservative responses than when loss is emphasised (e.g. Thaler, Tversky, Kahneman & Schwartz, 1997). Recently this research has led to the distinction between two types of thinking. Type 1 thinking being automatic and largely without the involvement of working memory, while type 2 is effortful and involving working memory (Kahneman, 2011). Effortful and rational type 2 thinking might be seen as akin to search and so labelled as such, while solutions that appear as if from nowhere, so not utilising working memory would seem to relate to type 1 thinking. However, Barr, Pennycook, Stolz and Fugelsang (2014) suggest that both type 1 and type 2 thinking are seen in creative processes, finding different correlates to type 1 and type 2 thinking in different creativity measures. In relation to this thesis, the body of work exploring type 1 and 2 thinking highlights that people do sometimes base their problem solving judgements on something beyond reasoned cognitive calculations, this again suggests that affective aspects should be considered in processes previously considered to be cognitive, such as insight.

Outside of the experimental domain, Bechara, Tranel and Damasio (2000) demonstrated the impact of damage to areas of the ventromedial prefrontal cortex (vmPFC) on decision making in everyday life that they attributed to a disruption in the integration of emotional information. Patients with vmPFC dysfunction showed impaired performance on the Iowa Gambling Task, their selections leading to large losses unseen in healthy control samples. Damasio (1994) proposed that damage to the vmPFC prevented the integration of emotional information (the intuitive feelings about each hand of cards) based on previous experience in the task. These he named somatic markers, to avoid the controversies and inconsistencies over the terms emotion or feelings, and also to highlight the role of bodily changes in this process (Bechara and Damasio, 2005). His research demonstrated congruence in effects of the vmPFC damage both in decision making tasks, and in impaired integration of previously experienced emotions (Damasio, 1994). The somatic marker hypothesis proposed that these emotional elements serve an important role in enabling previous experience to influence decisions (but not always in conscious awareness).

As such this highlights the role of biological and emotional aspects in relation to processes traditionally seen as rational and cognitive. The next sections will therefore consider firstly, the different theoretical perspectives of emotion in the context of insight (1.2.3 and 1.2.4) and then the biological basis of emotion and insight (1.2.5).

1.1.9 Insight research taking a basic emotions approach

One predominant approach in emotion research has been to identify and categorise discrete emotional experiences such as being happy, sad or angry. In "The expression of the emotions in man and animals", Darwin (1872) identified a collection of distinctive physiological responses to emotional situations. He sought to verify responses across cultures with missionaries and others who had been in contact with cultures remote to the West. He further identified comparable emotional responses in animals, including congruent illustrations of animals and photographs of human facial expressions.

Ekman (1972, 1992) developed this idea, reviewing literature to identify images showing facial displays of discrete emotions that could be used in his seminal cross cultural research. He demonstrated that the expressions produced by natives from Papua New Guinea were mostly identifiable to participants in the United States, however there seemed to be problems distinguishing between surprise and fear faces (Ekman & Friesen, 1971). From this cross cultural recognition, Ekman built a body of research to support the notion of basic emotions which he claimed are: evolutionary in origin; universally exhibited and recognised; and include the original six taken to Papua New Guinea: happiness, sadness, fear, anger, disgust and surprise (Ekman, 1972; Ekman & Friesen, 1971; Ekman, Sorenson & Friesen, 1969; Izard, 1971). Ellesworth (2014) however highlights the arbitrary nature by which the final set of images and therefore discrete emotions was arrived at in Ekman's original study. The set of emotional facial images verified in other research and available to take to Papua New Guinea was limited by time and resources and therefore was a somewhat arbitrary selection (Elleswoth, 2014). However, despite these limitations Ekman's research has had a fundamental impact on understanding of discrete emotions.

Little research has explored the associated range of discrete emotions to insight. While two studies explicitly explore the basic emotions of happiness and surprise in their research (discussed further below), the relationship between the other emotions and insight remains uncharted. This immediately highlights one potential avenue for research questioning whether, and in what circumstances these remaining basic emotions of sadness, anger, fear and disgust might be experienced in the phenomenology of insight.

1.1.9.1 Insight: happiness and certainty.

Danek et al.'s (2014a, 2014b) predominant research focus was to validate a new task to elicit and measure insight moments using magic tricks. Participants were shown video clips of a magician performing a trick and asked to solve the puzzle of how he did it. In identifying the secrets behind each illusion, participants were asked to identify whether their solution occurred through insight or not. This provided the critical within participant and within task comparison between insight and non-insight episodes necessary for research aiming to identify aspects unique to an insight experience, such as brain activity (method first adopted in development of CRA problems by Jung-Beeman et al., 2004, see section 1.1.3.1).

However whilst validating their magic trick paradigm, Danek et al. (2014b) also explored the phenomenological aspects of the insight moments they elicited. After participants had completed all the magic tricks they were asked to give a single qualitative description of their insight moments produced in the experiment. This was done retrospectively and a description was not collected for their experience of non-insight solutions to enable a direct comparison. The researchers' describe how they identified "meaningful, self-created categories" (p. 5) (although not explicitly named as such by Danek et al. (2014b) this appears to match Hsieh and Shannon's (2005) description of a conventional content analysis). Three raters were asked to allocate each description to one of the categories, providing frequency data of the qualitative responses (given at two time points, on the same day as the magic trick task, and also in a recall session 14 days later). In addition to responses that simply mirrored the instructions and definitions given, cognitive and emotional aspects were identified. Descriptions of somatic reactions in insight were categorised separately from either the cognitive or emotional experiences. This is interesting accounting for the suggested physiological contribution to emotional experience discussed in section 1.2.5 below.

The three emotional descriptions identified by Danek et al. (2014b) in their analysis of participants' qualitative accounts of their insight moments were: relaxation and release of tension; happiness; and performance related emotions (e.g. pride and satisfaction). In distinguishing emotions as discrete entities, Danek et al. (2014b) can be seen to be taking a basic emotions approach. The clearest mapping being the identification of happiness in relation to insight, one of Ekman's (1972) basic emotions.

In addition to participants' describing their insight moments using qualitative methods, Danek et al. (2014b) also asked their participants to rate using Visual Analogue Scales, the extent they experienced happiness (although retrospectively labelled as this the scale rated against was actually pleasant - unpleasant), surprise, suddenness, certainty and impasse. Here again the basic emotions of happiness and surprise are used to quantify the extent that these emotions were reported as being experienced during insight. However, again comparison ratings were not measured for non-insight solutions meaning it is difficult to attribute the reported experience to insight rather than as a generalised response to solving a problem (through either insight or non-insight).

Shen, Yuan, Liu and Luo (2015) conducted a series of studies exploring emotional experience and insight. They firstly asked participants to describe their solution moments for each CRA trial (subsequent to providing their answer and feeling of insight ratings). The researchers took care to avoid too much priming of responses by offering a description of insight based on experiences and examples, rather than using terms relating to positive affect, suddenness or certainty. This produced a corpus of descriptors which were categorised as distinctive to problems that featured an Aha moment and those that did not. The authors do not make clear whether their categorisation was done by comparing response frequencies for the descriptors between the Aha and non-Aha trials or on some other basis. Furthermore, they report the descriptors most frequently used for insight solutions without offering a comparison to non-insight trials. This makes it difficult to eliminate the possibility that the emotions reported were simply in response to having found the solution rather than demonstrating that insight moment descriptions were distinctive from non-insight solutions. From the data reported for Aha solutions the descriptor happy was most frequently offered followed by certain, calm, then excited. A follow up study repeated the CRA task, asking participants to select from a list of descriptors rather than provide open text responses. Comparisons of the mean frequency that each descriptor was selected in insight and non-insight trials found differences in happiness, loss, hesitation, and nervousness but not for certainty or ease. Their data collection approach and analysis methods are congruent with assumptions made of basic emotions, treating their descriptors as discrete entities including happiness which as highlighted above was one of Ekman's (1992) original basic emotions.

Shen et al. (2015) additionally ran a study asking a new sample of participants to sort all the descriptor words given in the free report study for similarity. Using statistical methods (Euclidean Alternating Least Squares Scaling) they identified a model presenting the descriptors in two dimensions: motivational (approach - avoid) and psychological (cognitive - emotional). The authors do not make explicitly clear how this model relates to their findings from the CRA studies, other than to suggest that it supports the notion that insight experience is multi-dimensional. This dimensional approach (see section 1.13 below for discussion of dimensional approaches to emotion) would appear to be at odds with the discrete approach taken in their other two studies.

In sum, the above studies have attempted to capture qualitative and quantitative descriptions of insight experience and emotion. They are consistent in identifying happiness as a discrete emotion associated to insight.

1.1.9.2 Insight and surprise.

Whilst both Danek et al. (2014b) and Shen et al. (2015) identify happiness as a discrete emotion relating to insight, they differ in terms of surprise, which is another of Ekman's basic emotions. Danek et al. (2014b) identified surprise as the second most important emotion after happiness. In contrast, Shen et al. (2015) discarded surprise from further exploration as it did not figure substantially in the free responses given in their initial, exploratory study.

Gick and Lockhart (1995) suggested that surprise is an emotion associated with insight. They posited that there are two potential aspects that contribute to this experience in insight. Firstly, surprise at the difference between the solution compared to the original notion of what the solution would look like. An example of this can be seen in Danek et al's (2014b) qualitative reports; "In most cases, it [the solution] is quite different than I had expected before" (full qualitative responses are included in the article's online supplementary information). Secondly, Gick and Lockhart (1995) suggest the suddenness and ease by which an insightful solution arrives also surprises participants. Again there were many reports of this in the qualitative responses of Danek et al.'s (2014b) study, as well as supporting ratings of surprise.

Surprise is unusual in emotions as there is disagreement as to what (if any) valence can be attributed to it (Topolinski and Strack, 2015). Some posit that surprise is a response to a difference between an event and a prior belief and as such does not have an attached valence (Meyer, Niepel, Rudolph & Schützwohl, 1991, Meyer, Reisenzein & Schützwohl, 1997; Reisenzein, 2000). This position suggests that positive and negative feelings result from a subsequent evaluation of the surprising event in terms of whether is it desirable or undesirable. Such a notion of surprise echoes the first explanation for surprise in insight given by Gick and Lockhart (1995) and outlined above, where the event is the solution moment which is at odds with the problem solver's prior beliefs about the problem. So from this perspective the surprise attached to insight would not be seen as positive or negative.

Bartlett and Izard (1972) however, suggested that surprise is a positive emotion related to pleasantness, further asserting that this is in line with a common sense view that surprise is seen as a positive experience. Shen et al.'s (2015) model of descriptor words identified surprise as being approach based, positively valenced in the context of insight. However, very few participants from a relatively small sample (only 19 participants in the first study) reported surprise in Shen et al.'s study, meaning caution should be employed in the generalisation of this finding.

Ekman's et al. (1997) describe how fear and surprise were found to often be indistinguishable in their cross cultural facial expression research (see section 1.12). This highlights the possibility that surprise relates to negative experience (Ekman et al. 1997). Noordewier and Breugelmans (2013) aimed to test the idea that surprise might initially be experienced as negative. They were building on research indicating a tendency to like and strive for order and predictability; surprise being a deviation from this, therefore evoking a negative response. They first asked participants to recall a surprising event and rate that event for how positive or negative it felt; at the time it occurred and shortly after (so having had an opportunity to conduct an appraisal of the surprising event). They demonstrated that surprising events were initially rated as more negative, and were seen more positively after a short time.

Noordewier and Breugelmans (2013) then conducted studies where faces were rated for valence. Participants were shown Ekman's emotional facial images: adding the label of 'surprise' to pictures depicting surprise led them to be rated more positively than when no description was given. These two studies suggest that there is a positive appraisal bias for the concept of surprise, and this might explain experiences of surprise being remembered as positive, and furthermore the identification of something as surprising leading to more positive emotional interpretations. In order to offer ecological validity to their findings, Noordewier and Breugelmans (2013) used images from Dutch versions of popular television shows, the Antiques Roadshow and Ground Force; both of which incorporate moments of a surprise "reveal" for their general-public stars. They showed stills of the first 5 seconds of the surprise reveal moment to participants, asking them to rate the valence of each image. Images from early in the surprise moment (first two seconds) were rated more negatively than from those at four seconds, post surprise event. This, the researchers suggest further supports the idea that the initial emotion of surprise is negative. However the validity of the findings might be criticised in terms of how naturalistic the TV images were. TV production processes may have introduced confounds, for example if the members of the public in the background of the filming did not look suitably surprised (presumably in congruence to stereotypical lay expectations of surprise) the sequences might have been re-shot to better reflect the 'surprise' being portrayed. There is no way of judging the extent of these types of production and editing changes and whether they may have interfered with the naturalistic expression of surprise portrayed.

Topolinski and Strack (2015) followed up this work, measuring emotional facial muscle responses to experimental elicitation of surprise. Under a rouse to hide the intention of the study, participants were asked to read trivia facts previously rated by independent raters as being high or low in surprise, whilst their facial muscle movements were recorded. Muscle movement typically associated with frowning and therefore negative emotions (the M. corrugator supercilii) was recorded for high surprise trials. Contrary to expectations, muscles traditionally associated with surprise, creating the classic wide eyed expression through lifting the brow (the M. frontalis medialis) were not implicated. This again supports the notion that surprise is a negative emotion at the time of its occurrence. This may be an interesting line of research to pursue in terms of mapping the progression of emotional responses in insight. Using insight elicitation methods for positive Aha and negative Uh-oh moments where the timing of the elicitation can be mapped, corresponding facial muscle movements could then be recorded. This of course would be contingent on reliable elicitation and recording methods for both Aha and Uh-oh moments, something yet to be ascertained (but see Chapter 6 for an exploratory attempt).

Topolinski and Strack (2015) are clear to highlight that subsequent valenced feelings (either positive or negative) evolve as the content of the surprise is further appraised. This fits with Gross' (2015) notion that an emotional response develops by constant cycling through a valuation process allowing for changes in emotional valence over time (see section 1.2.4). Noordewier and Breugelman (2013) suggest that the positive bias in memory for surprise may relate to the subsequent appraisals of the surprise event as something good, with a latency memory effect where the initial negative response is forgotten. This demonstrated that the disconnect between the phenomenological recall of emotion surrounding an event and the experimental findings is relevant for future exploration of emotion and insight. It highlights that a body of evidence should be amassed drawing from a range of different methodologies exploring insight as it happens. For example recording how emotion develops over an experience of insight using: i. self-report phenomenological qualitative and quantitative capture; and ii. experimental measures associated with emotional experience such as physiological or neurological markers.

Others suggest that while surprise associates with different discrete emotions, surprise itself is a purely cognitive process because it has no valence (Oatley & Johnson-Laird, 1987; Power & Dalgleish, 2007). For example, Vanhamme (2000) identified allied emotions providing valence to surprise: surprise and joy giving a positive experience whilst surprise and anger been seen as negative. If the findings of Noordewier and Breugelmans (2013) and Topolinski and Strack (2015) continue to be demonstrated across more experiments in different contexts they could begin to provide more robust evidence of an initial negative valence to surprise. As such this would challenge the view of surprise not being an emotion based on it having no valence, and more clearly re-establish surprise as a basic emotion. Furthermore, this may provide an avenue to examine the differences between insight and non-insight moments. If surprise does indeed render a brief negative facial response, and surprise is a marker of insight, then one could derive and test hypotheses exploring differences in facial muscle responses for insight and non-insight moments.

However, from the research described above it is clear that there is yet no consensus in terms of the "emotional chameleon" (Noordewier and Breugelmans, 2013, p. 1327) that is surprise. This is threefold, in terms of: firstly, the extent that surprise is associated with insight; secondly, the exact nature of surprise as an emotion, and thirdly, if surprise is an emotion in the first place. Furthermore, it is unclear the extent that surprise might be separable form other basic emotions such as negative fear, or positive happiness responses. This may account for the different basic emotions makeup found to associate with insight between studies.

Furthermore, little research accounts for the experience of basic emotions other than surprise and happiness in insight. Ellsworth (2014) cautions that a basic emotions approach constrains emotion research by disregarding most emotional experience and is removed from the experienced flow of emotional states. As such it may be desirable to explore other approaches/theories in the study of emotion when considering insight.

1.1.10 Emotion: dimensional perspective

An alternative perspective identifies different dimensions with which to measure and describe emotional experience. Probably the most often described dimension is that of valence. As highlighted above, this can be seen to be used in discussions of basic emotions. With most (see discussion above regarding the exception of surprise) being designated as discrete examples of emotion which have a positive or negative valence. Gross (2015a) asserts that it is this valuation, whether an event is 'good for me' or 'bad for me' that determines if something is seen as emotional and, if it is, how the unfolding emotion is regulated. Gross (2015a) is clear that this valuation can be formed of internally perceived events as well as external stimuli. Therefore framing insight as an internal world event, the 'good for me' or 'bad for me' judgement may be pertinent to whether an insight leads to an Aha or Uh-oh moment respectively. This idea is in line with Shen et al. (2015) who propose insight events be considered incidences of endogenous emotion.

Russell (2003) proposed that two dimensions best capture moment to moment experiences of core affect in his circumplex model. In addition to pleasure (valence) he identified that arousal was also important, arguing that emotional experience is psychologically constructed; based on core affect (pleasure and arousal); and attributed to events. Russell (2009) uses the terms arousal and activation (antonym being deactivation) interchangeably. Accordingly, psychological construction of emotion incorporates both biological and cultural influences. Biological influences may be interpreted as physiological changes in relation to arousal or valence. Cultural influences highlight that there is also a learned aspect to emotional experience. So from this perspective emotional experience is seen as a construction incorporating both aspects.

Jarman (2014) asserts that emotional experiences are secondary consequences to the purely cognitive insight moment (see section 2.1.5 for more detailed discussion of Jarmam's (2014) research). This stance is maintained in a more recent paper detailing the mental itch experience in everyday, extreme insights (Jarman, 2016). However, examination of the two cognitive components (arousal and motivational urgency) that Jarman (2016) identifies, sees congruence with dimensions seen for Russell's (2003) core affect. Firstly, Jarman's (2016) arousal experience would appear consistent with the similar term in the circumplex model. The second component identified by Jarman (2016) was motivational urgency. Again an interesting analogy can be seen to dimensional accounts of emotion. Alternate descriptions of the valence dimension labelling extremes as approach - avoidance (motivations) or positive - negative (valence) rather than pleasure - displeasure (Russell and Barrett, 1999; see also section 5.1.3 in Chapter 5 regarding defence cascade model.). The motivational urgency identified by Jarman (2016) reflects that his research was focused on problem solving, assuming participants were experiencing insights as solutions to problems with activated goals. As such, the motivation described was purely an approach motivation; the negative aspect to this, avoidance motivation being omitted. However this does demonstrate that there is an arguable, alternative (to the cognitive explanation given by Jarman, [2016]) seeing an emotional interpretation of Jarman's (2016) findings.

This highlights that the dimensional perspective might be a promising approach from which to explore emotion and insight. As such, positive insight would be expected to be rated as pleasurable whilst negative insight as unpleasant. This is congruent to Danek et al. (2014b) who asked their participants to rate their positive insight experiences against this scale (pleasant to unpleasant), but did not elicit negative insights so leaving the picture incomplete (see more detailed explanation of this research in section 1.2.3.1).This simple distinction would additionally avoid the problems outlined above in identifying discrete emotions and fit with the implicit conceptualisation of insight as valenced (positive and negative) taken throughout this thesis. In terms of arousal, this again is highlighted as pertinent in everyday problem solving, as demonstrated by Jarman (2016) where differential motivation and so arousal will be seen for different problems and between different individuals.

1.1.11 **Biological basis of emotion and insight**.

When considering the biological basis of behaviour consideration can be made of activity in the brain and body. This section will briefly explore both in relation to insight and emotion, firstly a neuroscience approach, then physiological.

There is an extensive body of work that has explored the neural processes in and around insight problem solving that in the main is beyond the scope of this thesis (for reviews see Dietrich & Kanso, 2010; Kounios & Beeman, 2014). In general studies that explore insight identify the anterior cingulate cortex (ACC) and areas of the prefrontal cortex (PFC) as important (Aziz-Zadeh, Kaplan & Iacoboni, 2008; Cranford and Moss, 2011; Jung-Beeman et al., 2004; Kounios et al., 2006; Sandkuhler & Bhattacharya, 2008; Subramaniam, Kounios, Parrish & Jung-Beeman, 2009; Zhao et al.,2013). However, many do not actually record activity at the time of insight, one of the few that does being Jung-Beeman et al. (2004). Despite this, most identify the ACC and PFC as key areas relating to insight and interpret this activity as relating to the integration of remote associates (e.g. Subramaniam et al., 2008; Zhao et al., 2013).

The area of the brain most associated with emotion is probably the amygdala, however as discussed by Craig (2009) this represents one component of the underpinning neurological activity to an emotional experience. He proposes that an integration of information pertinent to emotion occurs in the insula; particularly sensory information from the body and external world (somatosensory areas, amygdala and hypothalamus), hedonic information judging valence (accumbens), is assimilated with motivational and social cognitive signals from the ACC and PFC. Further studies investigating interoception, the process by which bodily signals are integrated in higher order neural processing, implicate this in the experience of emotion (for detailed explanation see section 5.1.5.1). For example, Schandry (1981) showed stronger emotional responses in those with better interoceptive accuracy. Interoception in the brain again sees a principle role of the insula, ACC and PFC (Critchley, Wiens, Rotshtein, Ohman & Dolan; 2004, Hertbert, Pollatos & Schandry, 2007; Terasawa, Fukushima & Umeda, 2013; Weibking & Northoff, 2015).

In sum, this highlights how similar brain areas and functions, namely the role of the ACC, in integration are seen for emotional experience and in insight. However, as identified above (section 1.2), and further discussed in Chapter 5 (section 5.1.2.2), implicit assumptions by insight researchers regarding emotion as an after effect rather than integral to it may have led to the relationships between the neurology of emotion and insight to be overlooked. As such, this adds weight to a need for an approach that considers insight and emotion together.

One problem with studies that take a neuroscience approach is that the conditions in which such data is collected, for example in an fMRI, lead to very unrealistic or even unpleasant experiences (Shermer, 2008). As this study is aiming to explore naturalistic experience of insight, it would seem pertinent to take approaches that align to this. As such the invasive and uncomfortable data collection methods associated with neuroimaging may not be the best approach to adopt for this aim.

In addition to the biology of the brain, somatic aspects can also be considered in relation to insight and emotion. These are explored in more depth in Chapter 5 and 6, but will also be summarised here. Jausovec and Bakracevic (1995) were the first to report biological aspects in relation to insight problem solving. Their results suggested a gradual increase in heart activity when problems were solved with search compared to a late jump in activity just prior to a solution in insight. Little research was then reported until several recent papers that again focused on physiological changes with insight. For example, Lackner et al. (2013) also focused on heart rate change when participants viewed humorous, insight eliciting cartoons finding different activity for these against non-humorous control pictures. Shen et al. (2016) recently published research whilst this thesis was being written up (so all thesis data having been collected and analysed) measuring electrodermal activity (EDA) and heart rate variability (HRV), showing effects for EDA but not HRV (for further information see section 5.1.3.1). As discussed in the introduction literature review in Chapter 5, similar physiological responses in terms of EDA have been seen in response to emotional elicitation, for example when participants are presented with pictures with emotional content greater EDA responses were seen for pictures rated as more emotionally arousing (for example Bradley and Lang, 1996; Hempel et al., 2005; Lang, Greenwald, Bradley & Hamm, 1993; Levenson, Patrick, Bradley and Lang, 2000; Sánchez-Navarro, Martínez-Selva, Torrente & Román, 2008). These corresponding physiological responses seen in insight and emotion offer additional belated (in terms of the publication after the design and data collection phases of this thesis) support for further exploration in this thesis of the relationship between physiological changes, emotion and insight. Furthermore, collection of physiological data, such as heart rate and EDA is less invasive than neuroimaging techniques, so offers a promising method for the measurement of more naturalistic problem solving of interest in this thesis.

1.2 Outline of research in this thesis

As highlighted above the overall aims of this research programme are to explore the insight from a naturalistic perspective, with particular attention to emotion and related biological processes. This section will firstly address the researcher's approach to this research in a reflexive section, then outline the individual studies undertaken and identify how they contribute to this overall aim.

1.2.1 Reflexivity

Where qualitative research is undertaken it is typical for the researcher to outline their philosophical standpoint and theoretical position in relation to their analysis. Long (2014) offers a useful review of recently published (2003 - 2012) creativity research, which unsurprisingly highlights that overall the majority of studies (83%) in this field take a quantitative perspective. The rest were either seen to be qualitative (13%) or mixed methods (4%). Of these, the predominant qualitative method used was case studies. The majority of the rest were categorised as 'basic methodology', as they included descriptions of the qualitative data collection methods (i.e. interview, observation) but gave little detail about the qualitative methodology used in analysis. Furthermore, for studies that were classified as mixed-methods, these were labelled as such in the sense that they used a mixture of qualitative and quantitative methods separately, with separate and specific research questions to each part. Long (2014) identified that in the field of creativity, no authors explicitly discussed the methodological perspectives of their studies or the philosophical assumptions underpinning their work.

This thesis can therefore be seen to take a congruent approach to that identified by Long (2014). It takes a post positivist perspective, primarily undertaking small q qualitative research that will inform a predominately quantitative approach (Braun and Clarke, 2013). However, in contrast to Braun and Clarke's (2013) identified pathway of exploratory, qualitative work aiming to generate research questions for subsequent quantitative studies in a sequential design, this thesis is effectively looking to firstly verify the existing, large experimental knowledge base and offer ecological validity to findings after-the-effect and secondly to identify any gaps in that theory.

This stated aim to be both inductive and deductive means that some qualitative methodologies are incompatible with the research approach in this thesis. For example Grounded Theory where there is an avoidance of preconceptions from previous literature (Braun and Clarke, 2013). Furthermore, Braun and Clarke (2013) highlight Grounded Theory's foundations in sociology means that it has a focus on social structures and processes rather than the psychological aspects of interest in this thesis. An additional consideration is that participant's experiences of insight in everyday life are unlikely to be deeply held or reflected upon. Methods such as Interpretive Phenomenal Analysis would therefore not be appropriate as there would not be enough depth to the data for this approach. Thematic analysis provides a flexible alternative in terms of theoretical perspectives and can be used both inductively and deductively (Braun and Clarke, 2006). As such this will form the basis for the qualitative analysis undertaken in this thesis.

1.2.2 Overview of studies

The first aspect that is explored in this research is the experience of insight in everyday life. Study 1 uses open ended questions to elicit qualitative descriptions of insight from online and face to face participants through a questionnaire. Qualitative analysis will be carried out on descriptions given, using a novel method, Integrative

Thematic Analysis. This has been developed for this thesis to protect against biases in analysis introduced by the first researcher (the author of this thesis), who necessarily has expert knowledge of insight. This should ensure that the conception of insight identified is not simply a reflection of the knowledge from previous research-based work. This study will provide for the first time an empirically obtained picture of everyday insight experience. This will inform definitions developed through a purely experimental approach and offer ecological validity to comparable laboratory based findings.

The second study in this thesis then aims to focus specifically on negative insight. Study 2 will again adopt similar qualitative methods described for Study 1 above. A working definition of negative insight will be developed and offered to participants, based on findings regarding everyday insight experience from Study 1, and the research relating to positive insight. This study will therefore enable a more complete characterisation of negative insight in everyday life. It will provide new knowledge to inform and update definitions of insight to incorporate negative insight. Furthermore, it should provide functional explanations and lay interpretations of the adaptive role of negative insight in everyday life.

Study 1 and 2 aim to capture snapshots of everyday experience of insight minimising memory effects in the recall of the experiences by asking (in the first instance) for those that occur within 24 hours. However, these studies collect data through an anonymous questionnaire and so there is no opportunity to probe responses to check understanding where descriptions are ambiguous. Furthermore, the question of prevalence of insight is not addressed through this method. As such Study 3 will adopt Experience Sampling Methodology (Csikszentmihalyi & Larson, 1987) taking event contingent reports of insight in real-time, following eleven participants over a week (Moskowitz & Sadikaj, 2011). De-brief interviews, conducted to review the reports each participant made over their week should provide rich detail of everyday insight, with the opportunity to fully explore and understand their experiences. The qualitative reports and interview transcripts will again be analysed with ITA to elicit further understanding of everyday experience of insight. Furthermore, this will enable the prevalence of insight in everyday life to be reported for the first time.

The research will then begin to explore emotional and biological aspects of insight. In the first instance, in Study 4 this will be done using an established laboratory task to elicit insight and search solving, the CRA task. Performance on this task will be compared to aspects relating to emotion, including self-reported individual differences in the experience of emotion and interoceptive accuracy. Heart rate change over the solving period for insight and search solving will also be compared in order to identify somatic markers of insight.

Having used an established elicitation method in Study 4, Study 5 will finally look to develop a more naturalistic task to experimentally explore insight and creative problem solving processes. A computer based version of Connect 4 is proposed, that in addition to eliciting insight and search solving, will also incorporate emotional aspects of insight and look to stimulate the newly identified negative insight (with a corresponding, negatively valenced search experience). Furthermore, a continued problem solving experience is seen, more akin to everyday solving, when playing a game; with a series of moves each representing separate solving episodes building toward a superordinate goal of winning the game by getting four counters in a row. Similar measures to those recorded in Study 4, so heart rate, an individual differences measure of experience of emotion, and interoceptive accuracy will be taken in order to test theories relating to somatic markers for insight and individual differences in emotional experience and interoception in relation to insight. This also provides an opportunity to collect phenomenological reports of the different solving experiences rendered in order to compare to findings using other problem solving tasks. Finally, by targeting repeat participants from those who take part in Study 4, some longitudinal comparisons on the measures taken will also be made. The beneifts of which will be to explore test-retest reliability of the measures used in these studies.

In summary, this thesis aims to explore physiological and psychological aspects of emotion (positive and negative) insight. This is in terms of everyday insight experience, something that previous research has tended to overlook. Using qualitative data collection and analysis to elicit a detailed, rich characterisation of everyday insight experience. Building on these findings, additional research in a more controlled, experimental environment will explore aspects (psychological and physiological [heart rate change]) of emotion, identified in daily life insight, firstly using an established problem solving task. Finally a novel problem solving task will look to elicit both positive and negative insight and search solving experience.

2 Everyday experience of insight: Questionnaire study.

2.1 Introduction

2.1.1 Circularity Problem in Insight Research

For all of the current approaches to the study of insight outlined in Chapter 1, there is a danger that they rely on a circular argument. The characterisation of insight (on which definitions are based) is made in consideration to performance on insight problems (Dominowski and Dallob, 1995; Ollinger and Knoblich, 2009). In turn, these problems are designed to elicit aspects identified by the working definitions of insight derived from earlier studies. Furthermore, many novel paradigms to investigate insight are validated by comparison to classic insight problems. For instance, Cunningham, MacGregor, Gibb and Haar (2009) used the Repertory Grid (REPGRID, Kelly, 1955) technique to identify characteristics of classic insight problems. This was done by comparing different triads of ten established insight problems. For each, a characteristic was identified which was common to two of the triad, but not the third. This process was repeated between different combinations of the problems and by different researchers in order to identify six key characteristics of insight problems: they elicit a focus on prominent but un-useful concepts blocking alternative productive conceptualisations; solutions require a change in assumptions regarding spatial aspects; or the expected form or structure; sequential nature of a problem; misdirection in problem (either explicitly in question or in assumptions made about the question); unclear what form a solution takes. They then considered the merits of new paradigms including rebus puzzles and remote associate word problems in relation to these characteristics. While such corroboration of new insight problems in accordance to established research tools may assure the reliability of new methods and measures, it does nothing to establish the ecological validity of the conception of insight studied. As demonstrated, the circularity problem means that validation of new insight research methods has been contingent on a characterisation of insight derived from classic insight tasks.

2.1.2 Reliance on Student Samples in Insight Research

A further point to note with regards to validity is the samples from which participants were drawn for the body of insight research. This can be seen in

Appendix 1 which summaries the participant details for the insight studies identified in the initial literature review conducted for this thesis and described in chapter one. The majority of studies which do describe their participants investigate insight using student samples. MacGregor, Ormerod and Chronicle (2001) do include a sample which they refer to as being members of the public, however these were from a convenience sample of attendees at a University Open Day, so quite likely potential students. While this is not uncommon in the context of psychology research it may be problematic in generalising findings. It could be questioned if students are representative; as they are generally young and above average intelligence (for example, Sears, 1986). Furthermore, students are in a learning environment and presumably (hopefully!) actively engaged in learning. As learning has been explicitly linked to insight one might ask if the insight characteristics seen in this population are replicated in older or working participants. Pertinent to this point, Ovington, Saliba, Moran, Goldring and MacDonald (2015) highlight that most anecdotal examples of insight are described in scientists and inventors which again neglects the experience of insight in a more general population. A first step to address this problem might be to include more general samples in insight research to make comparison to results from student participants.

2.1.3 Insight Tasks Contribution to Circularity in Insight Research

As discussed above the circularity problem may have led to ever more narrow definitions of insight in research outlined in Chapter 1, where some researchers only define insight in terms of problem solving without reference to other possible aspects. As highlighted, there are varied accounts of the cognitive and affective aspects of insight. These can often be seen to map to the type of research methods and insight elicitation adopted by the researchers. For instance, look-ahead ability in relation to the nine dot problem was used to characterise CSP theory by MacGregor and his research team (MacGregor, Ormerod and Chronicle, 2001; later Chu and MacGregor, 2011). However this is suggested to be less useful in describing problem solving behaviour in other insight tasks, for instance problems which require a single step, and therefore the role of progress monitoring is limited (Jones, 2003).

A further potential product of this recursive approach to the study of insight is the possible omission of important aspects. Weisberg (2014) concurs, highlighting that our present conception of insight is unable to explain all real life examples. He draws attention to Perkin's (2000) discussion of the accidental discovery of penicillin: Alexander Fleming observed in that bacterial growth was suppressed in cultures corrupted by mould, leading to his 'breakthrough' thought of using this characteristic to create an antibiotic. Weisberg (2014) suggests that such insight incorporates the aspect of problem finding (identified by Csikszentmihalyi and Sawyer, 1995), which current models of insight are unable to account for. A further exclusion from current conceptions can also be seen in the case of negative insight: the Uh-oh moment highlighted in section 1.2. As such, one of the aims of the current research is to identify and provide evidence of Uh-oh experiences and accordingly a novel example of insight as negative insight.

The omissions outlined above highlight that, in addition to validation against previous research it is important to ensure that new methods developed to elicit and investigate insight have ecological validity. In other words, researchers must seek to ensure that the experimental incidences of insight studied, map to everyday insightful experience. In order to do this an accurate description of everyday experience of insight must first be obtained.

2.1.4 Ecologically Valid Experience of Insight

2.1.4.1 Case studies in insight.

With-in their discourse regarding insight many researchers do offer comparison to real-life case-studies. They compare these examples to the characteristics they have experimentally identified, as seen above with regards to the case of penicillin. This is often in their introduction to the topic as exemplified by Ollinger and Knoblich's (2009) opening to their chapter on "Psychological Research on Insight Problem Solving". They highlight Wertheimer's conversations with Albert Einstein regarding his discovery of the theory of relativity (as recounted in Wertheimer, 1959) and discuss how this relates to insight. Others use examples in relation to their research findings. Cunningham et al. (2009) highlight how creators of the user-interactive technology such as Wii and i-pod changed defined structures or forms: one of the characteristics of insight problems their research identified. In the case of the Wii they suggest the way in which a game player interacts through the remote was re-defined. While in the case of the i-pod; a changed view of portable data storage was offered, leading to a new market of digital music and media players. For another of their characteristics; the difficulty in verifying what a solution will look like they again draw from case-study material, relating this to Watson and Crick's search for the structure of DNA.

However there can be argued to be problems in using case study examples in terms of the subjectivity of their interpretation. For example, Ohlsson (2011) used Edison's invention of the lightbulb filament as a case study to examine the production of novelty. He outlines how Edison and his team carried out extensive research into different materials: looking for the one with the right properties to be used as a filament, focusing initially on platinum but finding a solution relatively quickly once attention moved to the exploration of carbon. He (Ohlsson, 2011) uses this case study to exemplify the aspects of impasse and re-structuring central to his model of insight. However others use the same Edison case study to highlight the extensive role of analytical, effortful search in so called insightful creations (e.g. Perkins, 2000). Wiesberg (2014) likewise criticised its use, highlighting aspects of historical accounts which contrast to the suddeness and unexpectedness of the search switch described by Ohlsson (2011). This demonstrates the problem with using historical accounts as exemplars of insight. Whilst aspects of these accounts can be suggestive of insight, without the ability to question the historical character, this cannot be definitively determined and so be open to conjecture and therefore argument as highlighted above.

Klein and Jarosz (2011) used ‘real-life’ examples of insight from books, magazines and newspaper articles (again many being historical case studies). In addition they composed examples from their research discussions and interviews for other studies and from the personal experience of the lead researcher. As a result they compiled a collection of 120 insight "incidents" (Klein and Jarosz, 2011, p. 337). Their criterion for inclusion was that the person made a “radical shift" (Klein and Jarosz, 2011, p. 338) in his or her mental model and that this was towards an improved, more precise or useful representation (adaptive function of insight). They then coded the incidents for 14 features identified from their initial sorting and according to previous literature. Some were common aspects identified in previous insight research, such as the occurrence of incubation or impasse. While other features reflected contextual aspects: an accidental discovery, or elements of the person's cognitions such as identifying connections or contradictions. They concluded that some assumptions regarding insight are incorrect, for example that insight is sudden, asserting that it can be a gradual process. However, this demonstrates how the researcher's original definition influences their findings. As they did not exclude search type processes from their working definition, it is unsurprising that they found evidence of it in the incidents they analysed. This is contrary to many contemporary researchers, who actually contrast search type problem solving strategies to those of insight: unsurprisingly, they do not find insight to include such stepwise, search processes (Cranford and Moss, 2011;2012; Danek et al. 2014; Jarosz, Colflesh and Wiley, 2012; Jung-Beeman et al., 2004; Subramaniam et al., 2009). Both approaches are clear examples of the working definition determining the subsequent characterisation of insight in research findings.

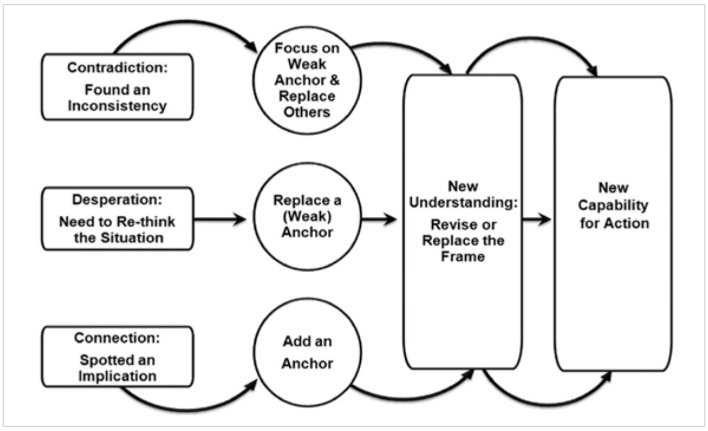


Figure 2.1 Anchor model of insight. Adapted from A naturalistic study of insight by G. Klein & A. Jarosz, 2011. *Journal of Cognitive Engineering and Decision Making,* 5(4), 335-351. Copyright 2011 by Sage Journals.

Klein and Jarosz's (2011) aim was to conduct an investigation of everyday experiences of insight and in collecting such examples they could be argued to add validity to the experimentally derived notion of insight. Their proposed Anchor Model of Insight (see Figure 2.1) does widen the scope of insight experience outside of the problem solving realm. It suggests that insight can result and follow three pathways: an identified contradiction or inconsistency in information; an unexpected connection; desperation when all options for a situation are exhausted. However, as outlined above their method of identifying insight incidents was contingent of their working definition of it and therefore influenced their findings. Additionally, the incidents used mostly relied on retrospective, often secondary source reports of the insightful experience. Such reports would likely be subject to inaccuracies introduced such as by retrospective memory bias or an author’s poetic licence.

2.1.4.2 Errors in recall of insight events.

Gruber (1995) highlights three typical errors which can result from the interpretation of historical accounts of real-life insight incidents. Firstly telescoping: individuals' lose detail due to limitations of their memory, often exhibiting primacy and recency effects (Ebbinghaus, 1902). This means that they remember less of the middle part of an episode potentially leading to a false report of suddenness and completeness of a solution, as some of the process (probably the more laborious working part) is omitted from memory. Secondly, Gruber (1995) identifies that memories may be embellished or altered through rationalisation. These alterations result from a more rational and intuitive interpretation of the situation, being made from the frame of the individual at the time of recall. This may therefore be influenced by aspects such as additional knowledge not available at the time of the incident, or changed social conventions at the time of recall. Furthermore, an expectation that creative invention results from moments of insight might mean such moments are more likely recalled as such.

Errors may finally result from what Gruber (1995) classified as decontextualisation: the moment of insight stands out and is recalled while surrounding contextual information is not. This may not just be due to memory effects, but also related to perceptual and cognitive interpretations at the time of encoding. Maier (1931) demonstrated such an effect in participants undertaking his two strings problem (outlined in section 1.1.4.2). Participants who were unable to solve the problem were given an implicit hint, by an experimenter brushing past one of the ropes and causing it to swing. This group demonstrated enhanced solving of the problem in relation others in a no hint condition, suggesting that the cue helped them solve the problem. However, none of the participants reported that the brushing of the rope helped them reach a solution. This would suggest that although the cue was demonstrated to help, the participants did not see it as contextually relevant to their problem solving and so did not report it.

2.1.4.3 Research of insight in 'Great Minds'.

Csikszentmihalyi and Sawyer (1995) carried out two hour, in depth interviews with older [over 60 years] participants who were prominent creative individuals in their field. From analysis of these transcripts, they identified two types of insight problem solving. Firstly, "presented insight problem solving": akin to the type of insight problem solving elicited and examined in cognitive psychology research. Secondly, "discovered insight problem solving": longer term (in relation to the likely duration of all stages, preparation, incubation, insight and evaluation) and ground-breaking in its outcome (Csikszentmihalyi and Sawyer, 1995, p.337). 'Discovered insight problem solving' could be argued to congruent to the notion of problem finding discussed above in the context of the discovery of penicillin.

Marton, Fansham and Chaiklin (1994) used historical data to explore eminent scientists. They analysed the transcripts of routine (annual) television interviews undertaken with newly awarded Nobel prize winners in physics, chemistry and medicine. The researchers identified that for the majority of years in their period of study (1970-86), a question was asked of the prize winners regarding scientific intuition. Intuition, although defined by the authors as an "immediate comprehension" (p. 457) often sounds more similar to an account of insight in Marton et al.'s (1994) descriptions. For instance, they discuss historical accounts of scientific intuition (Archimedes, Kekulé and Poincaré), which are seen by others as examples of insight (see Gruber, 1995). Furthermore they contrast analytic thinking to intuition, a distinction again more often seen in relation to insight (Cranford and Moss, 2011;2012; Danek et al. 2014; Jarosz, Colflesh and Wiley, 2012; Jung-Beeman et al., 2004; Subramaniam et al., 2009). Marton et al. (1994) found that the scientists likewise saw intuition as distinct from logical reasoning. They furthermore identified that the scientists described a feeling of certainty in their direction of research, often without empirical grounding for their decision.

Both Csikszentmihalyi and Sawyer (1995) and Marton et al. (1994) were drawing from primary sources, but were still likely subject to the types of error outlined by Gruber (1995). Furthermore, the participants they identified were all prominent in their fields and renowned for the work which they were asked to discuss. It is therefore likely that these accounts had been made many times previously and so particularly increasing the likelihood of rationalisation errors and embellishments due to changes in interpretation occurring through repeated re-telling.

Approaches as outlined above by Klein and Jarosz (2011), Gruber (1995), Csikszentmihalyi and Sawyer (1995) and Marton et al. (1994) fall into what Sternberg and Davidson (1995, p. 327) termed the "Great Minds Approach". By focusing on individuals who exemplify creative or insightful endeavour it assumes that key characteristics of insight might be gleaned. Such an approach neglects the role of insight in the everyday life of ordinary individuals. Furthermore, by focusing on eminent individuals, the accounts garnered are by their very nature retrospective, often collected years after the events described and subsequent to many renditions in which memory refinements as outlined by Gruber (1995) likely introduced errors.

2.1.4.4 Insight in real-time.

One example which explored the creative processes including insight from primary sources and direct real-time observation was Hargadon and Bechky's (2006) workplace study. They selected creative groups within different companies and drew data from a range of sources including direct interview of members of the groups; documentation produced by the workgroups; and observation of the creative groups at work. By use of real-time data collection from primary sources, they likely minimised the likelihood of errors highlighted by Gruber (1995). Hargadon and Bechky (2006) characterised the social nature of creativity at work, suggesting that moments of interaction lead to re-framing as a kind of "collective insight" (Hargadon and Bechky, 2006, p. 496).

Dunbar (1995) likewise sought to explore first hand, the processes of scientific discovery in an occupational setting. He observed molecular biologists operating in a simulated genetics laboratory and identified aspects which underpinned their insights. They included the use of analogy and noting of inconsistent or surprising experimental results. These can be seen to be parallel to the three components identified by Klein and Jarosz (2011) in their Anchor model of Insight discussed in section 2.1.4.1. Dunbar (1995) furthermore highlighted the role group discussions in insight which can be seen as congruent to Hargadon and Bechky's (2006) findings outlined above.

2.1.5 Phenomenology of Insight Experience

A series of recent studies have sought to identify the characteristics of the insight experience which it is suggested may serve to unify experimental and naturalistic insight accounts (Jarman, 2014). Topolinski and Reber (2010) proposed a theoretical account to explain the phenomenological accounts of insight in previous academic literature which describe the suddenness, ease, positive feeling and certainty that characterise insight experience. They assert that feeling aspects, such as the positive affect often described are products of a cognitive experience, a response to the change in processing fluency resulting from finding a solution to a difficult problem. A number of attempts have been seen to empirically explore this assertion.

Jarman (2014) asked a sample of online participants to think of a difficult problem that required a novel approach or solution, from this 37% reported having a "mental click" (p. 279) insight experience. Participants were asked to rate their experience on a series of scales which Jarman (2014) devised to measure two cognitive aspects of insight. He concurred with Topolinski and Reber (2010) that affective components are secondary and directly attributable to cognitive experiences, and so used these to validate his cognitive focused scales. The first aspect of interest was radicality, how much cognitive change a person experienced during their insight. Secondly, a measure recorded how sudden the cognitive shift in insight was perceived to be. These aspects were compared to reports of processing fluency in multiple regression in how they predicted assumed experiential outcomes including affective ones (relief, satisfaction and how good it felt), excitement, intensity, mysteriousness and impact of the insight. From this Jarman (2014) demonstrated that his aspects explained variance in the outcome factors beyond processing fluency, suggesting that these additionally contribute to the insight experience. However the scales designed, analyses made and resultant conclusions are all based on the assumption that cognitive factors lead to affective outcomes, without any empirical support for the direction of these assertions. This again is a demonstration of circularity, where the implicit idea that insight is a cognitive phenomenon influences the research rationale and hypotheses tested. So while

Jarman (2014) did collect data from an everyday sample reporting real-life problem solving, the issues outlined above in terms of circularity and memory reports remain.

Danek et al. (2014b) and Shen et al. (2015) both sought to capture the phenomenal experience of participants in experimentally elicited insight moments (see section 1.2.3.1 for further detail). Both in the first instance asked for open ended qualitative accounts of the insight experiences that participants had in solving magic tricks and word puzzles (CRA taks) respectively. However, neither robustly demonstrated that the experiences described were exclusive to the experience of participants in their insight solution moments compared to non-insight solutions also elicited in both studies. Despite this, both studies reported affective as well as cognitive aspects in insight experience in an experimental environment. So rendering hints as to possible phenomenological components of insight but not in a real life context, or with sufficient experimental control to conclusively attribute these to insight.

A recent study did seek to collect qualitative accounts of insight in real life. Ovington, Saliba, Moran, Goldring and MacDonald (2015) used an online questionnaire to reach a large sample of participants and collect qualitative data describing insight experience in daily life. Firstly, the study identified a substantial minority (20%) of participants who did not report having experienced insight. A demographic profile of those reporting insight (or not) suggest that females are more likely to report having insight experience than males. No age or other demographic trends were detected. Those reporting having experienced insight were asked to provide descriptions of where they usually experienced insight. Responses were coded by one researcher, and a second applied the coding guide to the data to provide a high rate of agreement between the two. This essentially represents quantification of the qualitative data, something akin to a content analysis (Hsieh and Shannon (2005) (for full description see 3.2.3.2). From this frequencies of reports mapping to each category were recorded with participants' most often reporting insight occurring at night, at work and in the shower. While this study begins to demonstrate the when and who of insight, the reports given were generalised accounts of insight from memory. These would again be susceptible to the introduction of biases and memory effects (Gruber, 1995) (see above section

2.1.4.2). Furthermore, in quantifying and categorising the accounts of insight given some of the rich detail of qualitative data may have been lost.

Ovington et al's (2015) participants were given a detailed definition of insight reflecting current research, framing it cognitively and as a solution moment in problem solving. Participants were asked to indicate if they felt the definition given matched their own ideas of what insight is. This can be seen as an opportunity to introduce new aspects or challenge the conceptions of the research definition of insight and so protect against the circularity problem in insight research (see section 2.1.1). Only a small proportion of participants identified that they saw a difference (10%). This may suggest that the definition used in research matched lay perceptions of insight. However, within those who offered additional definitions, the majority outlined aspects mirroring the definition given in the first instance by the researchers. The participants may not have recognised that the components they offered matched the original definition, suggesting they either found it difficult to disengage from the definition given or did not understand it. This highlights the need to explore the impact that giving a definition of insight has on the qualitative responses collected.

The different studies collecting phenomenological accounts of insight have taken different approaches in capturing experience, some from real life incidences others from experimental insight elicitation. However problems have been highlighted in the research approaches described, meaning that the effects of circularity and memory biases in the researchers' assumptions and participants' reports are not always acknowledged. Furthermore, while some studies describe the data collection and analysis as qualitative, the methodology utilised is not always clear or may actually be more aligned with a quantitative approach.

2.1.6 Research Rationale and Study Aims

The intention of the research in this chapter is firstly to collect the insight experiences of a general population sample, so not exclusively students, scientists or others selected according to any creative characteristics in their everyday lives (so again not in a specified creative context). It will employ an online questionnaire which will aim to capture self-reported experiences of insight accounting for memory bias by in the first instance asking for recent experiences of insight (within the last 24 hours). Furthermore, in order to explore the possibility that working definitions in insight studies influence the consequent insight characterisation made, participants will be grouped and given different working definitions to compare responses given. As this study is exploratory in nature, the qualitative accounts will also be analysed qualitatively, using an adapted form of a recognised methodology (Thematic Analysis, Braun and Clarke, 2006). Together, this novel approach will aim to draw conclusions on how insight is experienced in the every life of ordinary participants whilst minimising biases introduced from memory effects and the influence of previous research in this area.

2.2 Method

2.2.1 Participants

Participants were a voluntary, snowball sample recruited through online (on social media) and leaflet hand-outs with links to the online questionnaire. A hard copy version of the questionnaire was also distributed to a convenience sample of the local (non-university) and university population. Seventy-six participants (female n = 55) were recruited from both student (female n = 27, male n = 10, M_{age} = 27.3 years, SD_{age} = 8.95, $range_{age}$:18 - 53 years) and non-student ((female n = 28, male n = 11, M_{age} = 42.9 years, SD_{age} = 13.69, $range_{age}$: 21 - 74 years) samples, all gave informed consent. The study was approved by the University of Buckingham School of Science ethics committee.

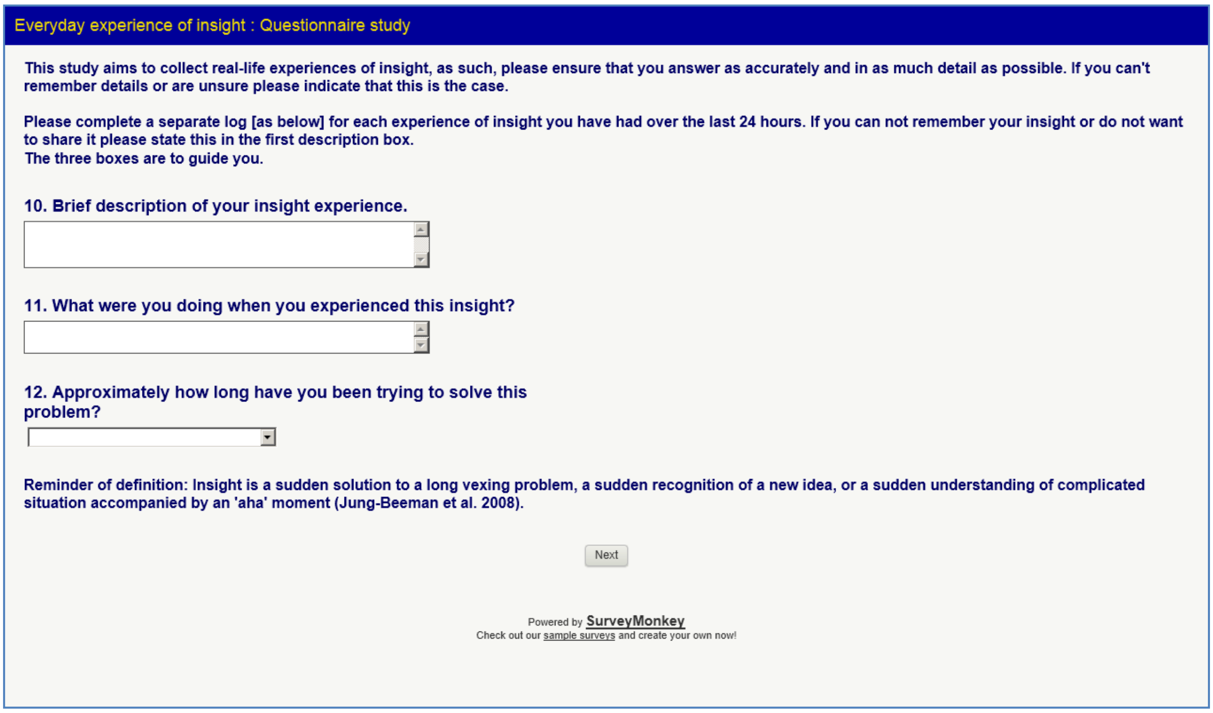
Seventy-seven additional commencements were made to the online questionnaire, but participants withdrew before reaching the end. This led to an imbalance in the number of participants' in each of the definition groups. There were more participants in each of the definition groups (emotion definition, n = 63 and cognitive definition, n = 54) than the no definition group (n = 35). Allocation of participants to the definition groups in the case of survey monkey used the in-built page randomisation feature, sending participants to pages with one of the three definition conditions [positive/negative definition; full definition; no definition]. It is assumed that this allocation is at random chance, but the questionnaire's allocation is only visible for participants who completed the qualitative open text response pages, so equal allocation of the three cannot be verified for the online data. For the paper questionnaires, equal numbers of the three versions (incorporating the different definitions) were printed and distributed, in this instance a drop out would include potential participants who received a copy of the questionnaire but did not complete and return it.

2.2.2 Materials and procedure

An online questionnaire, the 'Insight Log' was designed using Survey Monkey. On giving consent by checking a box in Survey Monday and providing demographic information (age, country of main residence/birth and occupation) first time participants are randomly allocated to one of three groups who each received a different definition page. All contained a simple image of a matchstick figure with a light bulb (see Figure 2.2), one with no accompanying definition [no definition abbreviated to ND]. A second cognitively focused definition (abbreviated to C) gave Beeman et al.'s (2008, p. 20) description of insight that explicitly refers to problem solving: "Insight is a sudden solution to a long vexing problem, a sudden recognition of a new idea, or a sudden understanding of complicated situation accompanied by an Aha moment". The final group was given a wider definition of insight in line with the notion of Klein and Jarosz (2011, p. 338); "Insight is a change in mindset or shift in thinking", but with additional prompts that the experience might be accompanied by an 'Aha moment' for a positive realisation or by an 'Uh-oh moment' when it is negative" [emotion focused definition abbreviated to E].

Figure 2.2 Screen shot of online questionnaire definition page.

All participants were then asked if they had experienced insight in the last twenty four hours. A positive response fed to 'insight log' pages. Each insight experience was captured on a single survey page ('Insight Log' page, Figure 2.3) with three questions about the insight experience. Two required open text responses with the following cues "Give a brief description of your insight experience" and "What were you doing when you experienced this insight? What were your thoughts leading to the insight?" A final question asked the participant to record "Approximately how long have you been trying to solve this problem?", for which they were offered the following dropdown options; "minutes, hours, days, weeks, months, years or my insight wasn't a solution to a problem". These questions aimed to capture experience in participants own words and so avoid extensive or prescriptive instructions



Everyday experience of insight : Questionnaire study

This study aims to collect real-life experiences of insight, as such, please ensure that you answer as accurately and in as much detail as possible. If you can't remember details or are unsure please indicate that this is the case.

Please complete a separate log [as below] for each experience of insight you have had over the last 24 hours. If you can not remember your insight or do not want to share it please state this in the first description box.
The three boxes are to guide you.

10. Brief description of your insight experience.

11. What were you doing when you experienced this insight?

12. Approximately how long have you been trying to solve this problem?

Reminder of definition: Insight is a sudden solution to a long vexing problem, a sudden recognition of a new idea, or a sudden understanding of complicated situation accompanied by an 'aha' moment (Jung-Beeman et al. 2008).

Next

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Figure 2.3 Screen shot of online questionnaire 'Insight Log' page.

There was the opportunity to log a number of insight experiences from the last twenty four hours (up to five experiences). Where there was no experience of insight in the last twenty four hours participants were asked to share a memorable insight experience from further in the past, again using the standard 'insight log' page as outlined above. The inclusion of this question aimed to maximise experiences of insight captured, while differentiating between recent and memorable but more likely memory biased retrospective ones. A final de-brief page thanked participants and invited them to return in the future to share any further experiences of insight. As such, the questionnaire enabled return participation from the same URL. Return participants were not grouped or offered insight definitions, they were directed straight to an 'insight log' page on giving their consent and demographic information (as above).

Most of the participants who withdrew from the online questionnaire dropped out at the point they were asked to give a qualitative description of their insight. In the initial incarnation of the questionnaire there was not opportunity to complete the questionnaire without giving experience details. The questionnaire was later amended to enable completion without adding these details and an opportunity to indicate a reason for not adding details from the following options: I have never had an insight; I have had insights but cannot remember them; I do not want to share my insight. However, due to design limitations in the online version, these options were not as obvious as would have been desirable if preparing the questionnaire from scratch. Following this change participants continued to withdraw at this point in the study without explanation.

2.2.3 Analysis of data

2.2.3.1 Quantitative Analysis: Demographic and response analysis.

Descriptive statistics are presented for the demographic aspects of the participant sample. Comparisons between the frequency distributions of responses were made using Chi-square analysis for gender, definition group or student/non-student status comparisons.

2.2.3.2 Integrative Thematic Analysis (ITA).

The data collected was predominantly qualitative and consisted of textual excerpts of the personal accounts of insight experience given via the insight log page of the questionnaire. The accounts given were relatively brief, and it is unlikely that accounts given by participants would be particularly deliberative. As such methods that take a phenomenological approach would not have enough information to analyse (see also section 1.3.1). Therefore a form of thematic analysis was carried out following assumptions and guidance outlined by Braun and Clarke (2006) where one researcher: familiarises themselves with the data; groups excerpts; identifies potential themes; finalises themes giving them names and descriptions (see Figure 2.4a). A second research might then be asked to confirm that the excerpts match the themes identified (typical confirmatory triangulation – see discussion below). However, as highlighted in section 2.1.1 there is a circularity problem in insight research. Knowledge of previous insight research will influence the interpretations made in the thematic analysis, for example potentially directing attention to aspects in the data that align with previous assumptions. The second researcher would then also be prone to confirmation bias when agreeing the themes identified.

The use of two or more researchers in qualitative analysis can be seen to align with the catchall term proposed by Denzin (1978) as researcher/ investigator triangulation (Denzin, 1978)In a recent critical review of mixed methods approaches employing investigator triangulation [IT], Archibald (2016) identified there was little explanation of this process beyond Denzin’s (1978) original statements on triangulation that included one outlining the "use of multiple observers/ investigators in a single study" (p. 229). It was found that in practice IT was confirmatory (as highlighted above specifically in relation to Thematic Analysis), and did not specify any criteria necessary or important to the characteristics of the researchers to support the notion that their combined use increased the robustness of findings. Furthermore, the literature was unclear on the roles that each researcher took in any triangulation process, and there was no acknowledgment of their philosophical or paradigmatic stances. Little detail was provided as to how researchers agreed on the final findings of their analysis, with most applications of IT seeing the use of a priori codes or a second researcher reviewing themes identified by the first, so being used as a consistency check.

An adapted form of Thematic Analysis was developed for this study. This aims to explicitly outline research design aspects in relation to the use of more than one researcher in analysis. For example in terms of the approaches to analysis each research takes (see below). It furthermore provides detail of the methodological steps taken by each researcher to arrive at their findings. As such this can be seen to address deficiencies highlighted by Archibald (2016) in typical IT applications.

As shown in Figure 2.4b Integrative Thematic Analysis (ITA) requires two researchers to independently conduct the early stages of thematic analysis, identifying themes within the data. Using a second researcher who is naïve to the research question or general supporting literature, and so using a purely inductive approach protects against the circularity effects identified above in section [see section 2.1.1]. Once themes are identified independently, the researchers work together to integrate their themes and produce a final representation of the data. It should be highlighted that the actual process of thematic analysis is much more iterative than shown in the process diagrams in Figure 2.4, here the process is simplified to illustrate the adaptations made in ITA.

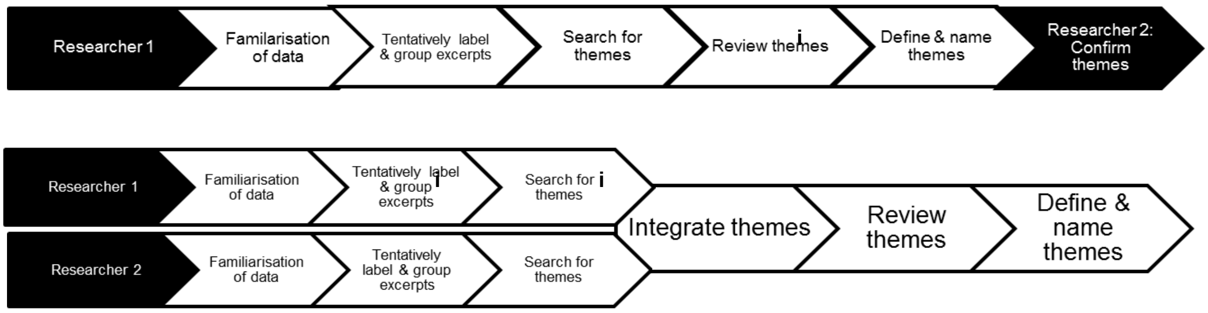


Figure 2.4 Integrative Thematic Analysis (ITA): a. Typical process of Thematic Analysis (Braun and Clarke, 2006). b. Adopted process where themes are developed by integrating the independent analysis of two researchers, one naïve to the research question and background literature (so taking an inductive approach).

Braun and Clarke (2006) highlight that in poor thematic analysis the initial questions asked of participants constitute resultant themes. In addition to ensuring that the themes identified in this study were not reflections of the questions asked, it was also ensured that themes did not mirror the definitions given to participants. Therefore where a theme linked to something explicitly identified in one of the definitions given, supporting excerpts were required from the other definition or no definition group to verify it as a valid theme.

2.3 Results

2.3.1 Quantitative Analysis of Participant Response Patterns

As shown in Table 2.1, 71% of participants reported an insight experienced in the last 24 hours (binomial test, $p < 0.001$, $n = 76$).

Survey Monkey allocated participants to groups at random. There is no way to check the exact allocation as only where a participant response is given can this be recorded. Therefore the allocation of participants who withdrew is not known, but it is expected that across participants there would be equal allocation to each of the three groups (C, E and ND) meaning an expected proportion of 0.33 for each group. Examination of response frequencies for the different definition groups see significantly less than expected responses collected from participants in the No

Definition group (18%) than groups given a definition (binominal test, No Definition expected proportion 0.33, versus aggregated Definition group responses, p = 0.008, n = 76).

Table 2.1 Frequency of reports of insight within the last 24 hours according to sex, student status and definition group.

		Within the last 24 hours:	
		Insight	No insight
Total		**54**	**22**
Sex	Female	39	16
	Male	15	6
Status	Student	27	10
	Non-student	27	12
Definition group	ND	10	4
	C	15	10
	E	29	8

As highlighted, this study aimed to obtain responses from both student and non-student samples. Comparisons were made in reporting of insight as being experienced in the last 24 hours or not (offering an insight from memory instead) and there were no differences in the patterns of reporting across sex or student/non-student participants. A summary of response frequencies for different groups can be seen in Table 2.1.

2.3.2 Thematic Analysis

Thematic analysis was undertaken on the textual descriptions of insight given. Two participants returned to share a second insight experience. Two participants had two experiences within the previous 24 hours, while a third logged three. The themes identified by the two researchers and resultant integrated themes are shown in Table 2.2. The excerpts of insight in the following summary of the final themes are provided with codes detailing the sex (F/M), age, student/non-student status (S/NS) and definition group (no definition, ND; cognitive, C; emotional, E).

Table 2.2 ITA process demonstrating independently identified themes / sub-themes that lead to final integrated themes for the everyday experience of insight.

	Theme*	Sub-Theme*	Final Theme**		
			Content	**Process**	**Feelings**
R1	Self Realisation		**Personal**		
	Social Aspects			**Social Facilitation**	
	Problem Solving		**Intellectual** **Practical**		
		Active Search		**Active Search**	
		Time Away		**Time Away**	
	Feelings	Certainty			**Positive**
		Uh-oh			**Negative**
R2	Life Reflections	Positive Affirmations	**Personal**		**Positive**
		Change/Self Improvement	**Personal**		**Negative**
	Theoretical/ Conceptual	Trying Hard/ Stress	**Intellectual**	**Active Search**	**Negative**
		Relaxed/Quiet Time	**Intellectual**	**Time Away**	**Positive**
	Visual-Spatial		**Practical**		
	One-Solution Problems		**Intellectual** **Practical**		
	Learning/ Being Taught			**Social Facilitation**	

* ITA stage iii – Candidate Themes / Sub-Themes ** ITA stage iv & v

The final themes are also shown in Figure 2.5. In the later stages of ITA (when the independent researchers' themes were being integrated) it was identified that the themes could be grouped to represent different aspects in a typology of insight. Three themes described the content of their insight as being Intellectual, Practical or Personal. The themes Time Away, Active Search and Social Facilitation all represent process accounts of insight, while two themes related to an affective component of the insight, either Positive Feelings or Negative feelings. Thematic analysis allows for a single excerpt to support a number of themes within the data. So in this study a single insight description represented a data excerpt, for example the insight description:

> While doing the statistics for my dissertation. I was having trouble figuring out how to analyse one aspect of my data. I suddenly realised what I had

to do, and did it right then and there. I had been thinking hard about what I had to do, but then my mind wandered. During the wandering I realised the solution to my problem. (F, 20, S, E)

This description (except) supports a number of themes identified, it is Intellectual in content (solving an issue with statistical data analysis), having occurred whilst the person was taking Time Away from the problem (e.g. daydreaming) and can be seen as Positive (it is assumed that this solving moment was a positive experience).

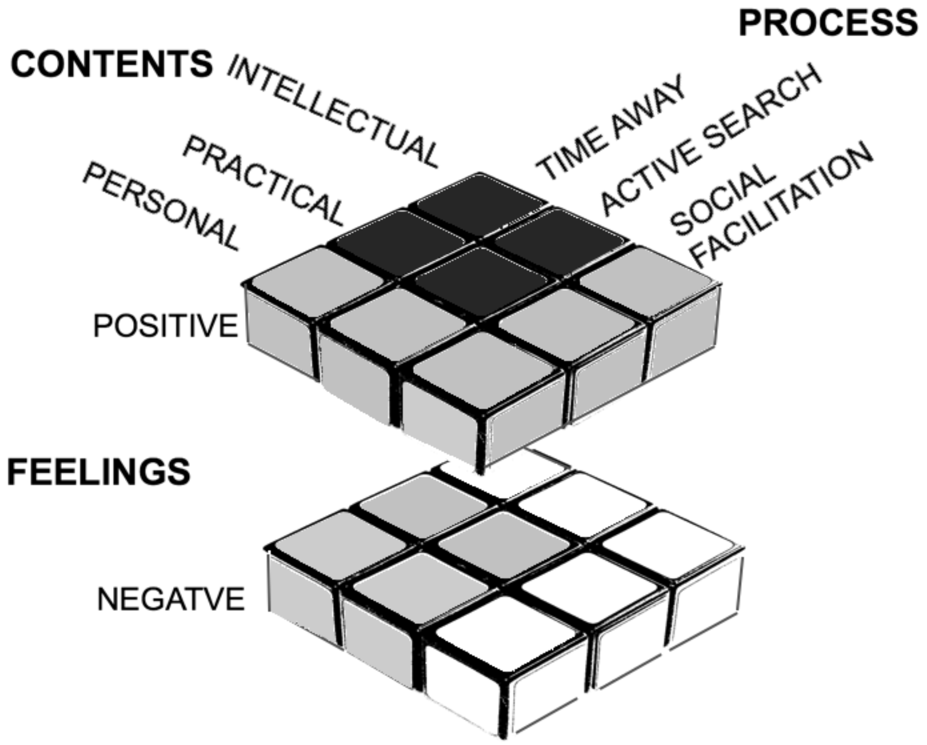


Figure 2.5 Final model of typology of insight identified using Integrated Thematic Analysis. Themes interact in three aspects: Content, Process, and Feelings. Both dark grey and light grey cubes demonstrate themes with distinct supporting excerpts in this study. Light grey cubes highlight novel aspects identified by this research. Dark grey cubes demonstrate the predominant focus of previous experimental approaches. White cubes did not have strong support from the excerpts in this study but provide conceptually possible categories for future research to investigate.

2.3.2.1 Intellectual [Content].

This theme encompasses insights that are theoretical or conceptual in nature, often in an educational or scientific context. The excerpt above represents an intellectual insight, the participant describing their understanding of the correct statistical test to apply to data (scientific) for their dissertation (education). Support for this theme was seen across all participant groups, for example a non-student shared the insight, "I was reading an article at the time, and a particular phrase struck me. I suddenly realised that there was a connection between the subject I was reading up about, and my more usual area of study" (F, 53, NS, E). Both these examples could be argued to link to academic pursuits. Insights that were intellectual in a more general way were also shared: as seen in a participant's "realisation of how easy it is to have a sense of entitlement, and to subconsciously disregard the reality of those less fortunate, and thus how hypocritical it is to criticise, for instance, politicians for doing the same" (M, 41, NS, C).

2.3.2.2 Practical [Content].

Practical insights incorporated descriptions of physical manipulation of objects as seen in the following insight about a magic trick.

> Sometimes the method behind a trick requires an awkward body position that, if not justified within the context of the performance, makes the method obvious to the audience. In this situation I need to keep my arm bent in a certain way. I realized that my arm looks totally natural in that position if I am holding something up to my face, as if trying on a pair of glasses. It just suddenly made sense. (M, 28, S, C)

The Practical theme often saw insights set in a problem solving context, so solving hands on immediate problems such as “how to use tyre air pressure pump at garage for the first time, could not work out how to attach it to tyre valve [and] suddenly realised how to attach it after examining the device” (F, 41, S, E). It is worth noting that both student and non-student participants offered examples supporting this theme. Additionally, the above car tyre example while being offered by a student describes a distinctly non study related problem solving incident.

2.3.2.3 Personal [Content].

Participants also described insights relating to themselves in terms of their thoughts and feelings about their own lives. Some were quite general personal insights relating to broad depositional realisations for instance, the “power of focusing on one thing in life, and all else will fall into place automatically” (M, 24, S, E). Other insights related to something more specific like an impending event, "“I can't make my wedding perfect. Sometimes I need to save my energy and accept a compromise solution earlier” (F, 35, NS, ND). Alternatively a particular area of an individual's life such as their "next job role - it's in my hands and with the years passing by I just need to challenge myself and make it happen" (M, 55, NS, C).

2.3.2.4 Active Search [Process].

Active search describes a theme where participants have an insight whilst in the process of attempting to solve a problem. They often describe active engagement in problem solving, searching for answers by reading, using the internet or thinking through the problem. Whilst participants were explicitly asked to describe what they were doing when they had their insight, descriptions incorporating their active problem solving attempts were volunteered in the first response which asked them to describe their insight. This reduces the likelihood that the theme is simply a reflection of a specific leading question. One example of response to the open ended request to describe their insight starts by describing their Active Search:

> Helping my son with his homework. He had written a creative writing passage but he was over his word count, we were brainstorming together to try new ways of saying what he had written but in less words. Then I had an Aha moment and we reduced the word count with him. (F, 36, S, E)

The above example describing the search to perfect a magic trick (see under Practical theme above, section, insert 2.3.2.2) also supports the Active Search theme.

2.3.2.5 Time Away [Process].

In contrast to the Active Search theme, participants also described having insight about problems whilst taking Time Away from attempting to solve them. For example a post graduate student reported having an insight regarding his studies during a break "eating lunch whilst watching things on YouTube with [his] girlfriend" (M, 21, S, C). Many insights occurred during other mundane or routine activities such as walking, running or travelling. Others describe having their insight either at night or first thing in the morning, for instance, "I woke up with a novel idea for student assessment" (M, 40, NS, C). The time away may also constitute a shorter break from problem solving effort, for example in daydreaming: "I had been thinking hard about what I had to do, but then my mind wandered. During the wandering I realised the solution to my problem" (F, 20, S, E).

Another set of descriptions highlight how participants had insights that were improved solutions to problems they had already solved, so again they were not actively searching for a solution and in this sense having Time Away from active problem solving. This is illustrated by a participant describing an insight about their study design: "I realised that there was a better way of manipulating a psychological construct. Happily I was in the process of designing a study so hadn't already started collecting data" (F, 27, NS, E).

2.3.2.6 Social Facilitation [Process].

This theme recognises the social environment in which many of the shared insights occurred where participants attribute their insight to a contribution from others, or as a result of a social interaction. The former often occurred in a teaching environment: "someone was explaining how something worked, and I didn't understand, until it suddenly clicked and it made perfect sense" (F, 23, NS, C). As this example from the non-student sample illustrates, teaching may occur in everyday contexts outside the classroom or lecture hall. The teaching/being taught aspect of this theme was identified by the second researcher.

A case which can also be seen to support insights in other socially driven contexts such as where the individual's insight is driven by joint attempts to solve a problem. This effort is exemplified by one participant's insight: "a Lecturer needed a kidney bean but, of course, there were none in the office so I suggested using blue tack, to mould the kidney bean" (F, 44, NS, ND).This insight can be seen to be socially driven as the participant was helping her colleague to solve their problem. Both were actively engaged in effortful problem solving.

Other insights were socially facilitated as a coincidence of a social interaction rather than through the deliberate efforts of another person to impart a new understanding or solve a problem. For instance as the result of a conversation, the insight of "understanding the rationale for someone sending their child to private school over a perfectly good standard state run school" occurred whilst "chatting at a social event" (F, 46, NS, E). The inference here is that the participant's insight was incidental to the conversation they were having rather than the key focus of the social interaction.

2.3.2.7 Positive Feelings [Feelings].

The Positive Feelings theme reflects either explicit or assumed positive affect relating to an insight. Implicit in insights describing the finding of a solution to a problem is the notion that this is good for the person, and so positive. The above example of with the kidney bean, while not describing an emotional component can be seen to be positive. Some participants did explicitly describe an emotional aspect as seen in this insightful crossword solving moment.

> I had [ ] a surge of sudden understanding, almost like switching on a light - which made me very happy. I then immediately thought 'Oh! That's lovely!' because I thought the solution was extremely clever, novel and elegant. I had no doubt it was correct. (F, 53, NS, E)

Other aspects of the positive emotion theme relate to feelings of intuition and certainty during insight. These aspects were not mentioned in either of the definitions given to participants. The following excerpt illustrates both of these expressions.

> It was a crystallisation of a research problem I'd been thinking about [ ] before I had traced the whole path, I suddenly knew where it was going, and really had this feeling of crystallisation, of a definite form emerging. Though initially indistinct, I knew it was what I needed for the research problem to move on a step. (F, 35, S, C)

The second researcher identified more general expressions of positivity in the insight descriptions, naming the theme Positive Affirmation. Insights such as "I have finalised realised that life is too short and I should enjoy myself" (M, 24, S, E) fit this aspect of Positive Feelings.

2.3.2.8 Negative Feelings [Feelings].

This theme represents insight incidences which were negative realisations. The negativity was often inferred rather than explicitly stated, for example participants did not use the term Uh-oh. It is clear from the following that this realisation would be seen as bad for the individual, and rather than expressing an Aha! would likely have uttered an oh-no or far worse!

> Driving home when I suddenly realised that I hadn't saved the essay draft I'd worked on all day, as I had downloaded it from my [online cloud file] and worked on it in uni [versity]. So I realised I had lost a whole days work. (M, 21, S, C)

Other experiences are more ambiguous and without accompanying contextual information make it difficult to draw firm conclusions. An example can be seen in the insight: "a realisation that I had misinterpreted an EU regulation" whilst "discussing it in a meeting" (M, 54, NS, E). This was initially interpreted by the first researcher as a positive example of social facilitation and learning. It should be noted that the first researcher is based in a small science department within a building predominately housing the University's Law School. Accordingly, this is the frame in which it was first interpreted, where in an academic context such misinterpretation is expected and likely a normal part of legal study and learning. However, when the participant's job role is taken into consideration, a different interpretation might be made. The participant from the non-student sample and is a consultant. In this context, such a misinterpretation can be seen to potentially have more far reaching and negative implications, and as such could represent an example of an Uh-oh moment generated in response to the definition given (the participant received the emotion focused definition).

As with the Positive Feelings theme the second researcher identified more generalised affective descriptions in their theme Trying Hard/Stress. The stress of the situation where this participant had their insight is very apparent: “crying while trying to sleep” (F, 18, S, C).

One of the participants who shared more than one insights from within the last 24 hours presented a series of insight experiences which can be seen to represent an Uh-oh, negative insight followed by an Aha, positive insight. She firstly records, "going to work, my car key wouldn't open my car" (F, 44, NS, E). Her following insight log is "I found the spare key to my car after the main key wouldn't work." The participant's first insight finds them identifying a problem, which in this instance is subsequently solved. Similarly problem finding can be seen in a number of experiences, often shared in the context of the ultimate solution to the problem they found, for example one insight being, "the filter in the dryer was full of washing powder which I cleaned and put back yesterday, today when I came in I found that the filter could no longer fit properly, I have now reported it to housekeeping" (F, 58, NS, E). Here it can be seen that in order for the participant to solve the problem by reporting it, she had to have the insight as to the true nature of the problem, not a simple powder accumulation, but that the filter did not fit. Both of these examples result from participants' given the emotional focused definition that explicitly refers to Uh-oh moments. However, a similar sequence can be seen in an insight report made about a daily inspection of a new house build with the participant realising that a "garage door opening [was] too small (built incorrectly), organized two props from another site to enable opening to be enlarged and door fitted correctly" (M, 52, NS, ND). The negative realisation of the incorrect build (negative insight?) enabled him to seek solutions to the problem. This example again comes from the No Definition group. All of these suggest that negative insight, the described initial Uh-oh moment changed the perception of, or alerted participants to a problem which all then attempted to solve. The resultant problem solving actions in response to the negative insight moment of "suddenly realising I'd misunderstood a crucial element of an author's methodology" (F, 29, S, E) are described by one participant, "after some reading came to understand this better and how it can be applied in my own research." However, as the majority of these sequenced descriptions are from the Emotional focused definition group, not enough support can be offered for a separate theme or sub-theme from the data analysed.

2.4 Discussion

The prime aim of this study was to collect and analyse the real-life, everyday insight experiences of participants (from non-student as well as student samples). As the majority of insight experiences were reported within 24 hours of experiencing them, the characterisation of insight resulting from analysis of these can be seen to be relatively accurate with minimal memory effects on the events recalled. Fundamentally the collection of these examples demonstrates in the first instance that insight is a phenomenon experienced and understood outside of the narrow research community interested in it and the usual student samples used to research it. After a brief examination of the prevalence of insight, the majority of this discussion will focus on the themes identified in the results including the identification of the first research examples of negative insight, the Uh-oh moment. It will highlight where these correspond or contrast to the body of (mainly experimental) insight research; both examples outlined in the Introduction (section 2.1) and drawing from outside of the original literature review's realms where unexpected themes emerged. Finally, the novel methods employed in this study, grouping participants to give different definitions of the concept of interest and the development of ITA will be assessed in relation to the findings of this study and in terms of future avenues of research both within the scope of this thesis and beyond.

2.4.1 Prevalence of Insight

As shown in Table 2.1 it can be seen that the majority (71%) of insight experiences collected were experienced within the last 24 hours. This gives an indication of the prevalence of insight in daily life, something research is only beginning to address (Ohlsson, 2011). From this it might be inferred that the majority those who experience insight do so on a daily basis. However, the nature of the data collection only provides a snapshot of experience within those participants who completed the study. This does not account for those who did not finish the survey or any sampling bias in recruiting participants in the first place. As such further research might look to clarify prevalence, perhaps using Experience Sampling Methods (see section 4.1.3).

Ovington et al. (2015) recently presented a different measure of prevalence relating to the percentage of people who reported having ever experienced insight. Interestingly, their research suggested that there is substantial minority of the population who do not experience insight. This might explain the high proportion of withdrawals from the insight log. Participants were initially unable to complete the online version of the insight log without giving an insight experience (either from within the last 24 hours or a memorable insight from further back). For participants who do not have such experiences, the only option would be to exit the questionnaire, recorded as a withdrawal by researchers. However, this is only conjecture and research which more closely follows participants as they experience insight in their daily life may inform further in the future (see Chapter 3).

2.4.2 Typology of Insight

A typological model of insight was identified (see Figure 2.5) using ITA. This demonstrates how the themes are represented and interact within the data. So an insight incidence can be described in different ways. Firstly, in terms of the content of the insight, describing what the new thought or understanding is, whether it was Intellectual, Practical or Personal. The process aspects of insight examine the context in which the insight occurred, what the person having the insight was doing at the time of their insight: actively searching for a solution to problem (Active Search), taking a break from problem solving efforts (Time Away) or saw Social Facilitation of an insight. The final aspect saw themes describing an affective component to insight: Positive Feelings or Negative Feelings.

2.4.3 Feeling Aspects of Insight

2.4.3.1 Positive Feelings: happiness and certainty.

The identification of the themes relating to the affective experience of insight in daily life suggests that it is not a purely cognitive experience. Many of the insights shared included explicit descriptions of emotions, and as reflected by the two themes, these can be seen to be both positive and negative. This study provides congruent support to that of Danek et al. (2014b) and Shen et al. (2015) who also recently highlighted an emotional component to the phenomenological experience of insight. With insights shared in this study describing positive emotions such as happiness likewise identified by both Danek et al. (2014b) and Shen et al. (2015) (for further discussion see section 1.2.3.1). The recorded experiences of insight from these were elicited in a laboratory based task for which this study offers complementary evidence of a positively valenced, emotional component of insight with greater ecological validity. Together they represent an exploratory foundation to initiate further research into insight phenomenology, in particular they highlight the value in considering both cognitive and emotional components of insight.

2.4.3.2 Negative Feelings: Uh-oh moments.

This study provided the first documented examples of negative insight. These are examples where the new idea or realisation that a person suddenly has, is negative; so the insight alerts them to the fact that things are worse than they originally thought or knew. Previous theoretical discussions have raised the possibility that an insight might be negative and experienced as chagrin: annoyance at not having seen the solution or idea sooner (Gick and Lockhart, 1995). However this still centres on the notion that the content of the insight is essentially good for the person having it, representing the end of their search for a solution. In this sense the insight content remains positive, but this is overshadowed by annoyance (negative emotion) at having missed it before (Homer Simpson's D'oh). Congruent to this Danek (personal communication) identified that some participants rated solving problems through insight negatively, again contrary to the idea that this always elicits positive emotions. Interestingly, no examples of chagrin were shared in this study. It may be that people do not equate such occasions with insight, as the subsequent annoyance might mask the Aha moment itself. Alternatively, making chagrin public may lead to additional negative feelings of embarrassment: reporting such an occurrence would possibly be avoided in favour of other insights (Brown & Garland, 1971). Finally, occurrences of chagrin could just be rare and so none of the participants had such an experience in their previous 24 hours to share.

Some of the examples seen that support the Negative Feelings theme saw a negative Uh-oh leading to subsequent Aha moments. As highlighted in section 2.3.2.8, one excerpt explicitly described how the negative insight led them to attempt to resolve the problem, in this instance by reading up on the author's work following the Uh-oh moment exposing their misunderstanding. Runco (1994) suggests that an affective component is particularly pertinent to problem solving. He posits that with no emotional salience things would not be considered to be problems, and furthermore there would be no motivation to try and solve them. The Uh-oh moments described in the Negative Feelings theme can be seen to align to this idea, with the emotional negative Uh-oh moment identifying a salient issue that motivates problem solving. This is likewise similar to Guildford's (1950) example of a creative individual using an uneasy feeling they have about something to explore it for problems (see also 1.1). This highlights the need for further research to verify the role of negative insight in everyday life and in relation to problem solving, see Chapter 3 for further discussion.

The examples of insight shared where participants' describe finding an improved solution to a problem they have already solved, while not necessarily experienced as negative Uh-oh insights can be seen to similarly be incidences where something new in a situation not judged to be problem is seen. Relating this to Wallas (1926) stage model of creative problem solving (see section 1.1.3) participants would presumably be in the verification stage or beyond (being satisfied that the problem is solved) when they had their insight. This and the examples of negative insight confound the stage model and demonstrate an out of sequence progression: the insight serves to reinitiate problem solving, seeing participants identify that the new [insightful] solution is identified as better than the original through verification.

2.4.3.3 Divergent and convergent problems.

Perhaps an additional aspect to consider is in terms of the types of problem that the insight relates to. Guildford (1967) distinguished between convergent and divergent problems. Convergent problems, are those with one or a limited few final solutions. The second researcher identified a candidate theme of One-Solution Problems analogous to convergent problems. Participants shared insights that occurred giving a solution to a problem, like how to fit an air pump to a car tyre. These offer daily life examples of convergent problem solving to fit alongside many traditional insight elicitation paradigms which also employ convergent problems, for example CRA problems (Bowden and Jung-Beeman, 2003b, see1.1.4.1). The Gestalt tradition of insight problem solving likewise presented problems with one (or a very limited few) solution(s) so were in that sense closed, convergent tasks.

However some insight problems do have varied solutions and so are perhaps less convergent than at first considered, for instance Perkins (2000) highlights some differing solutions for the nine dot problem (see Figure 2.6) The most offered solution is the one shown in Figure 2.6a, where all the dots are drawn through using four straight lines without lifting the pen from the paper. However there are additional solutions where the dots can be crossed through by drawing a single straight line, either by folding the paper (Figure 2.6b and d) or making a cylinder shape (Figure 2.6c). A quick internet search renders even more obscure and perhaps creative solutions to this problem, for instance that shown in Figure 2.6d which appears to require an aptitude for origami!

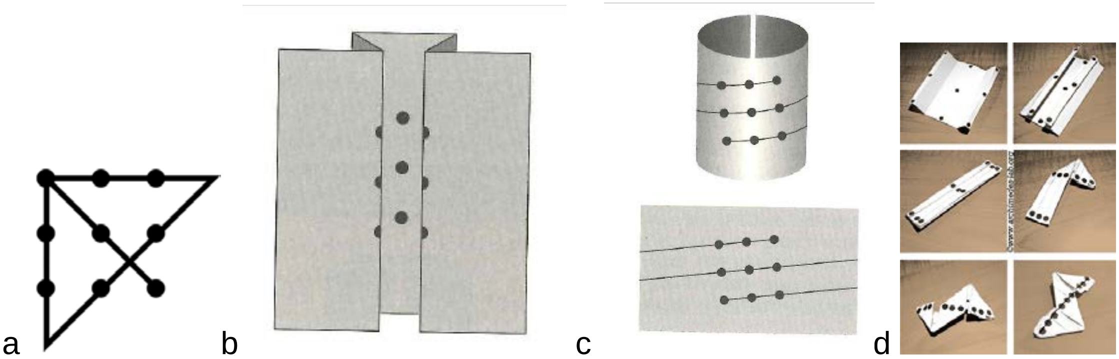


Figure 2.6 Solutions to the Nine Dots problem. b and c adopted from Perkins (2000) downloaded from http://www.unlearning101.com/fuhgetaboutit_the_art_of_/quiz/

While there are more solutions in the nine dot problem, these again are not open in the sense of traditional divergent tasks such as Guildford's (1967) Alternative Uses Task (AUT) or in many examples of many of the insights presented in this chapter's results (section 2.3). For example the description relating to research design where the insight mapped a path through an indistinct problem. The second researcher again identified this aspect in the candidate theme Theoretical/ Conceptual, reflecting the divergent nature of the problems, however, both of these candidate themes had an intellectual content, and it was this aspect that was finally agreed between the researchers.

2.4.4 Content of insight

2.4.4.1 Practical/Intellectual.

The examples of insight that support the Practical and Intellectual themes have much in common with previous experimental approaches to insight. Most tasks used to elicit and explore insight in the laboratory produce insights within the Practical or Intellectual domain. Gilhooly and Murphy (2005) identified such a distinction. They compiled a selection of insight tasks previously used in experimental insight research, including Gestalt problems such as Duncker's (1945) candle problem and tumour problem and Maier's (1931) two strings problem (see section 1.1.4.2 for further details) and non-insight tasks, for instance the Tower of Hanoi (Egan & Greeno, 1974). They carried out cluster analysis to identify tasks where participants performed in a similar way, so a group which the same participant generally did well or poorly on all. From this nine clusters were identified, which in the main fell as exclusively insight or non-insight tasks within a cluster. They also asked participants to complete a battery of cognitive tests measuring aspects including fluid intelligence, working memory, verbal ability, and visuo-spatial ability. Multiple regressions statistically explored which of the cognitive abilities predicted performance on the insight tasks. Gilhooly and Murphy (2005) identified that insight tasks could be differentiated into verbal insight tasks and spatial insight tasks, verifying this distinction with the fact that different cognitive abilities facilitated performance on each type. The spatial insight tasks map to the Practical theme, with the second researcher using this label to describe the theme.

It is perhaps harder to say that Verbal insight tasks are directly analogous to the Intellectual theme, as this would seem to incorporate wider aspects than simple verbal ability or vocabulary. However closer examination of Gilhooly and Murphy's (2005) grouping of tasks sees them select tasks specifically in terms of the spatial criteria and label all remaining tasks as Verbal. However, this label is to reflect that performance on vocabulary tests was a significant predictor of performance on this group of insight tasks. Regression examines correlational relationships, so vocabulary may not be the underlying ability utilised in all of the insight tasks rather a proxy for another aspect unexplored by Gilhooly and Murphy (2005). The Intellectual theme describes insights that are conceptual in nature, all of the problems described as Verbal by Gilhooly and Murphy (2005) are conceptual in the sense that they are essentially thought experiments presented in written or verbal form. They are solved through conceptual means, thinking through the problem. Participants solving the spatial insight problems meanwhile could employ mental imagery of the spatially based, practical tasks. So from this perspective the distinction highlighted in this study between insights that represent problem solving in the Intellectual and Practical domains is congruent with that identified in experimental insight problem solving tasks.

2.4.4.2 Personal insight.

The Personal theme was unexpected as most insights within cognitive research are framed as intellectual or practical problem solving. However, examination of counselling psychology literature finds discussion of insight in the context of therapy. Across traditions (humanistic and psychoanalytic) change within an individual is effected by self-insight; without a recognition of their problems individuals' are unlikely to experience therapeutic change (Connolly et al., 1999;

McLeod, 2013; Williams and Lynn, 2010). Tolor and Reznikoff (1960) created the "insight test", which presented hypothetical scenarios with a choice of responses designed to measure the clients defence mechanisms and therefore identify their 'psychological mindedness', in other words their readiness to engage in change. In psychotherapy, insight is seen as the agent to initiate change (Moro, Avdibegović & Moro, 2012). Clients reflecting on their own therapeutic journey likewise identified that their insights did not represent final solutions to their problems, rather served to help them define their problems as they work through them (Timulak & McElvaney, 2013).

That is not to say that all of the participants in this study are assumed to be sharing instances of Personal insight resulting from therapy. Hillis et al. (2015) emphasise that as clients move through therapy they aim to develop "Stimulating Mastery (p. 125), which enables them to deal with everyday life problems using an understanding of self or others in relation to themselves. The Personal insights in this study likely reflect these desirable and likely innate problem solving approaches to daily life.

From this standpoint personal insights could be argued to be analogous to the concept of problem finding discussed above (section 2.1.4.3), as in essence insight helps the client to see what their problems are and where they stem from, initiating a problem solving process, therapeutic change. Many of the experiences supporting the Personal theme demonstrate this, where insight clearly communicates a realisation of a need to change rather than their insight being an outright solution to their problem. For instance, one participant's insight identifies that they have to challenge themselves in order to find their next job role, effectively their insight sees them identifying the problem in themselves, rather than reaching a specific solution.

2.4.4.3 Intrapersonal insights of mini-c creativity.

An additional similarity can be seen between the Personal insights identified here and Kaufman and Beghetto's (2009, p. 4) "intrapersonal insights". Intrapersonal insight is the result of an attempt to explain different types of creativity. There is a classic distinction made between Big C creativity which occurs in eminent individuals: the Great Minds examples described in section (see section 2.1.4.3) are examples of Big C creativity. This contrasts with little c creativity described as everyday creativity, the examples of insight shared in this study would typically be categorised as little c. However, Kaufman and Beghetto (2009) identified cases that did not easy fall into either of the above. Firstly, professionals engaged in creative activities but not seen as eminent could not readily be classified as either Bic C or little c, so were labelled as Pro c. Secondly, they suggested that some everyday experiences were personally creative in the sense that they were novel and useful to the individual (Plucker, Beghetto and Dow, 2004). However to others they were not new nor relevant, and so not useful to them as such they were not satisfying a definition of everyday creativity seen in little-c. Kaufman and Beghetto (2009) labelled these as mini-c, and used the example of learning in describing it. The insights supporting the Social theme (section 2.4.5.3) that describe insights initiated through teaching are good examples of this. The new information or understanding being novel to the person having the insight, yet familiar to the teacher.

The Personal insights shared are likewise examples of mini c. Ideas and realisations about one's own career prospects or wedding (see section 2.3.2.3) are of little utility to others and so would not be seen generally as creative. Yet to the individual the thoughts are both novel and useful, so meeting the criteria for being creative mini c. This study therefore offers additional real-life evidence of Kaufman and Beghetto's (2009) mini-c in a different, novel context.

2.4.5 Process (in insight)

When considering what processes account for insight one approach is to identify factors that are necessary or enhance insight occurrence. One of the most debated aspects is whether reaching an impasse is a necessary precursor to insight (see discussions in section 1.1.5). The themes of Time Away and Active Search together contribute real-life evidence to support experimental work in this area and suggest that insight can occur either whilst actively searching for a solution or when an individual has reached an impasse and is perhaps not engaged in the problem solving task as seen in the Time Away examples. As seen in the methods of insight research outlined in Chapter 1 (sections 1.1.4 and 1.1.5) much of the experimental work into insight has adopted problem solving paradigms, most often with a single participant attempting to solve problems that elicit insight. The Social Aspects theme contrasts this and supports research exploring how insight occurs in social situations.

2.4.5.1 Active Search: Insight without impasse.

Examples where insight occurred whilst participants were actively searching for a solution suggest that impasse is not necessary in order to experience insight. Such a contingency is described by Weisberg (2014; Fleck and Weisberg 2004, 2013) in his stage model of problem solving (see section 1.1.5.5). Examples given in support of this theme offer real-life verification of pathways described. For example, one participant's description of their attempts to perfect a magic trick (section 2.3.2.2). Firstly stage one, there is no immediate match for the problem solution in memory, presumably because the trick being developed is new. No new information is rendered so the solver progresses to stage two. Stage two employs heuristics such as practicing the trick. Stage 2B sees the heuristic giving new information, the participant noticing the necessary awkward arm movement he has to make to perform trick. This new information takes the solver to stage 3, the new information leading to restructuring, the participant describes that they suddenly realise how holding a pair of glasses would mask this movement (stage 3A, solution through insight without impasse). This demonstrates insight in real-life without the solver reaching an impasse.

Klein and Jarosz (2011) furthermore suggested that insight could also be seen as a gradual search process which is in contrast with many other insight conceptions. However, as discussed this conclusion could be argued to map directly to the working definition that the researchers used (which included search strategies) to identify the everyday examples of insight they analysed (see section 2.1.4.1). The Active Search theme has relevance to this discussion as many of the excerpts supporting this suggest that insight was the product, and part of a very active and almost systematic search process. Participants typically give descriptions such as, "looking at lecture slides, a book and my notes" to "solve a statistical exercise" (F, 23, S, C). This participant was from the cognitive definition group and so received a full description of insight and the accompanying Aha moment. However there was no explicit mention of search in the definition. It might be assumed that the participant took all aspects of the definition on board. That said, without further direct probing of their experience (as is achievable with face to face interviewing techniques) it is possible that the participant based her judgement of what constituted an insight on her own understanding of what insight was and ignored the definition given (see also section 3.4.1.1 for further discussion regarding this). Alternatively she may have taken heed of one component of the definition, for instance, understanding a complicated situation and gave less consideration of whether it satisfied the additional aspects of a suddenness and an accompanying Aha. However such limitations aside, these types of experience again suggest that insight occurs whilst searching for a solution, and without the necessity of an impasse.

2.4.5.2 Time Away: Incubation effects in insight.

The Time Away supporting excerpts can be seen to provide real-life examples of various factors associated with different theories of incubation and impasse in insight. As described in section 1.1.5.3, in experimental work incubation tasks of low cognitive load were found to be most likely to elicit insight. Many of the examples of insight offered in this study contributing to the Time Away theme may be useful in supporting this notion. They describe how insight occurred whilst doing mundane tasks of likely low cognitive load and so can be seen as comparable to the experimental findings. For instance, participants described it occurring whilst walking or running. Furthermore, the Time Away tasks were often in different domains to the problems which they solved through insight during these times. This can be seen with the student who had an insight about his research whilst eating lunch and watching YouTube: one might assume that he was not watching videos relating to his work, his girlfriend might object! These types of example are congruent with the findings from Gilhooly, Georgiou and Devery (2013), suggesting that doing dissimilar tasks in Time Away from the problem may enhance solving.

The findings are also congruent with findings from another recent daily life study, Ovington et al. (2015) (see further description in section 2.1.5) found that the most reported locations for having insight included being in the shower, on transport, during exercise and in nature. All of these situations likely involve activities such as driving or riding on a train/bus that again might be argued to have a low cognitive load and likely different to the problem they solved. One participant in this study summarised in everyday terms the general finding from incubation research, she explained experiencing her insight whilst "walking to get some lunch. Time away from the computer is far more productive for 'big' thoughts I find" (F, 30, S, E).

The Time Away theme however extends beyond ideas explored in incubation studies, and incorporates shorter periods of time away. As highlighted by the insight in (section 2.3.2.5) that describes it occurring during mind wandering. Often colloquially termed daydreaming it is also referred to as stimulus-independent thought (SIT, Schooler et al., 2011). Research exploring the cognitive mechanisms and neurological correlates of SIT, particularly examining the impact of SIT on task performance found that time away was detrimental to it. In contrast this study highlights a potential beneficial outcome to SIT in line with that proposed by Dixon, Fox and Christoff (2014) who suggested that creative thinking might be one area where mind wandering is beneficial. They propose that this would involve alternating between mind wandering to generate ideas and metacognition to monitor and evaluate them.

Other explanations for why an insight might occur during mind wandering could relate to theories about incubation effects on creative thinking (see also section 1.1.5.3). Three theories are proposed and have been explored in the context of longer incubation periods away from divergent thinking tasks. In these situations Gilhooly, Georgiou and Devery (2013) provided evidence to support that unconscious processing best accounted for an increase in creative idea generation after incubation. The situations in this study describe an idea suddenly occurring during the Time Away rather than subsequent to it under resumed efforts to problem solve. These are analogous with Gilhooly's (2016) description of "breakthrough" solutions that emerge during time away from problem solving attempts.

However, aspects of the theories explored by Gilhooly, Georgiou and Devery (2013) might still be pertinent to mind wandering. The proposed benefits of incubation in terms of breaking set, so moving problem solvers away from an unhelpful aspect of the problem might still be seen in mind wandering. Schooler (2013) highlights that SIT is detrimental to the focal task because it takes attention away from it. Where attention is a necessary and helpful thing to the task, such as reading tasks that Schooler et al. (2011) describe, then SIT is likely undesirable. However, such a removal of attention would be a positive thing if the problem solver is focused on the wrong aspect of the problem, enabling them to break set. Furthermore, there is evidence that focused attention in experimental insight tasks may be detrimental to problem solving. This was highlighted by the verbal overshadowing effect that saw a decrease in problem solving performance during verbal protocol analysis, so when attention was paid to, and thoughts verbalised (Schooler, Ohlsson & Brooks, 1993). In addition, situations that compromised participants' attention to the task, such as listening to irrelevant speech or under articulatory suppression saw an increase in insight solutions (Ball, Marsh, Litchfield, Cook, & Booth, 2014). Alcohol consumption is likewise suggested to enhance insight problem solving by reducing inhibition and as a result seeing less focused attention (Jarosz, Colflesh and Wiley, 2012). Interestingly, Sayette, Reichle and Schooler (2009) recently found that alcohol consumption increased incidences of mind wandering during a reading task, which the authors again attribute to its effects on attention.

In sum, the examples of Time Away offered in this study provide daily life examples of insight in during incubation and mind wandering to corroborate experimental studies in this area, furthermore that may contribute to the identification of novel questions to explore in the future. For instance one aspect that was not apparent in the experiences shared was the reasons that caused participants to take time away from their problem solving efforts. As highlighted in (1.1.5), some researchers assume that reaching an impasse causes the cessation of problem solving efforts in favour of an unrelated activity, but there is yet little naturalistic evidence of this in daily life problem solving.

2.4.5.3 Social Aspects.

The insights in this study which describe social aspects to insight highlight that thinking and problem solving in real life do not occur in a vacuum. This corresponds to Csikszentmihalyi and Sawyer's (1995) observation from their interviews of eminent creative individuals, that insight occurs at a "social, interpsychic level" (p. 337) in contrast to the focus on individuals' mental processes and behaviour which predominates cognitive psychology. They further assert that a lack of social interaction may reduce the likelihood that insight occurs. Dunbar (1995) likewise found that group discussions (held by their participants) contributed to insightful moments for participants in his simulated genetics laboratory. Hargadon and Bechky (2006) again demonstrated a social aspect of insight, evidenced in the emerging insight of one "creative collective" in their design of a novel basketball shoe. The insight to incorporate side air cushions was highlighted by the authors as the result of a group of individuals with disparate knowledge and expertise. One member had a medical background whilst another's technical expertise was pneumatics, it was their interaction which enabled individual member's existing knowledge to be re-structured in a group insight.

All previous examples of social aspects of insight draw from studies which selected participants due to their notable creative achievements (Kaufman and Beghetto's (2009) Big C) or careers with a creative component (Pro c). The examples from this study offer complementary evidence of socially derived insight more broadly in everyday life and in more mundane circumstance. Most of the insights of other studies were work related and focused on the work setting, Dunbar (1995) provided a simulated work setting for his molecular biologists, whilst Hargadon and Bechky (2006) followed work groups through the development of specific products or projects. Some of the insights shared from this study are also examples of group generated, work related insights, like the insight relating to a kidney bean (section 2.3.2.6). However, others may be considered more serendipitous insights from outside of the work realm. For instance, the insight about schools which occurred at a social event.

The insights occurring whilst learning or being taught can also be seen to overlap with the social aspect of insight: these represent deliberate, socially imparted or initiated insight. This is distinct to the concept of 'insight learning' most often discussed in respect of animal behaviour which describes a new adaptive behaviour within an individual; arrived at suddenly and not by trial and error, shaping, or social learning (see Shettleworth [2012] for full discussion). As discussed in section 2.4.4.3, these instances are also daily life examples of the mini c "intrapersonal insight" (Kaufman and Beghetto, 2009, p. 4). These insights are creative to the learner in the sense that they are novel and useful, but this creativity is unique to the learners, and would not be considered creative from a wider everyday perspective seen in little-c creativity.

2.4.6 Effects of Giving a Definition When Collecting Qualitative Data

A further aim of this study was to explore the effects of offering different, or no definition to the qualitative responses garnered. Such an approach protected against the possibility that the definition offered primed participants' responses. Participants in a recent study by Ovington et al. (2015) may have demonstrated a difficulty in disengaging from the original definition of insight they were given (see further details in section 2.1.5). Moreover, Danek et al. (2014b) identified that a third of their participants' open qualitative responses described insight mirroring the definitions participants were given. Accounting for this effect was important to counter the circularity problem of insight research (see section 2.1.1). Shen et al. (2015) also recognised the possibility that definitions given to participants could contribute to the circularity problem. They omitted aspects of interest from their definition to avoid leading responses. However this means that in choosing a single definition, researchers must effectively identify aspects that are not of central interest to their research question and yet be sufficient to aid participants in recognising the phenomenon of interest.

Using several and no definition groups as demonstrated in this study enabled exploration of aspects included in the definitions used. As highlighted in section 2.2.3, this provided stronger support for themes offered, drawing examples from groups where the aspect being considered was not included in the definition given. Therefore, accounting for definition priming enabled a richer analysis of the data and assessment of themes' validity. So where there was wide ranging, solid support from all definition groups the resulting theme could more confidently be ascribed as valid.

Within the Negative Feelings theme, the additional aspect of a series of experiences, an Uh-oh (problem finding) followed by an A-ha (problem solving) experience. The majority of these episodes arose from the Emotional focused definition group, so could have resulted from priming and so not confidently be ascribed as a theme or sub-theme in their own right. This highlights a further benefit to grouping for definitions, enabling a more nuanced discussion of the level of support seen for various aspects identified with in the data. This enables differentiation between themes which have strong support from all groups (such as the theme negative insight) and other aspects that are seen, but have less strong support (such as the outcomes from having an Uh-oh moment). Aspects with inconclusive support can be highlighted as such in order to elicit future research questions.

A further point of note is that there were fewer responses in the No Definition group (see Table 2.1). Survey Monkey randomly allocated participants to a definition group, so it would be expected that there would be equal numbers of responses collected for each group. This highlights that while there are issues in giving a definition, in terms of leading the participant's response, a definition is useful to maximise collection of data. It is not clear what aspect of not giving a definition decreased response rates. One might surmise that a definition helped participants to understand what type of experience they were being asked to share, but without further research into this it is not possible to make any such assertions. However, it may be pertinent for future exploratory qualitative studies of this nature to include a number of definition groups omitting and including the pertinent aspects of the study subject to protect against confirmation bias, but without a no definition group to maximise participant response rates.

It must however be recognised that there were dropouts from both of the definition groups as well as the no definition group, so other factors may also be pertinent to this observation. It is difficult to ascertain what a normal level of response completion is as most researchers discard any incomplete questionnaires and do not report this, as ethical guidelines generally consider these to be examples of withdrawn consent. Further research to explore why participants dropped out at the point they did may be pertinent, most having completed demographic and the closed questions about their insight experience whilst leaving the open responses unanswered.

2.4.7 Limitations of questionnaire design

The insight reports made in this study were often very short, for example, "what to do for a party [whilst] meditating". This restricted the level of analysis that could be carried out and sometimes led to debate of how an insight could be interpreted. The researcher has sought to make clear where such interpretation reaches beyond the data given. In ideal circumstances the opportunity to further explore responses with a participant would have enabled a far deeper understanding of the experiences shared. However this is offset by the number of participants that it would be practicable to do so with. It would also reduce the anonymity of completing an online questionnaire, where more sensitive insights might not be shared if participants anticipate having to explain them to a researcher face to face. Participants, knowing that their insights are identifiable to them and that they are to be questioned on them may opt not to share certain insights or create demand characteristics in the socially desirable version of an insight that they share.

2.4.8 Conclusion

In conclusion the application of ITA on the qualitative accounts of everyday insight collect identified through research, negative insight for the first time. Further exploration of everyday negative insight is reported in Chapter 3. On demonstrating, as this chapter has that an emotional component of insight is of interest, experimental research that seeks to validate these claims is described in Chapters 5 and 6. Finally, whilst this chapter established that people are able to recount insight, often from the last 24 hours, it did not provide any conclusive account of the prevalence of insight in everyday life. This question is considered in Chapter 4.

3. Everyday experience of negative insight.

3.1 Introduction

Negative insight is a sudden, sickening moment of realisation (Friedlander, personal communication 2016). While it has been identified as a feature of everyday insight in Chapter 2, there were not sufficient examples of negative insight to enable a characterisation of it. As such, the nature of negative insight is still unknown. A number of questions in particular are pertinent to this characterisation. Firstly, what aspects constitute negative insight in everyday life? Secondly, are these the same or different to positive insight in everyday life? Finally, what function does negative insight serve in its daily life occurrence?

As highlighted in section 1.2, and because this thesis has been the first to identify negative insight there is little literature to review. Therefore this study aims to take an exploratory approach to begin to characterise negative insight. As such, it will ask open questions to elicit, in the first instance an account of a recent (within the last 24 hours) negative insight experience. This is again to reduce memory effects in the recounting of insight experience highlighted as problematic by Gruber (1995). The incidences shared will then be analysed using Integrative Thematic Analysis (ITA) to enable as an objective analysis as possible to and minimise effects of findings from previous studies in this thesis (see sections 2.2.3.2 and 2.4.8). This should provide further information as regards to aspects that constitute negative insight.

With regard to the second question, a typology was identified for general insight experience in everyday life in Study 1 (see Figure 2.5). This, and the literature summarised in previous chapters for positive insight serve to provide a comparison point for negative insight. A Content Analysis of the negative insights shared will therefore be undertaken using the typology from Study 1 to code the negative insight examples. This should give an indication of the extent that negative insight in daily life is similar or different to generalised everyday insight.

As highlighted in sections 1.1.4 and 1.1.5, positive insight is described within a problem solving framework, specifically representing the solution point. Discussion in Chapter 1 illustrates how negative insight might serve to initiate problem solving, a contrasting function to that often posited for positive insight (see section 2.4.3.3).

Asking participants to describe what they were doing when they had their negative insight will help to identify the circumstances of their insight. However, to fully explore the situation surrounding negative insight a further question to probe what happened next will also be asked. Together these may help to explore the function that people attribute to negative insight in everyday life.

3.2 Method

3.2.1 Participants

Recruitment of participants was undertaken using snowball sampling via online social media and leaflet promotion. Sixty-seven participants (M_{age} = 38.14yrs, SD_{age} = 16.05) completed the online questionnaire (an additional 94 questionnaires were not fully completed and so not included in the data), Table 3.1 shows the proportion of participants in terms of sex, occupation and time that insight reported occurred. Nine insights were reported as being made by participants who had previously shared a negative insight. However there was not sufficient information recorded to pinpoint how many returning participants there were or link them to their original posts. As such it should be noted that the information in Table 3.1 reports the descriptive statistics of the same as if these nine responses were made by new, unrelated participants. As no statistical analysis is being conducted this should not be too problematic an assumption to make.

Table 3.1 Demographic breakdown of participants

		n
Sex	Female	53
	Male	14
Occupation	Students	53
	Non-student	14
Time of reported insight	Last 24 hours	35
	Over 24 hours	32

3.2.2 Materials and procedure

The format of the online questionnaire described in 2.2.2 was adapted to ask questions specifically regarding negative insight. As there were not a variety of research definitions available to compare responses against, a single definition was derived based on those used for positive insight (see section 1.1.2) and from the findings of Study 1. The definition used was: "Negative insight is a sudden new thought, understanding or idea accompanied by an Uh-oh moment. It is your sudden realisation that things are worse than you originally thought". On giving informed consent and providing demographic information (age, sex, occupation, country of birth/main residence) participants were provided with the negative insight definition and asked if they had experienced it in the last 24 hours. They were then asked to share an insight, in the first instance from the last 24 hours but otherwise one from further in their memory. Participants indicated how long ago their insight occurred, selecting from within the last: 24 hours; week; month; year; 1-10 years; over 10 years ago. They then described their insight responding to three open questions. Firstly, "Please give a brief description of your negative insight experience." Secondly, "What were you doing when you experienced this insight?" Finally, "What happened as a result of your negative insight?" Participants were then taken to a debrief page which provided information on how to contact the researcher and an invitation to return and share future negative insights.

3.2.3 Analysis of data

3.2.3.1 Integrative Thematic Analysis

The data collected in this study was first analysed using Integrative Thematic Analysis (see section 2.2.3.2). A direct content analysis was then conducted. The ITA was undertaken first to minimise the influence of the previous themes identified in Study 1. The remaining sections of this chapter are dedicated to the two different analyses in turn, firstly the Analysis of data, Results and Discussion relating to ITA then in respect to content analysis.

Note that a different "second researcher" was used for the ITA analysis in this study than in Study 1. Using the same person would have introduced subjectivity into this analysis due to their knowledge of the themes previously identified. The person selected was both naïve to the previous research conducted in this thesis and to insight literature more generally, this was to ensure they were taking a data driven approach in their analysis.

3.2.3.2 Content Analysis

A directed content analysis was undertaken following Hsieh and Shannon (2005). This method draws on previous theory to form a coding schedule. In this case the themes identified in Chapter 2 were used to code. Two researchers independently coded each negative insight for its Content [Intellectual, Practical and Personal] and Process [Time Away, Active Search and Social]. Note that the third aspect identified in Study 1 was not coded as this was the feeling component and in this study all were negative as this is the focus of the research. The definition for each theme was reviewed to take into account the context of negative insight, the amended definitions adopted are reported in Table 3.3. Definitions for Time Away and Active Search were amended, see section 3.6.3 for further discussion relating to this. An additional category of Not Insight was added as a result of the ITA (see sections 3.4.1 and 3.5.1) which identified this as a theme. It would be problematic to code incidences that are not insight using a typology developed for it. Therefore the introduction of this as a category negates the requirement to do so.

Hsieh and Shannon (2005) feature a hypothetical example in their explanation of directed content analysis where the questions asked of participants [in a semi-structured interview] probe for things related to the theory being used for coding. As the Uh-oh study aimed to also conduct data-driven thematic analysis, this aspect of the directed content analysis was not followed, and open ended, un-targeted questions were used in the questionnaire. The "second research" asked to code this data was actually the "second researcher" who conducted the ITA in Study 2, this ensured that they were very familiar with the themes and their definitions when coding. Initial agreement (using Cohen's Kappa) between coders was moderate for both Contents, $\kappa = .49$ (95% CI, .35 to .63), $p < .001$ and Process $\kappa = .50$ (95% CI, .35 to .65), $p < .001$ (Landis & Koch, 1977). It was identified that an area of uncertainty for both coders was in whether some of the descriptions represented insight, the definition of insight used to identify non-insight was changed to "non-insight or not enough information to label as insight"; coding was then repeated (see Table 3.2). This saw an increase to substantial agreement, for Contents, $\kappa = .76$ (95% CI, .65 to .88), $p < .001$ and Process, $\kappa = .80$ (95% CI, .32 to .91), $p < .001$

(Landis & Koch, 1977). Furthermore, it led to subjective reports that the researchers were more confident in their coding. As such results reported in 3.3.2 represent the coding of the first researcher.

3.3 Results Integrative Thematic Analysis (ITA)

ITA was conducted and identified six themes: Uh-oh No Insight; Social Environment; Time Away; Mental Time Travel; Gut Feelings and; Sucking It Up. The initial themes identified independently by each researcher and the final theme that they contributed to can be seen in Table 3.2.

Table 3.2 Characterisation of negative insight using Integrative Thematic Analysis: candidate themes identified independently by two researchers were then integrated into final themes which were labelled and described.

	Description	1st Researcher	2nd Researcher
Uh-oh No Insight	Participants describe experiences relating to an Uh-oh moment in direct response to a cue without any mental restructuring	Uh-oh no insight	Not insight (active problem solving)
Social Environment	Insights in this theme are embedded within the social environment in which they occur.	Relationships	Setting (Social)
Time Away	This theme sees insight occurring when participants were distracted or first thing in the morning or last thing at night. This was not identified by the first researcher, perhaps overlooked due to it being a theme in previous studies in this thesis.		It dawned on me
Mental Time Travel	Participants' insights see an association of events over different time frames, memories from the past, observations from the present and plans for the future.	Mental time travel	Mulling it over - situational cues
Gut Feelings	Participants relay their negative insight experience in terms of physiological descriptions.	Bodily descriptions	Gut feelings
Sucking It Up	This theme represents the participants' descriptions of their active attempts to resolve the issues highlighted through negative insight despite the negative nature of their realisation.	Initiation of problem solving	Sucking it up

3.3.1 Uh-oh No Insight.

A proportion of the respondents described experiences that focused on the emotional aspect of the definition for negative insight given, so the Uh-oh moment; but did not map to the other parts of the negative insight definition which describe cognitive restructuring. For example, "my baby was sick all over me and the floor ☹" (F, 22yrs). These represent a negative emotional response to stimulus in the environment rather than a negative new thought or realisation. A theme describing incidences of non-insight was identified by both researchers as seen in Table 3.2.

3.3.2 Social Environment

Many of the negative insights shared were embedded in the social world of the participants; some were pertinent to the individual or related to others that they know. The following example illustrates how the insight occurs as a result of a social interaction. Furthermore the insight represents a new understanding regarding a working relationship.

> I was talking to a client [on the phone] and realised comments I had made earlier had been misinterpreted and that that client was going to react in a way that would make it harder for us to work together. As a result of my negative insight, I was worried and attempted to I proactively clarify my meaning and apologise for any misunderstanding. This did not work. (F, 37yrs)

The relationship aspect was identified by the first researcher, and this was seen to align with the second researcher's theme that described the social situation as being intrinsic to many insights. Together it can be seen that there are social aspects in both the contextual and content components of negative insight moments.

3.3.3 Time Away

This theme was labelled as 'It dawned on me' by the second researcher and describes common situations where participants found they were having insights such as in moments of distraction, first thing in the morning or last thing at night. This is demonstrated in the insight below.

> Suddenly realising that I had an excess to my insurance policy upon which I was about to make a claim [whilst] trying to sleep. Had to rethink if I would still make the claim given the excess. (F, 45yrs)

The first researcher did not identify this as a theme, however during the integration process it was agreed that this was a valid theme. The first researcher had overlooked this theme due to their previous analysis of the everyday insight data in Chapter 2, where a comparable theme of Time Away was also identified. In both studies participants described their insight at times when they were doing things unrelated to it, for example whilst driving or watching television.

3.3.4 Mental Time Travel

Often the negative insights described a convergence of ideas or knowledge from different times or contexts. Perhaps, but not always, a situational cue suddenly being linked to events from memory and/or related to future plans. As such these negative insights represent a moment of convergence between current thoughts with memories from the past and plans for the future, exemplified in the title name of mental time travel and the following insight description.

> I realised a colleague at work was breaking the law. It came absolutely out of the blue while watching the news on a hotel television, and had nothing to do with what I was watching or any obvious process. I connected comments by two people made days apart (and days previously) and realised that there was only one logical conclusion. I suppose the negative insight was that I knew I had to report. (M, 50yrs)

It can be seen that there is an instantaneous putting together of different memories of conversations with a certainty of the future action that the participant must take. In this instance the participant does not consciously relate the negative insight to any situational cue. The following Uh-oh moment demonstrates how a situational cue (the rain) is related to both previous actions, in this case omitting to have done something and its future implications.

> Realising that as it was raining, I didn't have a lesson planned as my lesson was based on being outside. [I] felt slightly nauseous, heart rate

> increased, sweaty palms followed by me talking myself round - it will be fine - everyone still alive type thoughts. (F, 46yrs)

3.3.5 Gut Feelings

The second excerpt seen above (in section 3.4.4) also highlights the current theme of Gut Feelings. This sees participants describe physiological aspects of their negative insight. As above, in terms of typical arousal responses of the sympathetic nervous system like elevated heart rate and sweating, but also some more unusual ways as seen below.

> I keep on thinking [of] things that I missed from my last assignment that I should have included. Each time I think of something, I think that it's a bit less over my overall mark and that I will fail and I get a horrible anxious feeling and my face prickles. (F, 27yrs)

This theme was identified by both researchers, with the second researcher identifying sub-themes of "Oh Shit" and "It's Obvious".

3.3.6 Sucking It Up

Both researchers identified a theme that describes the active response that participants have to their negative insight. These represent both cognitively thinking about how to resolve the problem the Uh-oh moment has alerted them to or actual actions. The following negative insight demonstrates this initiation of problem solving.

> Earlier today I ordered a Mother’s Day gift for my mum from Amazon. Tonight I suddenly realised I hadn’t changed my default delivery settings, meaning I’ll be getting a cream tea hamper on Saturday whilst my mum gets nothing! I checked that the hamper had already been dispatched (it had) and laughed about it for a few min[ute]s with my partner. I then reordered - with the correct address! - and text my mum to apologise that she'll receive a late gift. (F, 27yrs)

In addition, the second researcher highlighted how there was an element of resolve demonstrated in recognising a set-back and looking to overcome it, often in a very pragmatic way. In the words of one of the participants in response to being asked what happened as a result of their insight, they "sucked it up" (F, 22yrs). While for the insight above the steps taken to solve the problem were relatively straight forward, for others the stakes were much higher likely involve far more 'sucking it up' as seen in this negative insight.

> The realisation that I had caused duplicate transactions to 750,000 bank accounts [whilst] trying to test a software patch. The incident was front page news in every newspaper. I had to explain the problem to the CEO of the bank that I worked for. It took 36 hours flat-out working for me and five colleagues to fix it. The bank lost £20 million as a result. I was not fired. (M, 56yrs)

3.4 Discussion - Integrative Thematic Analysis

The use of ITA, following methods outlined in Study 1 identified six themes within the everyday examples of negative insight collected. Five of the themes represented different aspects of incidences of sudden mental restructuring giving new negative representations: Social Environment; Time Away; Mental Time Travel; Gut Feelings and; Sucking It Up. An additional theme, Uh-oh No Insight, where no mental restructuring was seen was also identified. These will be discussed in turn, characterising negative insight and highlighting implications for current theory relating to positive insight and creative problem solving.

3.4.1 Social Environment

As seen in Study 1 (section 2.4.5.3) everyday insight is embedded in the social environment, with cues from this facilitating the occurrence of insight. The theme of Social Environment seen for negative insight however differs in that it represents not only the facilitation of insights, but that in many instances the social environment is an integral component of the negative insight. So in the negative insight in section 3.4.2, the facilitation of the insight can be seen due to a conversation with a client. However, the insight content was also related to social cognition, a realisation about someone else. This is again seen in the negative insight in 3.4.4, however this example shows it was the recollection of social conversations, and the implications of these, rather than the immediate social environment acting as a cue that contributed to the insight.

Gilhooly et al. (2007) developed a set of real-world problem solving tasks as an alternative cognitive test for older adults. They made the distinction between everyday problem solving and socio-emotional problem solving that had an interpersonal focus. This distinction maps to the insights in the Social Environment theme, furthermore that negative insights typically represent the moment that the participant became aware of an interpersonal problem or social faux pas.

As such this theme again emphasises the point made in section 2.4.5.3 that exploration of insight as a social process should be considered alongside research which focuses on the individual problem solver. The role of negative insight as problem finding (see section 3.4.5 below) identified by Csikszentmihalyi and Sawyer (1995) should also be further explored in the context of the everyday social environment.

3.4.2 Time Away

The Time Away theme seen in section 2.4.5.2 for general everyday insight experience was discussed explicitly in relation to problem solving and representing the realisation of a solution to a problem that had been put aside, therefore seeing it being solved during an unrelated task. However, in negative insight the sudden realisations were not problem solutions; in fact most often these identified issues that until the point of the insight participants were not aware of. The theme Time Away in this instance represents the second part of the definition, in that the negative insight was unrelated to the activity being undertaken and without any particular reference to unresolved problem solving.

In section 2.4.5.2 Time Away is discussed in relation to incubation in problem solving. As outlined previously (1.1.5.3) Gilhooly (2016) suggests that facilitation in problem solving through incubation is likely due to the implicit spreading activation that continues once problem solving attempts have been suspended. The insight moment occurring due to activation of a solution in relation to a goal-to-be-solved (activation having continued to spread during incubation) creating a positive feedback loop that raises the activation levels above the threshold of awareness. This would be experienced as the solution suddenly appearing in consciousness. However, in many of the negative insights shared in this study there was no (once conscious) goal that remained activated; the insight is the first time the participants become aware that there is a problem with a goal to be solved, in the words of one participant it appears "out of the blue" (M, 50 yrs). This experience cannot therefore be explained by current incubation theories.

However, perhaps thinking about this idea in a slightly different way might explain incidences of negative insight. One possible explanation for the continued activation is that the problem had emotional salience (this is the reason it is seen as a problem in the first place (see point made by Runco (1994) in section 2.4.3.2). The incidences that contribute to a negative insight, if emotionally salient may have likewise continued to cause spreading activation. When two or more disparate spreading activations associate and activate a goal-to-be-solved, this might again cause positive feedback in a way comparable to Gilhooly's (2016) description and consequently, a sudden awareness of the problem and the goal to be solved. The example identified in 3.4.4 demonstrates these ideas, the negative insight putting together separate conversations with different people to identify criminal activity by a work colleague and the need to report this.

An alternative explanation is that the negative insight in fact represents a solution to a problem, not recognised as such by the participant. So, in the case of negative insight discussed in section 3.4.4, the different conversations recalled may have been labelled by the cognitive systems as problems in the sense that they were unusual or had unexplained aspects to them. The negative insight resolving the disparities identified in each of the conversations, so while the participant recognised the problem of lawlessness at the insight point, this in fact provided a solution fully explaining the previous conversations. Thinking about this in terms of spreading activation, the implicit goal states were the separate, unexplained conversations. The negative insight, new to the conscious awareness of the participant actually represented spreading activation of these unresolved goal states; putting the separate conversations together to recognise the superordinate problem of a lawbreaking colleague. This highlights that further research exploring theories of incubation in negative insight is warranted, both in terms of everyday experience and experimentally controlled incubation and insight solutions.

3.4.3 Mental Time Travel

The insight described above and in 3.4.4 furthermore demonstrates the theme of Mental Time Travel: where participants are making associations between events in different time frames; past events, present cues and future plans. Jung-Beeman et al. (2004) discuss the role of remote association in insight and accordingly developed the Compound Remote Associates (CRA) task (see section 1.1.4.1 and 5.2.2.3 for further detail). The remote association of different events, thoughts and plans over time, possibly through spreading activation processes described above (in section 3.4.2) present interesting additional considerations for theories of creative problem solving and insight.

3.4.4 Gut Feelings

This theme sees participants describe their insight moment in terms of physiological components. Many theories of emotion incorporate physiological aspects (see section 5.1.3 for more in depth discussion). Barrett, Quigley, Bliss-Moreau and Aronson (2004) used implicit language cues to measure the extent people focus on arousal aspects in their emotional experience (see section 5.4.4 for a more detailed explanation). This theme likewise reflects an implicit focus on emotion arousal and physiology in insight experience. At no point was attention drawn to this aspect of emotional experience. The definition of insight given only refers to emotion in terms of valence (it being negative and an Uh-oh moment). This contrasts to the general experience of insight in everyday life (where most insights shared were positive) where very few descriptions related to physiological aspects, as such there was not an analogous theme. This may therefore point to a difference between positive and negative insight worthy of further investigation, both in everyday experience and using lab-based tasks (see Chapters 5 and 6 which explore positive and negative insight in relation to physiological aspects of emotion).

3.4.5 Sucking It Up: problem finding insights

As discussed previously in section 2.4.3.2 the case of negative insight highlights that insight might not be restricted to the solution moment of the problem solving process (as outlined by stage models of creative problem solving such as Wallas (1926) (see detail in Chapter 1, section 1.1.3). Sucking It Up sees participants attempting to solve the problems identified by negative insight, as such framing negative insight as the moment of problem identification. In this instance it positions insight before Wallas' (1926) preparation stage. Runco and Nemiro (1994) suggest that stage models of creativity are problematic if taken literally to mean that the creative process occurs in a linear progression through the prescribed stages. They propose that a more helpful interpretation (see Figure 3.1) is to consider interactions between stages in a non-linear fashion incorporating feedback loops and out of sequence progressions.

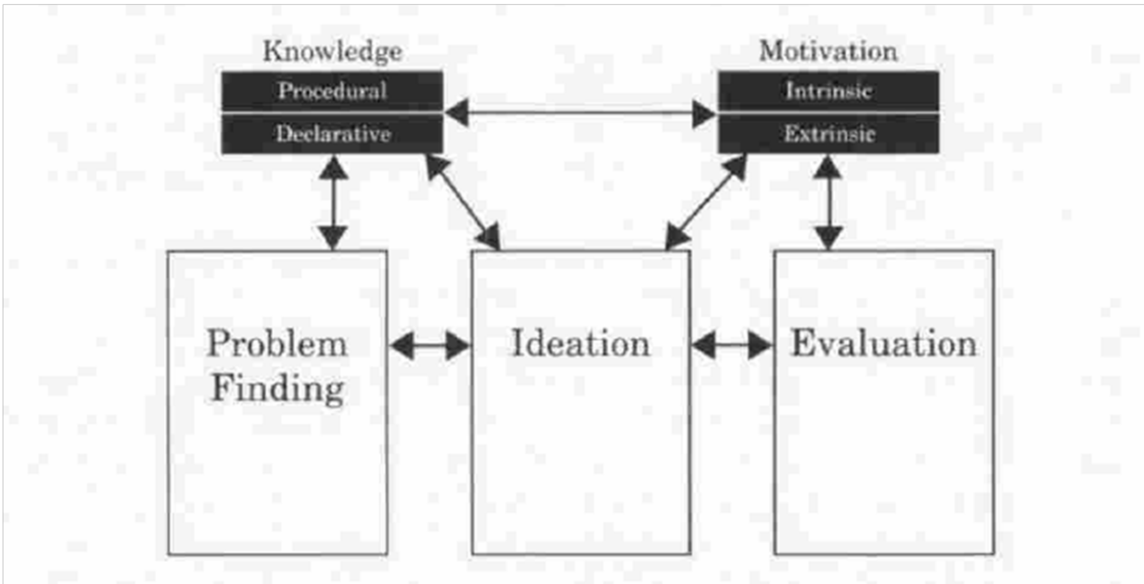


Figure 3.1 Two-tier model of creative thinking Adapted from Cognition and creativity by M.A. Runco & I. Chand, 1995*. Educational psychology review*, 7(3), 243-267. Copyright 1995 by Springer.

Runco (2000) highlights the importance of problem finding both as part of Wallas' (1926) preparation stage and within his own Two Tier Model of Creative Thinking (Runco and Chand, 1995). In this, problem finding represents one of a set of skills (along with ideation and evaluation) in the primary tier (see Figure 3.1). Runco and Chand (1995) highlight that problem finding embodies a number of different but related aspects including problem identification, problem definition and problem formation. However, no mention is made of insight as a possible problem finding process, or in the context of these three problem finding aspects. Runco (1994; Runco and Chand, 1995) discusses insight purely in terms of the solution moment rather than initiating it.

One research team who have identified a duality in the role of insight in problem solving is Csikszentmihalyi and Sawyer (1995). They firstly identified "presented insight problem solving" (Csikszentmihalyi and Sawyer, 1995, p 337) which is analogous to insight elicited in experimental research and complying with stage models that frame insight as the solution moment in problem solving. They contrasted this with "discovered insight problem finding" where creative individuals described insights that initiate a new area of research or unite previously disparate ideas or approaches in novel ways. In the latter type of insight, it can be seen to initiate efforts rather than as the culmination in endeavour.

As identified in section 1.1.5.5 Weisberg's (2014; Fleck and Weisberg 2004, 2013) Stage Model of Problem Solving (see Figure 1.3) can be seen to include possible mini Aha moments that occur along the problem solving process. In consideration of the Negative Feelings theme, some of these might be more appropriately labelled as possible mini Uh-oh moments. For example, at stage 1B and 3B, the moment where the proposed solution fails may result in an Uh-oh. In these instances the new information that results from the failure to find a solution causes the problem solver to reinitiate a stage in the problem solving model. Again this demonstrates that negative insight may serve to (re)initiate problem solving rather than conclude it.

Examining Weisberg's (2014; Fleck and Weisberg 2004, 2013) model in this way highlights a key problem with naturalistic research into problem solving: that real life problems do not happen in isolation, so it is not easy to parse experience into a neat series of problem solving episodes. There is also the question of scale, efforts in solving many separate problems may contribute to the satisfaction of a longer term, superordinate problem. Congruent to this point, Csikszentmihalyi and Sawyer (1995) identified that Discovered Insight Problem Finding represented the initiation of prolonged efforts towards a goal over a much greater duration of time than Presented Insight Problem Solving. Chapter 6 describes efforts to elicit positive and negative insights in a continuous problem solving context of the game Connect 4. Here the positive and negative insight and search move decisions represent efforts towards the superordinate goal of winning the game.

3.4.6 Uh-oh No Insight

The theme Uh-oh No Insight highlights a strength of ITA and a qualitative approach in enabling the researcher to check the events that participants reported were actually those of interest to the research question. If this was not verified, for example had participants completed a multiple choice questionnaire, these examples would have been reported by participants in their answers to questions. The researcher would have assumed that as they had been given a definition, the participants were describing the phenomenon of interest (in this case negative insight) leading to possible confounding data. This is particularly problematic when research is exploratory and no other literature is available to provide a comparison of results that might highlight irregularities. As demonstrated by this theme, it appears that some participants only attended to part of the definition, the Uh-oh moment, and did not describe incidences where the essential cognitive restructuring element of insight was apparent (see 1.1.4.2). As discussed in section 2.4.5.1 this supports the notion that caution should be employed in making the assumption that participants are answering purely in response to the definition a researcher has given them. Discussion in Chapter 2 identified that while participants responded solely based on their own conceptions of a phenomenon in the no definition group (to provide a check on the effects giving a definition, see section 2.2.3.2), it is also conceivable that they also draw in this when definitions are provided. This highlights that in addition to only focusing on one aspect of a definition, participants are likely also drawing on their own conceptions to respond and these may not match the researchers'. As such, the use of qualitative, open questions and responses can be seen to serve as a mechanism to detect any disparities between the two and avoid the introduction of resulting confounds into data.

3.4.7 Evaluation of ITA

The use of ITA in this study provided an opportunity to further evaluate it as a methodology in the exploratory study of everyday experience of insight. As discussed above in section 3.4.6, the identification of the theme Uh-oh No Insight highlights a strength of using qualitative methods to verify that participants are reporting experiences congruent to the research definition. Further benefits that related specifically to ITA as a qualitative method were also demonstrated.

Firstly, as described in section 3.3.3, the first researcher did not identify Time Away as a theme, perhaps overlooking this obvious trend in the data due to it being a theme in the previous study. The ITA process (see Figure 2.4) enabled this theme to be identified by the second researcher who was taking a naïve, data driven approach. The merits of the theme were then discussed between the researchers during the integration of themes. This protected the analysis from undue influence of a single researcher's previous knowledge and experience.

Conversely, whilst the theme Gut Feelings was identified by the first researcher it was important that it be independently recognised by the second researcher. This is because it maps very closely to the overarching research theme of this thesis; emotional experience and insight. As such, it was possible that the first researcher would see this theme through increased vigilance to emotion related cues in the data. The second researcher did not have such biases in their assessment of the data, again offering protection in the analysis from researcher expectation.

3.5 Results - Content Analysis

Each description of insight was coded for its Process and Content; examples of insights coded for each of the themes are reported in Table 3.3. Figure 3.2 shows the percentage of negative insights coded for the process and content that they demonstrate. Just under a third of the descriptions (n=21) shared were coded as Not insight (using the new definition which incorporated descriptions where there was uncertainty, in other words insufficient evidence to code for insight). In terms of contents, the largest proportion of negative insights (n = 26) had Intellectual content with the same proportions of Practical (n = 10) and Personal (n = 10) contents. Most of the negative insights coded for Process represented examples of Time Away (n = 22), followed by Active Search (n = 19), and a small proportion being categorised as Social Facilitation (n = 5).

Table 3.3 Coding scheme for Directed Content Analysis of Negative Insights for Contents and Process, based on definitions of themes from Study 1.

Title	Description	Negative insight example
Uh-oh Not Insight*	Description of emotional response to immediate stimulus without mental restructuring *or not enough information to code as insight***	Standing up to a boss [whilst] emailing. [As a result] I was ignored (M, 42yrs).**
Content Themes		
Intellectual	Insight related to theoretical problem or conceptual thoughts.	Suddenly realising that I had an excess to my insurance policy upon which I was about to make a claim (F, 45yrs).
Practical	Insight related to physical manipulation of objects.	I realised I did not have enough materials to finish the roof I was working on (M, 42yrs).
Personal	Insight related to the self, or the self in relation to others.	I realised that along with all the giddiness and excitement for my upcoming wedding, I'm also scared. I called several friends to talk about it. But the one thing that reassured me was seeing my fiancé and feeling the connection. (F, 25yrs).
Process Themes		
Time Away	Engaged in activities unrelated to insight they have.	Talking to my partner about something unrelated [to this insight]. I suddenly remembered that I hadn't changed the delivery address, and checked my Amazon account to confirm I was right (F, 27yrs). For insight description see section 3.3.1.6.
Active Search	Insight directly related to current thinking/ attention/activity engaged in.	Realising how bad staffing crisis is [whilst] working out shifts/rotas (F, 26yrs).
Social Faciliation	Insight occurring as a result of social interaction.	I was talking to a client and realised comments I had made earlier had been misinterpreted and that that client was going to react in a way that would make it harder for us to work together (F, 37yrs).

*Code added to both Process and Content coding schemes in account of theme identified in ITA of negative insights. ***Added on review of Codes*

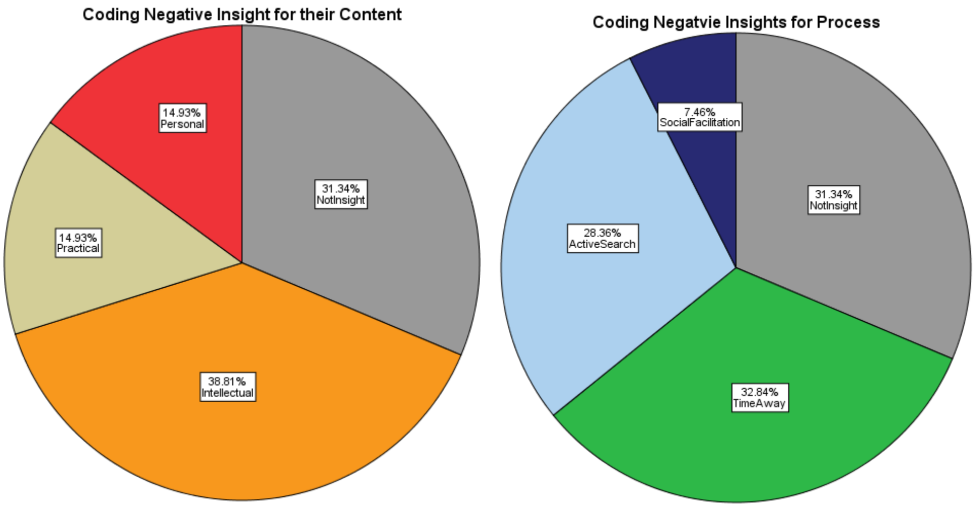


Figure 3.2 Content analysis of everyday negative insights (n = 67) using codes from Typology of Insight identified in Chapter 2. The additional category of negative insight was identified during the thematic analysis of the data.

In addition to considering the proportions of each aspect of the typology seen in the reports of Negative Insight made, representation of each combination of categories within the typology was also considered, as shown in Figure 3.3. As identified in section 2.3.2 the typology identified combinations of Contents and Process not evidenced for Negative Insight in the data set. A revision, in light of data from this study, shows that only Social Facilitation in the Practical domain for Negative Insight is yet to be evidenced in everyday insight.

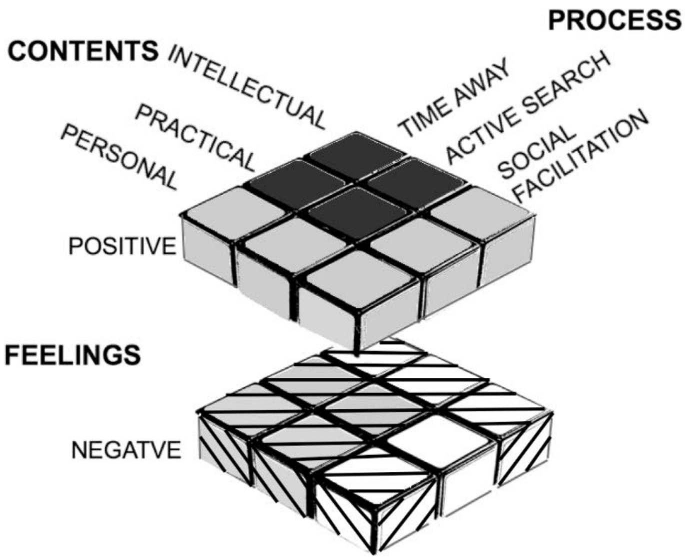


Figure 3.3 Review of Typology of Insight incorporating data from both Study 1 and 2: light grey cubes, strong support in Study 1; dark grey also corresponding to research literature; stripped cubes represent supporting

data from Study 2; white cubes remain theoretical with no strong support from everyday examples of insight collected.

3.6 Discussion - Content Analysis

As discussed above in section 3.1 the Directed Content Analysis aimed to provide a comparison between the negative insights shared in this study with the typology of insight identified in Study 1. The majority of insights in Study 1 were positive and so such a comparison could be argued to highlight aspects that are similar or different between positive and negative insight in everyday life. The examples of negative insight analysed demonstrated all of the contents and process themes identified for general insight experience suggesting that positive and negative insight are comparable in terms of these aspects.

3.6.1 Intellectual / practical distinction in problem finding

The majority of negative insights were of an intellectual nature. It is important to note that the label, Intellectual, in this study referred to generalised cognitive processes relating to conceptual thoughts or thinking about a problem in theoretical terms. The term was not pertaining to a person of high intelligence or in reference to any other personal attribute. As seen in the example in Table 3.3 the Intellectual insight was about a mundane every day realisation, not intellectual in the sense of an activity representing high intelligence, but in relation to its cognitive content.

As discussed above in section 3.5 negative insight operates as a problem finding mechanism in everyday life, the negative insights with an intellectual content see problem finding in a conceptual sense. This contrasts with Practical negative insights, where the problem identified is in physical form, or a mentalisation of real-life physical objects. As discussed in section 2.4.4.1, a distinction is made between different types of insight problems, some being related to more conceptual problems based on reading, while others being visuo-spatial problems (Gilhooly and Murphy, 2005). If negative insight does represent problem finding, it would be expected that the domain distinctions of the problem would likewise apply to the insight identifying it. The Content Analysis demonstrates such a distinction in the negative insights in this study, supporting this idea.

3.6.2 Personal negative insight: personal problem finding

As discussed in section 2.4.4.2, Personal insight was related to counselling psychology literature identifying it as problem finding about the self, seen as an adaptive behaviour desirable to enable problem solving to begin. As such it would be expected that personal negative insights would be reported in this study as moments where personal realisations led to problem solving behaviour. As demonstrated in the example in Table 3.2, the personal negative insight led to the participant seeking help by talking about the realisation with friends. The help seeking can be seen to represent a functional, problem solving response to the identified worry, an example of personal 'mastery' in everyday problem solving skills that Hillis (2015) aims to help clients develop through their therapeutic process.

However, quite a small proportion of the descriptions collected represented personal negative insights (under 15%). As reflected in the ITA reported above (section 3.4) this did not lead to a comparable theme being identified for the negative insight data. It may be that personal insight is not seen as negative in terms of the definition given for this study; that things are worse than originally thought. The personal problem finding seen in Study 1 (section 2.3.2.3) was in the main interpreted positively as a reconciliation of the way things are enabling subsequent identification of a way to move forward. As such, this may explain why personal insights were less reported in this study.

In terms of future research it may be interesting to explore reporting of everyday negative insights in the personal domain for different populations. For example comparing non-clinical to clinical populations or waiting list to treatment groups. As highlighted in section 3.4.1, Gilhooly et al. (2007) identified real-world problem solving tasks that had an interpersonal focus. The identification of positive and negative insights relating to intrapersonal problem solving could extend the kinds of real-world problems into this domain.

3.6.3 Time away/ Active Search

Many of the everyday examples of insight in Study 1 represented moments where solutions were found to previously known problems. Within these, a distinction was made between those where the person was still attempting to solve the problem when they had their insight (Active Search) and examples where attention had moved to other things, unrelated to the problem which was then unexpectedly solved through insight (Time Away). However, as identified through ITA above, many of the negative insights in this study occurred out of the blue where participants were not aware of a problem before their negative insight. This created a problem in coding for Time Away or Active Search, where the participants' attempts to solve the problem were central to the definitions of the two processes themes.

However, the similar theme of Time Away was identified in the ITA for this study that encapsulated these 'out of the blue' experiences (see section 3.4.2). In this context it was described as negative insight occurring when the participant was engaged in a task unrelated to the content of the insight. Extending this idea enabled coding of negative insights as Active Search when participants were actively engaged in the activity that they had their insight about, rather than actively involved in problem solving attempts.

The identification of these comparable distinctions for negative insight again highlights potential similarities with theory relating to positive insight. As discussed in section 3.4.2, the demonstration of negative insight during Time Away raises questions for incubation theories in insight. Furthermore, the occurrence of negative insight without an impasse, both whilst actively engaged in tasks related to the insight, and whilst doing other unrelated tasks provides evidence that is problematic for theories that assert impasse is necessary in order for insight to occur. This is because in both instances there is not an initial problem representation to be re-structured through an impasse (see discussion in Chapter 1, sections 1.1.4 and 1.1.5). As such this adds weight to the argument made in section 2.4.5.1 that insight moments in everyday life can occur without an obvious or conscious experience of impasse.

3.6.4 Evaluation of use of directed Content Analysis

The use of directed content analysis has enabled a direct comparison between the everyday insight experiences shared in the first study, that were predominately positive to the everyday negative insight experiences seen here. Reviewing the typology of insight, Figure 3.3 demonstrates that this study offered further support for categories identified as conceptually possible in Study 1, but lacking in actual everyday examples. As reflected by the remaining unshaded section, negative insight of a practical nature rendered through social facilitation is as yet unsupported by data collected in the two studies. However, such incidences are identifiable: the example seen in Table 3.3 coded as a Practical negative insight saw the participant identify problems in the amount of materials they needed to complete a roofing job. The report did not identify that this realisation occurred through conversations with others on the building site, however this would be perfectly plausible and so then would have represented the missing category. As such, the use of directed content analysis has provided further substantiation of the typology of insight identified in Chapter 2.

3.7 General Discussion

This study collected and analysed everyday negative insights using text responses to open questions for the first time. A strength of the qualitative methods employed was demonstrated in the identification of a portion of the reports that did not correspond to the research definition of interest, these were represented in the theme Uh-oh No Insight. This highlights that care should be taken in making the assumption that having been given a definition, participants will respond exclusively in line with it. Specific strengths of ITA were additionally identified in protecting against various biases potentially introduced due to the researcher's knowledge (in having conducted literature reviews), experience (in analysing data from a previous study) and expectation (paying attention to data salient to a specific research interest).

Five additional themes resulted from the ITA providing a characterisation of everyday incidences of a sudden new understanding of a negative nature. These were discussed in relation to the literature for positive insight and creative problem solving, helping to identify potential avenues for further study of both positive and negative insight. Furthermore, the discussions relating to spreading activation theories for incubation highlight the need to incorporate negative insight moments into these, extending the theoretical discussion relating to incubation facilitation and insight.

A further comparison was made directly to everyday experience of insight (in the main positive) provided in Study 1 using directed content analysis. This demonstrated comparable themes for everyday experience in negative insight enabling the conclusion to be reached that many aspects identified as pertinent to everyday experience of positive insight can also be applied to negative insight. Future work now needs to explore exactly what aspects are common or different between positive and negative insight in everyday situations and using experimental comparisons.

Finally, in relation to the third question posed in the introduction which aimed to identify participants' functional explanations of negative insight, the role of negative insight as problem finding was identified as a theme through ITA (labelled Sucking It Up) and discussed in section 3.4.5. Future research could look to further explore this function of negative insight. Firstly, through exploration of the everyday experience of negative insight, but also using laboratory based tasks to test predictions based on findings from this study, for example in terms of the utility of negative insight (see Chapter 7 for further discussion).

4 Everyday Experience of Insight: Diary Study

4.1 Introduction

4.1.1 Prevalence of Insight in Daily Life

Study 1 outlined in Chapter 2 has served to render examples of insight in daily life. These provide a tentative step towards an understanding of naturalistic insight experience. This, Ohlsson (2011) suggests is necessary to assess how experimental derivations of insight "conform" (p. 92) to reality. However central to Ohlsson's (2011) argument regarding the validation of experimental insight research is not only the importance of a comparison in terms of the content and context of insight in daily life, but also in identifying its prevalence. As discussed in section 2.4.1 the snapshot collection methodology employed by the questionnaire does not enable any assessment to be made of the frequency of insight experiences in everyday life within or between individuals.

4.1.2 Problems in the Recall of Insight Moments

As outlined in section 2.4.7 there were a number for problems identified in the reporting of insight moments using an anonymised questionnaire. This section will explore these issues in more detail.

4.1.2.1 Short textual responses in daily life of insight questionnaires.

One problem identified in the collection of qualitative insight experiences using an anonymous questionnaire (as in Chapter 2) was the difficulty in interpretation of the descriptions given (as seen in section 2.4.7). Congruent to this, Ovington et al. (2015) also identified that their participants' qualitative, questionnaire responses likewise lacked detail (see section 2.1.5 for further description of this study). For instance in Chapter 2, when participants were asked to indicate what they were typically doing when their insight occurred they gave short and generalised responses such as "working". The ability to probe participants' responses would help to ensure all details of the insight occurrence are shared in order to achieve a richer understanding of their experience, both in terms of the content of the insight and the context in which it was experienced.

A more interactive contact with participants might also help to explore why a high proportion of participants in Chapter 2 were unable or unwilling to provide a description of an insight experience, even when they had indicated that they had experienced insight within the last 24 hours (see 2.2.1). Having a dialogue with participants whilst exploring their insight experiences might expose reasons behind their reluctance to share insight experiences or difficulties they had in sharing. Furthermore it may explain the difference seen between those in Chapter 2 who were offered insight definitions to prompt their responses compared to those not given one, with more responses seen from those given a definition.

4.1.2.2 Memory effects in insight.

Finally, Study 1 (Chapter 2) sought to minimise retrospective memory effects by in the first instance capturing insight experiences less than a day old. However it might still be argued that this time delay could have impacted on reports.

Ebinghaus' (1885/1913) classic memory study identifies a logarithmic decline in recall through post memory event time; suggesting that the biggest reduction in memory happens immediately after the event, with the rate of decline then slowing as time progresses. However his studies did not focus on autobiographical memory which is used in the recall of personal life experiences (such as insight experiences). In fact, Rubin and Wenzel (1996) on reviewing data for 210 studies found that autobiographic memory was the exception in not following Ebinghaus' (1885/1913) described pattern. Surprisingly few studies focus on autobiographical memory decline in the first few hours after an event. One which has attempted to explore this is Kristo, Janssen and Murre's (2009) investigation of autobiographical memory recall. In an internet study they tested participants' recall from two to 46 days after they described a personal every day event. They identified that memory for details declined more rapidly than for the basic content (the what, who and where) or time of the event. As identified in section 2.4.7 of this thesis, and highlighted by Ovington et al. (2015), it is the detail of the insight experience rather than a basic content that is necessary to obtain a complete picture of how insight occurs in everyday life.

However a problem with Kristo et al. (2009) can be seen: the events that they asked participants to initially share were already up to a week old, and so subject to any immediate memory effects of interest in relation to the current research question.

So, while no definitive answer is offered as to autobiographical memory decline in the short term (less than 24 hours) it would seem reducing the time between an event and reporting of it, is the best way to reduce memory effects due to forgetting over time. There is no reason to assume that the inverse relationship between post event time and autobiographical memory recall seen for over 48 hours post event would not also occur earlier, even if the exact rate of decline is uncharted. As such, this would suggest that recording accounts of insight as close to the time of occurrence would likely render more accurate and detailed descriptions.

A more detailed representation of an insight event in memory may also prevent other distortions highlighted by Gruber (1995) see 2.1.4.2. For instance, memories are suggested to be embellished through the process of rationalisation and this may be particularly the case where memory detail is deficient. As suggested by Kristo et al.'s (2009) study above, it is the memory for detail which most quickly declines, thereby increasing the risk of rationalisation effects. If recall is richer in detail there is likely less need to make additions so reducing rationalisation. Accordingly, it would seem sensible to ask participants to record their insight experiences as close to their occurrence as possible and so: reduce many factors likely to introduce error in reporting; maximise the accuracy of the accounts of insight in everyday life collected; and minimise interpretation necessary from researchers.

4.1.3 Research methods for studying daily life

There are several ways in which researchers employ diary type methodologies to record experiences in daily life. Moskowitz and Sadikaj (2011) outline the basics of event-contingent sampling, the collection of self-reports of a specific behaviour of interest when it occurs in daily life. The report is triggered by the participant experiencing an event, identifying it as the phenomenon of interest and so making a report on it immediately. This can be contrasted with the predominant approaches of the experience sampling method (ESM. Csikszentmihalyi and Larson, 1987) or ecological momentary assessment (EMA, Stone and Shiffman, 1994): self-reports are made at random times determined by the researcher, for example participants are alerted by a pager to make a report or via an electronic data collection method such as PDA or mobile telephone. As identified above, collection of an insight description as proximate to its occurrence as possible is desirable, meaning that event contingent sampling would appear the most suitable method to employ for this research.

Reis (2011) highlights that a problem with event elicited methods in comparison to ESM or EMA is that daily life experiences may not be overwhelming or even noticed and so not reported. For example, in attempts to characterise daydreaming in daily life, the phenomenon of interest by definition occurs when attention lapses (Kane et al., 2007). However, one of the defining characteristics of insight is the surprise attached to it (see section 1.2.3.2). In Chapters 2 and 3 the theme of Time Away incorporated many insight moments that were described as occurring out of the blue (see sections 2.3.2.5 and 3.3.3 for further description). Similarly, Perkins (2001) coined the term 'breakthrough thinking' to describe insights. This illustrates how contrary to the example of day dreaming, that insights are noticeable events and so event contingent sampling would be an appropriate methodology to collect them.

4.1.4 Event-contingent sampling using mobile phone technology

No studies have explicitly investigated everyday insightful experience in real-time using any of the methods outlined above. However one study has undertaken a naturalistic exploration of serendipity (Sun, Sharples and Makri, 2011). Fine and Deegan (1996) cast serendipity as a special case of insight where the individual attributes its origin to a chance occurrence, for example a fortuitous social connection or timed event leading to an insight. Many of the examples of insight described in Chapter 2 might be argued to be serendipitous. For instance, the description of insight presented in section 2.3.2.1 sees the participant identify an association between something in an article she is reading with her usual area of study. The theme Social Facilitation (see section 2.3.2.6) reflects many instances where the insight resulted from a social interaction. None however (in Study 1) were identified by participants as fortuitous.

Sun, Sharples and Makri (2011) developed a mobile diary application ('app') to enable their participants to record their experiences of serendipity as they occurred over the course of a week. Similar to insight, they suggest that as serendipitous experiences are by their nature unpredictable a diary method is particularly suited to their collection using event-contingent sampling. The data collected by participants in the 'app' was then used to initiate discussions at a de-briefing interview. Transcripts of these interviews formed the basis of the authors' conceptualisation of serendipity, supporting the value of event-contingent sampling.

The resources necessary to build a specific mobile phone 'app', as Sun et al. (2011) did, may unfortunately be seen as prohibitive. In addition, in their study each participant was provided with a mobile phone on which to use the 'app' meaning they had to carry two mobile devices (their own as well as the researcher's) for the duration of their participation. Sun et al. (2011) identified this as problematic for their participants in their discussion and recommended the use of the participants' own mobiles to make reports in future research. This criticism can also be seen as applicable to the use of other electronic collection devices such as Personal Digital Assistants (PDA) which have also been used in past diary studies (for examples see Burgin, Silvia, Eddington and Kwapil, 2013; Le, Choi and Beal, 2006). However, aiming to get participants to use their own mobile phones in data collection complicates and likely increases the cost in developing an 'app': meaning it would need to be developed in multiple formats to match which ever type of mobile operating system that a participant owned.

An alternative would be to revert to a more traditional, pen and paper diary format as Kosslyn et al. (1990) did in their investigation of the everyday occurrence of another creative aspect, imagery. However, Stone et al. (2002, 2003) highlighted problems with this method. They used light sensors to record the times their participants opened their paper diaries (presumably to make an entry) and found that a substantial proportion (75%) had entries in their diary on days when they were not opened (shown by the light sensor log). This suggests that these entries were not made temporally close to the point of the experience they were recording, likely increasing errors in their reports through the memory loss and distortion processes outlined previously. At the very least, drawing participants' attention to the fact that their entries are time logged and explaining the impact of time on reporting accuracy are steps which could be taken to mitigate these behaviours.

4.1.5 Reactance in diary studies.

Bolger, Davis and Rafaeli (2003) raise a possible concern of the use of real-life diary studies in respect of participant reactance. This asserts that participants' behaviour or thoughts are changed by their involvement in the diary study. Sun et al. (2011) suggest that this might have been the case, with their participants reporting increased awareness and experience of serendipity compared to pre-study incidence. Interestingly, Sun et al. (2011) saw this as a positive outcome, and suggested that such methodology might be used as a tool to increase serendipitous experience in everyday life. Asking participants to process their [serendipitous or insight] experience at a deeper level could be argued in itself to change the experience so it is no longer representative of daily life. Unfortunately, this criticism might be directed at any research (both naturalistic and experimental) where informed consent is sought. Generally researchers take a pragmatic approach that rights of participants [usually] outweigh such concerns and so aim to recognise and design studies to minimise such effects. In the instance of diary studies there therefore is balance to be made between capturing an event as close to its occurrence and in as much detail as possible against the intrusion that the recording process makes in the participant's everyday life. Sun et al.'s (2011) dual approach can be seen to employ such balance: the immediate capture of an event using technology to minimise memory distortion coupled with follow up de-brief interviews to elicit richer detail of the experience.

4.1.6 Research Rationale and Aims of Study

This research therefore proposes to take heed of the above and utilise the proliferation in smart phone ownership and mobile access to the internet in conjunction with an online questionnaire [Survey Monkey] platform. With adaption, this medium will be used as an online portal for participants' to record their experiences of insight over a week (in line with Sun et al.'s (2011) study period) through either their mobile phones, tablets or other internet capable devices. As highlighted, Sun et al. (2011) de-briefed their participants in a semi-structured interview at the end of the study so eliciting additional rich information about the experiences their participants' recorded. Following a few participants intensively over a short period will likely elicit rich detail of their experience and an indication of how often they experience insight. In summary this study aims to capture real-time insight experience and explore this experience through post-event de-brief interviews in order to again validate the themes identified in Chapter 2. Additionally it may elucidate further on some of the other observations from the previous study which could not be explained, for instance the high participant drop out at the point where asked to provide an insight description.

4.2 Method

4.2.1 Participants

Participants were eleven volunteers approached by the researcher from a non-student sample local to the university. The mean age of participants was 37 years old (SD = 14.3 years, range 19 - 62 years).

4.2.2 Materials

The Survey Monkey online questionnaire package was used to develop an online portal for participants to use to make their reports of insight over the course of the week. Participants were issued a unique password to identify their online reports, along with QR code links to the log on page to aid ease of accessibility. On accessing the portal the participant could then: record details of an insight experience; view reminders of insight definitions; or send a message to the researcher. The 'insight log' page was similar to that used in Study 1, incorporating three questions to enable capture of the participant's insight experience as quickly as possible in their own words. An additional question was included asking participants to indicate how long ago their insight occurred. This was to account for occasions when a report was delayed (option of responses; "just now, a few minutes ago, in the last hour, in the last four hours, today, yesterday"). The survey enabled repeat visits from the same URL to ensure that participants could make multiple reports of insight over their participation period. Each report made was time and date stamped enabling a temporal record of insight logs to be made for each participant.

4.2.3 Procedure

Before giving consent, participants were provided with an information and consent sheet outlining the requirements of the study. Face to face demonstrations using the 'Insight Log' and an induction to ensure understanding of the insight definitions and examples was given. On providing consent, participants completed demographic information. Over a week (seven consecutive days) they recorded all incidents of insight as near to the time of occurrence as practicable (and safe). A final de-brief was given, including a face to face (or via Skype for two participants) semi-structured interview for a selection of the participants (n=5) who reviewed their own log with the researcher. One participant falsely logged their insight experience using the online questionnaire from Study One. The relevant log was located and removed from the questionnaire data set and added to the insight logs evaluated in this study.

4.2.4 Analysis of data

4.2.4.1 Content analysis.

A directed content analysis was planned, coding each insight recorded against the themes (see Figure 2.5) identified in Chapter 2 (Hsieh and Shannon, 2005) (see also 3.6.1).

4.2.4.2 Integrative Thematic Analysis.

An Integrative Thematic Analysis (ITA) (see 2.2.3.2) was conducted on the transcriptions of the de-brief interviews and insight logs. A different researcher (from those used as second researchers in Chapter 2 and 3), naïve to insight research literature and the purpose of this study was used to carry out ITA alongside the main author of this thesis.

4.2.5 Ethical considerations

This study obtained ethical approval under the University of Buckingham, School of Science and Medicine Ethical Committee’s terms of reference. All participants were aged 18 years or older and gave their full informed consent to participate in the study. Participants were able to choose the level of contact they had with the researcher during their participation week or withdraw from the study at any time. Their responses were treated confidentially by the researcher and anonymised subsequent to the end of their data collection period. No additional physical or psychological harm was incurred in participation in this study over real-life experiences. As such it was felt that no ethical concerns were raised by this study

4.3 Results

4.3.1 Use of the Insight Log

A total of seventeen insight logs were made by the eleven participants over their week, with the mean rate of 1.55 responses per participant (SD = 1.57). The pattern of response across participants is shown in Figure 4.1, illustrating that while one participant made no logs, another recorded six experiences of insight over their participation week.

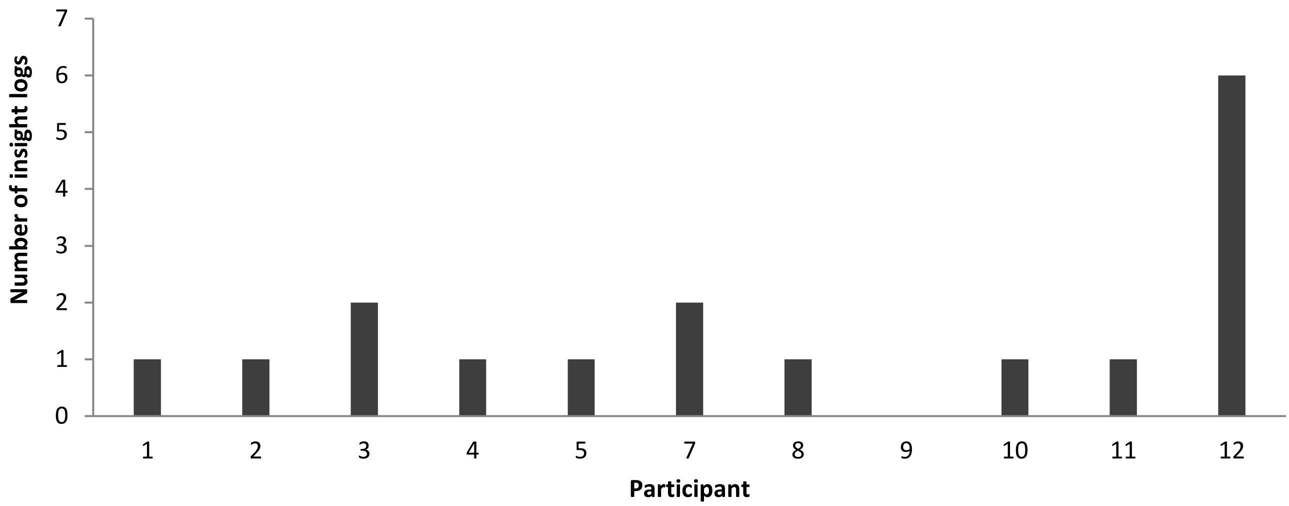


Figure 4.1 Graph to show number of insight reports made on each day of the study. Note participants' study weeks did not run concurrently, and commenced on different days of the week, so day 1 represents the first day of each participant's study week.

Figure 4.2 shows the distribution of insight logs made across the study week. It should be noted that participants did not all take part in the study over the same seven days. Individual participant's study weeks began on different days, the data displayed below represents the day in the individual's study week on which the insight was logged.

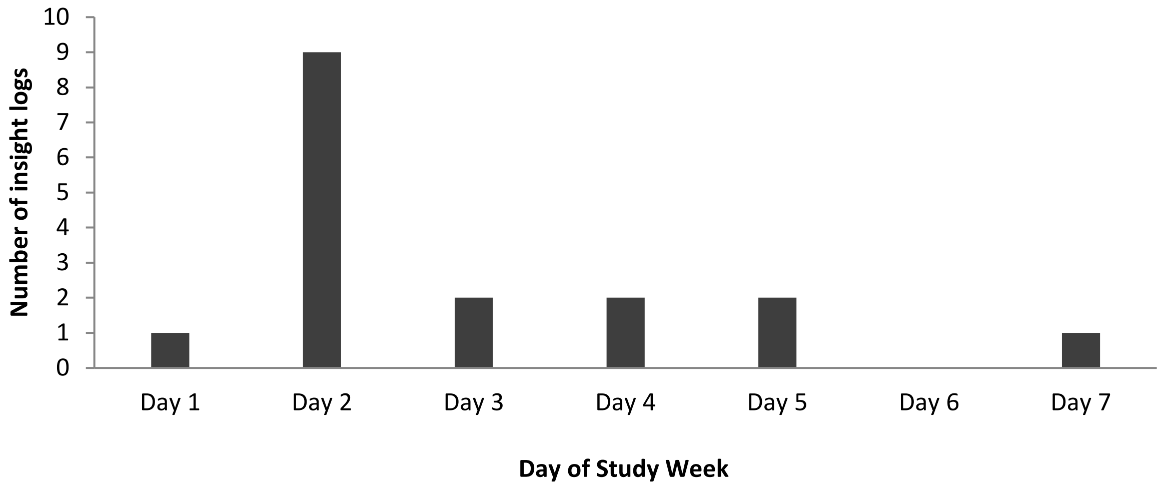


Figure 4.2 Graph to show number of insight reports made on each day of the study week.

Participants, in addition to logging details of their insight were also asked to record how long it had been since their insight experience. This was compared to the time and date stamp recorded by Survey Monkey for their entry. All stamps corresponded to the reported time frame. One participant indicated that two of her logs were made outside of the offered options, giving the time frame in the 'other' box. This was three days previous to the log stamp. From Figure 4.3 it can be seen that participants took different times to log their experience, with logs being between three days old to one made 'just now'.

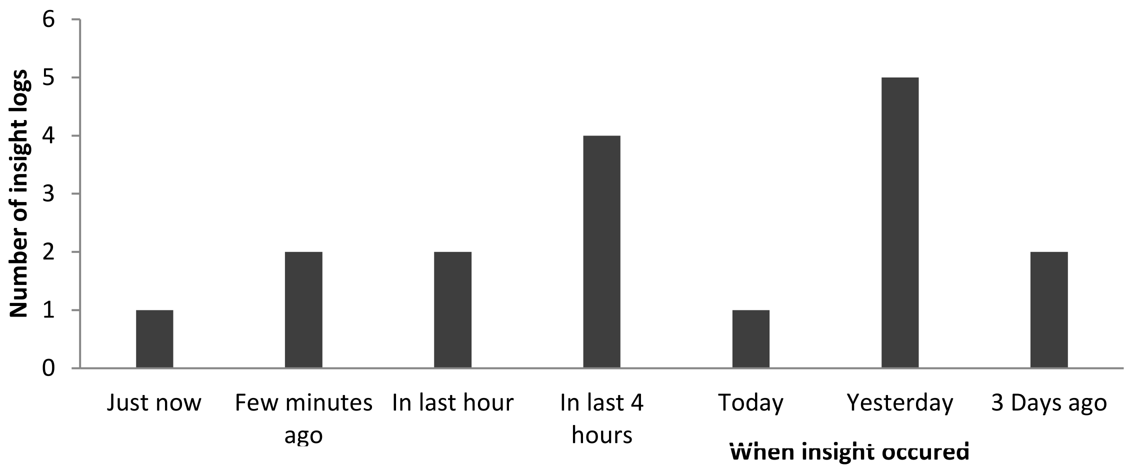


Figure 4.3 Graph to show time lag between reporting and experience of insight

4.3.2 Directed Content Analysis of Insight Logs

Figure 4.4 shows how the insight reports made in this study relate to the themes identified in Chapter 2. Initial plans to conduct a full content analysis were confounded by the low number of reports made. Additionally, as discussed in section 4.3.2 the themes identified were shown to fit superordinate aspects of insight: content, process and emotion. Categorising against these interacting themes leads to eighteen possibilities. With only seventeen insights collected from a small sample reflective of the predominately qualitative approach taken in this study renders such an analysis as meaningless.

However, the categorisation of insights shown in Figure 4.4 did illustrate firstly, that no negative insight examples were seen. Secondly, it identified three reports that could not be categorised using the scheme from Chapter 1. Two saw participants recording their Aha moment at having remembered that they needed to complete the log. A third describes her recalling a name: "couldn't remember a name of a Children's T.V. programme whilst talking to friends. Then it came to me. A bit of an Aha moment" (F, 36). These do not constitute insight in terms of the necessary novelty of the new thought, understanding or idea. As described by the above participant it seems that the Aha feeling rather than the constituent cognition led them to complete the insight log, this therefore might argued to constitute an additional theme of Aha Without Restructuring.

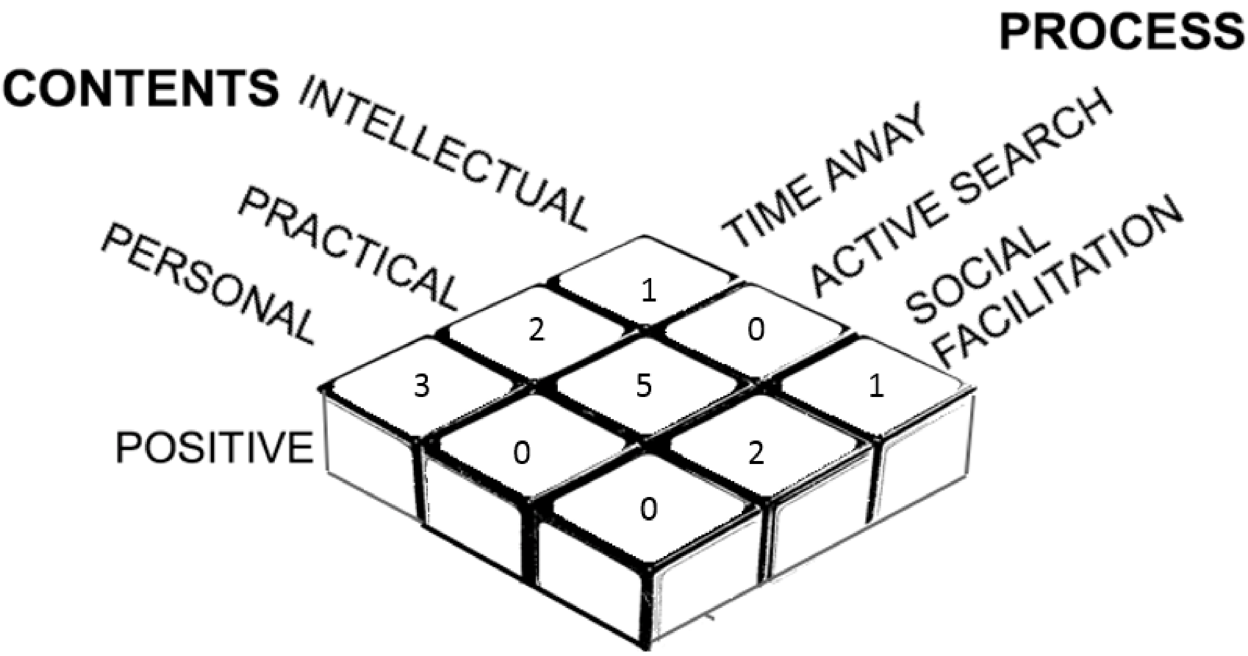


Figure 4.4 Categorisation of insights against themes identified in Chapter 2. Frequency of insights for each categorisation shown in relevant cube. No negative insights were described so only the positive aspects is shown. Three insights were did not fit this categorisation scheme.

4.3.3 Integrative Thematic Analysis of De-brief Interviews

Carrying out an Integrative Thematic Analysis of the logged insights and de-brief interviews led to the identification of the following themes: Individual differences; Facilitation or Blocking; and Solution Finding. Table 4.1 shows how the researchers' candidate themes were combined to provide the final representation of the participants' insight experiences.

Table 4.1 Integrative Thematic Analysis: candidate themes identified independently by two researchers (one naïve to the research question or related literature) were then integrated into final themes which were labelled and described.

Final Theme[b]	Description	1st Researcher	2nd Researcher
Individual differences	Similarities and differences within and between people in relation to insight experience.	Insight less reality Individual differences	Comparisons
Facilitation or blocking of insight	Factors seen to support or lead to having an insight Aspects associated with the inhibition of insight	Facilitation or blocking	Situation: unusual incidents Society Routine
Solution finding	Attention focused on attempting to resolve a current situation or solve a problem.		Solution finding

a ITA stage iii : candidate themes b ITA stages iv & v (see Figure 2.4)

4.3.3.1 Individual Differences.

This theme encompasses the idea that there is variation in insight experience between individuals' and within an individual's own life time. Furthermore, there was a general expression among the participants that their experience of insight over the week fell short of what they expected, or what they perceived as normal. This aspect was identified by the first researcher as a distinct candidate theme, Insight Less Reality. Participants described a desperation to have an insight: "it got to the point that I thought I wouldn't have any [insights] and I'd be [stupid] for not having any insights all week" (F, 26). The participant saw her lack insight as reflective of a personal deficiency. She perceived that other people have a certain level of insight occurrence which by comparison, her experience was below average. Furthermore she seemed to equate an absence of insight with a lack of intelligence. Other participants also identified that they didn't have many insights, one explaining, "I just carried on like normal, I just sort of waited but nothing happened" (F, 36).

A number of participants reported no clear examples of insight over their week. One participant made no reports at all, while others made a single report, classified above (section 4.3.2) in the Content Analysis as Aha Without Restructuring. The participant who made no reports reflected on this: "I think I don't understand what it is, what we're supposed to be looking for, but I don't know whether we all really have them [insight experiences] so I don't know what I'm looking for" (F, 56). Again, this description supports the idea that there are differences between people in their experience of insight. The participant musing that insight might not be a universally experienced phenomenon.

The second researcher's candidate theme of Comparisons captures participants' attempts to compare themselves to the different experiences of others. This is demonstrated by a participant musing over why he classified an experience as insight: "because it was an Aha moment, um, okay, I'm not like [my partner], I don't necessarily go Aha!" [accompanied by a jazz hands type action] (M, 25). The participant makes comparisons on how his interpretation of an event may be different to his partners; suggesting that this relates to dispositional aspects, such as personality traits, for example emotionality. Such comparisons see between person individual differences being explored in relation to insight.

Participants also made within person evaluations. For instance many participants suggested that they perhaps experienced more insight when they were younger. "I don't know because I'm older whether I get all these wow moments or a lot of down moments but less wow moments." This describes a proposed within person difference in insight experience with age. Another sought to clarify what aspects of this were pertinent to insight experience.

> When you are younger […] you sort of have more social outgoing and I think things happen. So when I was younger you don't plan things and

> things happen and you just […] Where now when you're older everything is sort of planned isn't it and you just can't go, ah I'm going out. (F, 36)

This exploration is captured in the theme of Facilitation or Blocking of Insight (see below, section 4.3.3.2).

4.3.3.2 Facilitation or Blocking of Insight.

This theme describes the participants' reflections on aspects that impacted on their insight experience. It sees them identify various factors that they saw as helpful or a hindrance to them having insight. For example one participant discusses, "because we all do the same things or similar things every day you might not have as many [insights] whereas when you vary different things every single day, every week you might have more" (F, 36). Another participant mused, "because I think…age, and I live in a bit of a bubble" (F, 56). Attributing everyday routine to the inhibition of insight was also identified as a candidate theme by the second researcher. In addition, the candidate themes of Situation: Working or Unusual and Society reflects the participants' exploration of factors that improved or decreased insight experiences. Firstly the idea that the daily routine of work served to block the potential to have insight, whilst unusual situations promoted them. Secondly, that social conditions or expectations in society would also have an influence. One participant explains: "because the majority of the time we're working alone and there's nobody else to have a wow moment with or you know to think oh yeah - wow" (F, 56).

In terms of facilitation, most participants were underwhelmed with the number of insights they had over their research week (see above, section 4.3.3.1), so discussions relating to this were focused on their reflections on a perceived past with more insight experiences. They explored these to try and identify aspects that facilitated them, as seen in this excerpt: "it was because it was something where I wasn't expected to know anything, I was under no pressure because it was all new" (F, 62).

4.3.3.3 Solution Finding.

This theme sees participants describe how their insights occurred during an active search to find resolution to an undesirable current situation or the solution to a problem. It sees a focus on problem solving where they are thinking about the current quest. It was identified by the second researcher, whilst being overlooked by the first. This aspect might have been too obvious or familiar to the first researcher and so unnoticed due to their experience analysing the data in Chapter 2 where analogous themes relating to problem solving were identified (Time Away and Active Search, see 2.3.2.4 and 2.3.2.5 respectively). Furthermore, the tacit assumption in many definitions of insight is that this occurs within a problem solving paradigm. However, justification of Solution Finding as a theme was determined during the integration phase of ITA, with the second researcher presenting a body of excerpts from across participants and interview questions to support their case.

4.4 Discussion

In general, the results in this study were a surprise in terms of the low number of insights collected. However, the follow-up interviews provided corroboration and elaboration on the experience or lack of experience of insight in daily life from previous questionnaire or laboratory based studies (see sections 2.15 and 2.4). It identified a number of findings of interest relating the individual differences in insight experience, situational factors relating to insight and insight prevalence. These are discussed in the sections below.

4.4.1 Individual Differences

4.4.1.1 Tendency to experience insight.

As highlighted by this theme, lay perceptions of insight include the notion that there may be quantitative and qualitative differences in people's experience of insight. In terms of quantitative differences, how often people experience insight, this study has highlighted that in general people appear to overestimate their insight experience (see section 4.3.3.1). Recent research has raised the notion of a continuum in tendency to experience insight. Kounios et al. (2008) contrasted a tendency to solve through insight with a preference for analytic solving, suggesting that these individual differences reflect underlying variation in information processing. This contrasts to the lay opinion in this study that differences may stem from emotionality and so experiential differences. Kounious et al. (2008) compared participants resting state EEG for those who reported more insight or more search solutions during an anagram task. They found increased activity in lateral areas in high insight reporters that they attribute to associative processes. However, the explanation for this difference could also incorporate emotional aspects (but see section 1.2.5 for discussion regarding the function in these brain areas as cognitive or emotion related). Regardless of the explanation for the differences, congruent to this study, Kounios et al. (2008) recognise that individual differences in insight solving tendency be an area of research to further explore.

Ovington et al. (2016) likewise have begun to research individual differences in insight disposition, reporting the creation of a trait scale for tendancy to solve problems through insight, the Dispositional Insight Scale (DIS). This is a 5 item scale measuring self-rated reports of everyday problem solving, asking participants to rate their tendency to experience solutions as: Aha moments; unexpected; being solved unconsciously; and whilst doing mundane activities. Due to a lack of previous insight tendency measures, validation against existing measures was problematic. Furthermore, as identified in this Chapter's study, people's perceptions of the amount of insight they have may not be accurate (see section 4.3.3.1). Using event contingent sampling of everyday insight experience (as seen in this study) could be used to offer a preliminary validation of the DIS in future work, but this would need to be done with larger sample, so perhaps without a de-brief interview, perhaps using a de-brief questionnaire including questions based on the findings from this thesis. As such, without further validation against actual behavioural measures the DIS currently can be seen to provide a measure of individual differences into participants' perception of insight, with further validation to confidently say it measures actual insight disposition.

4.4.1.2 Emotionality.

The theme of Individual Differences highlights perceived differences between people not only in quantitative terms, but additionally in qualitative experience. As seen in section 4.3.3.1, one participant suggested that he experienced problem solving and insightful moments in a different way to his girlfriend. He suggested that she was perhaps more emotionally intuitive or expressive, or attributed more emotion to such cognitive processes. As noted in earlier chapters, some researchers have discussed the contribution of emotional responses to insight. For instance in terms of emotion giving salience to certain cognitions leading to them being perceived as problems (Runco,1994). However this is very much as an aside to their main focus on cognitive processes. Little attention has been given to the type of affective responses, why or how they occur in relation to problem solving and specifically insight. This raises an interesting point that is not addressed by current research, the question of if and how affective responses to cognitive problem solving processes vary between individuals and how this relates to whether an incident is labelled as insightful or not. This aspect is explored further in Chapter 5.

An additional consideration in respect to individual difference is how the affective experience of insight varies within an individual between different situations or throughout their lifespan. This was raised by participants who were looking for explanations for their perceived lack of insight, identifying that they perhaps experienced affective aspects in general and in relation to insight differently when they were younger. This is in contrast to the responses of participants in Ovington et al.'s (2015) study. Here participants felt that they gained insight with age. However, Ovington et al. (2015) asked participants to think and describe their general experiences of insight. These could again be influenced by memory distortions (see 2.1.4.2). In this study the participant's retrospective comparisons to insight experience in their past would likewise be susceptible to recall biases. This highlights the need for further empirical, longitudinal investigation into the age effects, both in terms of experimental and everyday insight experience.

4.4.2 Not all Ahas are insight moments.

As seen in section 4.3.2, three of the insights shared did not fit the characterisation made in Study 1 or classic definitions of insight that feature an element of novelty, an insight being described as a sudden and new, idea or understanding (see 1.2). These experiences could all be described as sudden remembering without restructuring. The participants appeared to be using the Aha, a response to the suddenness of the event or emotional component to classify things as insight rather than the cognitive descriptions. Shen et al. (2015) demonstrated that participants differentiated between insight and non-insight problem solving trials for the emotional aspects of happiness but not for the more cognitive components such as certainty. Curiously, they contend that their findings, exploring emotional components of insight still support the idea that restructuring is the essential component for identifying insight moments. However, they do not clearly present a case for this assertion, as they did not measure ratings of re-structuring or surprise. It would appear that this assertion reflects the underlying assumption that insight is primarily a cognitive event with an incidental emotional component (see further discussion in section 5.1.2). This highlights that further work needs to be done to tease apart what and how emotion relates to insight moments. It furthermore demonstrates that while insight is often classified by its Aha moment, not all Aha moments necessarily equate to insight. Cranford and Moss (2010, 2011, 2012) demonstrated problem solving trials in the CRA that were solved immediately (within the first 15 seconds after presentation of the problem). They similarly hypothesise that these are examples labelled as insight due to the experience of an Aha, not due to any perceived restructuring of the problem or breaking of an impasse.

An alternative explanation may be that these Ahas due to remembering responses reflect a desperation that some participants felt to have an insight experience to report (see section 4.3.3.1). However, if this was the case it might be expected that such sudden remembering reports be made later in the participant's study week. From Figure 4.2 it can be seen that most reports were made earlier in the participation week, suggesting that rather than desperation being a motivation for recording these types of experiences, misunderstanding or difficulty in reconciling experience to the definitions given as discussed above may be a more likely explanation. This finding is comparable to the theme identified in Chapter 3 (see section 3.3.1) as Uh-oh No Insight, where participants appeared to reporting Uh-oh experiences that were not insight. In sum, this demonstrates that further empirical investigation of these ideas is necessary to qualify the roles of cognitive and emotional aspects in the labelling of an experience as insight.

4.4.3 Situational factors

Participants also discussed situational factors which might affect insight experience resulting in the theme Facilitation / Blocking. Experimental studies have investigated various situational and experiential aspects in relation to insight experience. As described in section 1.1.5.3, facilitation effects in problem solving have been explored for different incubation tasks between episodes of problem solving attempts. A further facilitation of insightful problem solving is suggested to relate to mood, with positive affect (both naturally occurring and elicited) suggested to enhance problem solving through insight (Isen, Daubman and Nowicki, 1987; Subramaniam, Kounios, Parrish and Jung-Beeman, 2009).

Less has been considered in terms of the situations which may lead to an inhibition of insight. Schooler, Ohlsson and Brooks (1993) suggested a verbal overshadowing effect on insightful problem solving. That describing one's thinking out loud whilst trying to solve insight problems was detrimental to performance in solving the problems: both in terms of solution rates and reaction times. However subsequent studies using verbal protocols to investigate cognition during insightful problem solving tend to challenge this finding (for discussion and recent study see Fleck and Wiesberg, 2013). Whilst this is not strictly a situational factor, it does demonstrate how factors that inhibit insight may be explored experimentally. Furthermore, with in business and management literature there are discussions in general terms as to the situational aspects that might stifle corporate creativity (for instance see Amabile, 1998), however comparable research has not been a major consideration for experimental insight research.

One of the inhibiting factors for insight that participants in this chapter identified was pressure. Many of them mused that one explanation for their lack of insight experience might have been the very fact that they were looking and hoping to experience insight. The Facilitation / Blocking theme therefore might be seen as an artefact of the methodology, reflecting not the participant's experience of insight but their experience of participating in this diary study. Additionally, this might explain the disparity between expectation and experience identified (see 4.4.4.2 below). It being nothing more than reflective of participants desire to please the researcher by having lots of insight to report and discuss. However, were this the case similar themes or observations would be expected from comparable studies. Sun et al. (2011) (discussed above in section 4.1.4) did not see a similar inhibition in their participants experience of serendipity. In fact their participants reported the converse, feeling that they were experiencing more serendipity than usual due to their participation, not less.

4.4.4 Prevalence of Insight in Daily Life

One of the aims of this study was to explore the prevalence of insight in everyday experience. Comparing the number of logs made by different participants (see Figure 3.3) suggests that there is individual difference in the incidence of insight, with one participant making six reports of insight over their diary week while one made none. The total number of logs, seventeen reports made by the eleven participants is comparable with Sun et al. (2011) who collected 23 diary entries from their identical sized sample. This would seem to support Ohlsson's (2011) assertion that insight in daily life is relatively rare.

4.4.4.1 Universality of insight experience.

A further striking and unexpected feature highlighted by this study is the notion that maybe not everyone experiences insight, at least not in the way current research descriptions conceptualise it. One of the eleven participants made no insight logs in her diary, during her de-brief interview questioning if she really knew what insight was or had ever experienced it. Intuitively it would seem that understanding the notion and recognising insight (particularly with the help of the definitions and examples provided) is straight forward. The difficulty in understanding demonstrated by some participants in this study perhaps challenges the assumed universality of insight experience (in the way current definitions describe). Additionally, the identification that three further participants did not experience insight, but rather reported incidences of remembering over the week can be seen as pertinent to this. This suggests that they likewise struggled to reconcile their experience to the descriptions of insight given, despite indicating through their induction that they understood the examples and descriptions provided.

A sizable minority (20%) in Ovington et al.'s (2015) study congruently reported never having experienced insight. This finding was published after the current study was designed and data collected. Ovington et al. (2015) indicated that this was contrary to their expectations, in deed there is little discussion in literature of the possibility that some individuals do not experience insight. Likewise this eventuality was not considered in the design of the current study. Insight is an intuitive and appealing idea to researchers and scientists. As mentioned previously, most anecdotal evidence and supporting cases studies come from this community (see section 2.1.2).

One of the initial aims of the first two studies in this thesis was to provide evidence of insight as a phenomenon experienced in daily life as well as in the laboratory. This surprising finding offers corroboration to Ovington et al. (2015). Furthermore, it does so using a methodology that provided the opportunity to probe participants about their reports, enabling the researcher to clarify their lack of insight experience. It is also interesting to note that many experimental insight studies report excluding participants for reasons including not experiencing insight (see Table 4.2). These observations previously to this current research are made as notes in Methods sections, and have not been explained or really commented on. This finding provides a potential explanation for these exclusions. Additionally, it might also explain why a proportion of participants in the questionnaire study in Chapter 2 failed to give descriptions of insight, perhaps they too did not experience insight.

This finding has possible implications for wider theories of creativity. For instance, proponents of everyday creativity including little-c and mini-c described in section 2.4.4.3 (Kaufman and Beghetto, 2009). Little-c creativity does not exactly equate to every day insight. For example, artistic endeavours, creative writing or adventurous cookery are not contingent on Aha, insight moments (Silvia et al., 2014). It follows that not experiencing insight would not exclude individuals from everyday creative acts. However, when describing mini-c, Kaufman and Beghetto (2009) also use the term intrapersonal insights. As discussed in section 2.4.4.2, insights shared by participants in Study 1 included those that describe realisations about themselves or others in relation to themselves. This has potential implications for therapeutic settings. As highlighted in 2.4.4.2, self-insight has a central role in the therapeutic process. If a substantial minority report that they do not experience insight, this may impact on their therapy. Further investigations of the population who report not experiencing insight in daily life would seem pertinent, both generally and in the specific context of therapy.

Table 4.2 Review of participant exclusions in insight studies.

Study	n	Participants data excluded No.	%	Reason / comments
Kounios et al. (2006)*	44	1	2	Expt 1 - n=19 , Expt 2 n=25 (1 participant replaced as reported all as insight)
Bowden & Jung-Beeman (2003)*	44	2	5	Assigned a single [insight] rating to nearly all trials (doesn't state what rating)
Cranford & Moss (2012)*	31	4	1	Reported as solving all by insight or search, not both
Jung-Beeman et al. (2004)*	18	4	2	Experiment One Only. Provided fewer than 10 insight or non-insight responses
Cranford & Moss (2010)*	31	6	1	1 reported 'other' too often, 5 reported only as insight or non-insight (no breakdown of proportion)
Subramaniam et al. (2009)*	79	0	0	From examination of scatterplots appears that 2 participants report over 90% trials as insight no participants appear to report under 10% of trials as insightful, i.e. have low insight
Kounios et al (2008)*	26	0	0	From examination of Figure 1. One participant with very low ratio (visually interpretation of about 0.1, aka 10% insight), this would have counted as exclusion using parameters set in many of other studies.
Collier & Beeman (2012)	57	0	0	Exclusions only made for bias in Tip of Tongue reporting
Daneck et al. (2014)	48	0	0	Exclusions only made for low solving rates
Chein & Weisberg (2014)	54	0	0	No mention of exclusions
Mc Carthy., Malony & Morrison (2013)	80	0	0	None cited as being excluded due to response bias towards all insight or non-insight
Haarman et al. (2012)	76	0	0	No mention of exclusions
Jarosz, Coldflesh & Wiley (2012)	40	0	0	None cited as being excluded due to response bias towards all insight or no-insight
Webbreit et al. (2012)	41	0	0	No mention of exclusions
Cranford & Moss (2011)*	22	0	0	None cited as being excluded due to response bias towards all insight or non-insight
Sandkuhler & Bhattacharya (2008)*	21	0	0	None cited as being excluded due to response bias towards all insight or non-insight
Hare et al. (nd) poster	68	0	0	None cited as being excluded due to response bias towards all insight or non-insight

4.4.4.2 Inflated lay perceptions of insight prevalence norms.

While researchers recognise that insight is rare (Ohlsson, 2011), the thematic analysis of participant de-brief interviews suggests that lay perceptions of insight prevalence may be in contrast to this. Participants described how their experiences of insight were deficient compared to their expectations both in terms of the amount they anticipated of themselves and what they considered to be a normal level for people in general. This is an interesting disconnect, and again worthy of future investigation. Firstly, exploring if the participants' had inflated expectations of insight above what they typically experience. This could provide an additional characteristic of memory effects in insight to consider alongside those raised by Gruber (1995) (see sections 2.1.4.2) that include telescoping, embellishment and decontextualisation. The alternative possibility is that participation in this study impacted on insight experience, reducing it. However, as discussed in section 4.1.5 which considered reactance effects to participation in research, it was concluded that participants might notice more insight, having been tasked to report it. This was in line with Sun et al. (2011) who outlined a perceived increase in serendipity experience reported by their participants. Yet, while serendipity might be argued to be a special case of insight the two are not directly analogous phenomena. As such, further research into people's experience versus expectations regarding everyday insight experience would serve to validate this initial finding.

The disparity highlighted by this study between actual experiences compared to expectations might also provide an explanation for the participants in Chapter 2 who indicated having insight within the last 24 hours, but then withdrew when asked to describe it. When asked if they had recently experienced insight participants' affirmative responses were based on their expectations of insight experience (of themselves or of general norms.) and the assumption that 'of course, I must have experienced insight in the last 24 hours'. Participants only realised when asked to describe their insight on the next page of the questionnaire that in actuality they were unable to provide an example. Either they had not experienced it or could not remember their insight.

4.4.5 Limitations of the study

One limitation outlined above in the context of content analysis is there not being enough data to conduct a meaningful analysis (see 4.3.2). However, as discussed this research was designed to take a qualitative approach. While it was not possible to conduct a full content analysis, categorising the insights following the methodology outlined by Hsieh and Shannon (2005) served to highlight a characteristic of the insight reports perhaps overlooked through the use of thematic analysis in Chapter 2. The necessity to categorise every excerpt (which is not the case in thematic analysis) identified a proportion of reports not fitting any of the themes identified in Chapter 2. The resultant new category was cursorily named Aha without adaptive re-structuring, a theme that was congruent to the Uh-oh No Insight theme seen in Chapter 3.

Participants did report feeling pressure to produce insight in their de-brief interviews. In future, one possible way to reduce this could be to extend the period over which diaries were kept and so increase the likelihood that participants have an insight experience to report. However, this would not have remedied the situation for the participant who reported not experiencing insight, who came to realise through her participation that she never had. Also, as discussed above it may be that the pressure resulted from the difference between participants' expected and experienced levels of insight rather than from their need make logs and please the researcher. Extending the study therefore would not likely reduce this feeling or alter levels of insight experienced. Furthermore a balance needs to be struck between giving enough time to collect a reasonable number of insights against the intrusion an extended participation period might have on participants' lives. This would possibly increase the likelihood of drop outs or missed reports. An alternative way to reduce this potential demand characteristic would be to recruit and manage diary participants through online methods, avoiding the personal contact with the researcher that possibly exacerbated the feeling of a need to please. However, this would mean losing one of the key aspects of the study, the ability to probe experience through de-brief interviews which served to identify the key findings made, such as highlighting individual differences in insight experience, and verifying the possibility that insight experience is not universal. Accordingly, any advantage gained from a distancing of the researcher and participants can be seen to be outweighed by the need to probe responses and elicit a rich understanding at this exploratory stage of the research.

4.4.6 Future directions

In sum this Chapter highlights the need for further research on individual differences in insight experience, both in terms of emotionality, age and situation. As the key interest of this thesis is the exploration of emotion and insight, Chapter 5 will further explore individual differences in emotional and insight experience. It will also consider different aspects of emotion (physiological and psychological) in relation to insight. Further investigation of factors such as age and situation fall outside the remit of this thesis so will not be included, but do serve as promising avenues for future research beyond this thesis.

Another key finding from this Chapter was the notion that insight may not be universally experienced, corroborating and adding rich qualitative evidence in support of similar findings by Ovington et al. (2015) and some results from earlier work in this thesis relating to participants' behaviours when completing the questionnaire in Chapter 2. This is likely an important finding (as outlined in section 4.4.4.1), that further research taking both qualitative and quantitative approaches should look to validate. However this again falls beyond the central focus of this thesis that is to explore the experience of insight and emotion.

Finally, the identification of an additional theme, labelled Aha Without Restructuring (see section 4.3.2) where participants were responding with examples of their experience that did not meet the definitions of insight given to them independently corroborates findings from Chapter 3 in this thesis. This has implications for future work that asks participants to make self-reports regarding their everyday experience. Researchers need to incorporate checks in their research design to ensure that participants are making reports regarding the actual phenomenon of interest to the researchers. This is particularly pertinent to online, quantitative questionnaire designs where there are no open response questions or face-to-face instruction and debriefs to check the actual experience participants are reporting.

5 Psychological and physiological factors in Compound Remote Associate Problem Solving

5.1 Introduction

Study 1 (Chapter 2) demonstrated that lay perceptions of everyday insight incorporated feeling aspects of insight in addition to cognitive ones. This focus on emotion in insight is echoed in recent attempts to capture the phenomenology of insight including emotion through self-reports from participants in experimental paradigms (Danek, Fraps, Von müller, Grothe & Öllinger, 2014b; Shen, Yuan, Liu & Luo, 2015 see more in section 2.1.5). These studies build on theoretical discussions of emotion and insight outlined in Chapter 1 (see section 1.2). A number of studies have also considered how state emotion impacts on peoples solving of insight problems, either leading them to solve more classic insight problems, or seeing an increase in the labelling of problems as insight rather than search (see also section 4.4.3). While these offer validation and identification for the first time of an experienced emotional component to insight, they tell us little about the nature of emotion at the insight moment.

Furthermore, the identification of the theme Gut Feelings in Study 2 (Chapter 3) again reinforces the experience of emotions in insight, but also raises the question of exactly how bodily changes relate to insight experience and emotion (see Section 5.1.4). As highlighted in Chapter 4 the role of individual differences in trait emotionality may be pertinent to the experience of emotion and insight (see section 5.1.6). An additional aspect to consider is the prevalence of insight. Until now this question has been posed in terms of the general prevalence of insight in everyday life, with the identification in Study 3 that there are likely individual differences, such as the disposition of insight (Ovington et al., 2016) (see also section 4.4.1.1). Together these all highlight that little is known about aspects of emotion at the insight moment. As such the exploration of everyday insight experience from a qualitative perspective seen in studies 1, 2 and 3 has provided interesting avenues from which this thesis will now further explore using a quantitative approach. This study will firstly aim to investigate insight and emotion related measures using an established, laboratory based, insight elicitation task, the Compound Remote Associates task (Bowden and Jung-Beeman, 2003b).

5.1.1 Compound Remote Associates

Compound Remote Associate (CRA) problems have been widely used to elicit insight and non-insight problem solving in controlled conditions (see also section 1.1.4.1). Interestingly, congruent to everyday insight findings seen in this thesis (reported in Chapters 2, 3, and 4) and by Ovington et al. (2015), the CRA task consistently appears to produce a proportion of participants for whom no insight was experienced (see Table 4.2).

A recent study by Salvi et al. (2016) compared performance in CRA problems with other tasks that elicit both insight and analytic, search-based solving experiences (anagrams, rebus puzzles and picture completion). They identified comparable patterns of performance across the different tasks. Furthermore, they demonstrated in line with ideas introduced by Kounios et al. (2008) that solutions labelled as insight were more likely to be correct than those labelled as search. This finding is interpreted in terms of the different processing that is proposed to occur in insight and analytic solving (Kounios et al., 2008; Salvi et al, 2016). This approach sees insight as an all or nothing process where processing occurs unconsciously and so is not available until the solution is reached. Whilst analytic solving through search offers partial solutions to participants on which they may draw to offer an incorrect answer. As such, Salvi et al. (2016) infer that insight solving is more accurate than analytic.

In addition to the increased accuracy seen for CRA solutions reported as insight compared to non-insight, insight solutions have also suggested to be solved more quickly than non-insight (e.g. Cranford and Moss, 2010, 2011, 2012;. Kounios et al 2008; Sumramaniam et al., 2008; Shen et al. 2015). However, Cranford and Moss (2010, 2011, 2012) in a series of studies built the case for two different types of insight being elicited, immediate and delayed insight (see also section 1.1.5.4). They argued that the latter represent insight resulting from an impasse, the former labelled as such due to phenomenological experience of suddenness and surprise. However, even within their own research the distinction between immediate and delayed insight varies. Cranford and Moss (2010) identify problems solved in the first

15 seconds (of a 30 second period) as immediate insight, whilst in their later, 2011 study they considered those in the first 10 seconds, again reverting to 15 seconds in their 2012 paper. While they do not explain this inconsistency in time selection, their overall rationale for making a distinction was to exclude trials without impasse, making the assumption that only these represent true insight. In their recent study, Salvi et al. (2016) also separated immediate insight trials, defining these as where problems were solved within two seconds of problem presentation. This is a far shorter period than seen in the Cranford and Moss (2010, 2011, 2012) studies, and highlights that there is no accepted distinction between immediate and delayed insight.

Cranford and Moss (2010) identified through protocol analysis that more impasse and restructuring was seen in delayed insight compared to search solutions, making the assumption that this was why participants labelled solutions as insight. Yet it may equally be the case that the impasse led to the same phenomenological experience, a rapid and surprising awareness of the solution as seen in immediate insight; and the participants were basing their labelling of trials as insight or not on this experience, not the antecedent cognitive processes. Taking this interpretation when thinking about the phenomenological experience of insight there seems little need to discriminate between the two types of insight. Particularly considering the arbitrary nature and variance of timings used to make such a distinction in previous research.

The recent studies discussed above again demonstrate the CRA to be a valid and robust method to elicit problem solving behaviour that is experienced as insight or search. Additionally, the similarity in terms of a proportion of the sample/ population not reporting insight both in CRA experiments and in self-reported everyday experience suggests comparability with real-life solving (see section 4.4.4.1). Furthermore, the CRA builds on the notion that insight represents a sudden synthesis of remote ideas, as seen in the mental time travel theme identified for everyday negative insights (see section 3.4.3).

5.1.2 Theories of Emotion in Relation to Insight.

5.1.2.1 Conceptual Act Theory of emotion.

The idea of integration of different mental components, seen above in insight and the CRA task can be explored in relation to theories of emotion. The conceptual act theory of emotion (CAT) posits a similar integration of experiential and perceptual aspects in embodied cognition, some of which are labelled as an emotion (Barrett, 2014). This approach argues that domain general processes integrate input from external and internal sensation (c.f. exteroception and interoception distinctions discussed in section 5.1.5) with knowledge (from memory) to provide the content of conscious awareness. The use of the terminology 'Conceptual Act' refers to this moment to moment integration (series of acts) of top down knowledge (conceptual) with bottom up sensory information (from the body and external world) to build a mental event, the sequence of which represent conscious flow (Barrett, 2014). The themes from Study 2 identified similar components, Mental Time Travel seeing an association of current environmental cues (external world information) with knowledge from remote memories and future plans (conceptual information) alongside the theme of Gut Feelings which described an awareness of bodily cues.

Barrett (2014) argues that it is attention that determines how each mental event (Conceptual Act) is labelled. So a focus on the external world would lead to the experience of a perception, whilst a focus on mental content would be seen as a cognition. When attention is paid to the internally generated sensations of the body, the mental event will be seen as an emotion. This may provide an alternative framework to explain how participants determine if a solution is labelled as insight or search. When attention is paid to the cognitive processes and the participant recognises using search strategies and being aware of these, the solving event according to CAT would be seen as cognitive. In contrast when attention is paid to bodily processes CAT would suggest that this be an emotional experience and so labelled as insight.

However, there is not yet evidence of where attention lies at the insight moment (in terms of towards mental processes, external perception or bodily changes); determining (according to CAT) if it is experienced as a cognition, emotion or sensation. As discussed in Section 1.2 insight has long been assumed a cognitive event but without research explicitly testing this notion, or exploring how emotional experience might unfold within this experience. For example, Gick and Lockhart (1995) discussed affective aspects making the assumption that they were in response to an insight moment. Topolinski and Reber (2010a), in a more recent theoretical paper likewise see affect as a by-product of the cognitive process of insight. This stance was subsequently adopted by Jarman (2014) who again dismissed affective aspects when designing scales to measure everyday experience. As highlighted here and also discussed in section 2.1.5, such assumptions appear to be based on insight researchers' intuition about the relationship between cognitive and emotional events; that cognitive events lead to emotional responses.

5.1.2.2 James (Lange) Theory of Emotion (JATE, 1884).

Emotion theorists have a long history of challenging this assumed order of cognitive events and related emotion. James (1884) theory of emotion (JATE) proposed a counter intuitive sequence to the feeling of emotion, contrasting it to the common sense notion that we think, then feel and then respond. He suggested that it is the physiological response to a detected stimulus that causes emotional feelings. James (1884) demonstrated the lay assumption of emotion through descriptions of a person encountering a bear: they firstly see the bear and so feel frightened (experience of emotion); leading them to tremble (physiological response); and perhaps run away (behavioural response). JATE proposed that conversely, the person felt fear (experience of emotion) because they were trembling in response to the perception of the bear rather than trembled because of their feeling of fear. While aspects of JATE are still debated (see journal edition for contemporary perspectives on JATE introduced by Russell (2014)), in particular the extent to which physiological, and psychological perspectives contribute to emotional experience (see section 5.1.3.2). James (1884) original challenge to the common sense sequence prevails; physiological changes are widely accepted as contributory to emotion experience rather than simply being a product of it (Barrett 2014; Craig, 2015; Damasio, 2000; Ekman, 1992).

The examples from insight literature highlighted previously (in section 2.1.5) would appear to follow the common sense sequencing criticised by James (1884): an individual suddenly sees a solution to a problem (think); which they are surprised by, and happy about (feel): and so jump in the air [possibly run naked down the street like Archimedes] and exclaim "Eureka" (respond). As such this positions emotion as a secondary consequence of the cognitive insight experience.

It could be argued that such implicit assumptions have little impact on insight research. However there are some examples where changing these underlying ideas could change the interpretation of findings made. For example, Kounios et al. (2006) assert from their neuroimaging research on EEG analysis of insight problem solving that "a sudden burst of gamma-band oscillatory activity … does not reflect subjects' affective or surprise reactions following solutions, because the onset of this activity coincides with, rather than follows, the conscious availability of the solution" (p. 883). Here they discount emotional explanations due to the assumption that emotion is a consequence of insight and so neural activity at the time of the insight could not be attributed to it. However, taking a theoretical standpoint such as CAT opens up an alternative interpretation of the neural activity at the point of insight. This approach relates the experience of insight (labelled as emotional, cognitive or as a perception) to the components that contribute to it, so bodily, sensory or knowledge based activity. By this account, neural activity seen at the time an insight occurred could therefore be ascribed as emotional, cognitive or perceptual. That is not to say that CAT is necessarily the standpoint taken in this thesis, but it does demonstrate how alternate conceptions of emotion and cognition can change interpretation and so are important to understand.

There has been little experimental research conducted into emotion and insight to explicitly test these ideas. Moreover, the sequencing of other obvious common sense behavioural experiences have been similarly challenged. For example, common sense understanding asserts that a decision is made to press a button, leading to a message being sent by the brain area responsible for motor action to the finger, causing it to move. However, carefully designed psychophysiological experiments have identified a counter intuitive sequencing that sees activity in motor areas of the brain initiating finger movement before the conscious decision to press the button was made (Haggard & Eimer, 1999; Libet, Gleason, Wright & Pearl, 1983, but also see Roskies, 2010). Such unchallenged assumptions highlight the need to begin to explore insight and emotion experimentally and carefully control aspects to differentiate between emotional and cognitive components.

5.1.3 Gut Feelings and Insight.

5.1.3.1 Physiological responses to problem solving.

While the various theories of emotion encompass bodily changes in different ways, the majority do not dispute a physiological component is associated with the experience of emotion (for example, Barrett 2014; Craig, 2015; Damasio, 2000; Ekman, 1992; James 1884). The theme of Gut Feelings identified in Study 2 highlights a comparable focus on bodily changes in negative insight that participants interpreted as emotional.

A few insight studies do identify physiological aspects, however none consider these in relation to emotion. The free report accounts of participants' insight moments collected by Danek et al. (2014b, see section 1.2.3.1) identified what the researchers termed "somatic reactions" (p. 10) to solving problems through insight. These were categorised separately to the emotional and cognitive aspects that were identified across participant responses. It is interesting to note that the researchers in this study assumed the somatic descriptions were reactions to insight rather than an integral part of it. Whilst, on examination of the actual textual responses given by participants, for example "Like a shot through my body" (p. 10), they do not describe any kind of sequence to the somatic descriptions in relation to other aspects of the insight moment. However as the authors identify, participants were not asked to provide descriptions of their non-insight solution moments, so it is difficult to attribute these findings solely to the insight moment rather than a generalised response to solving the magic tricks.

Jausovec and Bakracevic (1995) suggested that there are contrasting heart rate signatures demonstrated by participants solving different types of problem. Participants solved four types of problem (two of each): divergent problems; dialectic problems; insight problems and; search problems. The authors classified the problems according to Wakefield (1989) with both divergent and dialectic problems having open solutions whilst insight and interpolation having closed solutions. They measured participants' heart rate whilst they attempted to solve the problems, having five minutes for each problem. In the first study giving feeling of warmth ratings during this time, in the second study using Verbal Protocol Analysis. The researchers presented graphs for the last minute of problem solving before a solution is reached (time periods range from 45 - 70 seconds before the solution) for average HR change (from a baseline HR measure taken during a rest period prior to problem solving) in solving the different types of problem. It is unclear though, how a solution point was determined and verified for the open ended problems (in contrast to closed solution problems with a single identifiable solution). As such, and in line with others discussing these findings, results will only be considered for the search and insight problems (e.g. Lackner et al., 2013; Ovington et al., 2016; Shen et al., 2015).

For both studies, Jausovec and Bakracevic (1995) showed similar patterns of HR (see Figure 5.1a). Search problems seeing a gradual increase in HR through the problem solving period until the solution was found. In contrast, HR remained stable during insight problem solving until the last 15 seconds before the solution moment when a steep increase occurred. Accordingly, this pattern showed intriguing congruity with the feeling of warmth (FOW) ratings reported in their study and elsewhere (e.g. Metcalfe and Wieble, 1987), where a more gradual increase in feeling of warmth ratings is seen for search while insight typically shows static FOW ratings until just prior to the solution.(see Figure 5.1).

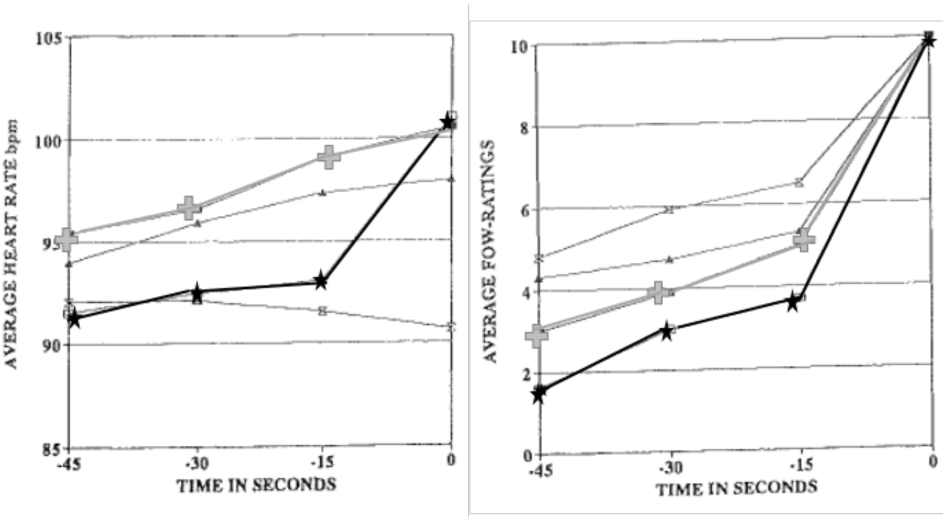


Figure 5.1 Original graphs from Jausovec and Bakracevic (1995) showing a). heart rate and b). feeling of warmth ratings through time (t=0 being the solution point) for insight (black line, star) compared to search (grey line, plus) problems. Results for two open ended problems were also presented (triangle - dialectic; hourglass - divergent). Adapted from What Can Heart Rate Tell Us About the

Creative Process? By N. Jausovec & K. Bakracevic, 1995, *Creativity Research Journal,* 8(1), 11. Copyright 1995 by Taylor & Francis.

A recent study by Lackner et al. (2013) also reported heart related measures during the moment of understanding humorous cartoons. Participants were presented line drawings, each for six seconds. Half of the drawings were of a humorous nature which the authors argued required an insight moment of comprehension of the joke. Control cartoons contained incongruous material where no comprehension, so no insight moment was elicited. Participants indicated whether they understood the joke (only trials where understanding was indicated were included as humorous trials in data analysis) or not for each picture presented and rated their amusement. Comparisons of changes in heart rate (HR), stroke volume and cardiac output (CO) and blood pressure were made during the picture presentation compared to baseline. For all physiological measures there were effects of time, with heart related measures decreasing on presentation of the drawing and then increasing after approximately three seconds. There were smaller changes in HR and CO for humorous images compared to controls both across the presentation period and in the half second time frame before comprehension was indicated (the same time point was used in the control trial as indicated by the participant for the humorous cartoon). This smaller change interpreted as a relative increase in HR for humorous compared to non-humorous was attributed to activation of the behavioural approach system, linked to the intrinsic reward and pleasure of humour and insight (Lackner et al., 2013).

However, it is problematic to attribute the heart rate changes reported in both the studies above purely to the insight moment. Jausovec and Bakracevic's (1995) participants did different problems to elicit the alternative types of solving (interpolation versus insight), meaning the differences in HR may be due to the task variances rather than due to insight compared to search solving. Whilst Lackner et al. (2013) did provide control trials where participants were undertaking the same activity, the differences seen may be due to humour effects, insight effects or a combination of both elicited in the experimental trials. It would therefore be desirable to explore these effects using a task that elicits both insight and search based problem solving and so eliminates task effects and enables any differences to be more confidently attributed to the different types of solving reported. The CRA task selected for this study has been shown to provide such a comparison (see section 5.1.1).

A very recent study (Shen et al., 2016) explored differences in electrodermal activity (EDA) and heart rate variability (HRV) between insight and search trials elicited using a Chinese language version of the CRA. Specifically, reporting a higher EDA for insight trials than search, but no difference in HRV. It should be noted that this article was published after the data was collected for this study. Detail is included here for completeness of the literature review. Further evaluation will explore the similarities and differences between this and the current research findings in the discussion (section 5.4.2).

5.1.3.2 Physiological responses to emotion.

By comparison to the paucity of physiological studies for insight there is more research relating to emotion and physiology. As highlighted previously, different approaches to emotion (see section 1.2) can be seen in efforts to explore related physiological responses.

Taking a basic emotions approach, Ekman's research team (e.g. Ekman, Levenson and Friesen, 1983; Levenson, Ekman and Friesen, 1990; Levenson, Ekman, Heider and Firesen, 1992) used Directed Facial Action (DFA) where posed emotional facial expressions elicit emotional experience. This draws on the idea that basic emotions are evolutionary, discrete, hard wired phenomena with distinct physiological and behavioural responses. Changes to average physiological measures were calculated between each emotional expression and a neutral pose. In the first of these studies Ekman, Levenson and Friesen (1983) reported discriminating HR and finger temperature between happy, disgust and surprise which saw low heart rates with anger, fear and sadness which showed high heart rate. Skin temperature was then further suggested to differentiate between anger (higher temperature) and fear and sad (lower temperature). However these results were in a small sample (n = 16) consisting of actors and scientists. These findings were replicated in a larger sample (Levenson, Ekman and Friesen (1990) collapsed results from three slightly different studies giving sample, n = 62) and in a cross-cultural comparison to a sample from West Sumatra (Levenson, Ekman, Heider &

Friesen, 1992), again demonstrating differences in HR, EDA and skin temperature patterns for the different basic emotions elicited through DFA.

However, the effects of HR seen in DFA has been suggested to be an artefact of the method reflecting the effort required to produce a particular expression (Boiten, 1996). So expressions of anger, fear and sadness requiring more effort and so increased heart rate compared to happy, disgust and surprise expressions. Levenson (2014), in reviewing the role of the ANS and emotion from a basic emotions perspective highlights the shortfalls of previous attempts to map emotion to ANS, suggesting that more accurate recording and sophisticated analysis of the temporal occurrence of emotion and corresponding ANS pattern would lead to more definitive conclusions to be made. Interestingly, and in addition to issues identified in section 1.2.3.2, Levenson (2014) does not include surprise in this review. Yet, surprise is one of the few basic emotions discussed in the literature in relation to insight. Furthermore, Kreibig's (2010) conclusion from a review focusing on basic emotions and ANS was that there was no one-to-one relationship with discrete emotions, stating further that changes in physiology and feeling of emotion were both possible independently. As such, and coupled with issues identified in section 1.2.3.2, a consideration of physiological changes in insight in relation to emotions taking a dimensional approach may be more appropriate to the research question and approach being taken in this thesis.

An often cited, classic study taking a dimensional approach to emotions saw Lang, Greenwald, Bradley and Hamm (1993) measure self-reported arousal and valence of emotional and neutral images (International Affective Picture System [IAPS] Bradley and Lang [2007]) presented to participants for six seconds. During presentation they recorded heart rate; electrodermal activity (EDA); and activity of the corrugator and zygomatic facial muscles (using Electromyography (EMG)) that relate respectively to frowning and smiling facial expressions. Lang et al. (1993) compared the half second interval with the largest heart rate change (acceleration) for each picture presentation for each participant using this measure in all of their heart rate comparisons (see Figure 5.2 below for overview of different HR measures used). They found that overall there was a relationship between HR acceleration and valence ratings, with the largest acceleration seen in response to positively rated images, followed by neutral then negative images. Furthermore a significant positive correlation was seen between arousal and HR change. However looking at both valence and arousal relationships to HR within individuals saw only a small proportion of the participants demonstrate significant correlations (9% to valence and 3% to arousal ratings) with stronger relationships demonstrated within individuals to EDA (significant positive correlation between conductance and arousal in 33% of participants). Despite the small proportion of participants demonstrating the effects overall these findings have been interpreted as demonstrating that if interested in valence aspects of emotion, as this thesis is for positive and negative insight, then HR would offer better discrimination than EDA.

A factor analysis was also run for the different measures taken for each picture (rather than participant's response). This identified two factors relating respectively to valence and arousal. Heart rate acceleration and facial muscle activity loaded with the valence factor, while skin conductance mapped to arousal. As such, subsequent researchers have taken these results to suggest that EDR best measures emotional arousal while HR is best for valence. Sánchez-Navarro, Martínez-Selva, Torrente and Román (2008) again obtained two factors through factor analysis of their measures which included eyeblink startle rather than EMG. In contrast to other studies they found that HR change loaded to the arousal factor rather than to valence. This may reflect the different measure of HR that they used (they do not say why), unusually comparing the last three seconds of IAPS presentation whilst most other studies focused on maximum HR change (either acceleration or deceleration).

Regardless of the differences in loadings, it is perhaps unsurprising that two factors were identified in these studies. The inclusion of self-report ratings for arousal and valence in response to each picture in factor analysis possibly driving this outcome. So the highest loading item on the factor named valence being the valence ratings, likewise for the arousal factor the highest loaded item was the arousal ratings. It would be interesting to see if the two factor structure remained on omission of these, however this is not reported. As such it is pertinent to explore outcomes of other research focusing on HR, EDA and emotion to verify the most appropriate measure in relation to problem solving and valence of emotion, the focus of this thesis (i.e. positive versus negative solving).

Subsequent studies have replicated Lang et al.'s (1993) findings using similar methodologies but again with slightly different HR measures in human samples (Bernat, Patrick, Benning & Tellegen, 2006; Bradley, Cuthbert & Lang, 1996; Bradley, Codispoti, Cuthbert and Land, 2001) and non-human animals (Bliss-Moreau, Machado & Amaral, 2013). For example, Bradley, Cuthbert and Lang (1996) introduced an eye blink startle (to a sound probe presented whilst participants viewed the different IAPS) measure in addition to EDA and HR. For heart rate they took the period of maximum negative heart rate change, finding that negative IAPS gave the greatest change, followed by neutral then positive images. Levenson, Patrick, Bradley and Lang (2000) explored physiological responses in a similar way in participants scoring high on psychopathy while Hempel et al. (2005) compared participants with schizophrenia to controls. In both cases, while the particular groups of interest in these studies fall outside the remit of this thesis, the control groups provide further corroboration of the effects of the earlier studies. Both replicating the relationship of arousal effects with EDA and implicating HR changes in valence (aggregate deceleration in Levenston et al. (2000) and acceleratory peak in Hempel et al. (2005)).

Pastor et al. (2008) identified differing predictions for the effects on EDA and HR if presentation of IAPS was blocked into series of congruently valenced images. They hypothesised that blocking by image valence would lead to a reduced orientating response when images were of a similar (valenced) content, whilst have little effect on arousal. The expected reduction in HR change effects and no difference in EDA supported this proposed relationship between arousal and EDA and valence with HR change. This theoretically driven finding supporting the results of earlier studies would appear to confirm that HR be the physiological measure that best discriminates in terms of valence, so most applicable to the research in this thesis.

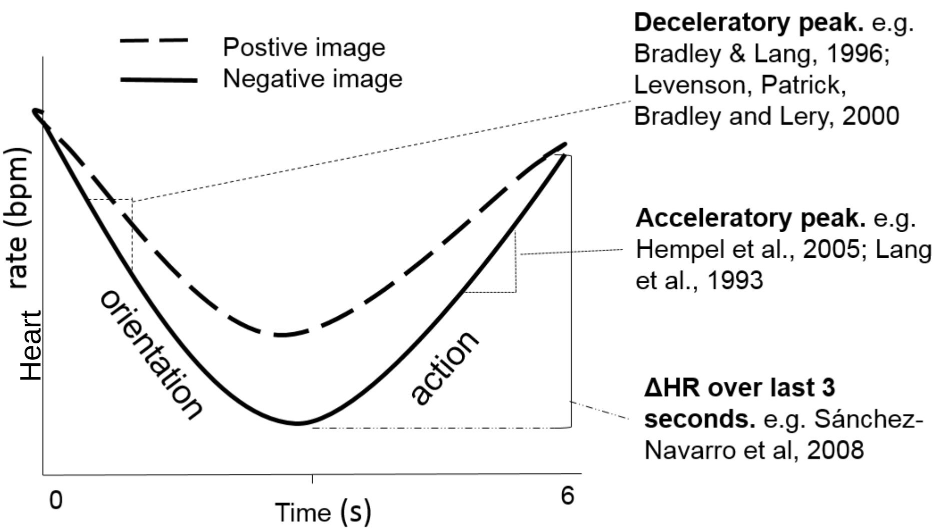


Figure 5.2 Classic biphasic HR response to emotional picture presentation with related HR measures reported in various studies.

Bradley, Codispoti, Cuthbert and Lang (2001) proposed a defence cascade model (Lang et al., 1997) that explains a graded response to stimuli over time and in relation to its proximity. They describe a biphasic HR response to stimuli (see Figure 5.2), where an initial HR deceleration relates to an orientating response where the stimulus is evaluated. The subsequent HR acceleration is then seen representing the action taken. This model was driven by animal research and the subsequent acceleration was related to the action (for instance fight or flight) in response to the stimulus. This pattern can be seen as consistent to the HR response seen in Lackner et al.'s (2013) humorous 'insight' condition (see section 5.1.3). Furthermore, as seen in Figure 5.2 the findings from studies using differing and seemingly contradictory HR measures outlined in the section above can be interpreted to support this model.

In summary, of concern to the current research is which physiological measures are most appropriate in the exploration of effects of insight and emotion. A number of aspects are pertinent. Firstly, it should be noted that research into physiology and emotion typically explore externally elicited emotion via delivery of emotion eliciting stimuli (such as IAPS) or events. Little research considers endogenous emotion, in other words emotion generated from within. Shen et al. (2015) highlight that insight is an example of endogenous emotional experience, so caution should be taken in applying the current emotion research to insight. However, there is little literature on physiology and endogenous emotional experience. As such the assumption will be taken that similar processes occur for emotion that is internally and externally generated. From the perspective of CAT (see section 5.1.2) this assumes that emotion is not a process but a focus of current attention on bodily information seeing emotion as a categorisation not a process, as such from this perspective the perceived experience and related bodily response are important, not the process.

Of the measures previously explored, and as highlighted above, researchers have implicated EDA in emotional arousal. However, it is identified that only extremely arousing stimuli generate detectable EDA responses, with weak discrimination in mild or low arousal (Bradley, Codispoti, Cuthbert and Lang, 2001). In terms of IAPS, extreme arousal is elicited by pictures that show positively valenced erotic images and picturing unpleasant scenes such as graphic mutilation. At the time this research was designed it was determined unlikely that responses to insight elicited in the laboratory would produce comparable levels of arousal, meaning that measures of EDA would not appear a sensitive enough in this situation.

In contrast, heart rate change is suggested to be discriminatory for emotional valence across the range of emotional experience rather than at the extremes (Bradley et al., 2001). As this thesis is considering positive and negative insight moments it can be determined that that the valence aspect of emotion be the most pertinent dimension to consider. Furthermore, the few studies that have explored physiological aspects in insight (at the time of research design, so prior to the Shen et al.'s (2016) described above) also focus on heart rate.

5.1.4 Individual differences in emotional expression.

An additional aspect to consider building on results from the previous studies in this thesis is individual differences in emotional experience. This stems from Chapter 3, which found that lay perceptions of everyday insight included the idea that the extent someone experiences things as insight may relate to individual differences in emotionality, so their tendency to experience or express emotion (see section 4.4.1). So the more emotionally expressive they are, the more they would identify the Aha and Uh-oh moments in problem solving, labelling these as insight.

One approach might be to consider general individual differences in relation to personality. Many personality measures do contain scales that on face value relate to individual differences in emotion. For example Emotional Stability in the big five, Neuroticism in the Eysenck Personality Questionnaire (EPQ) or Emotionality in HEXACO (Ashton & Lee, 2009, Costa & McCrea, 1992 ; Eynsenck & Eynsenck, 1991). Of these, the emotionality component of HEXACO might appear on face value to be the closest to emotional expression highlighted in Chapter 3. However, further examination of the scales within HEXACO sees aspects pertinent to emotional expression across the scales. For example Emotionality focuses on anxiety and sentimental attachment whilst tendency to be expressive is seen as part of extraversion and specific expression of anger is included as a component of agreeableness (Ashton & Lee, 2009). It may therefore be pertinent to consider measure that have a more specific focus on emotional expression.

5.1.4.1 Emotional expressivity.

Emotional expressivity is the extent that behavioural changes to the face, voice or posture (display behaviours) are displayed when experiencing emotion (Gross and John, 1995). Gross and John (1998) proposed a hierarchical structure for emotional expressivity that included five facets. Three made up core emotional expressivity, so the spontaneous and unchecked expression that would occur in everyday life. Two regulatory facets then act upon core expressivity, expressive confidence and masking. Insight, with its spontaneous experiences of Aha and Uh-oh moments more readily aligns with core emotional expressivity.

The three facets of core emotion expressivity originally identified by Gross and John (1995) were impulse strength, negative expressivity and positive expressivity. Impulse strength relates to the intensity that emotions are felt, so higher impulse strength would mean emotion was harder to hide or stop. The negative and positive expressivity facets of core expressivity demonstrate differential exhibition of behaviours relating to negative and positive emotions. So generally, there is higher expression of behaviours relating to positive emotion, such as laughter than for negative, for instance crying. However, individual differences are also seen in the expression of these facets (Gross and John, 1995; 1997). In relation to problem solving and insight the further breakdown of core expressivity to factors that relate to the valence of emotion may be useful going forward when tasks are identified that elicit both positive and negative insight moments (see Chapter 6).

5.1.4.2 Measures of emotional expression

Gross and John (1995, 1997) validated a questionnaire, the Berkeley Expressivity Questionnaire (BEQ) to measure emotional expressivity, identifying the three core factors: positive expressivity; negative expressivity and impulse strength. They compared self-report ratings to peer reports, behavioural responses to emotional film clips and average HR and EDA changes to validate this measure (Gross and John, 1997).

Larsen, Diener and Emmons' (1986) Affect Intensity Measure (AIM) also measures the strength of emotion felt and provides a single score. However, as identified by Gross and John (1998) it includes both positive and negative related items similar to those seen in the BEQ. Furthermore, items for the two measures mapped to similar factors in Gross and John's (1998) factor analysis conducted on these and other measures to arrive at their five facet model described above.

As such, either measure appears to effectively capture the core expressivity of interest in this study. However the BEQ might be preferable for a couple of reasons. Firstly the differentiation of core expressivity into three facets, two of which may be pertinent when exploring positive and negative insight. Secondly, Gross and John (1998) suggest that impulse strength represents the first stage of the emotion generation process, with differential translation of this to behaviour for negative or positive emotions. While emotional valence is of overall interest to this thesis, the physiological aspects of emotion and insight are particularly being explored in this study (see section 5.1.3). Impulse strength incorporates items such as "I have strong emotions" [BEQ 11] and "my body reacts very strongly to emotional situations" [BEQ7] that can be seen as relating to this aspect of emotion and insight.

5.1.4.3 Gross's Models of Emotion Regulation.

Subsequent to their work focusing on expressivity, Gross' (1998) research shifted to explore the processes in emotion regulation that act on core expressivity. Gross (1998) proposed different processes of emotion regulation occurring at different stages of an unfolding emotion. Antecedent strategies aimed to avoid, moderate, ignore or reappraise the possible emotional event, while response focused regulation looked to alter things once the emotional response was elicited. The tendency to regulate emotions through these processes impacts on the expressivity of emotion seen within and between individuals. Gross (2015) recently extended his model, emphasising a central role of valuation cycles throughout an unfolding emotion (see Figure 5.3a). The valuation cycle initiating with a world event, followed by a perceptual component, a valuation component and finally an action component. The world event could be either external or internal to the body/mind of the individual. Perception would then lead to a valuation of the perceived event as "good for me", "bad for me" or "indifferent" (p. 10). The valuation of either valence would lead to actions, either mental or physical. Gross (2015) suggests that cycles though this valuation process would continue until there is a change, for example the event being no longer present or evaluated as important. He further differentiated between first level valuation systems that generate emotions as core affect and, second order valuation systems that act upon them in regulatory processes. The specific emotion regulation processes identified in his earlier model acting within the second order valuation cycle to influence the first level core affect. Through the lens of this Extended Process Model of Emotion Regulation, the insight moment can be considered (see Figure 5.3b). The world event being an internal experience, with the perception of a new idea, understanding or solution relating previously remote mental associates together. These would be judged as being salient: 'good for me' valuations seen as positive insight and 'bad for me' valuations as negative insight, labelling the insight moment as an emotional cognitive event.

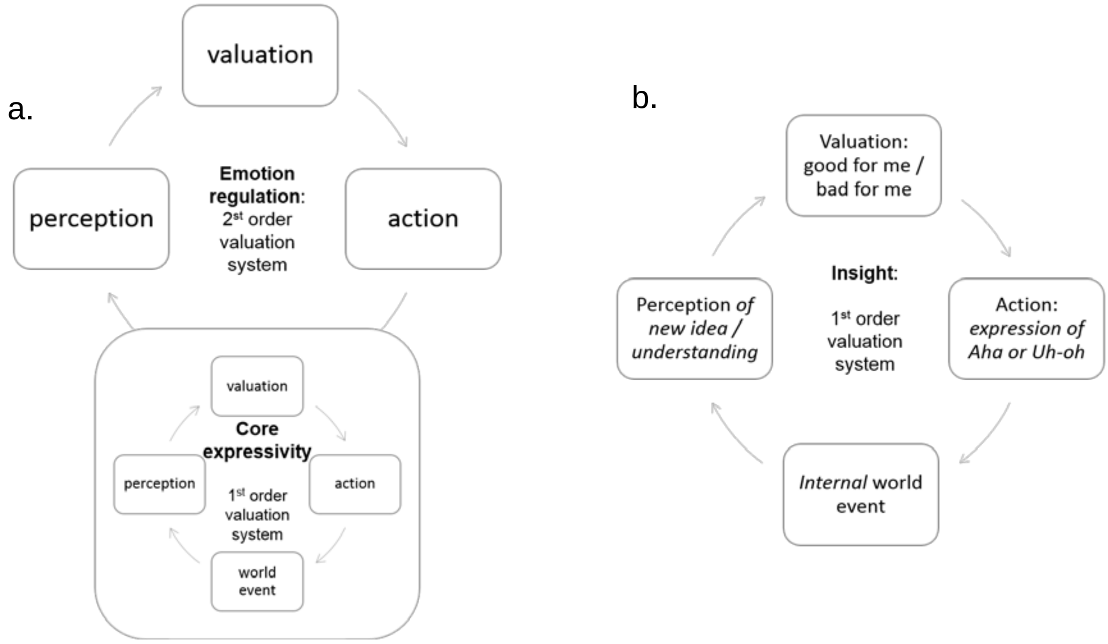


Figure 5.3. Gross (2015) Extended process model of emotion regulation. a. First order as core expressivity and second order emotion regulation valuation system. b. Insight through the lens of Gross' (2015) model.

The insight moment, a short lived momentary experience is congruent to this first order, initial experience of emotion termed core expressivity in Gross' (see Gross and John, 1995, 1997) earlier research. Later regulation (or not) might be seen as the insight unfolds. For example, the feelings of contentment that participants in Chapter 2 described as resulting from their insight would unlikely see any attempts to down regulate, savouring the moment and paying attention to the positive insight may represent attempts to up regulate or prolong the positive feeling.

Accordingly, when considering the insight moment, individual differences in emotionality would likely stem from processes in the first order valuation. As described above in section 5.1.4.1 the emotional experience at the insight moment is the spontaneous generation of experience relating to a sudden new idea or understanding rather than subsequent modification of this experience. The BEQ, measuring core expressivity that can be seen as congruent to the idea of first order valuations discussed in Gross's (2015) later model could therefore represent one measure of such individual differences in insight and emotion.

5.1.5 Individual Differences in Detecting Physiological Changes.

Exploring within the first order valuation cycle, another aspect where there might be individual differences is in the extent that bodily responses relate to emotional experience. However, Gross (2015) is less clear where physiological aspects of emotion fit within the valuation system. He does suggest that physiological aspects are part of the core affect, first order valuation cycle. So taking a JATE or CAT perspective, the perception component of the first order valuation could incorporate bodily information that is then evaluated for valence. This is in line with research that demonstrates that the extent an individual perceives or pays attention to their bodily changes impacts on their perception of an event as emotional (e.g. Schandry, 1981; Pollatos and Schandry, 2008; Wiens, Mazzacappa & Katkin, 2000 see full summary of findings below in 5.1.5.1); so for a problem solving realisation, how much of an Aha or Uh-oh moment they experience. Alternatively, bodily changes could form part of the action component, so be a response to the valuation made, perception of which would contribute to the second order valuations then made. Either way, Gross's (2015) model allows for individual differences in perception of bodily signals to impact the emotional experience that could be explored in the context of insight.

5.1.5.1 Interoception and Emotion

Interoception, most broadly speaking can be described as perception of changes within the body, this in contrast to exteroception which is related to perception of the external world (Mirams, Poliakoff, Brown & Lloyd, 2012). Scandry (1981) related interoceptive ability to emotion by comparing to the self-reported personality trait of emotional lability and state anxiety measures. Emotional lability represented the extent that individuals reported experiencing changes in emotion, were excitable or had their attention distracted by emotion. He furthermore suggested that state anxiety represented a behavioural measure of actual emotional experience. Results demonstrated higher levels of both emotion related measures in participants with better interoceptive accuracy (HBC, see section 5.1.6.1). Schandry (1981) asserted that this finding supported the involvement of visceral perception in experiences of emotion.

Building on this relationship between interoceptive accuracy and emotionality, a body of research has further explored interoception in relation to mental health. For example, Ehlers and Breuer (1992) proposed the Interoceptive Sensitivity hypothesis that posited increased interoceptive accuracy in people with panic disorder. However such a focus is beyond the scope of this thesis, the following review will therefore be limited to interoceptive accuracy in relation to emotion and insight.

Wiens, Mazzacappa and Katkin (2000) compared the responses of participants with good and poor interoceptive accuracy under experimental elicitation of emotions using film clips (Gross and Levenson, 1995). In addition, heart rate was measured at baseline and during the interoceptive accuracy task (HBD, see below section 5.1.6.2) showing no differences between accurate and poor interoceptive accuracy, this suggests that interoceptive accuracy was not simply reliant on more pronounced signals (such as higher heart rate). Electrodermal activity was measured at baseline and whilst participants watched the film clips. Participants rated the films for emotional intensity (arousal) and pleasantness (valence). Those with better interoceptive accuracy reported more intense responses to emotional film clips and showed pronounced electrodermal activity in response to amusing films. As such, the findings demonstrated differences in emotional behaviour (reported arousal to emotional film clips), with participants with better accuracy in interoception reporting greater emotional arousal and some enhanced physiological arousal.

Concurrent results have been found by other researchers using different emotion elicitation stimuli. For example, Pollatos, Kirsch and Schandry (2005) presented emotional picture stimuli (International Affective Picture System, IAPS; Lang and Bradley, [2007]) to their participants. They likewise found that participants with high interoceptive accuracy (measured using HBC, see below section 5.1.6.1) tended to rate the emotional (but not neutral) pictures as more arousing. This result has been reliably replicated by the same research team in subsequent studies (Herbert, Pollatos and Schandry, 2007; Pollatos, Herbert, Matthias and Schandry, 2007; Pollatos and Schandry, 2008). Pollatos, Herbert, Matthias and Schandry (2007) further demonstrated that increased interoceptive accuracy related to increased cardiac reactivity to emotional pictures, but not neutral ones. This further implicated interoceptive accuracy as having a role in emotion processing, with enhanced cardiac reactivity concurrent to reports of increased arousal in those with more accurate interoception. The demonstration of increased access to interoceptive information relating to enhanced emotional responses is in line with predictions made above (see section 5.1.4.3) from the Extended Process Model of Emotion Regulation (Gross, 2015b). Furthermore, increased HR activation (or earlier recovery from HR deceleration) was implicated in insight problem solving. As such a similar HR response is seen in emotion eliciting events and insight, with enhanced activation seen for emotional stimuli and insight solving.

5.1.5.2 Definitions of interoception.

Finally, however there are disparities in the terminology used in relation to interoception that need to be clarified for the purposes of this thesis. For example, the terms interoceptive sensitivity and interoceptive awareness are used interchangeably within the literature, often when referring to abilities measured using the same task and by the same research teams (for example, Herbert, Herbert and Pollatos, 2011; Herbert, Pollatos and Schandry, 2007; Werner, Duschek, Mattern & Schandry, 2009; Werner, Kerschreiter, Kindermann & Duschek, 2013). Garfinkel, Seth, Barrett, Suzuki and Critchley (2015) recently sought to provide clarity in labelling, distinguishing between interoceptive accuracy, interoceptive sensibility and interoceptive awareness. They proposed that performance on behavioural tasks measuring interoception be termed interoceptive accuracy. Interoceptive sensibility, they suggested is the tendency of an individual to notice their bodily processes while interoceptive awareness represents judgement as to how accurate their perception is. Garfinkel et al. (2015) suggest that interoceptive accuracy is the core construct within these distinctions. Furthermore, Garfinkel et al. (2015) demonstrated congruence between the two main accuracy measurement tasks (heart beat counting and heart beat discrimination, see below section 5.1.6) suggesting that this supports the construct validity of interoceptive accuracy. In contrast they report difference in awareness measures between HBC and HBD based methods suggesting they represent different metacognitive processes. Accordingly this study will use the accuracy measure in its investigations of interoception. As such, unless specifically stated otherwise, the use of the term interoception will be made with the tacit understanding that it is a generalised reference to interoceptive accuracy. However, it may be noted that item 7 on the BEQ (see section 5.1.4.2) rating the extent participants feel their bodies react to emotion might be classified as a measure of interoceptive sensibility, which is the extent individuals notice their bodily signals. The following section will now evaluate the difference ways that interoceptive accuracy has been measured.

5.1.6 Measuring interoceptive accuracy

The most established physiological feature used to assess interoceptive accuracy is heart activity. This is a convenient correspondence to above where heart rate is seen as the most relevant physiological measure to consider in relation to emotion and insight (see section 5.1.5). In terms of interoception, heart measures are likely favoured due to the fact that they can be easily, and through relatively non-invasive methods, measured to compare participant reports providing an accuracy score. Two main tasks have been developed to measure interoceptive accuracy of heart activity: heart beat counting and heart beat discrimination.

5.1.6.1 Heart beat counting task.

This task asks participants to count their heart beats over different time periods (typically 25, 35 and 45 seconds) without the use of physical detection methods, such as taking their pulse (Schandry, 1981). Counts are then compared to recordings of actual heart rate activity (heart beats recorded on an ECG or heart rate monitor) to produce an average accuracy score between zero and one, with increasing accuracy indicated by an increasing score and absolute accuracy rendering a score of one (use of error scores and the inverse accuracy scores typically attributed to Ehlers and Breuer, 1992). Schandry (1981, also see Wiens, Mazzacappa and Katkin (2000) above in 5.1.5.1) checked that the differences in accuracy performance were not simply reflective of differences in heart rate, demonstrating that there was no difference in heart rates at rest and during the task between good perceivers (those who got a correct count within two heart beats at least once during the experiment) and poor perceivers (with high error scores). From this the principle of using percentage error (or accuracy) scores was developed (e.g. Ehlers and Breuer, 1992). While there is variation in the labelling of this task, with it often being referred to as either an interoceptive sensitivity task or interoceptive awareness task, many refer to it as a mental tracking task (as seen in Knoll and Hodapp, 1992). However this label still introduces room for misinterpretation as to what exactly participants are mentally tracking. As such, for the purposes of this thesis it will be referred to as the Heart Beat Counting (HBC) task in explicit reference to the actual behavioural measure.

Some have contested the validity of the HBC task, their main criticism being that participants might achieve an accurate score using counting strategies based on intuitive ideas of heart rate (Knoll and Hodapp, 1992; Ring & Brener, 1996; Ring, Brener, Knapp & Mailoux, 2015). This position was supported by research demonstrating that providing information regarding heart rate improved HBC accuracy (Ring, Brener, Knapp & Mailoux, 2015), and this was perhaps related to attention (Matthias, Schandry, Duschek & Pollatos 2009). However, it is unsurprising that improvement might be seen if participants are provided explicitly with information about their heart rate. Furthermore, experimental measures have been implemented to check against this.

Schandry (1981) argued that participants were not employing such counting strategies, rationalising that more HR variation would see greater variation in HBC accuracy if participants were counting at the same intuitive rate. He found no correlation between these measures and so concluded that his participants were not using a counting strategy. Others likewise demonstrated that HBC accuracy was maintained between counts where HR was experimentally changed, through engaging in a cognitively demanding task or administration of caffeine (Stewart, Buffett-Jerrott & Kokaram2001; Zoellner & Craske 1999).

A second counting task was also used to check for intuitive counting strategies in HBC (for example Dunn, Evans, Makarova, White and Clark, 2010 (supplementary information); 2012; Ehlers and Breuer, 1992; Ehlers, Mayou, Sprigings and Borkhead, 2000; Knoll and Hodapp, 1992; Zoellner and Craske, 1999). Performance was compared for the HBC task to a time perception task where participants were asked to estimate time periods using a counting strategy (so report how many seconds elapse). Reports of low correlations between performances in the two tasks likewise dispel the notion that a counting strategy was used in HBC, as it would be expected for there to be a high concordance between the two if they were measuring the same thing (participants' counting accuracy).

5.1.6.2 Heart beat discrimination task.

The second task commonly used to measure interoception is Heart Beat Discrimination (HBD) (Whitehead, Drescher, Heiman & Blackwell, 1977).

Participants judge whether tones played to them are in synchrony (200ms after own ECG R spike) with their own heartbeat or not (500ms after ECG R spike) (Eichler and Katkin, 1994). An interoception score is generated according to the proportion of participant's binary responses (synchronous or not) that are correct (maximum accuracy therefore being a score of 1). Kleckner et al. (2015) suggest that at least 40 trials be used to ensure that the test has sufficient power and reliability. For less than 40 trials, practice effects see participant's accuracy improve over time. The authors also highlight that the task is hard with about half of their sample performing no better than at chance. This would therefore suggest that this task is ill suited to studying individual differences in interoception as it does not provide measurement of abilities for half the sample (is too hard). Furthermore, Sedeño et al. (2014) criticise HBD for its reliance on integration of internal HR with external tones, suggesting that this may distract attention from the interceptive signal and so reduce abilities to detect it.

5.1.6.3 Heart beat tapping (HBT).

One research group has devised a hybrid of the two main heart activity accuracy tasks discussed above, where participants firstly tap along with a playback of their own heart signal, then continue with the playback removed (Sedeño et al., 2014). They demonstrated reliability of the task over an 8 week test-retest. However, little further work has been done to validate this method.

5.1.6.4 Comparisons of heart based accuracy measures.

Knoll and Hodapp (1992) compared performance between the HBC and HBD task finding a significant correlation (r_s=0.59). This would suggest that the two tasks were measuring a similar thing. However, the authors' conclusions were very much judged from the standpoint of HBD being the gold standard due to the possibility of counting strategies in HBC. The research outlined in section 5.1.6.1 serves to dispel the notion of effects of intuitive counting strategies. Furthermore, for this study which is interested in individual differences a task needs to measure an ability over the full sample, while Kleckner et al. (2015) suggests that floor effects see nearly half of participants performing no better than chance on the HBD task. In addition, this study is exploring endogenous emotion and insight, so internally focused processing of information. It would therefore be sensible to likewise use an interoceptive accuracy measure that draws on the same processes. Both HBD and HBT rely on the integration of external perceptions of tones whilst in HBC participants focus entirely on internal signals. As such HBC would appear the most appropriate measure of interoceptive accuracy for this study*.*

5.1.6.5 Other interoceptive abilities*.*

The widespread use of heart activity accuracy measures take the assumption that these reflect a generalised interoceptive ability (Herbert, Muth, Pollatos and Herbert, 2012). In order to test this assertion other interoceptive abilities would need to be identified and measures developed.

Daubenmier, Sze, Kerr, Kemeny and Mehling (2013) considered respiratory interoception between meditators and non-meditators, expecting meditation to improve interception. They measured participant's ability track their own breathing, and detect and discriminate different respiratory loads (restriction of air being breathed through tube) with results being suggestive of meditators being more accurate. Whitehead and Drescher (1980) measured gastric interoception, comparing participants discriminating between light flashes in synchrony or asynchrony to their stomach contractions. However, participants were required to swallow a stomach tube to take part in this study, making this a very invasive methodology. A likewise intrusive study reported measurement of bladder interoception (Jarrahi et al., 2015). Participants' bladder fullness was manipulated with water introduced using a catheter, whilst neurological activity (fMRI) and self-reports of arousal (intensity of need to urinate) and valence (unpleasantness of feeling) were recorded. The focus of this study was to identify the brain areas relating to interoception and so no individual differences in detection were considered.

Whilst these studies highlight the possibility of measuring different interoceptive abilities, none have yet been compared to each other or to HBC or HBD. Furthermore, the procedures used are often quite invasive, questioning the applicability of findings to everyday experience of prime interest in this thesis. As such, for the purposes of this thesis results will be discussed purely in terms of the measure taken (HBC) and not be referred to, or assumed to represent general individual differences in interoceptive accuracy.

5.1.7 Individual differences in insight

The final aspect explored in this thesis, as identified in chapter 4 (section 4.4.1) are individual differences in the experience of insight in particular in terms of the prevalence of insight. In chapter 4 this was considered in terms of a general prevalence of how often do people experience insight, or how many insight do people have in a week? Congruent to this, Ovington et al. (2016) recently (after the studies in this thesis had been designed and data collected) attempted to measure everyday insight disposition, so the extent that individuals experience and differ in their experience of insight in daily life (measured by self-report Disposition of Insight Scale [DIS]). Kounios et al. (2008) compared neural activity (EEG) with individual differences in the proportion of anagram solutions reported as insight compared to search. This can be seen to measure the tendency participants showed to experience/ report problem solving as insight. The general tenet of this work would seem to imply that insight solving be preferable to search, relating dispositions towards reporting or experiencing insight as measures of creativity. However, such approaches have seen limited exploration or validation and furthermore have explored insight from a purely cognitive standpoint. No work to date has considered individual differences in insight and emotional experience together.

Cunningham and MacGregor (2013, 2016) (likewise not available at time of this research design), in a series of studies validated the Productive-Reproductive Thinking Inventory (P-R), a self-report scale that they suggest measures insight problem solving. However, this is problematic as it contrasts participants' productive and reproductive thinking. The authors identify that productive thinking is closely related to re-structuring seen in insight, whilst reproductive was defined as habitual and mechanical. It may well be that the scale does measure behaviours related to creativity that are under conscious control, so for example, "looking at a problem from a different angle" (p. 6). In fact many of those listed as productive thinking items map to behaviours that are training using creative problem solving tools targets (Vernon, Hocking and Tyler, 2016). However, by Cunningham and MacGregor's (2016) own definition of insight as discontinuous and not available to conscious thought, it is unclear how these conscious intentional behaviours lead to insight. Furthermore, their validation against classic insight problems does not check to ensure insight occurred (see further critique of this approach in section 1.4.3). It is more parsimonious to suggest that the P-R Inventory measures creative behaviours in relation to performance in insight problems that may or may not be solved through insight.

5.1.8 Rationale

The above literature review, building on the findings from the previous studies in this thesis highlights the need for experimental research to explore emotion and insight. Furthermore, investigating the role of bodily changes in insight. Finally, exploring how individual differences in the experience of insight and emotion, and in detection of bodily changes might impact on solutions being experienced as insight or non-insight.

Many aspects of this research question had little experimental work on which to build. Therefore where robust, established methodology was available it was favoured in the first instance over possibly more innovative but untested methods. For this reason the CRA task was chosen to elicit insight and non-insight problem solving (Bowden and Jung-Beeman, 2003b). Based on the findings summarised in section 5.1.1 the participants in this study would be expected to perform in a similar fashion. As such, **Hypothesis 1** predicts that insight solutions will be solved faster than non-insight. Furthermore, following from the recent work of Salvi et al. (2016) finding more incorrect responses were recorded in non-insight compared to insight, **Hypothesis 2** states that there will be more (commission) errors labelled as non-insight than insight.

In terms of the bodily changes, as outlined in section 5.1.3, HR was seen as the physiological measure most pertinent to the exploration of insight, particularly considered also in relation to emotion. Predictions were made based on the literature available at the time of research design (so prior to Shen et al., 2016). As such **Hypothesis 3** identifies that mean HR change will alter over the problem solving period. Furthermore, in line with theoretical predictions and the findings from Jausovec and Bakracevic (1995) and Lackner et al. (2013). **Hypothesis 4** asserts that Mean HR change will be different between insight and non-insight trials. Additionally, **Hypothesis 5** predicts that mean HR change will alter over time in different ways between the insight and non-insight trials. However, due to the difference seen in the two major papers in this field, specific predictions about the nature of the difference are not made.

As identified in section 5.1.4.2 there are several measures of the tendency to experience or express emotion. These are relatively old in the literature and reflect a time prior to a focus on emotion regulation processes. However, examination of Gross' (2015a, 2015b) most recent model of emotion regulation in section 5.1.4.3 it was identified that the core affect component measured in the original BEQ is most pertinent to the emotion likely seen in insight (see also section 5.2.2.2 in method). As discussed in 5.1.5, individual differences in insight have yet to be explored in relation to individual differences in emotionality. As such this study aims to explore the relationship between tendency to express emotion and insight. As such **Hypothesis 6** predicts that higher emotional expression will see increased labelling of solutions as insightful. The direction of the prediction specifically aims to test the idea identified in Chapter 4 that according to a lay perception of insight, greater emotionality leads to more experience of events as insightful.

As outlined in section 5.1.7 an additional aspect of individual differences identified that has been shown to impact of the experience of emotion is that ability to detect bodily changes. This further identified how the interoception task with a purely inward focus on heart activity, the Heart Beat Counting task (Shandry, 1981) (section 5.1.7.5) was most suited in the context of this experiment. As such the aim is to test the relationship between interoception and tendency to experience insight**.** Firstly**, Hypothesis 7**, that there will be no difference in HR between high and low HBC scorers will check that results are comparable with other studies. No difference in HR between conditions, eliminates alternate explanations for HBC scores based on accessibility of information being greater for those with a higher HR. With that check in place, **Hypothesis 8** predicts that higher HBC scores will see increased labelling of solutions as insightful. This assumes that more accessibility to interoceptive signals would lead to solutions points being experienced as more emotional, and so be labelled as insight.

In terms of the relationship between the two measures concerning emotion, interoception and emotional expression, **Hypothesis 9** predicts that HBC and EE will contribute differently to decisions as to whether a problem is solved through insight or non-insight.

Finally, as discussed in section 5.1.4.2 the BEQ contains an item that explicitly asks participants to rate the extent they feel bodily changes are involved in their emotional experience. Despite Gross and John (2007) finding no difference in physiological measures for the overall BEQ scores, it might be assumed that people who detect more of their bodily changes would report a greater involvement or awareness of these when experiencing emotion. As such **Hypothesis 10** asserts that there will be a positive association between HBC accuracy and BEQ07 ratings

5.2 Method

5.2.1 Participants

80 participants were recruited for the study from a convenience sample of colleges and universities local to the researcher, one withdrew during their participation leaving 79 participants (female n = 50, M_{age} = 25.22, SD_{age} = 8.68, range 18 - 55 years). The number of participants required was calculated a priori, based on effect sizes seen in previous research using G*Power (see Apendix 3).

5.2.1.1 Inclusion criteria.

Only adults over 18 years old were recruited for this study (see 5.2.7). Participants were all students, the majority being university undergraduate students, in line with previous research that has utilised the CRA task (see 5.2.2.3 and Table 2.1). In addition participants were required to have English as their first language (see pilot study described in Appendix 1 and also 5.2.2.3).

5.2.1.2 Exclusion criteria.

Exclusion criteria were identified in relation to potential effects discussed in previous research using the Heart Beat Counting task that could impact on heart rate data being collected. Many studies had no exclusion criteria for participants relating to this (for example, Ainley, Maister, Brokfeld, Farmer and Tsakiris, 2013, Herbert, Pollatos and Schandry, 2007; Knoll and Hodapp, 1992; Schandry, 1981). However other studies excluded participants for different reasons, some based decisions on self-report information (for example, Meissner and Wittmann, 2011; Werner, Kerschreiter, Kindermann and Duschek, 2013) whilst others conducted clinical interviews (for example Herbert, Herbert and Pollatos, 2011). Participants in this study were asked to self-report that they met the criteria to participate in the study and not have a diagnosed cardiac or neurological condition or be taking Benzodiazepines or antihypertensive drugs (Stewart, Buffett-Jerrott & Kokaram, 2001; Werner, Kerschreiter, Kindermann and Duschek, 2013

5.2.2 Materials

5.2.2.1 Insight log.

A paper form of the insight log was used. The Insight Log has three versions that include alternate explanations of insight (emotion focused definition, cognitive focused definition, no definition), see further descriptions of the development of the Insight Log in Chapter 2 (section 2.3.). Participants completed one of the three versions, describing their insight experience.

5.2.2.2 Berkeley Expressivity Questionnaire (BEQ).

The BEQ (Gross and John, 1995) is a 16 item questionnaire where ratings are made against statements such as “I laugh out loud when someone tells me a joke that I think is funny". Ratings are given using a Likert scale from 1 (strongly disagree) to 7 (strongly agree), some of the items are reverse scored. The scores for each item are averaged (mean) to give an overall Emotional Expressivity score. The items form three subscales measuring: positive expressivity; negative expressivity; and impulse strength. Scores for each sub-scale are calculated from the average (mean) scores over the items that contribute to each. This measure has been shown to have good internal reliability (Gross and John, 1995, 1997), for this thesis’ study having a Cronbach’s Alpha of .83 which again can be interpreted as good (Nunnally, 1978) In addition, comparisons between self-reported expressivity scores and ratings by close peers demonstrated concordance in the ratings suggesting that that self-reports were accurate representations of individuals’ public expressivity behaviour (Gross and John, 1997). Experimental comparisons were also made, demonstrating that self-ratings mapped to behavioural responses to laboratory induced emotional situations (Gross and John, 1997).

Alternative scales also measure relatively comparative constructs including the Emotional Expressivity Questionnaire (EEQ) (King and Emmons, 1990); Emotional Expressivity Scale (EES); The Self-Monitoring Scale (SMS) (Snyder, 1974); The Affective Communication Test (ACT) (Friedman, Prince, Riggio & DiMatteo, 1980) and the Affect Intensity Measure (AIM) (Larsen, 1984). Gross and John (1998) identified three factors by conducting factor analysis on items from all of the scales. The BEQ and AIM showed the highest correlations with the three core expressivity factors which is of most relevance to this study (see section 5.1.6 for further discussion). Sixty-nine percent of the BEQ items contributed to the final factors, compared to fifty-five percent of the AIM. Additionally, item 7 within the BEQ directly asks participants to rate the statement, "my body reacts very strongly to emotional situations". This can be seen to relate to interoceptivity, another aspect of interest in terms of the research question in this study. As such, the BEQ was the selected measure for emotional expressivity in this study.

5.2.2.3 Compound Remote Associate (CRA) task.

The Compound Remote Associate task aims to elicit insight and non-insight problem solving in participants (Jung-Beeman et al., 2004). Participants are presented with a triad of words and are required to find a word that forms a compound word or phrase with each of the three presented. For example, when presented with flower, luck and belly the solution is pot: The new word can pair either before (e.g. pot luck) or after (e.g. flower pot) the three words. On giving their answer, participants are then asked to give a feeling of insight. This can be done using a Likert scale where participants rate the degree to which they felt a solution was insight (Bowden & Jung-Beeman, 2003a), alternatively participants are given a forced choice response of insight or non-insight (Jung-Beeman et al., 2004). As this research was looking to make comparisons between insight and non-insight problem solving, the second approach was adopted in line with a substantial body of previous work (see sections 5.1.1 and 1.1.4.1). The definitions used by Jung-Beeman et al. (2004) to make this distinction were used unchanged to enable direct comparison to previous research.

A pilot study was used to identify a corpus of 26 word triads for use in this study. See Appendix 1 for full details of the pilot study. The protocols described in the pilot were adopted.

As discussed in section 5.1.1 the CRA provides scores and reaction times for solutions solved through insight and non-insight (search). However, in addition this study will also calculate each participant's tendency to solve/ label a trial as insight based on their performance on the CRA. This is an adaption of the method employed by Kounios et al. (2008), using the CRA rather than anagram puzzles to calculate the proportion of insight to non-insight (see section 4.4.1).

5.2.2.4 Heart beat counting (HBC) task.

In the Shandry (1981) Heart Beat Counting task actual heart beats recorded (using ECG or a heart rate monitor) are compared with a participant's count of their own heart beats over the same period. The following instructions were given to participants:

> You are asked to count your heart beats silently. The beginning and end of the counting phase will be signalled to you by the researcher. At the end you will be asked to verbally give your count to the researcher. Concentrate only on your heart beats. You cannot take your pulse or use any other physical manipulations to improve detection. You will do three counts, with a 30 second break between each count to give an average.

As described in the instructions, counts were repeated for three different time periods, 25, 35 and 45 seconds to give three sets of corresponding counts from the heart rate monitor and participant self-report. As no online data regarding heart beats recorded was available, neither the researcher nor participant had information about the accuracy performance during data collection.

The Schandry (1981) HBC task is one of two main methods that purport to be a measure of interoceptivity, see discussion in section 5.1.6 regarding these methods. Summarising this, the HBC task was selected for due to its established use in research exploring interactions between cognitive and emotional aspects. Furthermore, although there is demonstrated congruence between these tasks (Knoll & Hodapp, 1992, also see section 5.1.7.3) the HBC task is suggested to be less reliant on integration of internal and externally directed attention (Stewart, Buffett-Jerrott & Kokaram, 2001) and more sensitive to individual differences (Dunn et al., 2010). As the research question is focused on endogenous processes of insight and related emotion, a task that likewise focuses internally rather than the integration of external and internal information seems more suited in this instance.

5.2.3 Apparatus

5.2.3.1 Heart rate monitor.

Heart information was recorded using a sports, frequency heart rate monitor (HRM), RS800CX (Polar Electro Oy, Kempele, Finland). The heart signal was detected via chest mounted electrodes and sampled at 1000Hz by the H3 sensor (Polar Electro Oy, Kempele, Finland) and transmitted and stored in a watch. Data was subsequently uploaded onto a secure password protected personal computer and analysed using Polar Pro Trainer 5 software which filters and corrects for missed beats and false positives (based on software built by University of Kuopio, Niskanenetal., Finland, 2004).

A HRM was chosen over ECG as it offers increased portability; enables participants to fit the electrodes themselves; and will enable greater replication due to the commercial availability and relatively low cost of the equipment (Vanderlei, Pastre, Hoshi, Carvalho & Godoy, 2009). Successful use of the Polar HRM system has been seen in an increasing number of studies (for example: Durlik & Tsakiris, 2015; Koch & Pollatos, 2014; Luque-Casado, Perales, Cárdenas & Sanabria, 2016). Furthermore it has been shown to have comparable reliability and validity to ECG across experimental settings in psychology, medicine and sports and exercise contexts (Kingsley et al., 2005; Nunan et al. 2009; Radespiel-Tröger et al., 2003; Vanderlei et al., 2009). It has also been seen as a 'gold standard' (Spierer, Rosen, Litman, & Fujii, 2015, p. 265) against which new heart rate recording technology is validated.

5.2.3.2 Stimulus presentation and reaction time response software.

The BEQ and CRA task were presented (on a 330mm screen), and typed responses and reaction times recorded using PsychoPy software version 1.80.03 (Peirce, 2007; 2008).

5.2.4 Procedure

To reduce any time of day effects on heart activity all participants were tested in the afternoon (Alibhai, Tsimakouridze, Reitz, Pyle, & Martino, 2016). On giving informed consent and completing demographic information participants fitted the Polar H3 sensor chest belt according to the manufacturer's instructions. On verifying that a signal was being sent to the receiver watch participants rested for five minutes to enable baseline heart rate to be recorded. Participants were given verbal and written instructions explaining the different tasks in the study. Instructions relating to the CRA task omitted the feeling of insight ratings at this stage to avoid confounding Insight Log responses. Participants then conducted their first three HBC sessions, timed by the researcher and recorded on the HRM watch using the Lap Timer function. Participants' gave their count for each session verbally which was recorded by the researcher. The HBC task was administered straight after the rest period to obtain a baseline HBC accuracy score. The participants then completed the BEQ and a hard copy of the Insight Log, the order off these counterbalanced across participants. Participants were then reminded of the instructions for the CRA task and given the additional instruction about giving feeling of insight ratings. After the three practice trials checks were made to ensure they understood the task. A time synchronisation was carried out by the researcher between the HRM using the Lap function and the CRA task recorded in PsychoPy. Participants then completed the CRA on the laptop. Immediately on completing the CRA the second HBC task was conducted. The CRA and second HBC were always delivered at the end of the experiment in order to explore HBC accuracy at a possibly elevated heart rate due to undertaking the CRA, seen as a cognitively challenging task (following approach by Stewart, Buffett-Jerrott & Kokaram, 2001). On completion of the experiment participants were fully de-briefed and given the opportunity to remove the chest band in privacy.

5.2.5 Data Clean-up Protocols

5.2.5.1 *Heart beat counts from HRM.*

Excel files were extracted using Polar Pro-trainer 5 software summarising heart rate and heart beat counts for Lap times. The relevant lap times were identified and corresponding counts for each of the HBC sessions.

5.2.5.2 *CRA data.*

PsychoPy .csv data files were cleaned removing rows and columns produced but not containing data pertinent to the research questions. Responses were compared to the answers given in Sandkühler and Bhattacharya (2008) by two independent markers. Responses that did not match the answer were either marked as incorrect or correct dependent on the subjective assessment of the marker. Inter-rater reliability (Cohen's Kappa) was calculated for the two scorers, $\kappa = .66$ (95% CI, .22 to 1), $p < .001$ and it was found that there was substantial agreement between the scores (Landis & Koch, 1977). Therefore the scoring of the first researcher was used in further analysis. Correct trials were further sorted for each participant into insight and non-insight so that frequency scores and reaction times could be calculated.

5.2.5.3 Heart rate data.

For each correct trial, the time at solution point was calculated by adding the Laptime that was recorded when the HRM was synchronised to PsychoPy. The heart rate recordings at intervals through the problem solving process were then extrapolated, taking readings at the solution point, every second for five seconds after solution, and 25, 20, 15, 10, and each of the five seconds leading up to solution (note that HR were only recorded for the length of trial. For example, when a problem took 17 seconds to solve heart rate data was taken from 15 seconds prior to solution). Change heart rate scores (ΔHR) were calculated by subtracting the baseline heart rate for the participant from the heart rate at each time point. Raw heart rates and ΔHR information was then sorted for insight and non-insight trials and averages

5.3.5.4 Exclusion of outliers

Outliers were excluded from datasets for values that fell outside 1.5 times the Interquartile Range following Tukey (1977).

5.2.6 Analysis of Data

5.2.6.1 *HBC accuracy score.*

An accuracy score was calculated using the formula 1/3 Σ (1-(| HRM count – participant count |) / HRM count). This is a standard method adopted in studies using the Schandry HBC task (Ehlers and Breuer, 1992).

5.2.6.2 Assumptions for inferential statistics used.

Tests of normality (Shapiro-Wilkes test) were carried out on all variables. Where outliers were identified they were removed, apart from a few exceptions which are specifically detailed in the results below. The removal of outliers did not always lead to an indication of normality via the Shapiro-Wilkes test. However as discussed by Field (2016), in larger samples (in his discussion he indicates any sample of over 30) the Shapiro-Wilkes test can be overpowered leading to increased likelihood of a significant result. Furthermore, in such 'large' samples, the central limit theorem suggests that the assumptions of normality are less problematic to tests (Field, 2016). As such, unless otherwise stated it can be assumed that analyses reported have been conducted on samples with outliers removed and using parametric tests.

Additional assumptions in terms of sphericity are important for within participant ANOVAs. Where sphericity is shown to be violated (using Mauchly's test of sphericity) this will be reported and degrees of freedom corrected using using Greenhouse-Geisser estimates of sphericity (Field, 2016).

5.2.6.3 Reporting and analysis of effect sizes.

According to recommendations outlined by Bagley (2009) this thesis will present and focus interpretation on simple effect sizes and confidence intervals with descriptive statistics. For completeness, significance (p-values) and standardised effect sizes will also be reported, and to some extent used in interpretation. Standardised effect sizes used will be uncorrected. Whilst this is at odds with Baguley's (2009) suggestion to favour corrected effect sizes, there a number of reasons for this approach. Firstly, there is widespread poor practice in the reporting of corrected effect sizes, particularly in relation to eta squared measures for ANOVA (Baguley, 2009; Levine and Hullet, 2002). Secondly, there are contrasting opinions on the best measure to report. Whilst the most widely reported measure is the corrected effect size partial eta squared, Levine and Hullet (2002) advocate eta squared (but note their discussion is in the main relating to between participant ANOVA) whilst Bakeman (2005) propose general eta squared. As there is a lack of consensus, and to avoid the introduction of any spurious assumptions/ corrections this thesis will report the most conservative, uncorrected Eta squared.

5.2.7 Ethical Considerations

Participants were all over 18 years old and were given information sheets to ensure they gave informed consent. It was made clear in the information sheet that the researcher was not medically trained, and that heart information would only be analysed in relation to the stated aims of the study. Participants were directed to address any concerns regarding their health to their own GP. All data was anonymised, and clear instructions were given as to withdrawal procedures that were possible up to the point that data analysis took place. This research was approved by the University of Buckingham, School of Science Ethics Committee.

5.3 Results

5.3.1 CRA data

T-tests were conducted on the CRA data. Solutions reported as insight were solved faster (M = 8.7s, SD = 3.7) than non-insight (M = 11.8s, SD = 4.4s). This difference, 3.26s 95% CI [1.91, 4.62], was significant $t(71) = 4.80$, $p < .001$, $d = 0.80$. There were more incorrect solutions reported as non-insight (M = 1.77, SD = 2.42) than insight (M = .52, SD = .85). This difference, 1.25, 95%CI [.72, 1.79], was significant $t(78) = 4.70$, $p < .001$, $d = .75$.

5.3.2 Heart Rate Change

Tests of normality were conducted on the Heart Rate Change (∆HR) variables for insight and non-insight solutions at each time point. Significant Shapiro-Wilks test results and inspection of normal Q-Q plots suggested that the data did not meet assumptions of normality for ΔHR variables: insight, time -2s and +5s; non-insight, time -5s; non-insight, solution point (0s) and; non-insight times 3s and 5s. Removal of four outliers common to these measures left all ΔHR variables demonstrating normality.

A repeated measures ANOVA was conducted comparing ΔHR for solution type (insight versus non-insight) and time (in 1 second intervals from 5 seconds before to 5 seconds after the solution point). Mauchly's test of sphericity indicated that the assumptions of sphericity was violated for the effects of time, $X^2(54) = 604.48$, $p < .001$, and interaction effect of solving x time, $X^2(54) = 489.43$, $p < .001$; therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (respectively $\varepsilon = .33$; $\varepsilon = .34$).

A significant effect of solution type was seen, $F(1, 65) = 14.25$, $p < .001$, $\eta^2 = .01$. Heart rate change was less for insight solution (m = -3.51, SE = .53) compared to non-insight solutions (m = -4.47, SE = .53) where the difference was .95 bpm, 95% CI [.45, 1.46].

There was also a significant main effect of time, $F(3.28, 213.31) = 23.62$, $p < .001$, $\eta^2 = .04$. Planned polynomial contrasts suggest a quadratic relationship, $F(1, 65) = 56.74$, $p < .001$; this can be seen in Figure 5.4. Furthermore, no interaction effect was seen between solving and time, $F(3.35, 217.66) = 2.00$, $p = .11$, $\eta^2 = .003$.

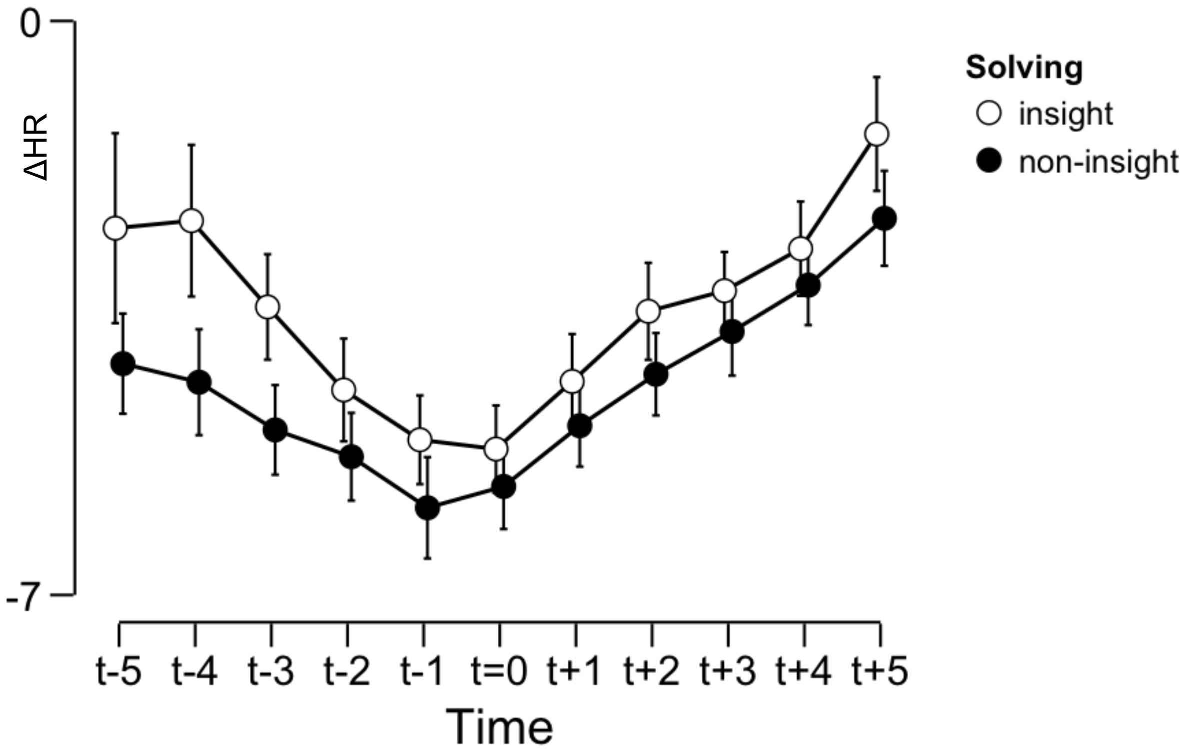


Figure 5.4 Plot showing mean HR change (compared to resting baseline) for different solving types, Insight and Non-insight over time (t = -5 through 1 sec. intervals to t = 5, where t = 0 is point of solving). Error bars show 95% confidence intervals.

5.3.3 Emotional Expression (BEQ)

There was no relationship between emotional expression (BEQ score) and solution labelling, $r = .05$, 95%CI [-.28, .19], p (one-tailed) = .34. This can also be seen through visual inspection of Figure 5.5.

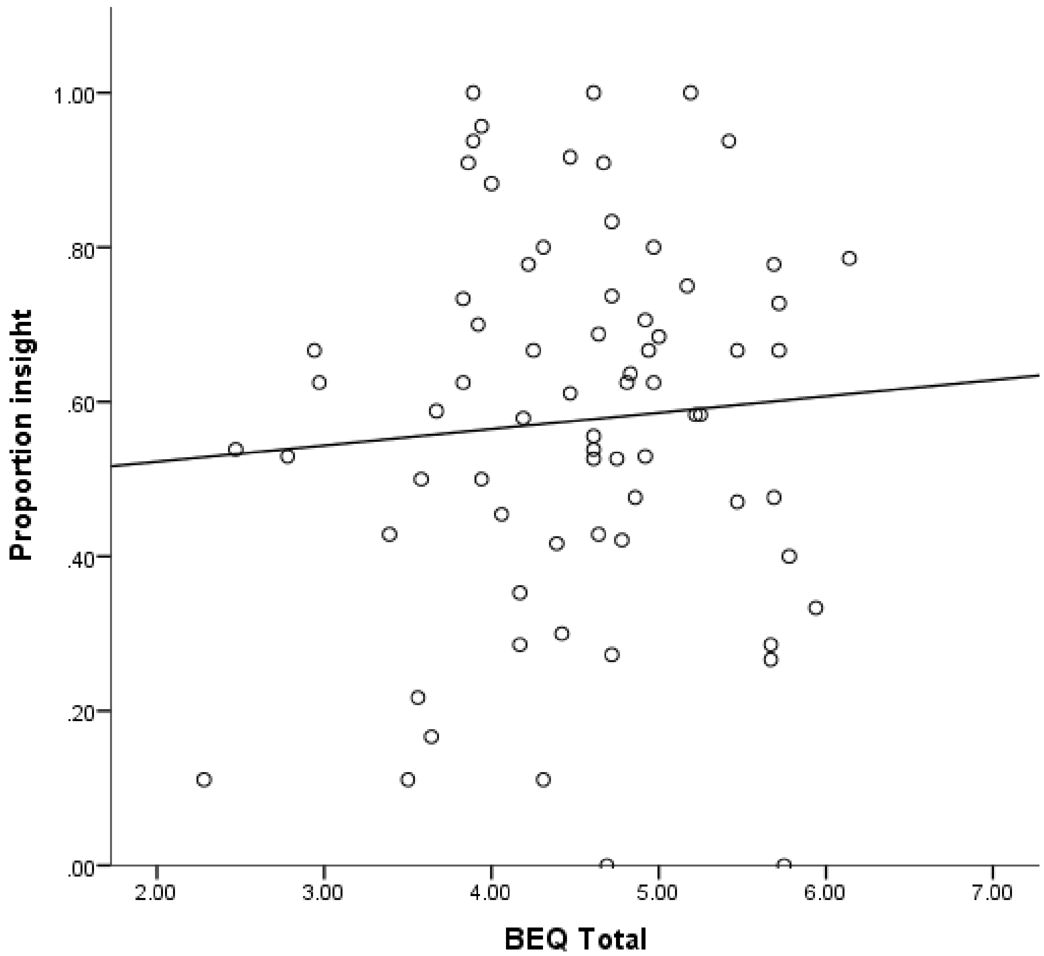


Figure 5.5 Scatterplot showing BEQ Total score in relation to proportion solved by insight.

5.3.4 Heart Beat Counting Accuracy (HBC)

Visual comparisons were made between the number of heart beats counted by participants and measured by the HRM. Out of the 79 participants, only four consistently counted more heart beats than was measured, the rest provided underestimates in the heart beats counted.

Outliers for HBC accuracy were identified on the dataset with outliers already removed as described in section 5.2.6.2. On removal of these further two outliers from the dataset (in addition to those removed to normalise ΔHR scores) the HBC accuracy measure was then found to meet assumptions of normality as determined by the non-significant nature of the Shaprio-Wilk test, $W(71) = 0.985$, $p = 0.552$.

HBC scores were converted to a nominal variable split at the median score (M = .62) giving a dichotomous measure of more accurate and less accurate heart beat counters. An independent t-test was conducted between baseline HR for more and less accurate HBC, t(69) = 2.16, p = .03, d = .51; finding that less accurate HBC had higher baseline HR (M = 83.06, SD = 12.42) than more accurate HBC (M = 77.17, SD = 10.40). The mean difference was 5.86bpm, 95%CI [.47, 11.28]. The standardised effect size can be interpreted as a moderate effect, furthermore the confidence intervals suggest there was a difference in the baseline heart rate, with less accurate heart beat counters having a greater heart rate than more accurate.

No relationship was seen between Heart Beat Counting accuracy (HBC1) and labelling of solutions as insight, r = -.05, 95%CI [-.28, .19], p (one-tailed) = .34. This is also demonstrated graphically in Figure 5.6.

As there was no relationship demonstrated between either HBC or BEQ scores to solution labelling, further planned regression analyses to compare the relative contributions of each measure were not conducted.

Finally, there was no relationship between HBC accuracy and ratings for BEQ7, r_s = -.12, 95%CI [-.34, .12], p (one tailed) = .16.

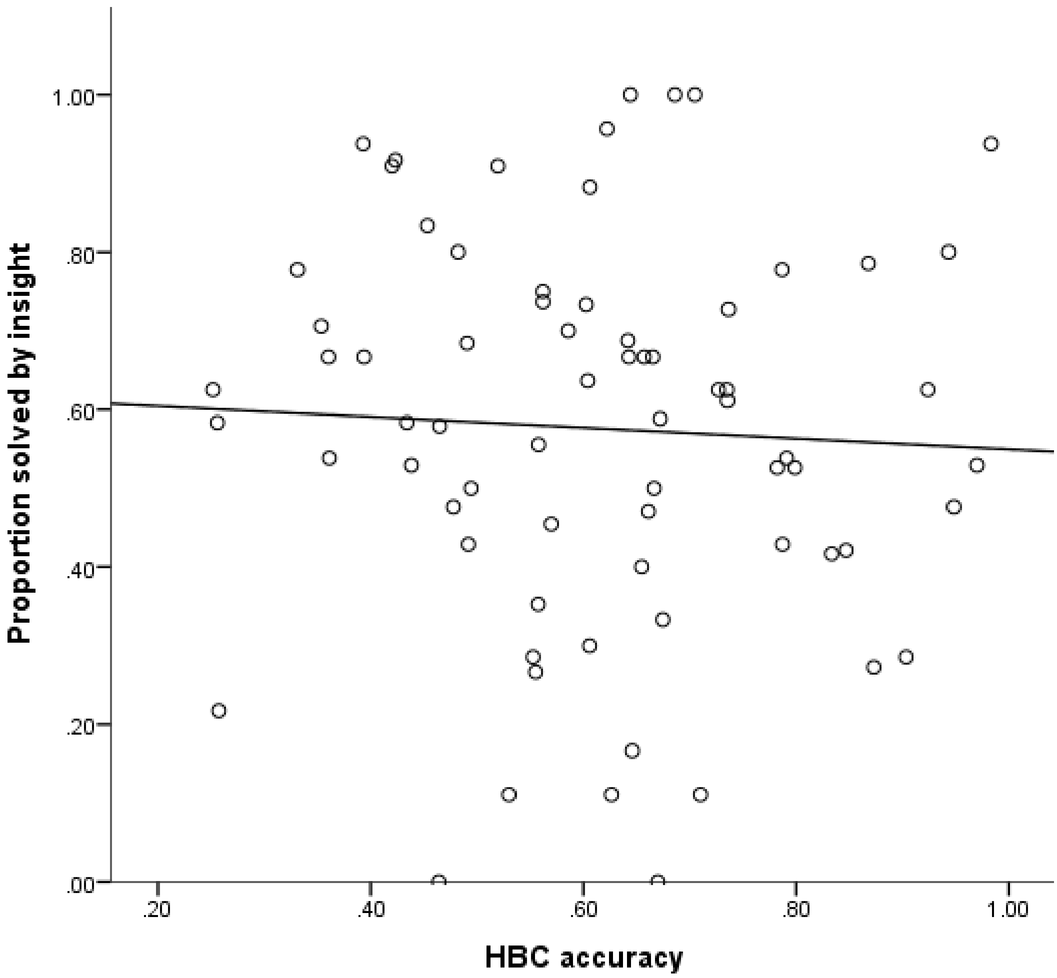


Figure 5.6 Scatterplot showing HBC accuracy in relation to proportion solved by insight.

5.4 Discussion

This study aimed to draw on the qualitative findings from earlier studies in the thesis and literature review conducted to experimentally explore how individual differences in the experience of insight and emotion, and in detection of bodily changes might impact on solutions being experienced as insight or non-insight. An established insight elicitation task was used, the CRA and results to hypotheses outlined in section 5.1.8 are discussed below in relation to the previous findings of this thesis and related current literature.

5.4.1 Compound Remote Associates

Hypothesis 1, that insight solutions would be solved faster than non-insight solutions was supported by the data in this study. This is congruent to the performance seen in previous samples (Cranford and Moss, 2010, 2011, 2012; Kounios et al 2008; Sumramaniam, Kounios, Parrish and Jung-Beeman, 2008; Shen et al., 2016). However, while many report descriptive statistics for solution reaction times, only Cranford and Moss (2010) and Subramaniam et al. (2008) conduct statistical analysis on these results. As such this provides further replication of this effect in CRA problem solving. Furthermore, both the studies were conducted in the U.S.; therefore this study demonstrates comparable performance in a non-U.S. sample.

Hypothesis 2 was also supported, this study again demonstrated that there were more (commission) errors labelled as non-insight than insight. This is in congruence with the findings of Salvi et al. (2016) who interpret their results as showing that insight solving is more accurate than analytic processes (see section 5.1.1). However, an alternative explanation might be offered based on how participants label each solving episode, drawing on their phenomenological experience. For example, they may have made judgements based on feelings of certainty, the more certain they were, the more likely to label the trial as insight. Such a process could also account for the higher correct solutions seen in insight. As such this offers the alternative interpretation; that rather than insight simply being more accurate (as suggested by Salvi et al, 2016), solutions that are felt to be more accurate are therefore labelled by participants as insight.

For this alternative interpretation to be true, that insight is judged as such based on increased certainty regarding a solution, it would firstly need to be demonstrated that certainty was higher just prior to a solution being given. Hedne et al.'s (2016) study may offer findings that support this. They presented magic tricks for participants to solve, measuring feeling of warmth (see section 1.1.4.4) ratings during solving and a confidence rating for the solution (after it had been given). Hedne et al. (2016) assert that while post solution confidence was rated higher for insight than search, there was no difference in FOW during solving. However, this post solution confidence rating was an absolute measure, while the FOW comparison this conclusion was drawn from represented a change score from early to late in solving FOW. Furthermore Hedne et al. (2016) following earlier approaches (by Metcalfe and Wieble, 1987) did not include the last FOW rating considered too close to the solution point. This makes sense when aiming to detect differences in confidence in solving, as a rating of confidence at the point of insight associated with the insight solution would mask the earlier lack of ideas regarding the solution. However, Hedne et al. (2016) did report that there were higher FOW for this last rating in insight compared to search. Supporting the idea that the feeling of certainty (how close to a solution or confidence in a solution) is higher immediately before and after a solution labelled as insight

In a final comparison of note, Hedne et al. (2016) made inferences about metacognitive aspects using the participants' reason for choosing their multiple choice solution. One of the options being that it was similar to their own solution. They took this as an indication of the participants' assessment of their own solution, suggesting that for trials labelled as insight, participants were more likely to stick with their own solution despite it being incorrect. At face value this would seem at odds with the idea presented above, that participants might be labelling solutions as insight because of their correctness. However, on further consideration this may still be the case. If the participants made judgements based on their feeling of correctness, not actual correctness (which they had no way of actually knowing) and insight trials were labelled as such because of this feeling of certainty or correctness; then it is logical that for insight, more would stick with their identified solution. Whilst for non-insight, if labelled as such due to a decreased feeling of certainty, a subsequent change of mind would be more likely.

The work of Hedne et al. (2016) and possible interpretations regarding accuracy of insight and search solutions highlight that reports of the certainty of participants would further inform this discussion. As such, future research could look to compare ratings of certainty in insight compared to search solving (see section 6.1.5). Danek et al. (2014b) included a rating of certainty in their phenomenological reports of insight, however did not collect comparable ratings for search solutions with which to compare (see section 1.2.3.1).

5.4.2 Heart Rate Change in Problem Solving

Hypothesis 3 was supported, there was a significant main effect of time on the HR change seen, with a decline in HR from five seconds prior to solution with an increase through the solution button press and in the five seconds post solution. Neuroscience studies using the CRA methodology typically made adjustments of 2 seconds to allow for the latency of button press following awareness of a solution (Cranford and Moss, 2011; Jung-Beeman et al., 2004; Sandkuler and Bhattacharya, 2008; Submramaniam et al., 2009). This timing appears to roughly coincide with the lowest part of the 'U' shaped quadratic relationship which though visual interpretation of the time series plot seen in Figure 5.1 occurs just prior to the solution button press.

This pattern is in contrast to those reported by Jausovec and Bakracevic (1995) who reported an increase in HR in both insight and interpolation (search based, non-insight) problem solving in the run up to the solution moment. However, by visual examination of the time series for HR reported in Lackner et al.'s (2013) study a comparable 'U' shaped response can be seen, with an initial decline in HR on presentation of the cartoon and the lowest point of the curve occurring around three to four seconds after presentation. This also coincides with the reported mean response time for participant indicating they understood the joke (argued by the authors as being an insight moment, see section 5.1.3.1 for further discussion).

This bi-phasic pattern of HR response is similar to that seen on presentation of emotional stimuli described by Bradley, Codispoti, Cuthbert and Lang (2001) (see also section 5.1.5) and also comparable to the HR response to oddball stimuli that occurs alongside the P300 ERP (Guerra et al. (2016) (see further description in section 1.9.1). Bradley et al. (2001) suggest than an initial deceleration of HR on presentation represents an orientating response to the stimuli, where attention is paid to aspects of a potential problem to determine whether they need to cascade and produce an appropriate behavioural response (for example fight or flight) (Lang et al., 1997). A prolonged deceleration to negative stimuli was suggested to represent a stalling of the cascade response. This is where a stimulus is evaluated as negative but not increasing in threat, as in the presentation of a negative IAPS. The orientating response is maintained because of the continued presence and so evaluation of the picture but without a change in threat no progression down the defence cascade is necessary. Essentially the orientating response, can be seen to as a problem evaluation. Prior to the solution moment, a similar problem evaluation is seen in the CRA task which might explain the similar deceleration pattern, with restoration of HR occurring on resolution of the problem, so at and subsequent to the solution being recognised.

Hypothesis 4 predicted a difference in mean HR change between insight and non-insight, this was supported with a smaller HR deceleration seen in insight compared to search trials. This is again comparable with the pattern reported by Lackner et al. (2013), with a smaller decrease (from baseline) in HR for the humour condition compared to control cartoons.

Guerra et al. (2016) saw a reduced initial HR deceleration and late HR acceleration for larger P300 responses. Larger P300 responses have been suggested to relate to emotion or an orientating response towards an object of interest or salience (McCarthy & Donchin, 1981; Guerra et al., 2016; Herbert, Pollatos and Schandry, 2007; Pollatos, Kirsch and Schandry, 2005; Pollatos, Gramann and Schandry, 2007; Verleger, Jaskowski & Wauschkuhn, 1994). As summarised in section 5.1.9.1, the more emotional, salient or surprising the event the larger the P300 response. This is congruent to the notion that insight experience is more emotional and surprising (see section 1.2.3) than non-insight solving, thus seeing the associated neurological and physiological response, namely a dampened biphasic HR response in insight compared to non-insight.

Hypothesis 5 predicted a different HR response over time between insight and non-insight. Essentially, this hypothesis related to the pattern of HR reported by Jausovec and Bakracevic (1995), which saw a steady increase in HR for interpolation (non-insight) with a flat unchanging HR up until the point of insight marking a rapid acceleration. As such, an interaction effect for HR change over time between the two solving types would have been seen. No interaction was reported, and as discussed above and seen in Figure 3.1, patterns of HR over time did not map to the findings of Jausovec and Bakracevic (1995).

Shen et al., (2016) recently explored EDA and HRV differences between insight and non-insight trials of CRA solving. This approach contrasts with the measures chosen in this thesis. Shen at al. (in press) used EDA following decision making research, for example Bechara, Damasio, Tranel and Damasio (1997). They demonstrate a statistically significant difference in mean EDA in for problem solving periods reported as insight compared to search, with a greater EDA in insight. As discussed above (see section 5.1.3.2) research exploring EDA responses to emotional arousal demonstrated effects at extreme arousal but not intermediate (Bradley, Codispoti, Cuthbert and Lang, 2001). Assuming the insight experiences elicited using the CRA would not cause extreme arousal this measure was discounted. It is therefore interesting that Shen et al. (2016) found an effect, and may indicate that the assumption that insight experiences would not be arousing were incorrect. However, Shen et al (2016) compared means across the whole problem solving period, an exploration of EDA over time during problem solving may better help to explain the EDA differences seen.

In terms of HRV, Shen et al.'s (in press) rational for its use is less clear. They discuss papers that actually use HR such as Jausovec and Bakracevic (1995) and Lackner et al.'s (2013) (see section 5.1.3.1) inferring the use of HRV. In terms of results, they found a difference in HRV between the problem solving and baseline rest measures, but were not able to discriminate between the solving types (insight compared to search). HR reflects a composite measure of combined sympathetic and parasympathetic nervous system activity (Tulppo et al., 1998). In contrast, HRV, particularly high frequency HRV provides a measure of parasympathetic activity, often treated as a state measure with low HRV related to poor health and life outcomes (Thayer et al., 2012). It may be the difference between solving and baseline rest HR seen in Shen et al.'s (2016) study related to the increased parasympathetic activity seen during rest. In the types of comparison where short-lived effects of different solving experiences are considered, both of which involve activation and so sympathetic activity, a measure that incorporates sympathetic activity (such as HR) would seem more appropriate.

In summary, the HR differences over time and between insight and non-insight demonstrated in this study can be seen as representing somatic differences in problem solving. Furthermore, the finding has been related to research showing similar responses to emotional or surprising events. As discussed in previous chapters, the emotional aspects of insight have been highlighted through qualitative methods. This provides a preliminary association between HR responses in emotion to insight. The findings will enable further exploration of emotion in insight, likely looking to manipulate the problem solving experience to elicit differing types or intensities of emotion to compare physiological responses.

5.4.3 Emotional Expression and insight

Hypothesis 6 aimed to explore the relationship between a tendency to express emotion and label solutions as insight. There was no evidence to support such a relationship. This prediction was in part made to test the lay perception identified in Chapter 4 that more emotional people would be likely to have more Aha moments and so identify more insight. A priori power calculations indicated that a sample of 62 would be necessary to detect a medium correlation. With 73 participants this would suggest that the study was sufficiently powered to detect a relationship if one exists. It therefore may be interpreted that people's tendency to express emotion, incorporating the strength of felt emotion on which expression is based (Gross and John, 1995, 1998) has little impact on insight.

This would seem to challenge the lay impression identified in Study 3. The notion that a more expressive person might experience more insight may be too simplistic. As identified by Gross' (2016) later work, the expressive behaviour seen by others, on which an opinion of the emotionality of an individual is based is a complex process incorporating core expressivity as measured in this study, but also emotion regulation processes that act on it. The relationship identified by the participant in Study 3 may reflect that those more likely to express emotion also see an increased tendency to express insight. As identified in models of emotion (e.g. Gross, 2016) experiencing and expression of an event (emotion or insight) may be distinct. Gross and John's (1995) original definition of emotional expressivity given in 5.1.4.1 related to display behaviour. However, the CRA measures participants' self-reported experience of a solving episode as insight or not, rather than their expressive behaviour in relation to an insight. As such it may be that there would be more of an association between the expression of insight, so behaviour or self-reported and emotional expressivity. This is something for future research (beyond this thesis) to consider.

However, several questions remain that mean the experiment conducted here may not be a sufficient test to conclusively discount the presence of a relationship. Firstly, there are questions in terms of the insight tendency measure used. Following Kounios et al. (2008), the tendency measure calculated in this study compared the proportion of solutions labelled as insight to non-insight. However, research has not been conducted to explore the validity or reliability of this method. One way to explore its validity would be to compare an individual's tendency to experience insight on one task (be it the CRA, as in this study or anagrams as seen in Kounios et al. [2008]) to others. An alternative would be to compare performance on a lab. based task to other measures of insight tendency. One recently identified measure is the Dispositional Insight Scale ([DIS] Ovington et al., 2016) that provides a self-report of the extent that participants think they experience insight. As highlighted in section 4.4.1, this task has not been fully validated through mapping to actual experience. As such it currently serves as a measure of subjective insightfulness, perhaps also a mark of insight expressivity. As discussed above, there may be more of a correspondence therefore between emotional expression and DIS scores that future research could explore (note that this scale was published after data collection in the final study of this thesis).

As such it can be seen that there may be problems with the measure of tendency to experience insight used. Further research would look to test the reliability and validity of this measure (see Chapter 6) before strong conclusions could be made regarding the results from this study.

The second issue regards the BEQ, which as identified in section 5.1.8 was validated against peer reports, behavioural data and other measures of emotional expression (see section 5.1.4). However further research might explore its reliability, as comparisons within individuals over time were not made.

In sum, further research to better comment on the validity and reliability of the measures of tendency to experience insight and emotional expression would enable more conclusive comment to be made in relation to this null finding.

5.4.4 Heart Beat Counting and insight

Hypothesis 7 was to check that more accurate heart beat counters did not have higher baseline HR than less accurate. A significant difference was found, however the difference with higher HR in less accurate HBC was opposite to the scenario that Schandry (1981) identified; with those who were worse at the task having the most available signal. As such this would suggest that participants were not exhibiting improved HBC due to greater availability of signal.

In addition, as described in section 5.3.3, participants consistently under estimated the number of heart beats. This supports the notion that participants were actually detecting and counting their heart beats rather than using generic counting strategies (see section 5.1.6.1). If they were simply counting, based on an intuitive idea of heart rate, it would be expected that inaccuracies would be seen in both directions, overestimates as well as under. The predominance of underestimates is consistent with the explanation that participants were missing beats in their counting. Furthermore, those with higher baseline heart rates would likely miss more beats than those with lower, offering a congruent explanation to the difference identified testing hypothesis 7.

Hypothesis 8 predicted that higher HBC scores would relate to increased labelling of solutions as insightful. That increased interoceptive signals would lead to solutions points being experienced as more emotional, so with a greater feeling of Aha, and so be labelled as insight. No relationship was identified in this study, which was sufficiently powered to detect a medium sized effect.

However, Feldman-Barrett, Quigley, Bliss-Moreua and Aronson (2004) demonstrated that the relationship between uses of physiological signals in emotional experience may not be a simple linear one, with increasing access to physiological signals meaning increased emotional experience. They used experience sampling methods (see section 4.1.3 further description of ESM) to collect reports of everyday emotional experience and compared this to interoceptive accuracy (HBD). They assessed participants' ratings of different emotional adjectives to produce measures for each participant's focus on emotional arousal or valence. They found that participants with good interoceptive accuracy focused on arousal aspects of emotion, whilst those with poor interoception reported emotion in a different way. For insight then, very accurate heart beat counters may use this information to judge emotion, and so as predicted in hypothesis 8 label more solving as insight as a result. Participants with less accurate HBC scores, according to Feldman-Barrett et al.'s (2004) findings would use other cues in their experience of emotion and insight. This dichotomous relationship may be hidden in the comparisons made in this study.

The potential problems identified above (see section 5.4.3) with the measure of insight tendency would be equally problematic for this comparison. One study does report a test - retest for HBC over four weeks, finding a correlation of .58 (Mussgay, Klinkenberg & Rüddel, 1999). This would suggest that the HBC is a reliable measure, however this study used participants from clinical populations, so it would be desirable to corroborate these findings in a non-clinical sample.

5.4.5 Interoceptive Accuracy Versus Sensibility

Hypothesis 10, specifically aimed to compare the extent that participants experienced bodily reactions in relation to emotional situations in comparison to their abilities to actually and accurately detect their heartbeats, predicting a positive relationship between the two. No relationship was found which may seem surprising. However, similar findings have been seen comparing interoceptive accuracy with self-reported interoception, for example Häfner (2013) found no relationship between HBC abilities and various questionnaires that measured how conscious people are of their bodies. Mehling et al. (2012) developed the Multidimensional Assessment of Interoceptive Awareness (MAIA), a self-report questionnaire that encompassed nine sub-scales. These measured the extent that unpleasant bodily sensations were noticed, strategies for coping with them and the extent that bodily sensations are attended too and trusted. Calì, Ambrosini, Picconi, Mehling, and Committeri (2015) found that the MAIA measuring interoceptive awareness showed a low correlation to HBC accuracy (interoceptive accuracy). This can be seen to show a congruent disconnect between reported awareness of bodily signals and actual accuracy seen in this study. The BEQ item 7 specifically relates awareness of bodily changes to emotional experience while the MAIA focuses more specifically on interoception. However, examination of the MAIA sub-scales see some explicitly linked to emotion, for example the emotional awareness scale, seeing further parity with the results in this study.

5.4.6 Limitations and Future Directions

As highlighted in this discussion, a difference was identified in pre-solution HR change between insight and non-insight trials that might be considered a somatic marker for insight. A strength in this finding is that the insight and non-insight comparison was rendered using an established and widely validated method. However, it is not known whether findings will replicate in other tasks that elicit both insight and non-insight moments. Furthermore, the CRA only elicits positive insight moments (see section 5.1.1 for further discussion) meaning effects in negative insight are yet to be quantified. As such, one future direction (explored in the next study) will be to identify problem solving tasks that elicit positive and negative insight in order to compare results relating to heart rate change.

Findings with regards to speed of problem solving and accuracy were consistent with other studies using similar problem solving paradigms. However, these all elicit discrete solving episodes culminating in a solution (or timing out). Participants then begin solving a new and unrelated problem, with no feedback from the last. This is not how solving happens in real-life. As highlighted by the Fleck and Weisberg (2004, 2013) there is a continuum of solving where attempts to solve are made, mistakes identified and renewed attempts made in light of this new information. As such, the findings that have been shown in this study and in line with others could be explored in a more naturalistic solving situation (see Chapter 6).

One question that discussion regarding accuracy and insight highlighted in section 5.4.1 was that participants' ratings of certainty for solutions labelled as insight and search was not recorded. Moving forwards, where participants are making these distinctions, such ratings could also be collected. Danek et al. (2014b) included certainty as one of the phenomenological measures taken for insight solving, as such these scales could be adopted in future work to resolve this problem (see Chapter 6).

Some criticisms of HBC were further demonstrated as unfounded based on findings from this study. Firstly the lower baseline HR in more accurate HBC suggests that accuracy is not due to an increased signal (see section 5.4.4). Furthermore, the participants consistently counted below their actual heart beats. This contrasts to expectations should intuitive counting strategies have been employed. Together these provide further confidence in the interoceptive accuracy task used (heart beat counting).

Other questions tested in this study involving both HBC (interoceptive accuracy), BEQ (emotional expressivity) and proportion insight found null results for which theoretical explanations are discussed above. While conducted with a sample size rendering sufficient power to detect a meaningful effect, problems identified in terms of validity and reliability of the measures used mean conclusions should be drawn with care. Further validation of the tendency to report/ experience insight calculation would increase confidence in findings relating to this measure. Addressing questions of reliability, with a particular focus on the BEQ, but also for the HBC would again be useful to inform conclusions made about these results. These will be explored further in Chapter 6.

6 Psychological and physiological factors in Connect 4 Problem Solving

6.1 Introduction

6.1.1 Elicitation of negative and positive insight

As highlighted in section 5.4.6 the identification and verification of negative insight in everyday life presents a problem for current experimental methodology investigating insight in the laboratory. Current tasks only aim to elicit positive insight, although as discussed by Danek (personal correspondence) these are not universally experienced as positive. Accordingly new tasks need to be identified that elicit both positive and negative insight to enable controlled exploration and comparison between the two. Furthermore, it would be desirable to also produce comparable positive and negative non-insight, search experiences alongside insight to provide within participant comparisons of solving type (insight/ search) and valence (positive/ negative) in problem solving.

Section 3.4.5 identified that negative insight occurred not as the culmination of problem solving but often as problem identification to initiate problem solving attempts. It is therefore unlikely that negative insights will result from the established approach of presenting problems and asking participants to come up with solutions that they then label as insight or search solving. As such a task more akin to real-life solving may be necessary, relinquishing some control that stand-alone problem presentation affords. One potential experimental domain could be that of games, where the superordinate goal of winning is underpinned by a succession of moves against an opponent that could each be considered episodes of problem solving in determining the best move. Chess has been suggested to be a game that enables higher order cognitive processes such as decision making and problem solving and can be explored in a controlled yet naturalistic way (Charness, 1992; Connors, Burns and Campitelli, 2011; Gobet and Simon, 1996). It is a dyadic game where moves might be made positively building towards a winning position, or negatively to prevent an immediate loss (Leone, Fernandez Slezak, Golombek, & Sigman, 2017). This challenge saw the establishment of the de Groot (1946/65) paradigm to study chess expertise, presenting an established board and asking participants for their next move or testing their memory of the board. Whilst this gives a high degree of control, such a snapshot approach has been argued to not capture the true experience of playing a game of chess (Friedlander and Fine, 2016).

Leone, Petroni, Fernandez Slezak and Sigman (2012) compared expert chess players HR as they played rapid chess (time limited games) against online competitors. ECG recordings were made of nine players over 25 games. The game platform enabled measures of response time for the player's move and opponent's move to be recorded and marked on the ECG feed. An introspective review of game was conducted with the player reporting moves that were remembered as strategic, either identifying a goal or searching through moves and blunders (so where mistakes were made). The contrast made between the two types of strategic thinking could be seen as equivalent to the distinction made in this thesis between positive and negative solving but in the search domain rather than insight. Positive search, looking for the best move whilst negative search representing goal identification. Comparison of time series (5 seconds either side of move point) showed a HR deceleration prior to moves labelled as non-blunders that was not seen for those labelled as blunders. For opponent blunders a difference was seen in post move HR, with no rise for non-blunders but rise for blunders. HR time series are reported for search compared to non-search and goal-seeking compared to non-goal-seeking, but no direct comparisons made. This demonstrates the utility of dyadic games to explore somatic correlates of naturalistic problem solving and decision making.

However, this thesis focuses on everyday problem solving, not just in the sense of naturalistic solving situations, but in terms of everyday creativity in non-expert populations. Chess research, as seen above, typically explores expertise where skill differentials between players can be controlled for using Elo (1978) scores. Furthermore, to play chess a knowledge of different moves for each piece permitted is necessary excluding individuals who have never played before and making control, in terms of ability problematic for knowledgeable yet non-expert populations.

6.1.2 Connect 4.

A game like chess that sees players taking turns to move and elicits both positively and negatively motivated moves, yet requires less knowledge/ experience to play would be more suited for the purpose of this thesis. One such candidate is Connect 4. Players take turns to drop counters into a vertical grid, the standard version being seven positions wide and six deep. The counter falls to the lowest position, so the first to be dropped into a column will occupy the lowest row, otherwise it will sit above the previous counters in that column. The aim of the game is to be the first to get four adjacent counters in a line; this can be horizontally, vertically or diagonally. As such Connect 4 can be seen to be a relatively simple game, but also encompassing search strategies (Mańdziuk, 2012). Congruent to the distinction seen in positive insight elicitation tasks such as the CRA or magic tricks, decisions regarding a next move could therefore be arrived at through analytic means or in an experience of insight (Danek et al., 2014; Jung-Beeman et al., 2003b).

With a maximum of 21 moves leading to a full grid and stalemate, games of Connect 4 take far less time than chess, but retain the essential turn taking element to elicit positive, goal-orientated and negative, problem finding experiences during play. This study will therefore look to explore the feasibility of using Connect 4 to elicit positive and negative insight and search experiences. Little research has been carried out with Connect 4. Most that has falls in the applied computing field, looking at algorithms to compute the best moves to win (e.g. Allis, 1988). As such this study aims to develop the use of Connect 4 as a laboratory based problem solving paradigm with which to elicit positive and negative, insight and search experiences.

Connect 4 would furthermore appear to avoid some problems identified by previous research and in this thesis in using language-based problems (Sandkühler and Bhattacharya, 2008; Webb, Little and Cropper, 2016). Webb, Little and Cropper (2016) recently demonstrated that a reliance on language in classic insight tasks and CRA puzzles led to a reduction in solving accuracy for non-native language speakers. Tasks such as CRA and rebus puzzles as well as being language-based also often require knowledge of language use that is quite colloquial, very culturally specific and used infrequently in daily life. For example the Rebus puzzle, L U N A , with its solution being 'waning moon'; this is a phrase that someone learning English as a second language would be unlikely to be familiar with. Furthermore, Sandkühler and Bhattacharya, (2008) identified American English words included in the CRA developed in the U.S. may be unfamiliar to their European, English speaking sample. This demonstrates potential effects of local dialect within a population speaking the same language. All of the above demonstrates that the use of language-based tasks to elicit insight may mean that limited samples (for example excluding non-native speakers) would have to be used. Connect 4, with its simple rules that are not rooted in a particular language should provide a task that has much wider accessibility for participants.

Chapter 2 in this thesis identified different domains in which insight occurred, intellectual, personal and practical. Language-based tasks might be argued to fall in the realm of intellectual problem solving. Salvi et al. (2016) contrasted their language based tasks (CRA, anagrams and rebus puzzles) with a visual task, picture completion. Without a reliance on language it might be expected that this task be easier, but the contrary was found with the picture completion task showing lower accuracy, suggesting that this task may have been too difficult so likely to create floor effects. Many of the practical insights identified in Chapter 1 were of a visuo-spatial nature (see section 2.4.4.1), likewise playing Connect 4 can be seen to incorporate these aspects with participants competing in the visuo-spatio environment of the Connect 4 grid. As such, in addition to eliciting both positive and negative solving, Connect 4 also expands the domains in which solving experience is elicited.

6.1.2.1 Validity of Connect 4 as an experimental problem solving task.

A novel problem solving task such as Connect 4 would need to be checked, firstly in terms of validity to ensure it elicits the experiences that are predicted. As seen in other problem solving tasks such as the CRA or magic tricks (see section 1.1.4 and 1.1.5 for greater detail regarding the range of tasks used) participants are given definitions of the experiences they are then asked to report. Definitions for positive insight and search experiences are prevalent in the literature, however there is less available for negative insight (see Chapters 2 and 3). As such the definitions for negative insight used in this study will take into account findings from earlier studies in this thesis and align to the positive solving experiences in order for participants to label each solving experience (move made in the Connect 4 game).

In order to validate Connect 4 in this context it would need to reliably elicit the range of solving experiences consistently for participants. Further congruence could be sought by comparing findings relating to performance in Connect 4 with other insight eliciting tasks such as the CRA in the previous study in this thesis, and work of other research teams. Section 5.1.1 outlines these findings and particularly highlights the finding replicated in study 5 (see 5.4.1) that insight solving is faster than search based solving. This study will again provide an opportunity to measure the time taken to make each Connect 4 move and compare those labelled as insight to search.

In terms of valence there is no research specifically incorporating negative insight on which to build predictions regarding move times for positive compared to negative. However, findings from decision making research may be informative. Lejarraga, Hertwig and Gonzalez (2012) highlighted that decision making research had in the main tended to present all of the information pertinent to making a decision (termed by Lejarraga et al. (2012, p.335) as "decisions from description"). This they argued is unlike how decisions are made in real-life, where a search takes place to identify information relevant to the decision, termed "decisions from experience" (p. 335). Their research has focused on the factors that impact on the length of search undertaken before a decision is made. Taking Yates et al.'s (2003) definition that a decision is a "commitment to a course of action" (p. 15), in the context of Connect 4 each move represents the culmination of problem solving where a final course of action is arrived at (where to place the counter in the grid). The problem solving process, and so the length of search, perhaps could be considered in light of Lejarraga et al's (2012) findings. They identified that in conditions where loss is highlighted as more extensive (so longer) search is conducted compared to when gains are emphasised. This effect was recently replicated even in situations where a search was costly (so the more searching done, the greater the cost) (Lejarraga and Hertwig, 2016). Therefore in Connect 4, moves motivated by loss avoidance (labelled as negative in this study) might be expected to involve a more extensive search, and so take longer than moves motivated by gain (positively labelled moves).

However, in Study 2 it was identified that negative insights typically identified a problem akin to Csikszentmihalyi and Sawyer's (1995) Discovered Insight Problem Finding or Runco and Chand's (1995) Problem Finding. The identification of a specific problem, framed as awareness of impending loss in the Connect 4 context might be argued to provide a more concrete and immediate goal than the positive moves which are focused toward the superordinate goal of winning the game. As such, this might predict that negative insight see faster moves than positive.

6.1.3 Accuracy of Insight Compared to Search.

In Study 4 a comparison was made between the accuracy of solutions labelled as insight and search. In Connect 4, there are up to seven (number of available columns until they begin to fill towards the end of the game) choices for each move, none of which are dichotomously correct or incorrect, meaning an accuracy score cannot be calculated in the same way when using Connect 4. However, an indication of the cumulative quality of moves and solving decisions would be reflected in winning a Connect 4 game. Therefore a comparison of games won could be made to the proportion of moves reported as insight for each player. If, as suggested in previous studies (In Chapter 4 of this thesis, Salvi et al., 2016), insight solving is more accurate than search, individuals who experience more insight should overall make better moves and so win more games.

6.1.4 Validation of proportion insight against other measures/tasks

Section 5.4.3 discusses the lack of validation of the proportion insight measure used by Kounios et al. (2008) and in Study 4. One possibility is to compare tendency to report insight for different problem solving tasks and explore if there is a task effect, so explore if some elicitation tasks lead participants to report proportionally more or less insight than search. Alternatively and perhaps more pertinent for the individual differences approach that Kounios et al. (2008) and this research has taken is to compare within participant effects over different tasks. The repeat participants in this study provides the opportunity for such a comparison, investigating if proportion insight scores are similar for individuals in different problem solving tasks.

6.1.5 Phenomenological self-reports

Danek et al. (2014b) aimed to further explore insight experiences elicited by their magic trick paradigm using post task ratings for fastness, certainty, pleasantness (referred to as happiness in their write-up), surprise and impasse (see further detail in section 1.2.3.1). They found that participants mean ratings were highest for happiness (pleasantness), followed by surprise, certainty, suddenness then impasse. However they only obtained ratings for solutions identified as insight, so no comparisons were possible to search type solving. This current study provides an opportunity to replicate these ratings and obtain comparisons not only for solving type, insight versus search but also for positive compared to negative solving. The rating of pleasantness will additionally provide verification that the participants' distinctions between positive and negative moves made whilst playing Connect 4 were rated as such when reflecting on the playing experience afterwards. The rating for suddenness will further provide an interesting comparison to the behavioural measure of move time discussed above (see section 6.1.2.1) exploring whether participants perceptions of suddenness for the different types of solving map to their actual move times. In terms of certainty, it has been suggested that this is one of the hallmarks of insight (for a more complete discussion see section 2.4.3.1), with everyday accounts of insight shared in Chapter 2 often encompassing certainty in their descriptions (see section 2.3.2.7). Section 5.4.1 highlights that certainty in insight compared to search may relate to confidence ratings such as feelings of warmth. The gradual increases in FOW seen for search solving over time reflect an increasing certainty about the problem solving attempt and solution being worked toward. This can be compared to relatively static FOW until the insight moment where a jump in FOW reflects the awareness of a solution accompanied by high certainty (Metcalfe and Weible, 2007 but also see section 5.4.1 for commentary on this in light of more recent findings). A measure of certainty in Connect 4 solving will again identify if similar experiences are seen for this paradigm as in previous insight tasks. The least applicable scale to this study is the rating of impasse. This would seem to be meaningless in the context of Connect 4 where participants are not seeking a single 'correct' solution (strictly convergent problem solving), so the feeling of getting stuck on the problem is unlikely (for full discussion of impasse see section 1.1.5.3). Furthermore, whilst many have asserted that impasse is important (or necessary) for insight, in terms of phenomenology as highlighted above by Danek et al. (2014b) who demonstrated that it is the least important aspect. Therefore, taking Danek's (2014b) view (see also section 1.1.5.4 for discussion on insight without impasse), Connect 4 is considered appropriate for insight elicitation and the ratings of impasse will not be necessary

6.1.6 Heart Rate Changes for Insight and Search and Positive and Negative Solving.

6.1.6.1 Replication of findings from Study 4 (Chapter 5).

Study 4 demonstrated a biphasic mean change HR response over time in positive problem solving. As seen in Figure 5.1 for both insight and search solving there was an initial deceleration leading up to the point of solution when a subsequent acceleration was then seen. This finding was discussed in section 5.4.2 in relation to its congruence to HR patterns over time during exposure to emotional, salient or surprising stimuli (Bradley, Codispoti, Cuthbert & Lang, 2001; Guerra et al., 2016). The difference in mean HR change saw a smaller (negative) change for insight solutions than search, linking this finding to research showing stunted biphasic responses for positive and surprising events (Guerra et al., 2016; Lackner et al, 2013). However, no previous research has explored heart rate in relation to negative problem solving or problem finding. Connect 4 provides the opportunity to measure and compare HR change for both positive and negative insight and search moves, so enabling to replicate and extend the findings reported in Chapter 5.

6.1.6.2 HR in negative and positive emotion elicitation

Theoretical models and research comparing physiological activity during processing of emotional stimuli generally suggest that there is a greater negative HR change seen in response to negative stimuli compared to positive (for example Bradley et al. 2001) (see 5.1.3.2 for further evaluation of this). Bradley et al. (2001) related physiological responses whilst viewing emotional pictures to the defence cascade model (Lang et al., 1997). This draws on an evolutionary, functional explanation for animal responses to aversive and appetitive stimuli. The model proposes a graded response to stimuli over time and in relation to the proximity of the stimulus. An initial orientating response is seen, where information about the stimulus is processed. This sees a reduction in HR, a moderate increase in EDA and dampened startle response. As such both the parasympathetic and sympathetic nervous system are activated. For negative stimuli, the freeze orientating state would move to activation as the proximity of the threat increases, this move to activation sees an increase in heart rate and further increases in EDA. In addition, a facilitated eye blink startle response would be seen reflecting increased attentiveness to the whole environment in light of the threat. However, where there is no immediate increase in threat proximity but the threat remains, a sustained period of cardiac deceleration would be predicted (fear bradycardia e.g. Kapp, Frysinger, Gallagher and Haselton, 1979). Bradley et al. (2001) suggested that viewing affective pictures likely reflects such a situation, as viewing aversive images sees no increase to the immediate threat detected (the picture is unchanging) negating the trigger of later responses in the cascade.

For pleasant appetitive stimuli, Bradley et al. (2001) again asserted that an orientating response would be reflected in an initial HR deceleration, cascading to action to approach the stimulus so then a HR acceleration (for example in the case of food or a (bonded or sexual) mate). Their results, later corroborated by Pollatos and Schandry (2008), see a mid-interval acceleration of HR subsequent to the initial orientating response leading to a triphasic pattern of HR response to positive stimuli. Bradley et al. (2001) are unsure of the explanation for this, positing that it possibly reflects success in the recognition/ coding process. This might explain the differing results seen for the effects of valence on HR depending on the measure used (see Figure 5.2 for details of different HR measurements taken in different studies). Measures of maximum negative HR change would therefore discriminate between the sustained cardiac deceleration seen for negative images compared to a reduced maximum deceleration for positive stimuli due to the mid-interval acceleration. When measuring maximum positive HR change, this would detect the intermittent increase in HR observed for positive pictures not seen for negative stimuli. However, rather than take a snapshot approach, it would seem preferable as done previously in Chapter 5, to measure and compare HR changes through time during an emotional event. This is particularly pertinent where not only mean HR changes but also the pattern of heart rate change may be useful in the discrimination of different valenced emotions.

In terms of negative and positive problem solving, drawing on the perspective of Shen et al. (2015) who saw insight as an endogenous emotional event, it might be expected to see comparable HR change patterns for positive and negative solving, so a bi-phasic for negative solving and triphasic for positive. However, it must be noted that results from Study 4 (see section 5.3.2) saw a biphasic response despite both insight and search experiences incidences that were assumed to be positive insight. However, no checks were made on this assumption. The use of phenomenological ratings (as described above in section 6.1.5) including the measure of how pleasant participants found each type of solving should provide such an assurance and so will be used in this study (see also section 6.1.5).

6.1.7 Emotional expression - BEQ

Chapter 5 (section 5.4.3) highlighted some questions regarding the test-retest reliability of the Berkeley Expressivity Questionnaire (BEQ). Data collection for this study takes place approximately a year on from that in Study 4.The repeated collection of data in the same location provides an opportunity to target individuals who participated in the previous study and so explore this property of the BEQ. In addition it will also render a replication of the result seen in Chapter 5 (section 5.3.3), comparing emotional expression to problem solving behaviour.

As Connect 4 will likely facilitate both positive and negative solving (see section 6.1.2), in addition to considering overall expressivity, a further comparison with the positive and negative subscales of BEQ can be made. These subscales represent the tendency to express behaviours related to positive or negative emotion, recognising that there are individual differences in these tendencies (Gross and John, 1997). As such a tendency towards expressing positive emotional behaviours may relate to the Aha moment when solving a problem and expressing negative emotional behaviours likewise be linked to Uh-oh moments during problem identification.

6.1.8 Interoception - HBC

As discussed in section 5.4.6, long term test-retest data for HBC accuracy would also be desirable for a non-clinical sample. Mussgay, Klinkenberg and Rüddel (1999) demonstrated a significant correlation between test-retest HBC accuracy over a four week period in a clinical sample. The use of repeat participants in this study as discussed in 6.1.7 should enable further longitudinal comparisons to be made. In addition, the prediction of a relationship between HBC and insight labelling made in Study 5 can again be tested against a novel insight elicitation task offering replication of the previous findings (see section 5.3.4).

6.1.9 Rationale

As outlined above this study therefore aims to offer a replication of findings from Study 4 using a novel problem solving task, Connect 4. In addition, as highlighted in section 6.1.2 this provides the opportunity to extend analysis to compare both positive and negative valence in the elicited insight and search solving experiences. Accordingly, Hypothesis 1 suggests there will be a difference in speed of moves reported as the different types of solving. Specifically predicting that moves reported as insight are predicted to be faster than search (Hypothesis 2) while positive moves will be faster than negative (Hypothesis 3).

As identified above in section 6.1.4, validation of within person proportion of insight scores is desirable, as such Hypothesis 4 aims to compare proportion of insight scores for participants in the CRA to Connect 4, predicting that there will be no difference in the proportion of insight reported between the two tasks.

In study 4 predictions were made and tested regarding the number of errors labelled for different solving. However, unlike the CRA, the Connect 4 problem solving task does not present convergent problems with a correct/ incorrect response, as such a comparable hypothesis would be meaningless for this study. However the overall wins/losses of Connect 4 should be indicative of the quality of the individual problem solving seen in the moves made, as such Hypothesis 5 suggests that participants who experience more insight (proportionally) will win more games.

Furthermore, as highlighted in section 6.1.5 phenomenological ratings following Danek et al. (2014b) will also be collected to verify the self-report solving valence as well as provide comparisons regarding the experiential aspects of different solving types. Hypothesis 6 predicts that insight moves will be rated as more sudden (fast) than search, likewise negative moves more sudden (fast) than positive. This provides a direct comparison of perceived suddenness to actual behavioural responses. Hypothesis 7 and 8 relate to pleasantness. The former providing a check on assumed experience for the different valence labels (as per section 6.1.6), expecting positive moves to be rated as more pleasant than negative. Furthermore, the latter (Hypothesis 8) expects that the Aha moment seen alongside positive insight solving will be rated as more pleasant than positive search, while negative insight and its accompanying Uh-oh feeling will be more unpleasant (so lower pleasantness rating) than negative search. Likewise, because of the Aha or Uh-oh moments, insight solving is predicted to lead to greater surprise than search (Hypothesis 9). In line with discussions relating to confidence and certainty (see 6.1.5), Hypothesis 10 predicts that insight will be rated as more certain than search.

Predictions regarding heart rate change (ΔHR) again aim to firstly replicate findings from Study 4 for a different problem solving task. Accordingly, Hypothesis 11 states that mean ΔHR will alter over the problem solving period, whilst Hypothesis 12 asserts there will be different mean ΔHR in insight and search trials. As highlighted above, the elicitation of solving experience with different valence affords additional exploration, Hypothesis 13 therefore asserts that there will be a difference in ΔHR for positive and negative moves. The different patterns of ΔHR (biphasic versus triphasic - see section 0) seen in relation to negative and positive emotion suggest that mean ΔHR will alter over time in different ways between insight and search moves and positive and negative moves (Hypothesis 14).

For BEQ, Hypothesis 15 expects there to be no difference between individual scores (BEQ_{total}) for participants taking part in study 4 (time 1) and this study (time 2). Higher BEQ scores are expected to be associated with increased labelling of moves as insight (Hypothesis 16). As discussed in section 6.1.7, it is expected that as $BEQ_{positive}$ increases so too will the number of moves labelled positively (as positive insight or positive search) (Hypothesis 17), likewise as $BEQ_{negative}$ increases, then the number of negative moves will too (moves labelled as negative insight or negative search) (Hypothesis 18).

A check to ensure there was not more availability of signals in more accurate heart beat counters will be made, therefore Hypothesis 19 tests that there will be no difference in HR between more and less accurate heart beat counters. Checks for test-retest reliability in HBC will also be made, with Hypothesis 20 expecting no difference in repeat participants' HBC accuracy at the two. Analogous to predictions in Chapter 5 (section 5.1.8), Hypothesis 21 predicts the higher HBC accuracy will relate to increased labelling of solutions as insight. Likewise, if correlations are seen in Hypotheses 18 and 21, the extent that each of these variables predict decisions in labelling of solving experience will be tested with the prediction that HBC and BEQ will contribute differently to predicting these decisions (Hypothesis 22). Also replicating comparisons made in Study 4, Hypothesis 23 asserts that there will be a positive association between HBC accuracy and BEQ ratings for item 7.

6.2 Method

6.2.1 Participants

Participants were recruited via advertisement within the University and local community and on social media. As it required face to face data collection participants needed to be local to the university. In total, 80 participants (54 of which were female, $Mean_{age}$ = 30.63 years, SD_{age} = 12.64, $range_{age}$ 18 - 66 years) were recruited. The number of participants required was calculated a priori, based on effect sizes seen in previous research using G*Power (see Apendix 3).

To enable longitudinal comparisons, repeat participants (N = 25) were targeted from those who took part in Study 5 (time between participation, M = 361 days, SD = 69). In contrast to the CRA, there were no language or difficulty limitations identified in playing Connect 4. As such the participation criteria widened the sample recruited to include those who were non-native English speakers and non-students. A breakdown of participants by these demographics are shown in Table 6.1. All participants gave informed consent, had the right to withdraw and were debriefed at the end of their participation.

Table 6.1 Number of participants in different demographic groups.

	Students	Non Students
Male	13	13
Female	33	21
Native English speaker	36	31
English additional language	10	3

6.2.2 Materials and apparatus

To allow comparison between results collected in this study to those in the previous (Chapter 5, see section 5.2.2) the same materials and apparatus were used, in the same way with the exception of the problem solving task employed (Connect 4 instead of CRA). See section 5.2.2 for methods relating to Materials; Insight Log, Emotional Expression (Cronbach's Alpha, α = .82 for the BEQ in Study 5 again being seen as good [Nunnally, 1978]) and Heart Beat Counting and Apparatus; Heart Rate Monitor and Stimulus Presentation Software.

6.2.2.1 Connect 4.

As outlined in section 6.1.2 Connect 4 was identified as a likely task to elicit positive and negatively motivated moves arrived at through insight or search (non-insight) experiences. However, very little research has been conducted using Connect 4, and none in psychological experimental contexts. As such a commercially developed, computer based version of the game was used, Connect Four Fun developed by TMSoft (tmsoft.com, copyright 2008-2016). The game has single player or two player options, the former being used in this study. The 'night' theme was selected and used for all participants due to its relatively neutral background. The single game setting was used as this meant the player always made the first move and the level of difficulty could be designated because the game also gives options in its settings to choose the level played at: easy, medium, hard, pro and expert. The multi-game settings alternated opponent according to the previous winner and that could possibly introduce confounds to results.

The game is played as subsequently described. In order to drop a counter into the chosen column the player needs to click on it. The counter then drops with the computer's move immediately following (and taking less than one second). On either the player or computer getting four in a row the game stops and the winner is identified. The game must then be re-set manually to play again. The number of wins/losses were therefore not remembered in the Connect 4 game, so were recorded manually by the researcher.

6.2.2.2 Phenomenological self-reports.

Phenomenological self-reports were collected through PsychoPy using a visual analogue scale to record the point on a line between two extremes, giving a measure between zero and one. The labels for the line, and corresponding question were delivered at random. For each type of solving (positive and negative, insight and search) ratings were collected for pleasantness, surprise, fastness and certainty, following Danek et al (2014b). The questions asked were adopted as shown in Table 6.2, reflecting the different task that participants had undertaken (moves in the Connect 4 game in this study compared to solving magic tricks in Danek et al. [2014b]).

Table 6.2 Questions asked of participants providing phenomenological ratings for the different solving types.

Phenomenological rating	Question	Label for extremes 0	Label for extremes 1
Pleasantness	Please rate your *positive insight* experience:	unpleasant	pleasant
Surprise	Please rate your *negative insight* experience:	not surprising	surprising
Fastness	The *negative search* idea came to me:	slowly	quickly
Certainty	I felt about the ideas I had through *positive search:*	uncertain	certain

Note: *italic* terms changed according to type of problem participants were rating: positive insight, positive search, negative insight or negative search.

6.2.3 Procedure

The same procedure was followed with participants as in Study 4 and described in section 5.2.4, but instead of the CRA task participants played Connect 4. Instructions were given regarding playing Connect 4 at the beginning of the experiment in the same way as CRA instructions described in 5.2.4. Participants were advised that Connect 4 is a game played in pairs (or in this case against a computer) where players take turns in dropping counters in a grid. They were told that the winner has to get four in a row, with the horizontal, vertical and diagonal configurations demonstrated by the researcher on a picture of the Connect 4 grid. Participants were informed that they would be playing two blocks of three games (so six games in total) and could choose the difficulty level (see 6.2.2.1) they played at for each block. Finally experiences were outlined as shown in Table 6.3, and participants were informed that they might notice these while they played. These descriptions were based on definitions given in the CRA for positive insight and search, but with the detail reduced to account for the four way choice being given in this study.

Table 6.3 Solving type descriptions given to participants playing Connect 4.

Solving type	**Description**	**Cue available whilst playing**
Positive insight	You suddenly have an idea for your next move or how to win	Aha
Positive search	You work out your next move or how to win	I've worked out a good move
Negative insight	You suddenly see a problem or that you are in danger of losing	Uh-oh
Negative search	You work out a problem or that you are in danger of losing	I've worked out there's a problem

When it came to playing Connect 4, participants were reminded of the instructions and definitions. As they played, at the point they decided on their next move participants were asked to press the button on the HRM watch, recording a lap time at this point. They were then prompted to tell the researcher which process they used to arrive at their decision (Table 6.3) and indicate the move they had decided upon (which column to drop the counter). Whilst playing, a summary of the four solving types, plus the option to indicate a move that was for none of these reasons was displayed to remind participants. Participants played a practice game with the computer set to 'easy'. This enabled them to get used to playing against the computer and the procedure of pressing the button on the watch to indicate they had decided upon a move and then pointed to the solving type and column. During the practice, participants were able to verify with the researcher anything they were uncertain about, for example the definitions of solving type. The participant was then able to choose the level they wished to play their first block (three games) at. As they played the researcher recorded the solving type for each lap time, and then made the move indicated. The final outcome of each game (win, lose or draw) was also recorded. Whilst playing the cursor is visible on the screen, therefore the researcher left the cursor in the position of the last move made (i.e. over the column of the last move), to avoid cueing the participant in any way. The participant was positioned facing the screen with the reminder sheet in front of them. They were seated next to the researcher, so no unintentional cues from eye movement etc., could be detected by the participant whilst playing the game. After three games the participant had the opportunity to stay on the same level or change. The final three games were then played following the same protocols.

As outlined in section 5.2.4, the second set of heart beat counting data was immediately collected. A final addition from the procedure seen in Chapter 5 asked participants to rate the different solving experiences they had reported whilst playing Connect 4 on the computer using the Phenomenological self-reports described in section 6.2.2.2. Participants then removed the HRM and were de-briefed, again in the same way as outlined in section 5.2.4.

6.2.4 Data Clean-up Protocols

Data clean-protocols employed in Chapter 5 (see section 5.2.5) for the tasks repeated in this study were followed to enable direct comparison of longitudinal data for repeat participants.

6.2.4.1 Heart rate during Connect 4.

Data from the first move made in each game was not included as there was additional time associated with setting up the new game. Furthermore, first moves tended to be made due to habit, for example "I always start in the middle" whilst subsequent moves reflected the participants' in-game problem solving that the task aimed to elicit. It was initially planned to take mean recorded heart rates for the five time points (approximately 5 seconds) before and after the lap time recorded for each move in line with the time series used in Chapter 5 (see section 5.2.5.3). However the mean time for each move was 11.6s, (range 5.5 - 19.1s), so using the same time frame would mean overlap between moves in the heart rate comparisons, as such the timeframe was reduced to 3 seconds. As in Chapter 5 (see section 5.2.5.3) measures of heart rate whilst problem solving (playing Connect 4) were compared to the participant's baseline heart rate and average time series for heart rate change (ΔHR) were then calculated for each type of solving (positive and negative, insight and non-insight). In addition, the time taken for each move (time of lap reflecting time from previous button press) was recorded to again give averages for each type of move.

6.2.5 Analysis of data

The same analysis of data protocols were employed in this study to those of the previous as outlined in section 5.2.6.

6.2.6 Ethical considerations

As highlighted above, procedures outlined in Chapter 5 were followed in this study, including the ethical considerations outlined in section 5.2.7.

6.3 Results

6.3.1 Solving experiences elicited by Connect 4

Table 6.4 shows the range of solving types experienced by the participants whilst playing Connect 4. Nearly two thirds of participants experienced all four solving types, whilst over 90% experienced at least three.

Table 6.4 Breakdown of participants' reported solving as positive insight (+i), positive search (+s), negative insight (-i) and negative search (-s).

Reported	Nos. of participants		+i	+s	-i	-s
4 solving types	**54**		✓	✓	✓	✓
3 solving types	**19**	6		✓	✓	✓
		1	✓		✓	✓
		5	✓	✓		✓
		7	✓	✓	✓	
2 solving types	**6**	2		✓		✓
		2	✓	✓		
		2		✓	✓	
1 solving type	**1**			✓		

In terms of overall performance, participants on average won 3.1 games (SD = 1.5), the number of participants and the number of wins is shown in Figure 6.1 Visual inspection of the frequency distribution suggests that Connect 4, played at self-determined difficulty produces winning scores that are generally normally distributed.

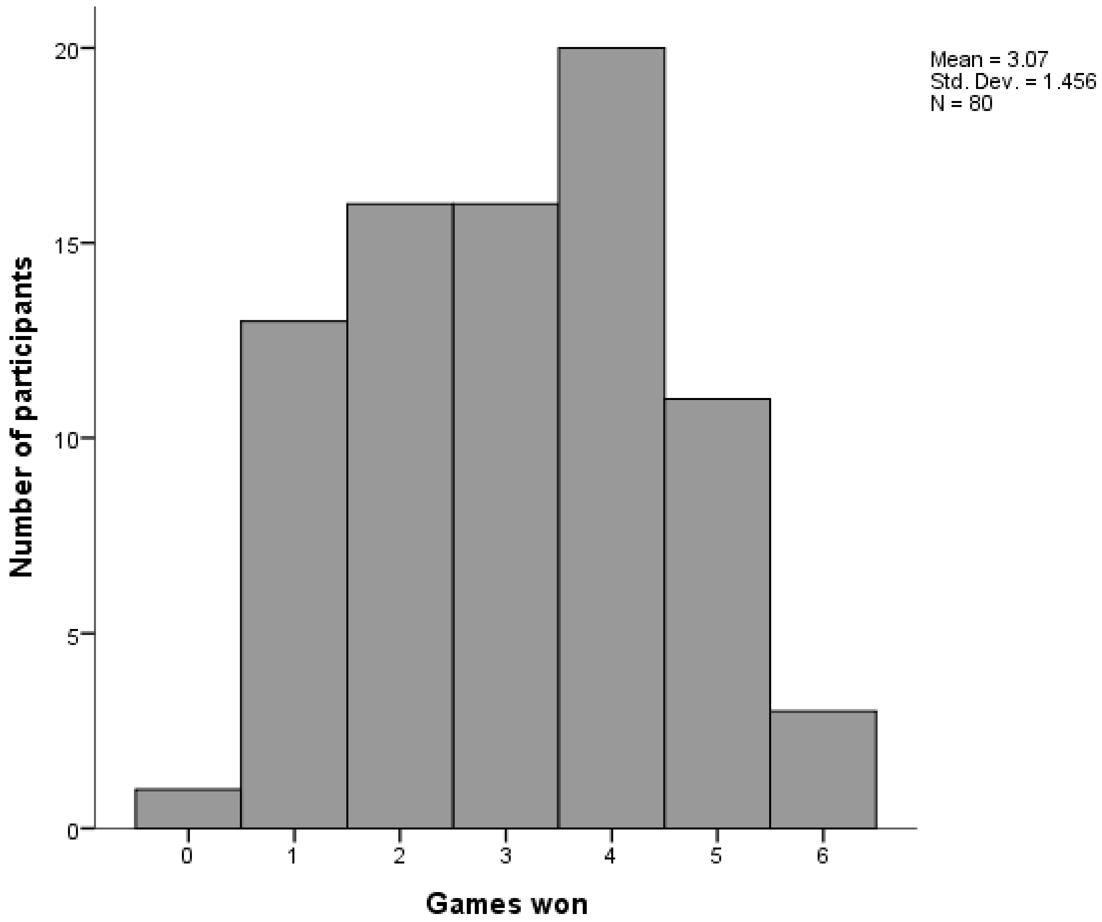


Figure 6.1 Frequency distribution of participant's wins in Connect 4

6.3.1.1 Speed of moves in Connect 4.

The overall mean time for a move across all participants for which move time data was available (N = 71) was 11.6s (SD = 4.4, range 5.5 - 19.1s). For nine participants the HRM lap presses did not map to the recorded moves made by the researcher so were not verifiable, these were therefore excluded from move time comparisons. Examination of normal Q-Q plots and tests of normality were conducted on the mean move times recorded for the data of 45 participants who reported all of the problem solving experiences: positive insight, positive search, negative insight and negative search. These identified that none of the measures were normally distributed (all rendering significant Shapiro-Wilks test results). Outliers were identified for each of the measures, and two that were identified for more than one variable were excluded. Exclusion of all the outliers for each individual variable would have reduced the sample size, so taking this into account and with regards to Field (2016) (see full description in section 5.3.1) the move time data was assumed to be normally distributed and parametric tests used for the analysis.

A repeated measures ANOVA compared move time (seconds) for solving type (insight versus search) and valence (positive versus negative). A significant main effect of solving type was seen, $F(1, 42) = 25.37$, $p < .001$, $\eta^2 = .07$. Mean solving time for insight was 9.9s (SE = .45) compared to 11.9s (SE = .51) for search moves where the difference was 2.0s, 95% CI [1.19, 2.78]. According to Cohen (1988) the effect size can be interpreted as moderate, in addition a confidence interval that does not include zero provides further support for this effect. The confidence interval suggests that insight moves were on average faster by at least a second, as shown in Figure 6.2. There were no significant main effects of valence or interactions between valence and solving type.

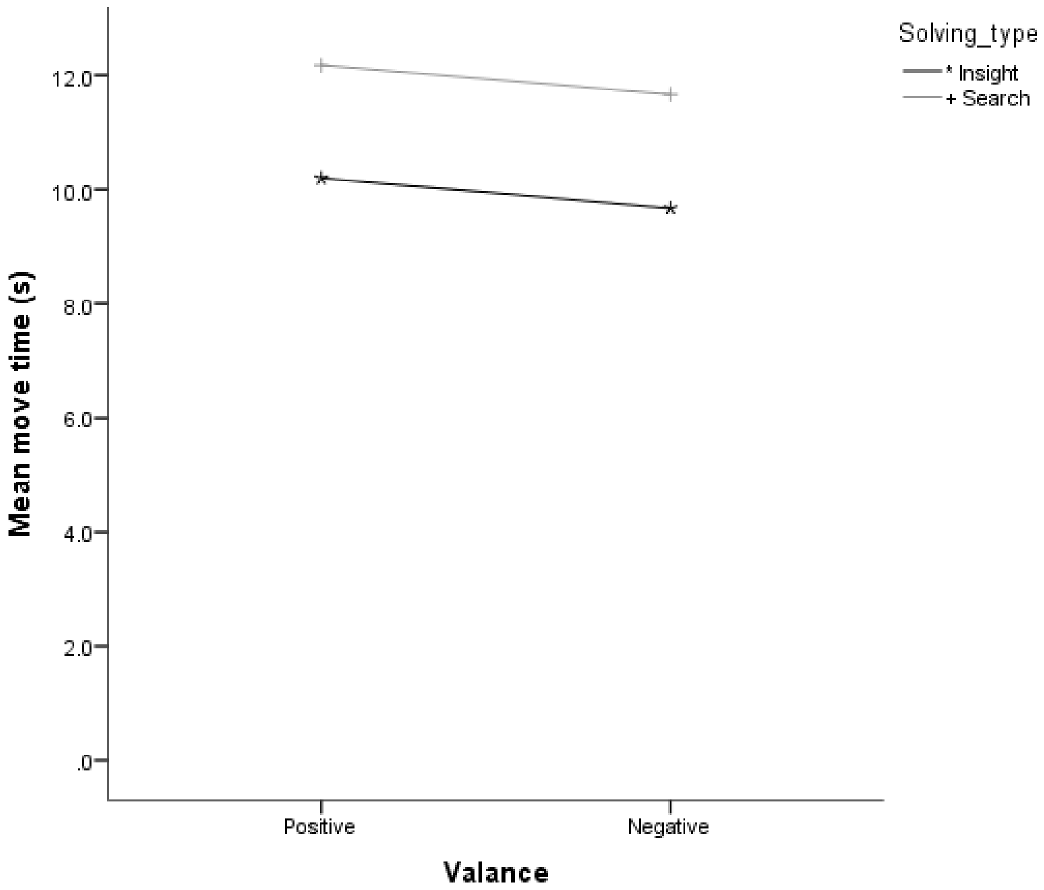


Figure 6.2 Graph to show mean time for Connect 4 moves identified as positive and negative insight and search.

6.3.1.2 Proportion of insight in CRA and Connect 4

The proportion of moves reported as insight compared to search (non-insight) was compared for the participants who completed both Study 4 and 5. Two outliers were removed, one who reported no insight experiences in the CRA, and a second who almost exclusively labelled moves in Connect 4 as insight (proportion of insight score = .95). With a smaller sample size, considerations of normality are more important (Field, 2016), removal of the two outliers rendered data normal according to the Shapiro-Wilkes test and inspection of the normal Q-Q plots.

A repeated measures t-test demonstrated a significant difference between the mean proportions of insight, $t\ (22) = 7.32$, $d = 2.25$, $p < .001$. The mean proportion of insight for the CRA task ($M = .63$, $SD = .22$) was higher than for Connect 4 ($M = .22$, $SD = .15$). The mean difference was .41, 95%CI [.30, .53]. Remembering that this is comparing proportions, the difference between tasks can be considered large.

The association between an individual's proportion reported as insight for the CRA was compared to Connect 4. No association was seen, $r = .09$, 95%CI [-.34, .48], $p = .70$, $N = 23$ as demonstrated by visual inspection of Figure 6.3 and a low r value with confidence intervals that cross zero.

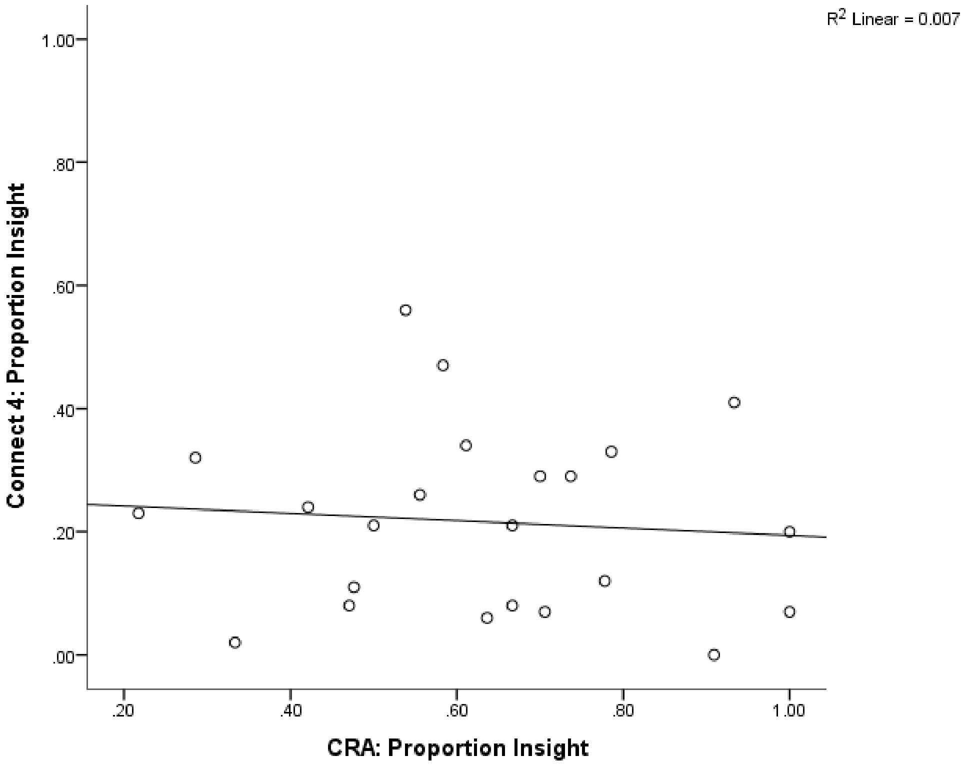


Figure 6.3 Proportion insight seen in CRA and Connect 4

6.3.1.3 Individual differences in solving type and winning in Connect 4.

The proportion of Connect 4 moves reported as insight compared to search was calculated (as described above in 6.3.1.2). Tests identified a single outlier, examination of this participant's data showed almost exclusive identification of trials as insight which is unlikely, more likely is a misunderstanding of instructions or definition of insight, therefore this data was excluded from analysis.

There was no association between proportion of insight moves and number of wins in Connect 4, r = .09, 95% CI [-.13, .31], p = .21 as demonstrated by a low r value and confidence intervals that included zero, and shown in Figure 6.4.

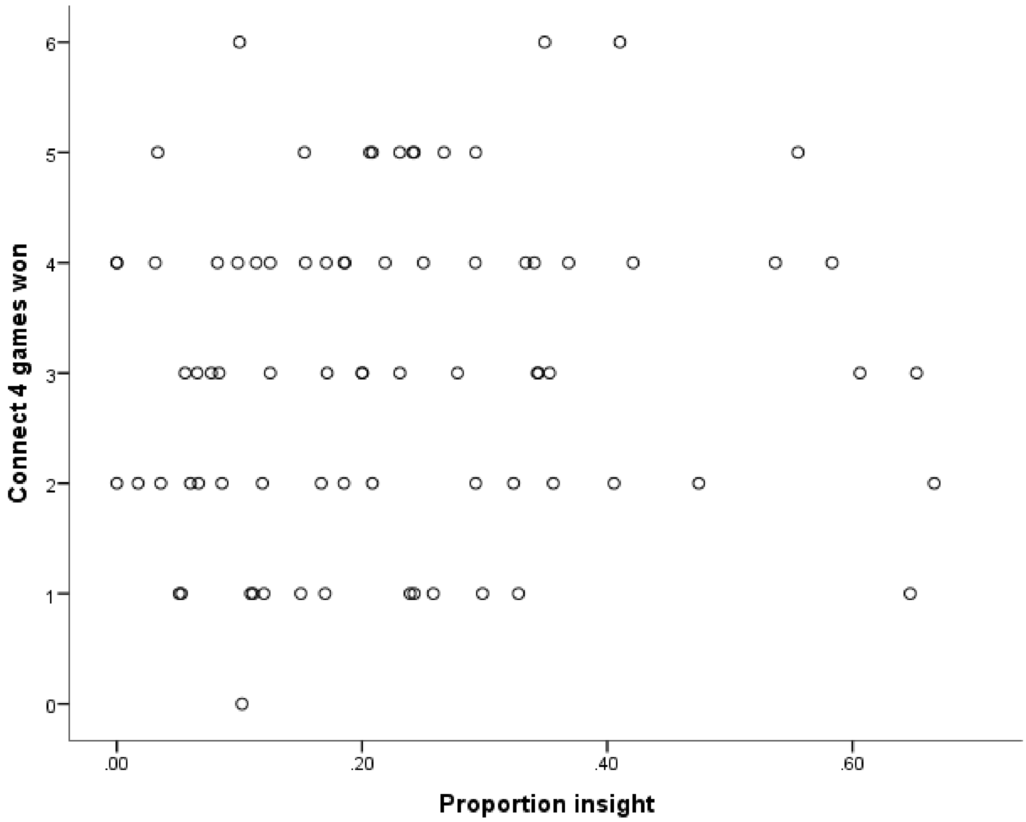


Figure 6.4. Scatter graph comparing proportion of insight reported by participants with their Connect 4 wins.

6.3.1.4 Phenomenological ratings.

Fifty four participants reported all four types of solving (positive insight, positive search, negative insight and negative search) to enable direct comparison of their ratings for these. An outlier was identified for one participant's rating for pleasantness of positive insight (rated as 0.37), this was removed from the analysis of pleasantness. Tests of normality and visual inspection of Q-Q plots identified that some of the phenomenological ratings were not normal, however (apart from the aforementioned) no outliers were identified that could be removed to correct the data. Furthermore, as per section 5.3.1 with the sample size seen here the data was assumed to meet assumptions of normality so parametric analyses were performed.

Perceived move speed, in a rating with extremes of fast (score of 1) and slow (score of 0) was analysed in a repeated measures ANOVA for solving type and valence. There were no main effects of valence or interaction effects. There was a significant main effect of solving type, $F(1,53) = 15.1$, $p < .001$, $\eta^2 = .07$. Mean fastness was greater for insight (M = .65, SE = .03) than search (M = .52, SE = .02), the mean difference was 14, 95%CI [.07, .21]. The standardized effect size might be interpreted as moderate (Cohen, 1988) however examination of the confidence intervals of the mean difference suggest that while they do not pass zero, as shown in Figure 6.5 the difference is small when considered in real terms and the range of the possible ratings provided.

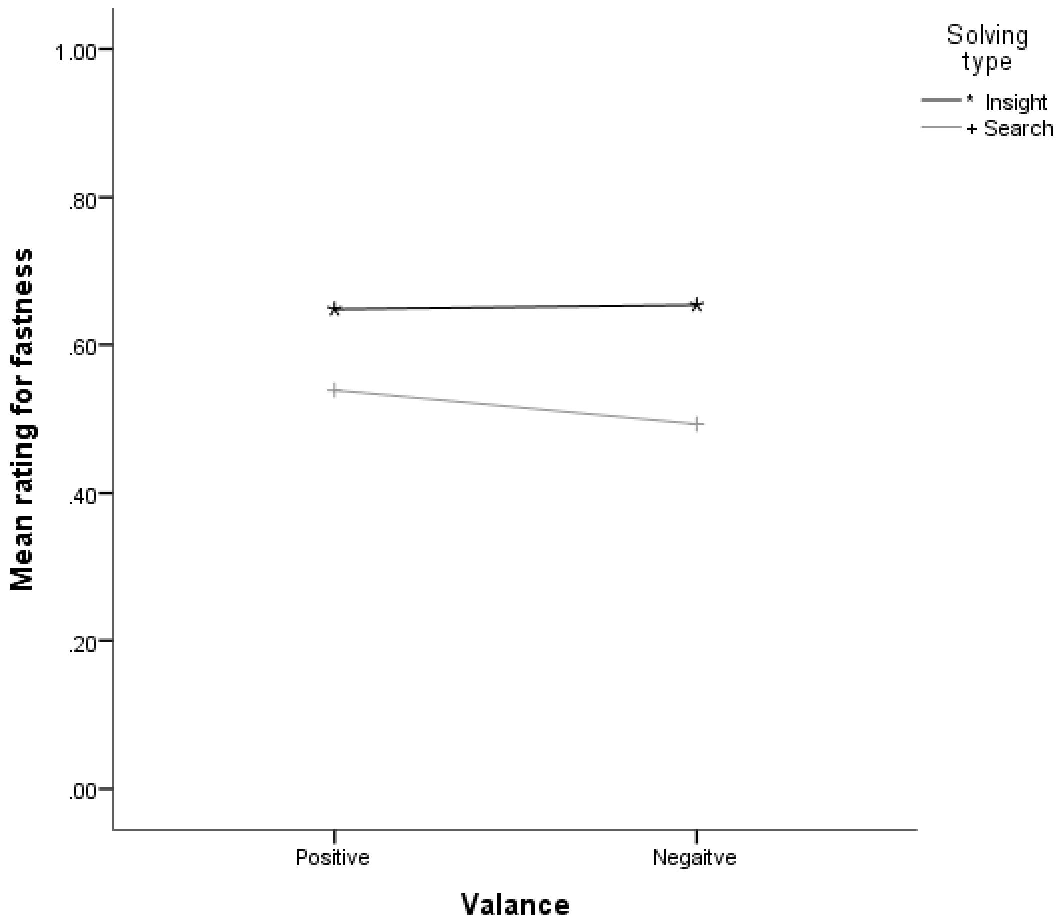


Figure 6.5 Mean ratings for fastness for solving type (insight / search) and valence (positive/ negative). Note extremes of visual analogue scale were labelled, slow - 0 and fast - 1.

A repeated measures ANOVA compared ratings of pleasantness for solving type and valence. A main effect of valence was identified, $F(1, 52) = 162.09$, $p < .001$, $\eta^2 = .57$. Positively labelled moves were rated as more pleasant (M = .78, SE = .02) than negatively labelled moves (M = .33, SE = .26), with a difference in pleasantness ratings of .45, 95% CI [.38, .52]. Such a standardized effect size would be seen as large (Cohen, 1988). Furthermore, the confidence intervals of the difference in ratings indicate that there was a real effect of valence on pleasantness reported. There was no main effect of solving type, however a significant interaction was suggested, $F(1, 52) = 9{,}15$, $p = .004$, $\eta^2 = .01$. Interpreting the standardized effect size, this might suggest a small effect. However, examination of the interaction plot in Figure 6.6 shows that positive insight ratings were seen as more pleasant than positive search while negative insight ratings were seen as more unpleasant than negative search.

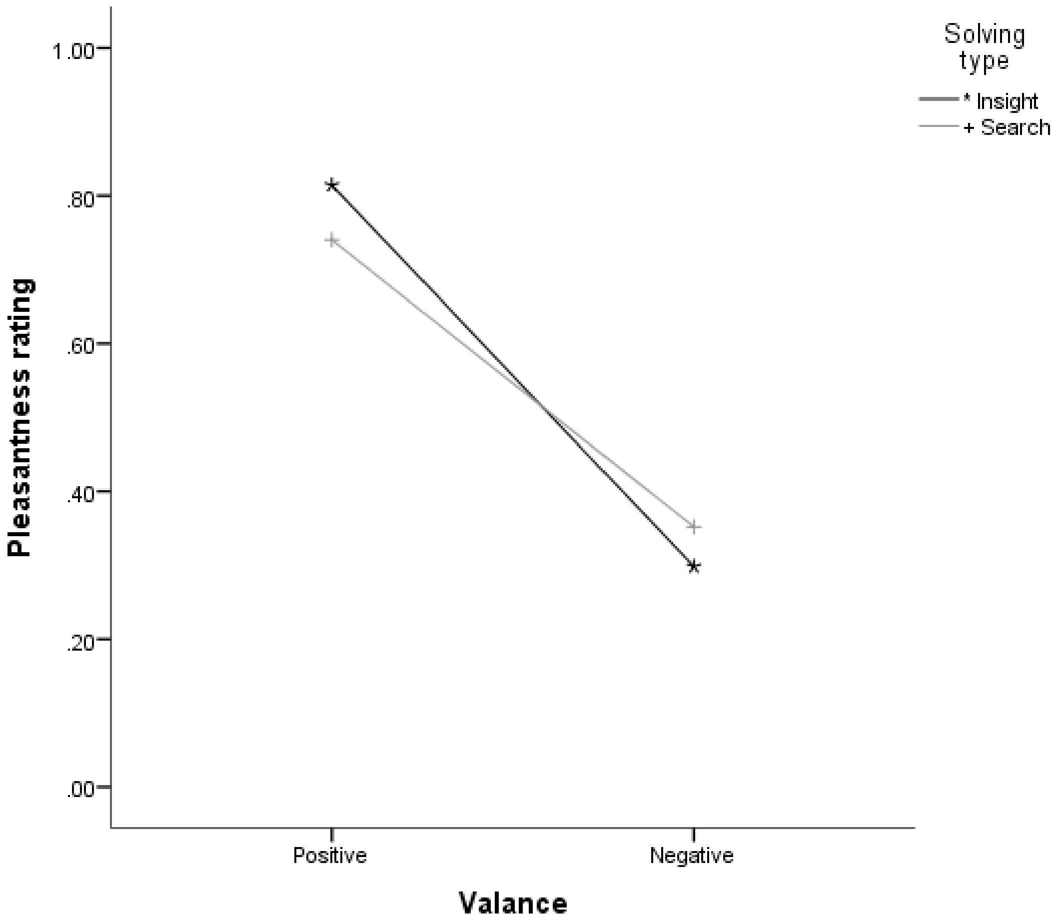


Figure 6.6 Pleasantness ratings for positive and negative insight and search moves. Note ratings were made on a visual analogue scale with extremes labelled as 1 - pleasant and 0 - unpleasant.

A repeated measures ANOVA explored solving type and valence effects on ratings of surprise. There were no main effects of valence or interaction effects for valence with solving type seen. There was however a main effect of solving type, F

(1,53) = 13.52, $p = .001$, $\eta^2 = .05$. Insight solving was rated as more surprising (M = .57, SE = .03) than search (M = .45, SE = .02). The mean difference in ratings was .12, 95%CI [.06, .19]. So while this is seen as significant, and the standardised effect size may be interpreted as moderate, the actual range of difference highlights a relatively small effect with insight solving being slightly more surprising than search as seen in Figure 6.7.

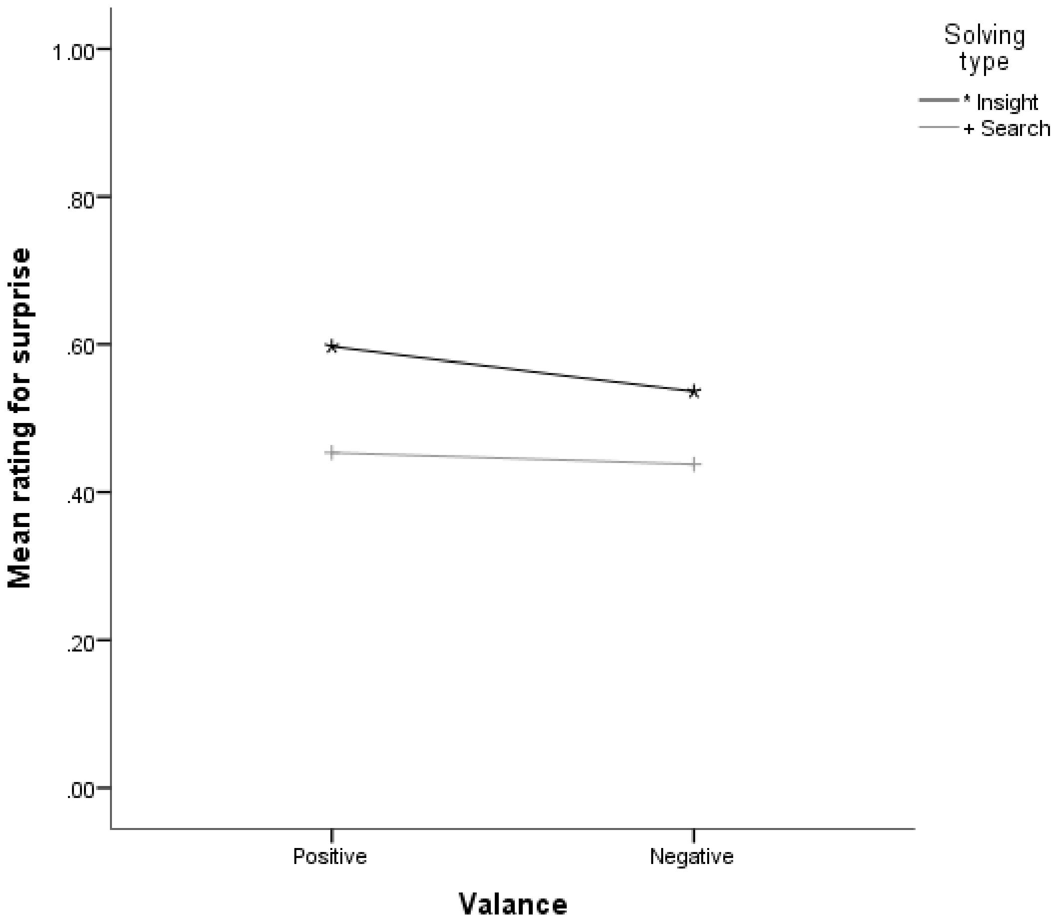


Figure 6.7 Mean ratings for surprise for positive and negative insight and search solving. Note extremes of the visual analogue scale were labelled as surprising - 1 and not surprising - 0.

Certainty ratings were compared using repeated measures ANOVA for solving type and valence. No significant main effects or interactions were seen. Furthermore, examination of Figure 6.8 illustrates the similarity of the ratings for different solving types and valences.

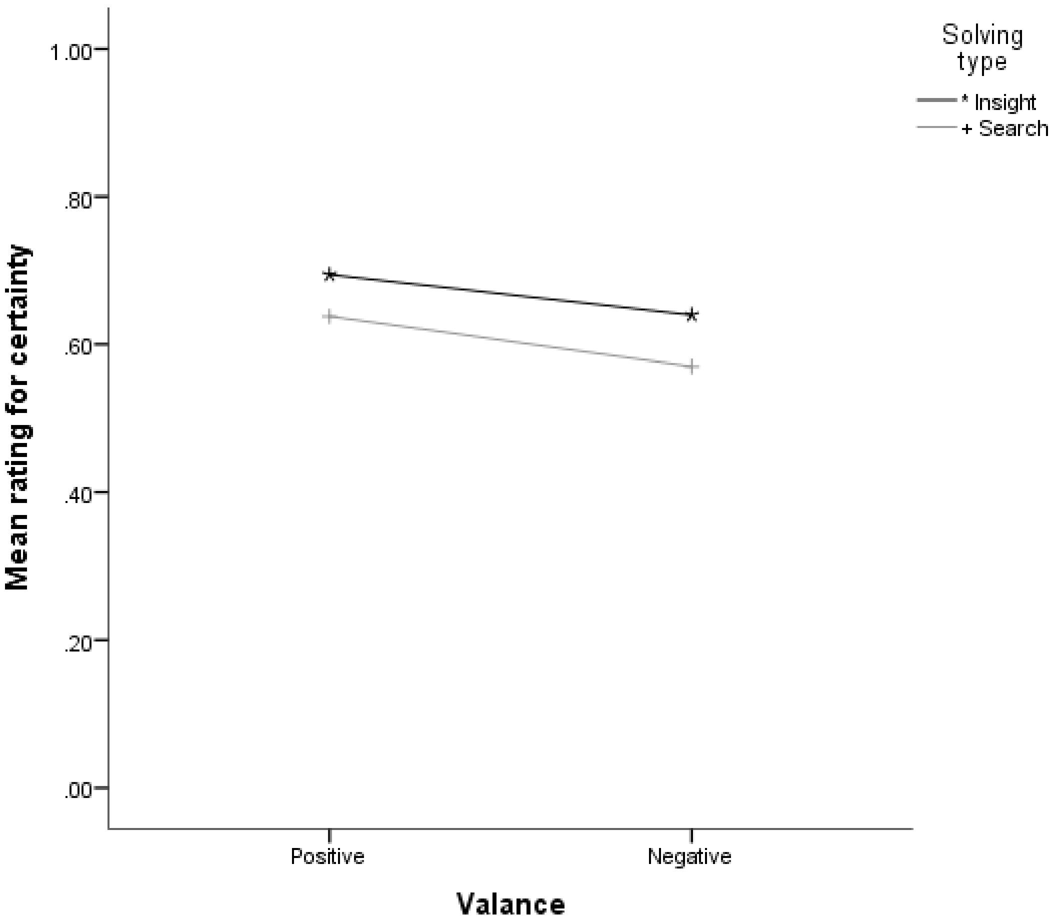


Figure 6.8 Mean ratings for certainty for positive and negative insight and search solving. Note extremes of the visual analogue scale were labelled as certain - 1 and uncertain - 0.

6.3.1.5 Heart rate change whilst playing Connect 4.

Two participants' data was excluded as they were identified as outliers in 17 of the 21 variables (4 combinations of solving, positive insight, positive search, negative insight and negative search recorded over 7 times in relation to the move decision). A three way repeated measures ANOVA compared solving type and valence with HR change (ΔHR) over time (where t = 0 is the point a move decision was indicated). There was a main effect of solving type, $F(1, 42) = 5.75$, $p = .02$, $\eta^2 = .01$, with a smaller mean ΔHR for insight (M = -.33 bpm, SE = .581) than for search (M = -1.24 bpm, SE = .52). The mean difference in ΔHR was .91 bpm, 95% CI [.14, 1.67]. Interpreting the standardized effect size according to Cohen (1988) suggests that this is a small effect. The difference of around 1bpm likewise can be evaluated as a minimal change in heart rate. The pattern of ΔHR seen in Figure 6.9 for insight compared to search trials might be interpreted as showing a trend to prolonged deceleration of HR in search compared to insight.

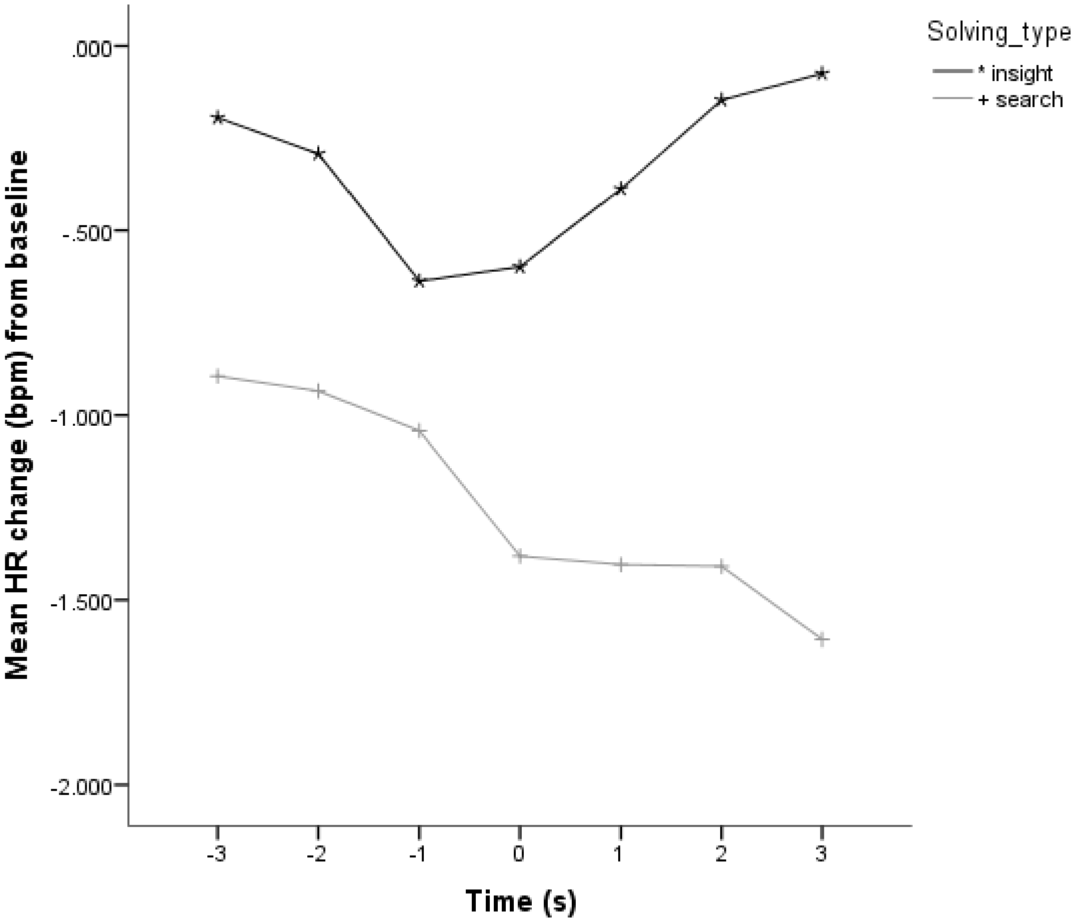


Figure 6.9 Graph to show mean change in heart rate from baseline for insight and search moves before and after point of decision (t = 0s) for Connect 4 moves reported as insight and search.

There was no main effect of valence or any interactions highlighted by the ANOVA. Exploration of Figure 6.10, showing the ΔHR over solving time for positive versus negative solving sees a continued decline in heart rate through the solving time while for positive a triphasic pattern may be determined with initial decrease, an increase then final decrease. However, caution should be employed in any interpretation of the graphical information seen in Figure 6.9 and 6.10 due to the small changes actually shown (note that the y axis only has a range respectively of 2bpm and 1bpm).

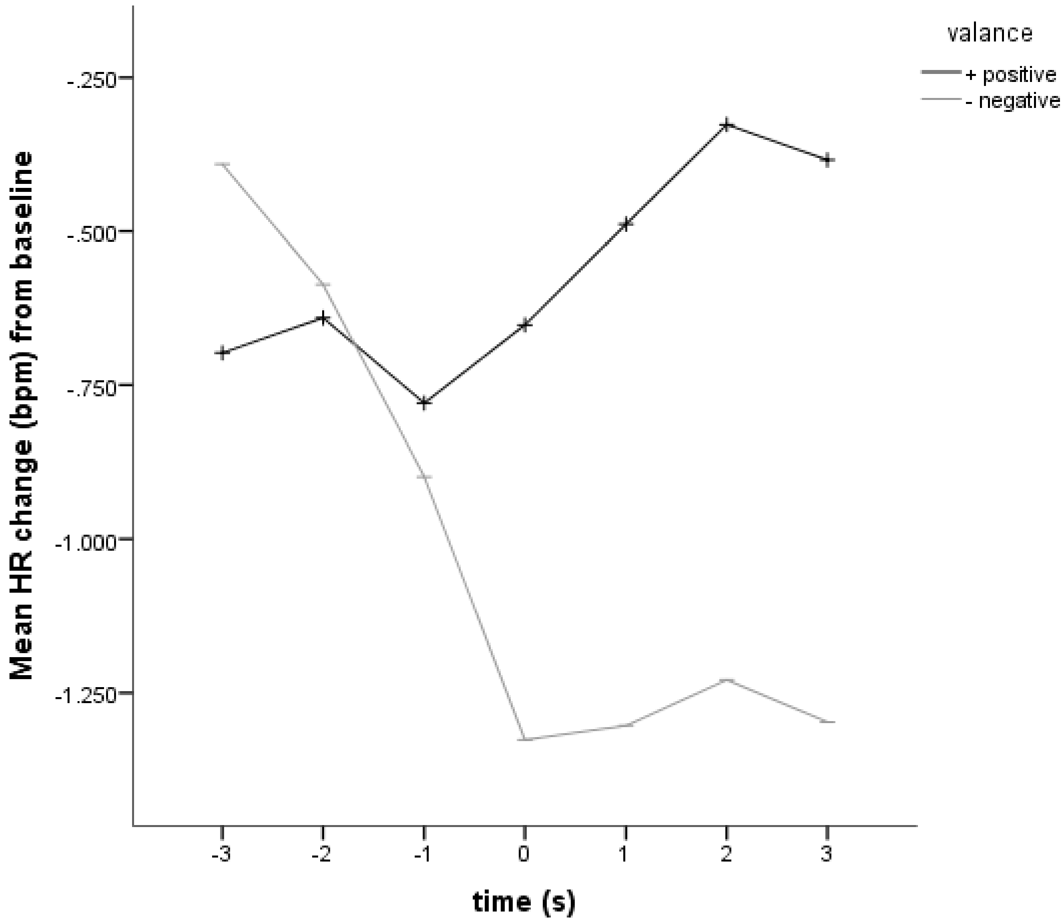


Figure 6.10 Graph to show mean change in heart rate from baseline for positive and negative moves before and after point of decision (t = 0s) for Connect 4 moves.

6.3.2 Emotional Expression - BEQ

6.3.2.1 Longitudinal comparison of scores.

There were 25 participants who took part in both Study 4 (time 1) and 5 (time 2) and had data for the BEQ. A repeated measures t-test identified that there was no significant difference, $t(24) = -.14$, $p = .89$, $d = .01$ between mean BEQ scores at the different testing times ($M_{time1} = 4.84s$, $SD_{time1} = .94$ compared to $M_{time2} = 4.85s$, $SD_{time2} = .82$), furthermore a very small mean difference can be seen of .01, 95% CI [-.16, .14].

6.3.2.2 Emotional expression and proportion insight.

There was no significant association between BEQ scores (recorded in this study) and proportion of insight moves, $r = -.17$, 95% CI [-.38, .05], $p = .07$, $N = 78$. This is shown in Figure 6.11, where the axis demonstrate the full range of possible data.

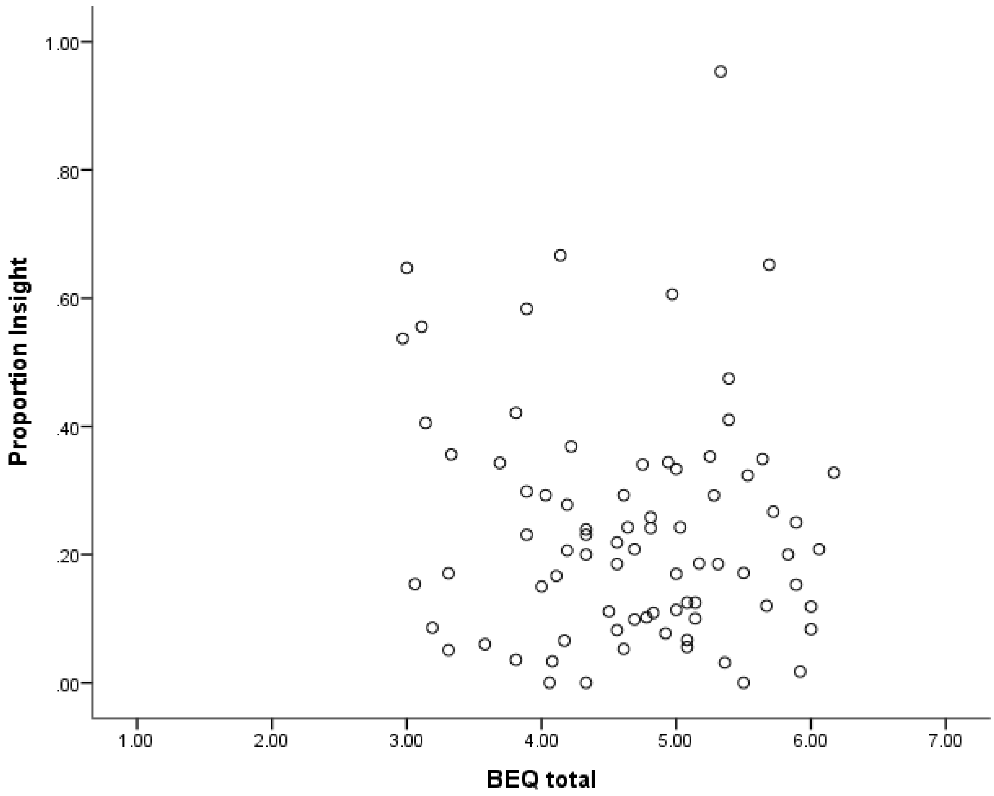


Figure 6.11 Relationship between proportion moves labelled as insight and participants' emotional expressivity (BEQ_{total}).

The association between the proportion of moves labelled positively and score on the BEQ positive sub-scale was explored and no significant relationship was identified, $r = .06$, 95% CI [-.17, .28], $p = .31$, $N = 78$.

6.3.3 Heart Beat Counting - HBC

Visual review of HBC performance showed that of the 80 participants, 3 counted more heart beats, the rest undercounted (or were accurate in their counts).

6.3.3.1 Baseline heart rate in more and less accurate heart beat counters.

An outlier was identified and removed from HBC accuracy data. A median split (median = .74) was then performed on the HBC accuracy scores to group into more accurate and less accurate heart beat counters. As shown in Figure 6.12 and using an independent samples t-test, $t(73) = 1.87$, $p = .07$, $d = .43$, there was no difference in baseline heart rate between more ($M = 74.0$ bpm, $SD = 8.7$) and less (78.3 bpm, $SD = 10.9$) accurate heart beat counters, the mean difference being 4.3 bpm, 95%CI [-.28, 8.77].

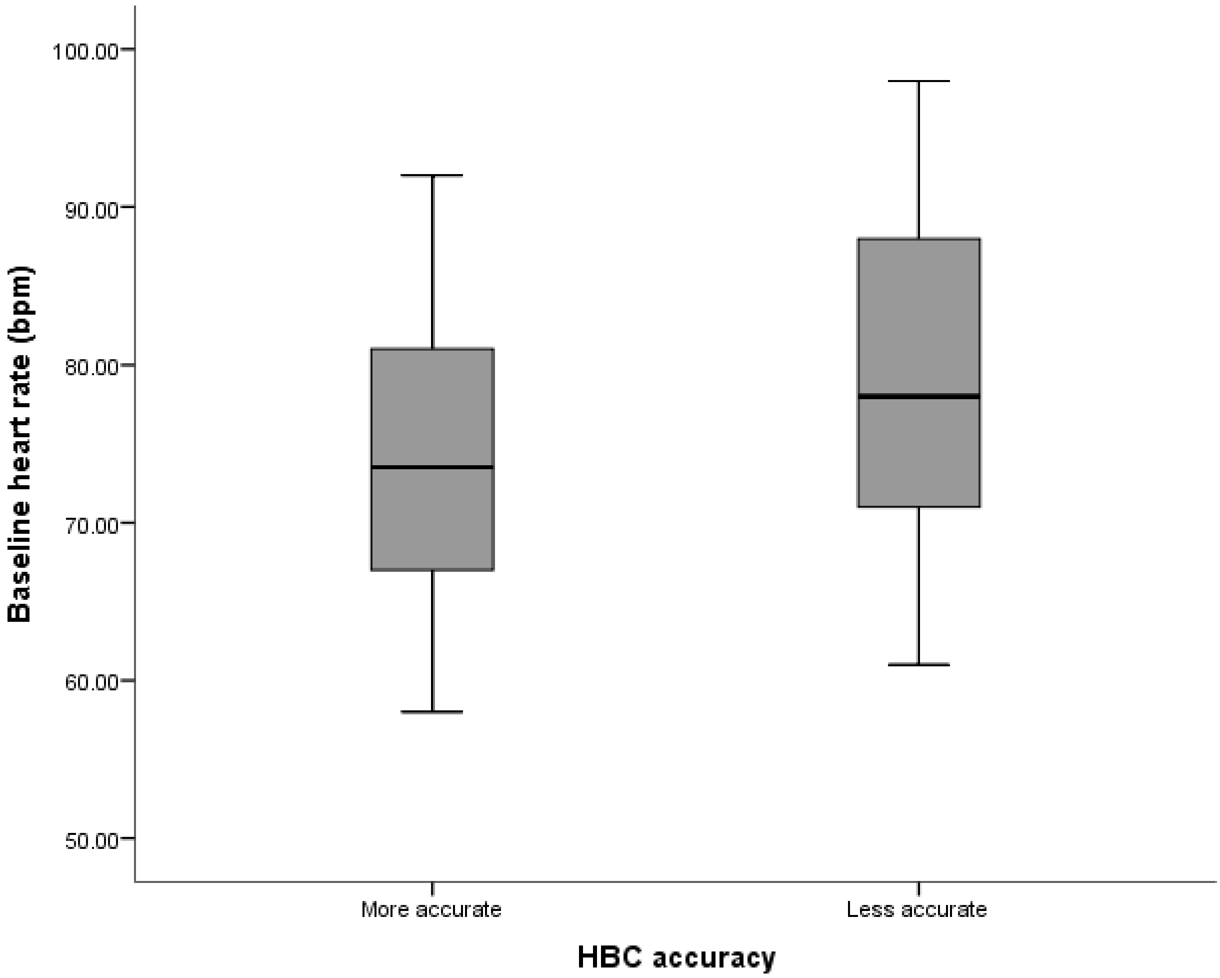
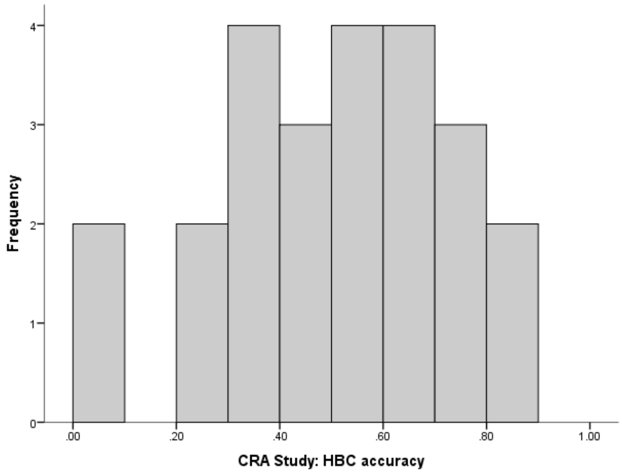


Figure 6.12 Mean baseline heart rate for more and less accurate heart beat counters (median split accuracy = .74).

6.3.3.2 Longitudinal comparison of scores.

Twenty four participants provided HBC scores during both Study 4 (Time 1) and 5 (Time 2), one the participants who took part in both studies had artefacts on their HRM recording during the HBC task so their data for this comparison was therefore excluded. A repeated measures t-test indicated that scores were significantly different between time 1 and 2, $t(23) = -.07$, $p = .001$, $d = .68$. Accuracy improved at Time 2 ($M = .66$, $SD = .20$) compared to Time 1 ($M = .51$, $SD = .24$). According to Cohen (1988) such an effect size could be interpreted as moderate. However, the mean difference was .15, 95%CI [.07, .23], the confidence intervals for this difference shows that improvements may range from very slight to considerable.

a.



b.

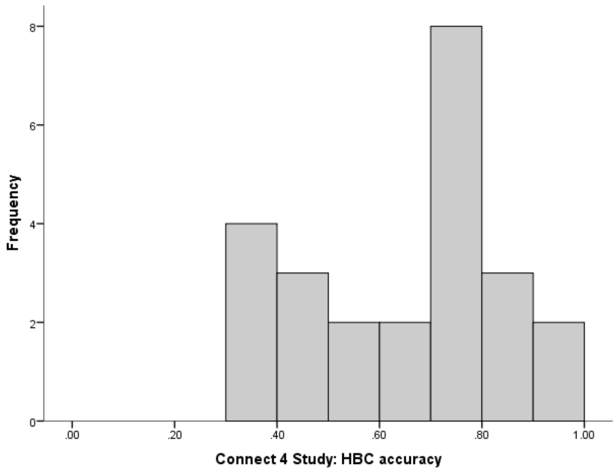


Figure 6.13 Frequency distribution of HBC accuracy for repeat participants in a.) CRA Study and b.) Connect 4 Study.

Figure 6.13 shows the frequency distributions of HBC accuracy for the repeat participants in the CRA Study and Connect 4 Study. As well as an increase in means, the distribution can be seen to shift towards greater accuracy.

To check for practice effects within participant comparisons were made between the first HBC session (prior to the problem solving task) and second HBC session (post problem solving task) in the CRA and Connect 4 studies. No differences were seen between the two sessions in either the CRA or Connect 4 participants.

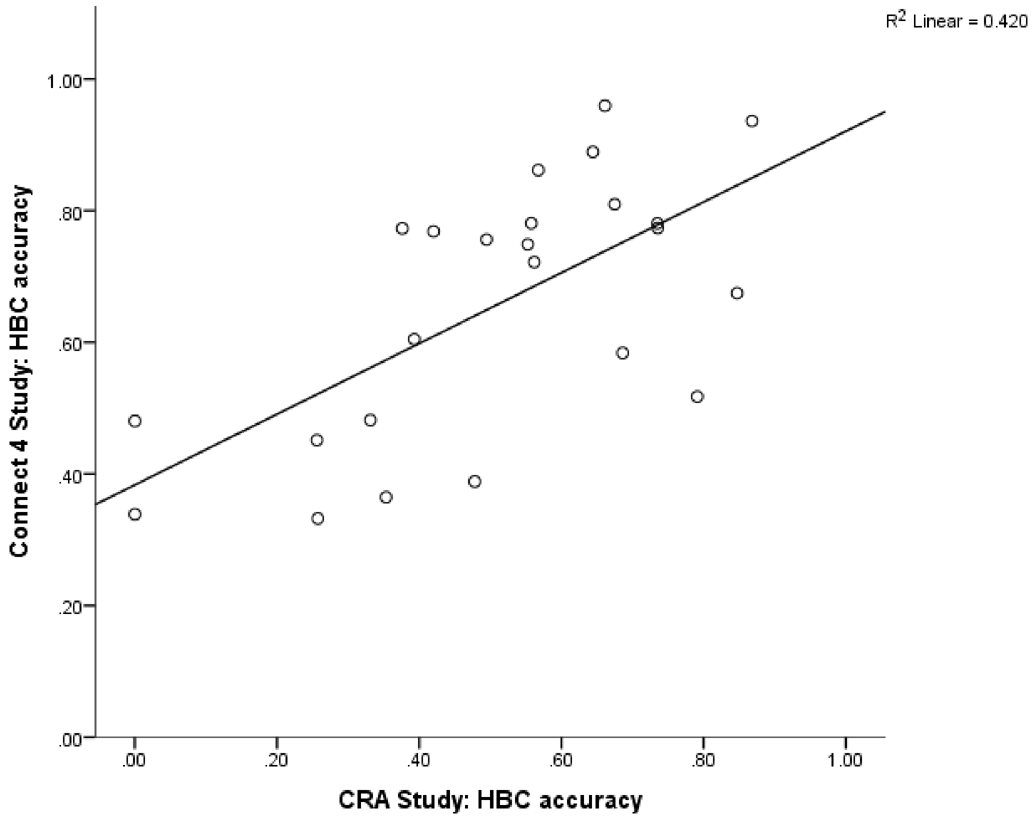


Figure 6.14 Association between HBC accuracy for individuals who participated in both the CRA and Connect 4 study.

To explore the individual differences in HBC accuracy between the two studies a correlation was conducted, $r = .65$, 95%CI [.33, .83], $p < .001$, $N = 24$. This association is interpreted as significant, not only due to the p value, but looking at the size and confidence intervals for the r value. This relationship can further be seen in Figure 6.14 with more accurate HBC scores in the CRA study seeing more accurate HBC in the Connect 4 study.

6.3.3.3 HBC accuracy and labelling of moves as insight.

The association between HBC accuracy and proportion of moves labelled as insight was explored on data with outliers removed (as discussed above, see 6.3.3.1 and 6.3.1.2). Little association was found between the two measures, r = .02, 95%CI [-.21, .24], p = .88, N = 75 as seen with the low r value and confidence intervals including zero. Furthermore, Figure 6.15 shows a spread of data across the two measures.

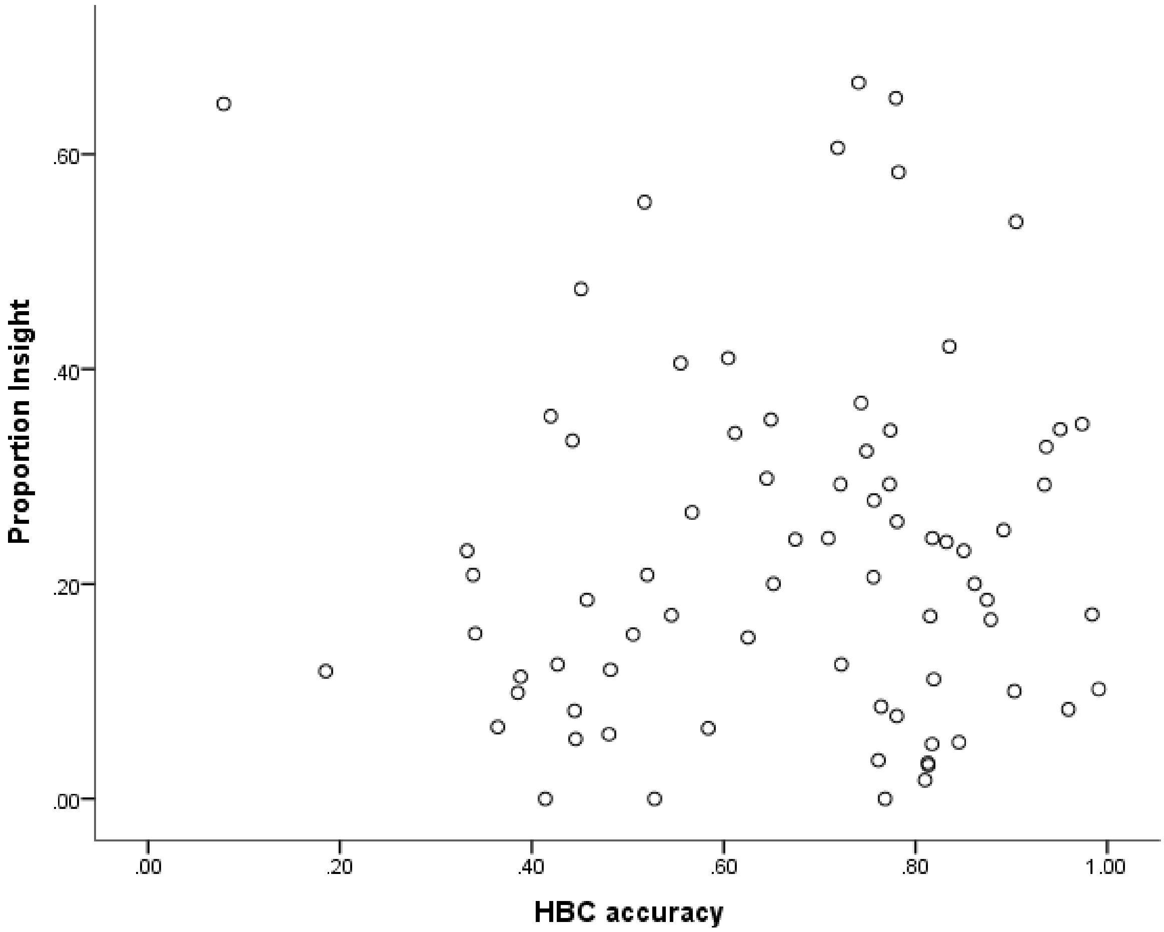


Figure 6.15 Graph showing relationship between heart beat counting accuracy and proportion moves labelled as insight.

6.3.3.4 HBC accuracy and ratings on BEQ item 7.

The relationship between HBC accuracy and ratings for BEQ item 7 were explored, r_s (1-tailed) = .27, 95%CI [.05, .47], p = .01, N = 75 rendering a significant result, moderate effect size and confidence intervals outside of zero, suggesting an association as shown in Figure 6.16.

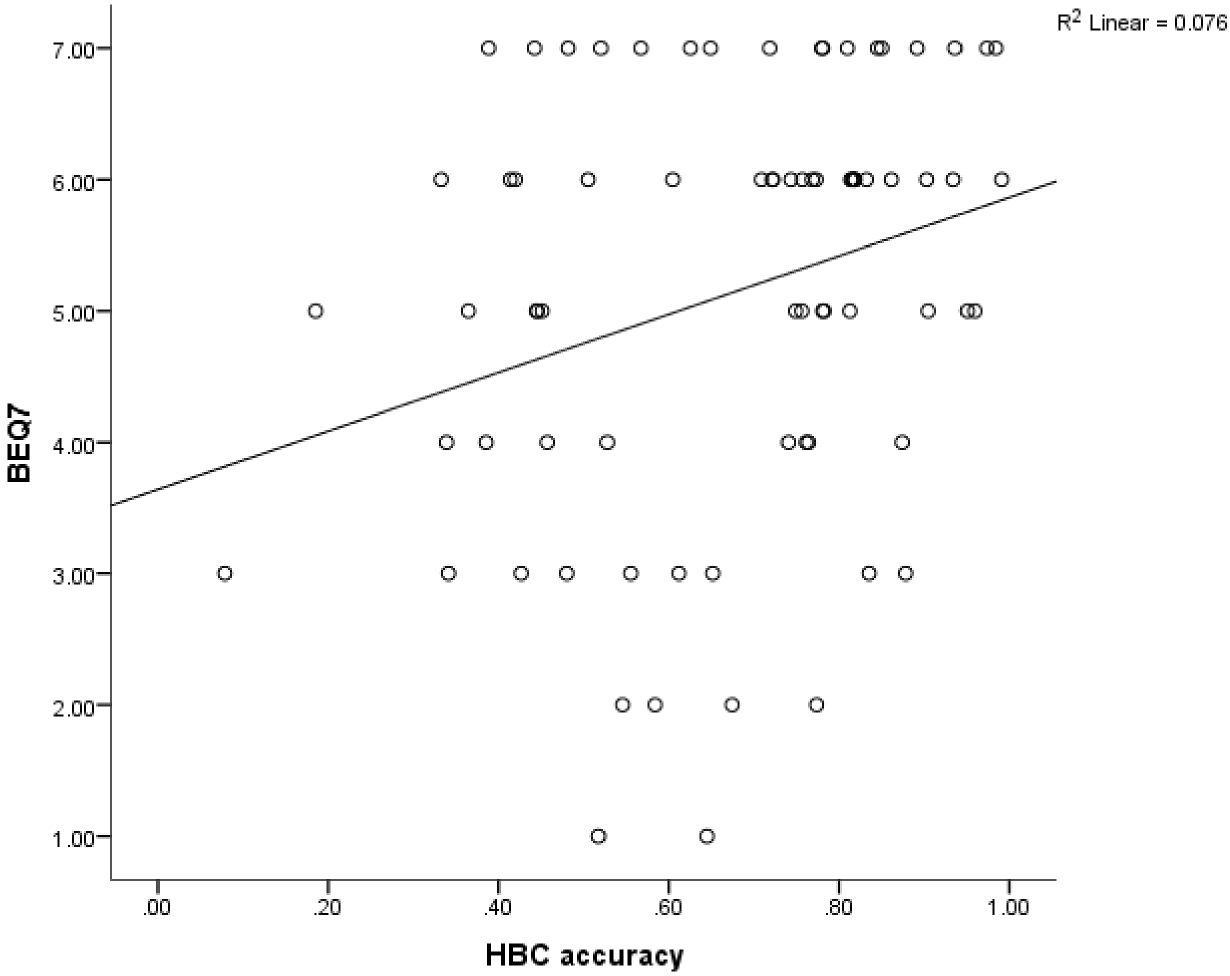


Figure 6.16 Graph showing relationship between heart beat counting accuracy and BEQ item 7.

6.4 Discussion

This study firstly validated Connect 4 as a naturalistic task to elicit problem solving experience including positive and negative search and insight. Somatic markers for solving type were again identified in this task, replicating to some degree results reported in Study 4 for CRA solving. Within participant comparisons of phenomenological reports were recorded demonstrating comparisons for different solving types and valence, extending previous research in this area. Finally individual difference measures in relation to insight and emotionality were explored, with inconclusive results. Each of these aspects will now be discussed in more depth, with future research and limitations highlighted for each.

6.4.1 Connect 4 as an Experimental Problem Solving Task.

This study sought to explore the use of Connect 4 to elicit problem solving experiences that are relatively comparable to how people solve problems in real-life, where often a succession of mini solving experiences contribute to a superordinate goal. As identified in section 6.1.2, in Connect 4 a player takes turns with an opponent to drop counters into a grid and so engages in problem solving to determine where to make each move, with the overall goal of winning the game by getting four counters in a row (be that horizontally, vertically or diagonally). This may be compared to Weisberg's (2014; Fleck and Weisberg 2004, 2013) proposed continuum of problem solving methods. As highlighted in Figure 1.1 (section 1.1.5.5) the model demonstrates 'mini' solving experiences towards the superordinate goal in the same way as seen in Connect 4. As reported in section 6.3.1 playing Connect 4 elicited self-reported insight and search experiences that were both positive and negative. Over half of the participants experienced all four types of solving enabling direct, within participant comparisons on a number of measures reported in 6.3 and discussed below. The vast majority reported at least three types (so did not experience one type), this can be seen to be comparable to other problem solving tasks where a proportion of participants did not report both search and insight solving (see section 4.4.4.1 for more detail regarding these participants who were generally excluded from the studies).

In terms of performance for the superordinate goal of winning a game, as shown in Figure 6.1 a range of winning scores (note the maximum score was six - the number of games played by a participant) were seen. There was not a huge skew seen towards either winning of all the games or none, suggesting that while participants were identifying their own level of challenge to play at, they identified a level that was neither too easy (this would have shown a negative skew) nor too difficult (shown as a positive skew). Participants generally seemed engaged with the game and to be making effort in the game, so actually attempting to problem solve and win the game. Observations made by the researcher of participants as they played the game included swearing (to self or computer), shaking their fist at the screen, celebrating winning a game (dancing and fist pumps!) and referring to the competitor (the computer algorithm) as a person, for example calling it 'he' (it was almost always male gendered) and directly commenting on their competition against 'him'. Interestingly Danek et al. (2014b) likewise identified their participants voiced similar competitive feelings towards the magician filmed performing tricks. They interpreted this as demonstrating the intrinsic competitiveness of problem solving. As such this indicates that the Connect 4 game represented a naturalistic problem solving scenario that participants were immersed in.

In addition to being satisfied that Connect 4 does elicit the expected experiences, it needs also to be evaluated in terms of its viability as a task to use in experiments. One factor is the range of participants who can take part. As identified in Chapter 5 and summarised in section 6.1.2, language based tasks may limit participant samples. Participants recruited in this study had a range of abilities and experience in playing Connect 4. This can firstly be seen in the range of levels that participants chose to play at, with all levels being selected across the participants from 'easy' through to the hardest level labelled as 'expert'. Furthermore, several participants identified that they had never played or heard of Connect 4 before: they were able to learn the simple rules in the single practice game and then play the six games. It is notable that everyday insight reported in Chapter 2 of this thesis identified experiences where the insight occurred in a learning context (see section 2.4.4.3). It is likely that the novice Connect 4 players in this study (if not others who had already played) were experiencing these mini-c kinds of creativity (Kaufman and Beghetto, 2009). Future research could explore such experiential effects more extensively, as no formal recording of experience was made in this study.

In terms of other non-language based tasks the magic paradigm introduced by Danek el al. (2014) provides an alternative, but only elicits positive solving experiences and not negative insight or search as in this study. Likewise, Salvi et al.'s (2016) visual completion tasks that give positive solving experiences to problems in the visuo-spatial domain. Furthermore, the picture completion tasks were actually found to be harder, so more limited in terms of participation than the CRA task (Salvi et al., 2016). Connect 4 can also been seen to operate in the visuo-spatial realm, eliciting insight experiences comparable to the everyday reports identified in Chapters 2 and 3 (see section 2.4.4.1) that is appropriate for a range of abilities.

As well as demonstrating validity as a problem solving task eliciting the range of solving types and accessibility for participants, Connect 4 should be assessed in terms of the time participants took to play it. Pilot testing identified that participation in the full study took between 30 and 45 minutes. In terms of Connect 4 specifically, a relatively short move time was seen across the participants and solving types (just over ten seconds per move). With a maximum of 21 moves in a game (leading to stalemate) this provides an estimate of a (average) maximum game duration of about four minutes (244s). This means that a number of games can be played in the course of an experiment, so providing the potential to introduce conditions and measure problem solving in each of these to obtain more powerful within participant comparisons (Field, 2016).

6.4.1.1 Limitations of Connect 4 task.

However, there were some problems identified by this initial exploration in the use of Connect 4. Firstly the Connect 4 game used was a commercially produced, computer based version aimed at leisure-time players. As such there was restricted capacity to alter features of the game for use in an experiment. This was limiting, for a number of reasons. Firstly, the time between moves was short, meaning that problem solving episodes overlapped, decreasing the time over which HR could be compared (see further discussion below in section 6.4.4.1). Secondly, there were no breaks between each move to obtain the participants self-reports, meaning a researcher had to be present to record this information. This potentially introduced confounds, however steps were taken to avoid cuing participants (described in the method, see section 6.2.3). Additionally, the disinhibited behaviour of some participants (see above) would suggest that (at least for them) the presence of the researcher did not constrain their problem solving experience. An alternative would have been to follow Leone, Petroni, Fernandez Slezak and Sigman (2012) who collected reported solving experience after each chess game rather than during. However as demonstrated by de Groot (1946/ 65) expert chess players are able to memorise and recall chess board positions and moves, each of which is more distinctive than moves in a Connect 4 game. As such this approach would not have rendered accurate reports of experience during game play. Furthermore, reports made temporally close to the experience replicate methods seen in other positive solving elicitation paradigms such as CRA or magic tricks (Danek et al., 2014a; Jung-Beeman et al., 2004)

Having a purpose built Connect 4 game would have enabled breaks to be built in between each move to collect ratings for solving type and automating the process. It would further have provided more accurate time measurements (see below section 6.3.1.1 for further explanations) and the opportunity to synchronise reports with other measurement equipment, negating the need for participants to press the actual HRM buttons as in this study (see section 6.4.3).

Overall however, this study identifies the potential of Connect 4 in future studies that aim to explore positive and negative, insight and search solving. It enables a wide and general sample to participate, with no prior knowledge or experience of the game. Furthermore, it is a sufficiently brief game in duration for it to be played more than once, so enabling within participant comparisons to be made or multiple incidences of events necessary for neuroimaging data collection. The limitations in the main relate to the version of the game used. The development of a computer-based Connect 4 game specifically for research purposes should eliminate these problems.

6.4.2 Phenomenological Ratings for Solving Experience in Connect 4

The phenomenological ratings recorded for participants' experiences whilst playing Connect 4 are useful for a number of reasons. Firstly they provide a replication of Danek et al. (2014b), who measured the phenomenology of their participants' insight experience, but did not provide comparisons to search (non-insight) solving. Secondly, some of the aspects measured related to theoretical discussions explored in this research. For clarity, an overall discussion regarding these ratings will be undertaken with signposting offered where a particular rating relates to another aspect of this study.

6.4.2.1 Pleasantness of different solving types.

Whilst (as described above in section 6.4.1) the participants reported experiencing the range of solving types, as highlighted by the qualitative work earlier in this thesis (see sections 3.4.6 and 4.4.2) caution should be employed in assuming that participants' reports directly correspond to the definitions given to them. As such Danek el al.'s (2014b) rating of pleasantness provides a useful check on participants' classification of positive and negative solving experiences. Hypothesis 7 predicted that positive insight and search moves would be rated as more pleasant (positive) than negative ones. As reported in section 6.3.1.4, this effect was demonstrated, with ratings for positive solving being considerably higher in pleasantness than negative.

Hypothesis 8, explored the relationship between pleasantness ratings for insight and search solving, finding no differences. The study was sufficiently powered (as determined through a priori sample size calculations) to detect an effect. A small interaction effect was observed between valence and solving type that saw more extreme ratings of valence for insight (so more positive for positive insight compared to positive search and more negative for negative insight compared to negative search). It may be that this relates to other properties of the solving not accounted for, one consideration might be arousal. As highlighted in section 1.2.4, this thesis focuses on the valence aspects of emotion, however recent research (published as this thesis is being written up) highlights that arousal may also be important (Shen et al., 2016). Shen et al. (2016) explored physiological changes in insight and search solving using the CRA (Chinese version) finding that insight trials saw higher electrodermal activity (EDA) than in search trials. EDA has been proposed to be an indicator of arousal (Lang, Greenwald, Bradley & Hamm, 1993), as such this finding suggested that insight solving is more arousing than search. Although valence and arousal are proposed to be orthogonal aspects of emotion (for example in Russell's (1980) circumplex model of emotion), an increase in reports of valence (more positive or more negative valence) is shown to relate to increasing arousal ratings (Bradley & Lang, 1999; Lang et al., 1999). This explanation fits the interaction effect described for solving type and valence in Connect 4 moves; if insight is more arousing as Shen et al.'s (2016) study suggests, this would lead to the more extreme ratings of valence seen in insight (compared to search) as shown in Figure 6.5.

6.4.2.2 Suddenness (perceived speed) of different solving types.

The suddenness of different solving types is measured in two ways in this study, using behavioural measures (see discussion relating to this below, section 6.4.3). The perceived speed, so how fast or slow solving was rated for each solving type was also measured. The prediction made in Hypothesis 6, that insight moves would be rated as faster than search was supported, while no differences were seen for ratings of move speed when comparing valence. Danek et al. (2014b) rated suddenness as the second least important dimension of insight experience, however as highlighted previously (6.1.5) no comparisons were made with non-insight solving. Shen et al. (2015) did not measure a rating for suddenness, however participants did indicate how much they felt they hesitated. This might be expected to be conversely related to perceptions of suddenness, so where there was hesitation it would be expected there would be less suddenness experienced. Shen et al. (2015) found that ratings for hesitation were significantly greater for non-insight experiences compared to insight. Together these results might be seen as complementary, supporting the notion of differences in perceived suddenness in insight compared to search. These results will be discussed further below (6.4.3), relating behavioural and phenomenological measures of suddenness.

6.4.2.3 Ratings of surprise in problem solving.

Hypothesis 9 predicted that insight would be rated as more surprising than search, with results supporting this as shown in Figure 6.6. This again is congruent with previous research that identifies the surprise aspect of insight as summarised in section (insert red for Surprise and Insight section in chapter 1). The identification in this study that moves labelled as insight in Connect 4 were rated as more surprising than search supports the assertion by Danek et al. (2014b) that surprise is an important component of the phenomenological experience of insight. This is at odds with Shen et al. (2015) who did not recognise surprise in their description of emotion and insight.

6.4.2.4 Ratings of certainty in problem solving.

Figure 6.7 and results presented in 6.3.1.4 highlight that Hypothesis 10 was not supported, there were no differences in certainty ratings seen between insight compared to search (nor positive versus negative solving). Shen et al. (2015) identified certainty as one of the emotional components making up their psychological structure of the Aha experience. Like in the Connect 4 ratings collected for this study there were no differences in ratings for certainty between Shen et al.'s (2015) insight and non-insight trials. Danek et al. (2014b) also identified certainty as important to insight, but as discussed previously did not isolate these effects from alternative solving (by comparing to ratings for non-insight solving). A further theoretical discussion relating to the role of certainty in insight and search solving can be seen below in relation to speed of moves (section 6.4.3.2).

6.4.3 Speed of Problem Solving in Connect 4

6.4.3.1 Speed of insight and search moves.

As reported in section 6.3.1.1, hypothesis 1 and 2 were supported, with moves reported as insight being faster than for search. This is in line with previous research, both the finding from Study 4 (see discussion section 5.4.1) in this thesis and in the wider literature (see sections 5.1.1. and 6.1.2.1), for example Subramaniam et al. (2008). While the previous studies reported solving time differences in the CRA, this study extends the finding to a different problem solving task that arguably elicits more naturalistic solving (see discussion above in 6.4.1).

Salvi et al. (2016) following arguments first presented by Cranford and Moss (2010) excluded solving in the first five seconds of the CRA trial arguing these might be labelled insight as a result of an impulsive response to quick solving for solutions arrived at through direct memory retrieval and recognition responses rather than insight. However, this rationale is really driven by the assumption that only solutions following impasse represent true insight. Weisberg's (2014; Fleck & Weisberg 2004, 2013) model, outlined in section 1.1.5.5 highlights that insight, Aha experiences may not always be the result of impasse, this is also congruent with the ideas discussed regarding the everyday examples of insight (Chapter 2 and 3), particularly with regard to negative insight where individuals were unaware of a problem rendering an impasse experience impossible. Additionally, solutions from the final five seconds were excluded by Salvi et al. (2016) as it was suggested that guessing strategies were employed in this time to avoid the problem timing out. These were more likely to be labelled as search. These two descriptions of behaviour in the time-controlled, single solving trials of the CRA could account for insight reaction times being faster than search, suggesting methodological reasons rather than aspects relating to the differences in insight and search solving. However, in the Connect 4 paradigm these factors are not seen. Firstly, in terms of memory solutions, people would be less likely to have memorised and recall specific Connect 4 boards than word relationships, and in their recall/ recognition of these, did not mistakenly label these incidences as insight. Accordingly, participants often questioned such experiences in their practice game. For example in taking early moves in the game they often relied on habitual moves, such as "I always start in the centre". These they identified as non-solving experiences rather than as either insight or search solving. Furthermore, participants were not given a time limit for each Connect 4 move, so the effects described to avoid timing out would again not be seen in this study. Taking this into account, it would seem to support the attribution of the difference in speeds seen, not to task effects but relating to some intrinsic property of insight solving compared to search that generalises across problem solving tasks.

6.4.3.2 Speed of moves and certainty.

Hypothesis 3 found no difference between the speed of positive and negative moves. This is in contrast to predictions made, based on findings from Study 2 and relating to certainty and loss aversion. Specifically that in loss or gain focused decision making (as highlighted in section 6.1.2.1) negative moves would involve longer deliberation than positive. Examination of Figure 6.2 shows almost no change between positive and negative move times in insight or search solving.

A more detailed consideration of Lejarraga, Hertwig and Gonzalez (2012) results sees that whilst they report an overall effect of increased searching in loss, 45% of participants either showed no difference in searching between loss and gain conditions or showed the opposite, searching more in gain. As such, it may be the case that the individual differences in loss aversion effects shown by Lejarraga et al. (2012, and replicated in Lejarraga & Hertwig, 2016) are likewise seen in this study's participants whilst playing Connect 4, with different responses to positive and negative conditions confounding predictions and leading to no net effect in terms of move time.

The individual differences in search strategies seen in loss identified by Lejarraga et al. (2012) led them to consider other factors that might be confounding the effect, exploring how certainty impacts on search behaviour and finding that greater uncertainty extended searching. Thinking back to the finding above (section 6.4.3.1) that insight moves were faster than search, the role of certainty might also be considered. As highlighted in section 2.4.3.1 (and briefly in 6.1.5), there is suggested to be greater certainty in insight solving compared to search. So where participants were more certain, this would suggest that they would stop their search to make their move and label this as insight. Where there was less certainty, a protracted search would be seen and their final decision (move) be labelled accordingly as search.

6.4.3.3 Limitations of phenomenological ratings.

However, as discussed above in section 6.4.2.4, participants did not rate their solving experiences differently in terms of certainty. Furthermore, this finding is congruent with Shen et al.'s (2015) finding of no differences in certainty between insight solving and other problem solving. This casts doubt on the explanation, if the assumption is made that the post hoc reports of phenomenology are accurate. As demonstrated earlier in this thesis (Chapter 4) there appears to be a disconnect between the problem solving experience that is reported as insight from memory compared to that experienced in real-time. Speculation regarding this contrast offers a potential explanation in memory effects, and again here this could be considered. The phenomenological ratings were taken at the end, temporally separate from the actual solving experience. Furthermore, it may be that the differences in certainty were too subtle and/or the rating system too crude to capture any differences.

This argument would seem to be supported by recent research by Webb, Little and Cropper (2016) who used Danek et al.'s (2014b) rating scales obtaining ratings for each problem (classic insight and non-insight and CRA puzzles) immediately on it being solved. They found a strong relationship between certainty and insight which was measured on a likert scale of 'experience of Aha' rather than as a dichotomous label (insight versus search). Section 6.4.1 identified the short-comings of the version of Connect 4 used in this study, recommending that a purpose-built programme would offer the opportunity to take ratings more proximate to each move. This would provide a finer grained picture of players' experience including in terms of the felt certainty attached to each move.

An additional consideration might be seen from the chess decision making approach, that doesn't really explore insight, but does extensively consider search. Recent findings from Leone, Fernandez Slezak, Golombek & Sigman (2017) suggest that in chess, echoing findings from experimental decision making, there is a speed accuracy trade-off for moves. With slower moves seeing higher quality moves than faster ones. Such assertions can be made due to methodological developments that assign quality scores to moves within a chess game. This will be discussed further below in the context of Connect 4 in section 6.4.5.2.

6.4.4 HR change in different types of problem solving

There was no heart rate change over problem solving time as predicted by Hypothesis 11 and reported in 6.3.1.5. This is in contrast to the findings (section 5.3.2) in Chapter 5 where a biphasic (initial deceleration followed by acceleration) heart rate change was demonstrated around the solution point of both search and insight solved CRA puzzles. There are a number of reasons why this may be the case. Firstly this could provide evidence that the processes seen in Connect 4 were distinct from the problem solving seen in the CRA, leading to different physiological signatures. However the range of ∆HR measures taken over problem solving time was more limited in this study using Connect 4 (3s pre and post move) than seen for the CRA in Study 4 and, typically measured in other studies that explored ∆HR over time (Bradley et al. 2001, Guerra et al., 2016; Lackner et al., 2013; respectively recorded 6s, 4s, 6s after stimulus). Furthermore, due to the methodological limitations of the Connect 4 game used, each problem solving episode leading up to a move decision was very close to the previous, as there was no break in the programme between moves. This led to the shortened HR comparisons, but also may have allowed for interference between solving episodes, with the physiological effects of one move impacting on the ∆HR seen for the next. This could mean that parts of the physiological response were missed by too short a recording period, or that interference between solving episodes prevented an effect from being observed. As such, any firm conclusion regarding the veracity of this result would require further investigation using a Connect 4 game with features discussed above (6.4.1).

Hypothesis 12 was supported, with a larger decrease in HR for search than insight solving. This corresponds to the finding from Study 4 where again there was greater deceleration in HR for search compared to insight solving. Lackner et al. (2013) likewise demonstrated a reduced overall HR deceleration for amusing 'insight' exposure to humorous cartoons compared to non-humorous controls. Jausovec and Bakracevic's (1995) results still showed a net higher HR for insight compared to search, but the direction of change differed, with acceleration shown in response to both solving types (see Figure 5.1a, also Section 5.1.3.1). In sum these results demonstrate that the HR difference identified in this thesis may be generalizable across problem solving tasks. It could be argued that differences in HR response between solving types is easier to detect than the time effects (it relies on net change rather than change over time). This may support the notion that similar processes were seen in both tasks, but the Connect 4 methodology employed was not sensitive enough to identify the effect over time.

Heart rate change differences between positive and negative trials were not seen, meaning Hypothesis 13 (and 14) was not supported. As shown in Figure 6.9, there were different ∆HR patterns discernible for positive and negative moves that might be argued to be comparable to those reported in studies where positive and negative pictures were presented to participants. An extended deceleration for negative, and a triphasic pattern for positive. However the differences across time only ranged within one beat per minute, as such these patterns were effectively meaningless as shown by the statistical test results.

The predictions made for HR difference in valence were based on research in a different paradigm. Participants, in studies such as Bradley et al.'s (2001) were passive observers of emotion eliciting stimuli. In the Connect 4 problem solving scenario participants' responded to their positive or negative situations by making a move. Bradley et al. (2001) explained the HR response to emotional images through the defence cascade model (Lang et al., 1997) where typically, an initial orientating reaction to assess a stimuli would cascade into a fight or flight response if the threat increased, or dissipate if it was not judged a threat or the threat retreated (Lang et al., 1997). The extended negative response, Bradley et al. (2001) argued was due to the static, unchanging nature of the negative images presented, as such there was no cascade to a response, simply prolonged orientating as the stimuli remained negative but unchanged (so leading to continued HR deceleration). However in this study the Connect 4 participants moved to action in both positive and negative situations by deciding on their next move, this potentially removed the extended orientating response responsible for the lowered HR in negative compared to positive picture presentations.

6.4.4.1 Limitations of HR change data collection

One aspect that limits the usefulness of HR data collected was the range of solving experience measured. As highlighted above in section 6.4.1.1, due to the version of Connect 4 used in this research, a maximum of three seconds prior and subsequent to move decisions was captured. This is in contrast to previous studies (and in Chapter 5) where longer windows of time were considered.

6.4.5 Individual differences in problem solving

A number of individual difference aspects were considered in this study. Such an approach is relatively new, with most insight research focusing on general cognitive, process differences. This approach was taken to investigate the lay idea identified in Chapter 4 (see section 4.4.1.2) that those with greater emotionality would be more likely to label solving experiences as insight, because individuals high on emotional expression would be more likely to experience or identify the signature Aha moment attributed to insight.

6.4.5.1 Proportion of insight

Kounios et al. (2008) investigated individual differences in the tendency to solve anagrams with insight, dividing participants' proportion insight scores to high insight and low insight groups (further described in section 5.1.7). This measure provides an individual differences metric regarding people's solving behaviour with which to compare measures relating to emotionality. However as highlighted in 6.1.4 this measure is yet to be widely validated. Hypothesis 4, therefore aimed to explore proportion insight scores across tasks in the same individuals, to offer such a validation.

Firstly a difference was seen between the tasks, with participants reporting a higher proportion of insight to search solving in the CRA compared to when playing Connect 4. This may have reflected the differences in the two tasks, with continued efforts across moves in Connect 4 towards the ultimate goal of winning (by getting four in a row) leading to far greater strategic thinking than in the CRA, where each solving episode is distinct.

Also of interest is whether participants showed the same tendency to report insight in each of the tasks relative to other players. There was no association seen between insight proportions on the two tasks. This would suggest that the proportion of insight measure reflected a task specific tendency that was not generalizable across the CRA and Connect 4 tasks. As such for this study the results using this measure will be discussed in relation to performance in Connect 4, with the cautionary note that this may not be generalizable to other problem solving experiences/ types.

Further research could explore whether there were similarities in reporting tendencies across a range of tasks. For example the four tasks that Salvi et al. (2016) used all present series of standalone convergent problems, but some are language based while others are more visuospatial. As such comparing these to Connect 4 for proportion insight reporting would help to pinpoint exactly where the differences originate. Further validation, as highlighted in 5.4.3, could compare real-life reported or actual tendencies to experience insight.

6.4.5.2 Relationship between tendency to report insight and performance on Connect 4.

Hypothesis 5 predicted that individuals who experienced more insight would perform better in Connect 4 and so win more games. This hypothesis aimed to provide a comparison to assertions in previous research that insight leads to more accurate solutions that search (but see section 5.4.1 for alternative interpretation of results). As identified in section 6.1.3 Connect 4 does not render moves that can be dichotomously labelled as correct/ incorrect. So the number of games won, taken as an indication of the quality of moves was compared to the proportion insight reported for each player, and as reported in section 6.3.1.3.

It may be the case that for Connect 4, insight moves were not better or more effective than search meaning that an individual making more moves due to insight was at no advantage to another using more search-based moves. As identified in section 6.1.3 it may be that Connect 4 is a more strategic game and so search problem solving be more effective, or as effective as insight. For further discussions regarding the merits of insight or search solving in terms of adaptiveness in see section 7.1.1.2.

Alternatively, it may be that the overall low proportions of insight reported created floor effects masking any advantage to insight within the composite measure of proportion of insight (compared to search). Another aspect to consider is that participants were playing at a self-selected level of difficulty. This would have introduced confounds effecting the number of games they won. A participant choosing a level that was initially too hard could switch to an easier one half way through and likewise for the reverse (switching from an easier level to a harder one).

Taking this all into consideration, no conclusions can be drawn from this aspect of the research, and no contributions can be made to the question of the relative accuracy or effectiveness of insight solving compared to search. Future research might aim to measure the effectiveness of each move drawing from similar efforts within chess (Sigman, Etchemendy, Fernandez Slezak, & Cecchi, 2010), perhaps in the purpose built version of Connect 4 discussed in section 6.4.1, probabilities for success for each possible move could be calculated and the probability or effectiveness (maybe in ranked order so chose best move, 2nd best etc.) of the actual move chosen for each time be recorded. This could then be compared to the labelling of each move as insight or search, and to other self-reported aspects such as Danek et al.'s (2014b) phenomenological scales.

6.4.5.3 Emotional expressivity and problem solving

The first aspect to consider regarding emotional expressivity was the test-retest reliability seen for participants who took part in Study 4 and Study 5 (tested through Hypothesis 15). Similar BEQ scores were seen at both times, suggesting that the BEQ is a reliable measure. In relation to BEQ scores reported in Gross and John's (1995) original study, the means seen in participants taking part in this research (M_{study4} = 4.8, SD_{study4} = .94; M_{study5} = 4.9, SD_{study5} = .82) are comparable to those in the original research, where they report by sex (male score 4.2, female score 5).

As discussed in section 5.5.3 no relationship was found between emotional expressivity and a tendency to experience insight whilst solving CRA problems. Hypothesis 16, examining this relationship in Connect 4 was likewise not supported, with no association seen (reported in section 6.3.2.2). The fact that both positive and negative solving is experienced in Connect 4 means that additional comparison could be made exploring the valence of solving in relation to expressivity. Two hypotheses compared participants tendencies to experience solving as positive (or negative) with their expressive behaviour for positive and negative emotions. There was no relationship between either of these. In sum, this would firstly support the finding in Study 4, that emotional expressivity is not related to tendency to experience insight in problem solving. Furthermore, positive and negative expressivity do not relate to positive and negative solving experiences.

6.4.5.4 Limitations in the individual differences measures used.

As proposed in section 5.5.3, the measures collected for proportion of insight and positive solving can be seen as distinct from the expressivity of insight. This measured participants' experience of each move as they played Connect 4 rather that their expression of the experience. This is analogous to asking participants to identify the emotion of a picture (positive or negative) rather than measuring how much it made them smile or frown, in other words express the emotion they experienced. No studies have considered behavioural markers of insight or if in deed there is individual differences in expressivity. As highlighted in 5.4.3 Ovington et al.'s (2016) Dispositional Insight Scale might be argued to measure expressivity as it asks participants to rate their everyday problem solving on scales relating to aspects indicative of insight experience. As discussed however, this has not been validated against actual behavioural measures to date.

6.4.5.5 Interoception: heart beat counting and problem solving

The HBC scorers with more accurate compared to less accurate scores were no different in their baseline heart rate, suggesting that availability of heart signal did not account for performance on the HBC. Furthermore, as discussed in section 5.5.4 and again seen in this study participants consistently underestimated their heart beat counts, as such suggesting that intuitive counting strategies were not being employed.

Longitudinal comparisons were made to explore the reliability of HBC scores over time, and it was demonstrated (as per Hypothesis 20) that HBC scores improved between Study 4 and 5. This may suggest that there were learning or practice effects. No immediate practice effects were seen between the first and second sessions in either Study 4 or Study 5. It is unlikely that participants purposefully replicated the methodology to practice after their participation in Study 4 or in preparation for Study 5 as this would require them to access an EEG or HRM (although they may have as this was not verified when they returned to take part in Study 5). It may be however that explicit counting of one's own heart beat or the question of how accurate they were is something that prior to their participation in

Study 4, they had never considered. It is possible that taking part in Study 4 led participants to become more aware of their heart beat and so see improvements over time because of this changed focus. Of all the tasks that they participated in, the HBC was the one that seemed to raise the most questions and interest (anecdotal observation of the researcher). The shift towards greater accuracy seen across the range of participants between Study 4 and 5 as shown in Figure 6.1.3 would seem to support this idea. Further research could consider the effects of practice or increased (or newly introduced) focus on heart beat counting to verify the improvements seen across studies in this thesis, and identify why this might be.

This finding does have implications for studies that use performance on the HBC as a proxy for an individual's generalised interoceptive accuracy that is assumed a trait characteristic. This finding complements others that demonstrate interoceptive accuracy may differ with in individuals across contexts. Ainley, Tajadura-Jiménez, Fotopoulou and Tsakiris (2012) demonstrated that improvements in HBC were seen when participants completed their counts whilst looking at themselves in a mirror compared to a blank screen. They suggested that the increased focus on self, improved interoceptive accuracy by focusing attention. Durlik (2016) reported a series of experiments in her thesis manipulating self-focus through social and physical threat. Interoceptive accuracy (HBD) improved for participants anticipating social anxiety (public speaking) and physical pain, but decreased in social exclusion and was unchanged under a social self-focus (being videoed). Durlik (2016) concluded that as interoceptive accuracy can be manipulated according to context it should be considered a state variable.

Accordingly, it is equally possible that improvements in accuracy seen in this thesis between studies was due to contextual differences rather than any learning or practice effects. For example, perhaps the knowledge of impending assessment on the HBC was heightened in the second study when repeating participants knew what to expect, this may be considered an anticipation of social evaluation, with the research explicitly advising that their count would be compared to actual heart beats recorded.

Furthermore, the demonstration by Ainley et al. (2012) and Durlik (2016) that assumed trait measures such as HBC and HBD potentially vary according to context, giving the ability to manipulate interoception levels might be utilised. This potentially provides a means to conduct experimental manipulations to make within participant comparisons of the effects of different levels of interoception on behaviour such as problem solving. For example, comparing proportions of experiences labelled as insight for high compared to low interoception conditions.

In this thesis however, despite a net increase in accuracy, comparisons of individual differences saw an association between HBC accuracy scores for an individual in Study 4 and 5, seeing more accurate scorers in the CRA study being similarly more accurate in the Connect 4 study. This was comparable to the test-retest correlation reported by Mussgay, Klinkenberg and Rüddel, (1999) (see also section 5.4.4). This may suggest that while there is inter-individual variation on HBC accuracy relating to context; a general accuracy level with variance around this in different contexts may be seen with which to make intra-individual discrimination and comparison possible.

Hypothesis 21 predicted that higher HBC accuracy would see increased labelling of solutions as insight, replicating the null finding in Study 4 no association was again seen for the Connect 4 task. As highlighted previously, Feldman-Barrett et al. (2004) suggest that for those with accurate interoception, arousal cues influence their emotional experience, while other factors (cognitive and contextual) being more important in individuals with less accurate interoception. Ginzburg, Tsur, Barak-Nahum, Defrin (2014) further propose a threshold effect in interoception, that individuals must be able to detect interoceptive signals for them to impact on other things such as confidence or body ownership or presumably have any effect on emotional experience or insight. Future research could explore this, with a large enough sample of accurate HBC scorers solving problems (CRA or Connect 4) to have the power to detect an effect. However, before such an undertaking the issues raised regarding the proportion insight measure would need to be addressed (see section 6.4.5.1).

6.4.5.6 Limitations of interoception and HBC task.

Of further consideration may be the interoceptive measure used. Garfinkel et al. (2015) identified three different aspects of interoception and compared performance on these. As highlighted in section 5.1.5.2 they found an association between the two principle measures of accuracy (HBC and HBD) but not between awareness measures based on the different tasks. For this reason the decision was taken to use accuracy measures in research for this thesis. Despite their findings, Garfinkel et al. (2015) advocated the adoption of an awareness measure. This can be seen as complementary to Feldman-Barrett et al.'s (2004) finding that bodily signals may have different importance dependent on how accurately they are detected, and additionally on how accurate the individual thinks they are. Following this argument, an individual who does not think they are accurate will likely pay little heed to any signals detected. An individual who is both accurate at detecting signals and knows they are, will use this information effectively. Where there is a disconnect, so poor actual accuracy but high perceived accuracy, bodily signals may be misinterpreted. This more complicated picture may explain the lack of correspondence to other measures with the interoceptive accuracy measure taken in this study.

However, these critiques depend on the integration of bodily signals being a conscious process, or at least being available to conscious monitoring for the awareness measure to be necessary. In fact, this maybe not be the case. Firstly, participant's (in both Study 4 and 5) apparent lack of intuitive knowledge about their own heart rate and were curious as to how well they did. Most made no indications of having even considered this previous to their participation, so might be presumed to have no conscious awareness of their interceptive accuracy (anecdotal observation of research, this was not explicitly measured). Garfinkel et al. (2013) illustrate an example where interoceptive accuracy effects are likely not conscious. They used a rapid serial visual presentation of words where participants detect two target words. Detection of the second word is masked if presented too close after the first, termed attentional blink. However, emotional words overcome the 'blink' and see improved detection. Garfinkel et al. (2013) presented the second word in synchrony with different stages of heart activity, comparing effects at systole and diastole. They demonstrated that while there was equal detection of words at both times, memory for words detected at systole was impaired (surprise free recall test). However, the impairment was reduced in those with accurate HBC scores. This shows an effect that was not conscious yet influenced processing reliant on an interaction of cognitive (detection and memory) and emotional (salient words breaking through the blink) processing. As such parallels can be seen to the processes being explored in problem solving in Connect 4 in this study that again may not be conscious. As such the recommendations to use awareness rather than accuracy measures made by Garfinkel et al. (2013) may be less applicable in this circumstance.

Interestingly, Hypothesis 23 was supported finding a relationship between HBC accuracy and BEQ 7. As identified in section 6.1.7, this item of the BEQ is essentially a measure of interoceptive sensibility, how aware individuals are of their bodily information. This finding contrasts to the null finding for this comparison in the CRA study, and also to other research comparing performance on interoceptive accuracy and sensibility measures which find no relationship (Cali, Ambronsini, Picconi, Mahling & Committeri, 2015; Garfinkel et al., 2015). The comparison of both Study 4 and 5 between HBC accuracy and BEQ7 was not related to the subsequent problem solving task being completed, therefore providing conflicting results. To remind, BEQ7 stated, "my body reacts very strongly to emotional situations". Participants who were more accurate at HBC rated this statement as more like them. This was interpreted as indicative of interoceptive sensibility, their tendency to notice bodily processes (see section 5.1.5.2). However, it may actually be an example of metacognition, as the statement relates bodily processes to emotional experience; participants rating this highly could be making judgements on how well the two correspond rather than purely their attention to bodily changes. This would be more in line with previous studies that show a correspondence between accuracy and awareness (e.g. Garfinkel et al, 2015). Further work might look to compare BEQ7 directly to validated measures of interoceptive sensibility and awareness to better evaluate this relationship.

6.4.6 Conclusion

To summarise, Study 5 demonstrated the potential for Connect 4 to be used in problem solving research to elicit more true to life solving experiences where a series of problems are solved working towards an overall superordinate goal. This task was demonstrated to provide a wide sample of participants with repeated positive and negative solving, experienced as both insight and search. It is notable in demonstrating for the first time that negative insight can be elicited in an experimental setting using a laboratory based task.

Future work would need to refine the methodology, ideally designing and building a Connect 4 version specifically for research purposes where greater control would enable more refined data collection and manipulation of variables.

Heart rate differences demonstrated in Study 4, between insight and search solving in word puzzles (the CRA) were replicated for solving in Connect 4, suggesting that this somatic marker be generalizable across solving contexts. However, time series differences previously seen were not detected. This may be attributed to the poor control seen in the version of Connect 4 utilised in this study, something to be explored with an improved paradigm in the future.

The use of phenomenological self-reports for different solving types (insight versus search) and valence of solving (positive versus negative) provided direct comparisons in terms of experienced pleasantness, fastness, certainty and surprise. Pleasantness ratings offered confirmation that participants were labelling positive solving experiences differentially to negative, furthermore that insight was seen as more positive or negative than search solving. Perceptions of fastness and certainty were discussed in relation to behavioural findings, for example supporting previous work demonstrating that insight solutions are faster than search. The idea that they were also more accurate was explored, although no conclusive results were reported.

Efforts to relate ability to detect somatic changes and individual differences in emotion experience in insight were not demonstrated that might be concluded to show no relationship between emotion and insight. However, this study represents a first effort to make testable predictions about such a relationship exploring likely candidates built on the qualitative information collected earlier in the thesis and drawing from emotion and insight research and theory. Notwithstanding the methodological issues also identified, a single null result should not mean that this relationship be discounted.

7 Overall Discussion

This chapter will discuss the findings from this thesis (section 7.1) and will furthermore evaluate the innovative methods developed (7.2). It will firstly provide an overview of these, then each will be considered in relation to: the impact of the findings; limitations and; future directions.

7.1 Theoretical and Practical Applications of Findings

This programme of study aimed to explore the naturalistic experience of insight. Firstly it examined everyday experience of insight using qualitative data collection (online qualitative questionnaires and a diary study) and analysis to offer validation to experimental work in the field, protecting against the circularity problem in insight research identified in section 2.1.1. The findings reported in this thesis demonstrate that positive insight experienced in everyday life, in general, closely maps to the construct explored experimentally by psychologists over the last century. However the novel identification of negative insight experiences, those sudden sickening new realisations, further develops our understanding of the role of insight in problem solving. As such, an amended definition of insight is proposed:

A sudden new understanding, realisation or idea that is accompanied by a positive feeling Aha moment, or negative feeling Uh-oh moment.

The role of positive insight in relation to simplified stage models of creativity is long established, occurring during the illumination moment when a solution is found (Wallas, 1926). This thesis identifies negative insight moments as sudden problem finding experiences, seeing insight in this context initiating problem solving attempts rather than concluding them and so occurring much earlier in the solving process. The implications of this finding are discussed below in section 7.1.1.

The everyday situations in which insight, both positive and negative can occur that were identified in this thesis can further inform future directions for both the study of insight and the application of findings from experimental insight studies. Further elaboration on these applications will be made in section 7.1.2

Having established ecological validity in the definition of insight proposed, Chapters 3 and 4 further investigated and validated the role of insight in everyday life. These challenged some key assumptions previously made in insight research.

Firstly, highlighting a juxtaposition between research and lay expectations in relation to the prevalence of insight; Insight researchers are clear that it is a rare experience (Ohllson, 2011), whereas Chapter 4 finds that lay perception is surprised by this, expecting insight moments to occur frequently and regularly in daily life. Questions of the prevalence of insight and individual differences in its experience are explored and further work to be done that should facilitate our understanding of this is identified below (in section 7.1.3).

The later research conducted in this thesis (Chapters 5 and 6), explored the biological underpinnings of insight drawing from research in insight but also the physiological changes relating to emotional experience. Findings demonstrate a somatic marker for insight, seeing a difference in heart rate change in problem solving experienced as insight compared to search. In addition to seeing insight as purely positive, other tacit assumptions regarding insight and emotion are challenged in the interpretation made in relation to such biological markers. The applicability of such findings is discussed below in 7.1.4.

7.1.1 Insight and Process Models of Creativity

7.1.1.1 Process models of creativity.

With Chapter 2 verifying the possibility first highlighted by Gick and Lockhart (1995) that insight might be a negative as well as positive experience, Chapter 3 reports research that explicitly collected negative insight moments. This identified a functional role of negative insight as problem finding. This extends consideration of insight within process models of creative problem solving (as discussed in section 3.4.5) beyond its occurrence at the solution moment, illumination in Wallas' (1926) model or part of Runco and Chand's (1995) ideation. The cases of everyday negative insight in Chapter 3 demonstrated that it typically alerted an individual to the existence of a previously unknown (or acknowledged) problem, so occurred at the beginning of problem solving prior to the preparation stage identified by Wallas' (1926) model. As highlighted, negative insight can be seen as a problem finding process. Runco and Chand (1995) identify this as part of their model, but do not recognise the role of insight in this component of it. This has implications for research based on such theoretical standpoints. For example, Vernon, Hocking and Tyler (2016) frame their review of creative problem solving training tools distinguishing between those that target problem finding, ideation and evaluation processes. Although not explicitly focused on insight, this demonstrates how models of creativity are used in applied research (in this case to identify interventions that promote creative problem solving). As such, findings from this thesis that contribute to such models can be seen as contributing to knowledge from which practical applications are developed. Furthermore, whilst the knowledge offered here is theoretical, it is garnered from real-life solving. This offers ecologically validity, to ensure that models do in fact represent problem-solving as seen in everyday life and are not simply lab-based conceptions.

An alternate process model focuses on how expertise in creativity develops with Kaufman and Beghetto (2009) categorising individuals' creativity, describing the process through four stages, beginning with mini-c creativity where acts are creativity to the individual to the Bic C creativity of eminent creative individuals (see section 1.1.3 for further description). The identification of personal insights in Study 1 and 2 can be seen to be examples of mini-c creativity, seeing corroborating examples with Kaufman and Beghetto's (2009) proposed intrapersonal insights in teaching and learning contexts. Furthermore, as discussed in section 2.4.4.3 this thesis extends to offer exemplars of mini-c creativity in personal development, work contexts and possible applications in counselling (see further discussion below in section 7.1.2.2).

7.1.1.2 Insight and search as adaptive behaviours.

Much is made, in the research literature and beyond into mainstream publication and media (often targeting business and leadership audiences), of the role of positive insight in problem solving. Insight is seen as being a panacea for creativity (Cunningham & MacGregor, 2016), with tales of eminent creatives arriving at their break through discoveries in flashes of insight (see section 2.1.4.3). The implication being that insight solving is somehow superior and therefore more adaptive than search. For example Kounios goes as far as labelling those with this desirable trait as 'insightfuls' (this is not seen in his peer reviewed article, Kounios et al., (2008), but in media discussions of his work, for example in Shulte (2015)). He identifies step that might be taken to increase insight experience based on research into insight, the implicit assumption being that insight as a proxy for creativity is a desirable and adaptive trait. The recent development of scales to identify insightful or creative individuals may also be argued to reflect a similar bias although presented more parsimoniously as a research tool (see section 7.1.3).

7.1.1.3 Limitation of focusing on insight solving.

A similar implicit bias is likewise reflected in the methods that insight researchers use. For instance there are often extensive descriptions of insight experience given to participants while the alternative experience is often simply labelled, 'not insight' or referred to as search with little explanation (e.g. Cranford & Moss, 2010; Jung-Beeman et al., 2004). This might be considered as a limitation of this thesis, as it followed this methodology in delivery of the CRA and to a lesser extent in Connect 4. An interesting future direction would be to explore the effects and potential demand characteristics of explicitly favouring one type of solving over the other in the framing of the research. For example, to address whether it is possible that participants over report insight as a demand characteristic when they know this is the researchers' interest and would the reverse pattern be seen if the emphasis was on search.

The same might be said for the qualitative studies conducted in this thesis, where again a focus was purely on insight rather than more general problem solving. However this approach was justified in respects of really aiming to understand how and if insight was experienced in everyday life, firstly as generalised insight (Chapter 2), then subsequently narrowing the focus again to explicitly explore negative insight (Chapter 3). Protection against leading participants in their responses was offered through varying the definitions given to participants. It is suggested that the time may now be to again ask a more broad question, perhaps following Jarman's (2014) approach who asked participants to share their mental click experiences or going even wider and simply asking participants to share problem solving experiences from their everyday life without offering an explicit focus on any solving type . Evaluation could then compare experiences to see to what extent insight or search processes were reported. This might be done through online questionnaires to collect larger samples and event contingent ESM with face to face follow-ups to offer rich accounts of solving experience in everyday life and some measure of prevalence.

Furthermore, interpretations of findings that insight researches make might also be argued to likewise reflect the bias of seeing insight solving as more adaptive or desirable than search. An example being in relation to the interpretation of increased correct responses being labelled as insight compared to search, a finding replicated in this thesis for CRA solving. This is more extensively discussed in section 5.5.4 and 6.4.5.2, but can be summarised in contrasting inferences made about the correct solutions. Firstly, researchers have generally interpreted more correct responses labelled as insight as being because it is a more accurate solving method (Kounios et al. 2008, Salvi et al., 2016). An alternative interpretation posited in this thesis is that feelings of certainty lead participants to label solving as insight. The corresponding increase in accuracy not being an intrinsic property of insight, rather reflecting participants' confidence in solutions.

Seeing insight as more accurate, or more adaptive than search may very much depend on the task at hand. Attempts to measure the effects of quality of solving experienced as insight and search in Connect 4, as reported in section 6.4.5.2 fell short. As highlighted, in a game with ongoing moves contributing to a superordinate goal of winning, a simple correct/incorrect metric cannot be applied to moves made towards that goal. In this thesis, insufficient information was collected to calculate the individual quality of moves selected, as this would require exact information about the grid and position of all the player and opponents' counters. However, a measure of quality was taken in the number of Connect 4 games that participants won (for full discussion of this see section 6.4.5.2). Any future versions of the game for research could incorporate algorithms to record the quality of each move giving a more fine-grained analysis of the relative quality or adaptiveness of moves labelled as insight compared to search (comparable to that done in chess moves by Sigman, Etchemendy, Fernandez Slezak, & Cecchi, 2010). In summary, this thesis highlights the potential bias of researcher's blanket assumptions that insight solving is more adaptive/ desirable than search. This is something that has not been tested, previously or in this thesis and without such testing care needs to be taken in making such claims.

The dual process theory is suggested to possibly provide a framework from which to view insight (Gilhooly, Ball & Macchi, 2014). This posits that there are two types of cognitive processing: Type 1 thinking that is automatic, low on cognitive load and based on heuristics; Type 2 thinking being effortful, involving conscious focused attention and drawing on working memory (Evans & Stanovich, 2013). Taking the simplistic binary distinction, search-based solving that is seen as involving conscious processing and effortful progress towards a solution might be mapped to Type 2 thinking, whilst insight moments defined by their spontaneous appearance into consciousness (implying unconscious processing) be more aligned to Type 1 thinking. However, different interpretations of aspects of insight and creative problem solving are made in relation to dual process theory, highlighting specific factors that impact on Type 1 and 2 thinking in insight solving and proposing the involvement of the different systems to different extents (c.f. Ball, Marsh, Litchfield, Cook, & Booth, 2014; Barr, Pennycook, Stolz, & Fugelsang, 2014; Gilhooly, Georgiou, Sirota & Paphiti-Galeano, 2014). Barr, Pennycook, Stolz and Fugelsang (2014) suggest that both types of thinking are employed in creative solving and insight. Pertinent to considerations being made in this thesis with regards to trait tendencies towards one experience or another (insight or search) is the view proposed by Sowden, Pringle and Gabora (2014) who assert that such trait like dispositions towards Type 1 or 2 thinking are less helpful than consideration regarding adaptive switching between the two systems. This approach does not assume one type of thinking is uniformly more adaptive than the other, alternatively proposing that each system be adaptive in specific contexts. Applying this to the insight/ search distinction, future research might consider the individual differences in switching or reported insight compared to search for different contexts, relating these to performance or quality metrics in solving.

7.1.1.4 Role of impasse and incubation.

As outlined in section 1.1.5, central to one of the prominent contemporary theories is the necessity of impasse, leading to unconscious incubation and therefore insight (Ohlsson, 1992; 2011). As such there are argued to be low feelings of warmth (see section 1.1.4.4), felt progress towards a solution during solving attempts until the point of insight (Metcalfe & Weibe, 1987). Research focusing on incubation, further posits that spreading activation best explains insight moments with the appearance of a solution available as sudden, conscious awareness (Gilhooly, 2016).

Findings from this thesis contribute to this debate in a number of ways. Firstly the identification of the theme Active Search in both Study 1 and 2 demonstrate that insights occur in everyday life whilst problem solving attempts continue. This supports the idea that impasse is not necessary to the experience insight (see section 2.4.5.1), suggesting that insight can occur whilst attempts are still being made to solve a problem. This is congruent with other models of insight such as Weisberg's (2014; Fleck & Weisberg, 2004, 2013) that again identifies various pathways to a solution that incorporate impasse and insight, but does not content that reaching an impasse is necessary in order to experience an insight moment. This research therefore offers ecological verification to this model. Further interpretation of the pathways in Weisberg's (2014; Fleck & Weisberg, 2004, 2013) model are proposed with consideration of negative insight; seen in section 3.4.5. Weisberg's (2014; Fleck & Weisberg, 2004, 2013) model demonstrates how a realisation that highlights an error during solving attempts is adaptive. Such a negative realisation serving to inform the problem solver and perhaps helping them to change track and use this information in their future attempts to solve the problem.

In terms of incubation, the identification of negative insights that occur "out of the blue" (see section 3.4.2) are problematic for spreading activation theories as they currently stand. Such theories asserting that unconscious processes require an activated goal, to which conceptual links continue to spread after conscious work has ceased, leading to novel connections that represent a solution appearing as-if from nowhere back into conscious awareness (Gilhooly, 2016). For many of the real-life negative insights seen in this thesis, there was no previous awareness of a problem, so presumably no activated goal state for activation to spread to. This thesis proposes an alternative explanation, considering spreading activation between salient experiences or thoughts that were not necessarily labelled seen as problems when they occurred. Figure 7.1 demonstrates in the top row (a-c) the ideas posited by existing theory (see Gilhooly, 2016) where an activated goal is seen resulting from previous attempts to solve the problem, the spreading activation that incorporates this goal with pertinent aspects of the problem leading to a sudden experience of finding the solution to the problem, as-if from nowhere. The bottom row demonstrates how spreading activation might lead to the identification of a problem (so new goal) in a sudden insight moment, where there was no previous conscious awareness on one, in this instance the problem appearing in consciousness out of the blue. Future research would look to explore this and provide evidence on which to incorporate negative insight into incubation theories of problem solving.

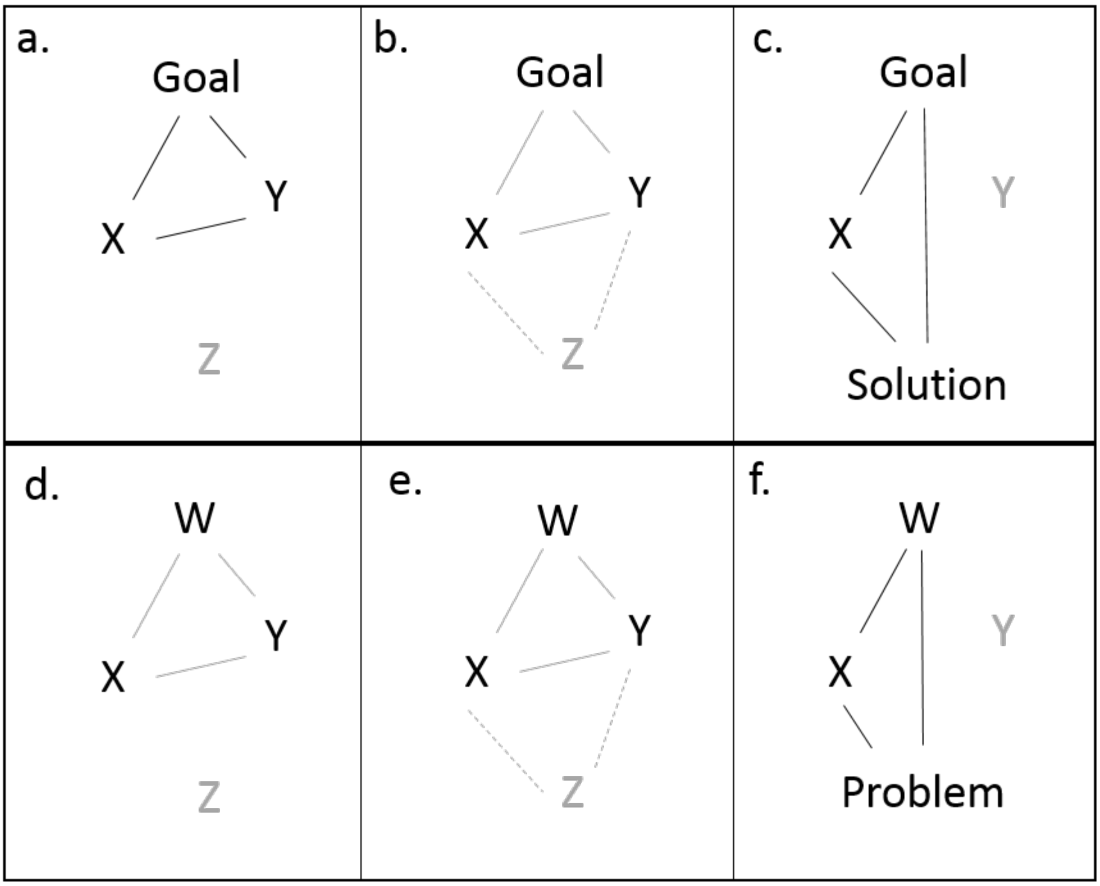


Figure 7.1 Conscious attempts (black lines) to solve a problem (a.) activate a goal and related concepts (X, Y). On reaching an impasse and getting stuck conscious attention moves elsewhere but activation spreads (dashed grey line) to related concepts (b), when this connects the solution to the problem it pops into awareness as a sudden insight solution (c). In negative insight salient concepts (d) continue to spread activation after moving out of conscious awareness (e). Spreading activation links previously unrelated concepts and identifies a problem that pops into awareness as a sudden negative insight (f).

A further aspect highlighted by this thesis in the Time Away theme from Study 2 is the reason why people move away from problems. The assumption is that people take time away from problems due to reaching an impasse. However, time away from a problem not only constituted prolonged periods where incubation might take place, Chapter 2 (section 2.4.5.2) identified shorter breaks of day dreaming or stimulus-independent thought (Schooler et al., 2011) as being implicated in insight. This corroborates a positive role of mind wandering which contrasts to it often being framed as maladaptive by distracting from the task in-hand (for example see Dixon, Fox & Christoff, 2014).

As identified in section 2.4.5.2, none of the everyday insight descriptions shared elaborated on the reason for taking time away from problem attempts. Furthermore, no other research has explicitly investigated reasons for taking time out in real-life solving. As such future studies might aim to validate these assumptions, possibly adopting methods similar to those seen in this thesis to capture everyday problem solving experience.

7.1.1.5 Integrating emotion and insight theory.

This programme of research saw, on identification of emotional aspects of insight attempts to integrate theory from the separate literatures relating to emotion and insight. Taking a dimensional approach to emotion (Russell, 1981) it was identified that in addition to insight having a positive valence, that sudden realisations may also have negative, 'bad for me' valuations attached (Gross, 2016). This thesis identified physiological changes in heart rate for the two different solving types, with less deceleration for insight compared to search solving. This was comparable to findings in both insight research, for example Lackner et al. (2013), and in response to emotional stimuli (Bradley et al. 2001, Guerra et al., 2016). This thesis is suggesting that similar processes may be seen in insight and emotion and so offers a possible verification of Shen's (2015) assertion that insight be framed as a source of endogenous emotion.

However, the discriminations in heart rate between positive and negative solving predicted for the Connect 4 study were not observed. As identified in section 6.4.2.1 this may be attributable to differences between the context in Connect 4, where participants are actively problem solving, compared to passive participants in emotion research who view presentation of emotional images with no goal. Furthermore, this thesis did not explore the second dimension of emotion in insight experience, this being the role of arousal. As identified in section 6.4.2.1, Shen et al. (2016) found that insight solving showed higher electro dermal activity (EDA) than search. Future research could look to explore the roles of EDA and heart rate change together, using a naturalistic problem solving task such as Connect 4 to provide comparisons of positive and negative insight and search solving. This would enable further integration of dimensional theory of emotion in insight. Further discussions regarding physiological aspects are discussed below in section 7.1.4.

As highlighted in Chapter 1, other discrete emotions have also been discussed in relation to insight, particularly happiness and surprise which are two of Ekman's (1972) basic emotions. In line with other phenomenological reports of insight collected in laboratory studies that implicated happiness (Danek et al., 2014b; Shen et al, 2015), Chapter 2 saw every day insight likewise described in these terms for example positive emotions such as happiness and certainty (see section 2.4.3.1). Comparisons of phenomenological ratings in Chapter 6 of this thesis add weight to this finding, with positive insight being rated as more pleasant (Danek et al. (2014b) used pleasantness and happiness interchangeably) than positive search and negative insight being more unpleasant that negative search. This demonstrates that phenomenological self-reports of problem solving used in lab-based tasks to discriminate solving are comparable to experiences of insight solving reported in everyday life.

There were conflicting reports in relation to the role of surprise, with Shen et al. (2015) discounting its role, while Danek et al. (2014b) suggested it was important. Findings from Chapter 6, do see a difference with insight solving rated as more surprising than search, supporting Danek et al.'s (2014b) view, however the effect is small suggesting that surprise may not be as central to the insight experience as has been suggested (see Section 1.2.3.2). Furthermore, not only is surprise in insight disputed, as identified in Section 1.2.3.2 there are debates regarding the construct of surprise as an emotion.

The final aspect that was related to positive emotions in everyday insight reported in Chapter 2 and 3 was certainty. A measure of certainty was also taken in Chapter 6 which conversely saw no difference in reported experience for insight compared to search solving. Certainty might be seen as analogous to confidence. A recent study found that, as suggested in everyday insight in this thesis (Chapters 2 and 3), participants were more confident of solutions (to magic tricks) they labelled as insight rather than search (Hedne, Norman & Metcalfe, 2016). But, conversely, the feeling of warmth (FOW) ratings made on the run up to solving in the study showed no difference for insight compared to search, across the course of solving (although the FOW ratings immediately before a solution was found were similar to post solving confidence reports, so high FOW just before solving saw higher confidence reports post solution). This demonstrates that certainty or confidence differences between insight and search are seen at the solution moment (just before or after), but not during solving attempts. It may be that the participants giving certainty ratings in Chapter 6 of this thesis were recalling their feelings during solving rather than at the solution point and so it could explain why there is a discrepancy between findings from different studies.

The use of phenomenological ratings more proximate to the actual solving, rather than post solving ratings (as seen in this thesis and Danek et al. (2015b) is one avenue to be progressed. A recent study, published after all research design and data collection for this thesis had been completed did take ratings for confidence, impasse, pleasure and surprise attached to each trial where a problem was solved (Webb, Little & Cropper, 2016). Rather than make assumptions about solving due to the type of problem solved (participants completed classic insight, non-insight and CRA problems that the authors designated as a hybrid of the two) or force binary categorisation of problems as insight or search participants gave a rating for their feeling of Aha. The ratings between Aha and confidence (certainty) showed high collinearity meaning that confidence ratings were removed from the multilevel analysis that was carried out to explore how well solving accuracy was predicted by the different ratings. This suggests that confidence ratings showed the greatest correspondence to feelings of insight (measured through the rated Aha experience) in terms of predicting accuracy, yet showed only a moderate level of prediction. The authors additionally highlight that there was more of an association between the Aha experience, than there was to accuracy. As such, the picture with regards to what contributes to the experience of insight is still unclear.

This thesis replicated the scales used by Danek et al. (2014b) that focused on perceived pleasantness, surprise, certainty and fastness of solving to provide a direct comparison of results for solving experiences labelled as insight and search. An alternative would be to utilise established and well validated measures of emotional experience. One of the most widely used being Self-Assessment Mannequins (Bradley & Lang, 1994). These take dimensional measures of emotion, providing ratings of arousal (calm to excited), valence (negative to positive) and dominance (control felt over stimulus: dominated to dominant). A dimensional approach in ratings would have better matched the approach taken in this thesis that focuses on dimensional aspects of emotion. However using such an approach would have made comparison to the work of Danek et al. (2014b) and other insight research using discrete descriptions of emotion as more problematic. This highlights that future work might consider reconciling Danek et al.'s (2014b) ratings taking a predominately discrete approach to emotion with the dimensional measure designed by Bradley and Land (1994) in consideration of emotion in relation to insight. Perhaps reviewing literature and providing a common framework in relation to emotional perspectives of insight from which researchers can draw needs to be a next step. Furthermore, comparing measures drawing from both perspectives with each other during problem solving would provide a better understanding of how the two perspectives and corresponding measures relate which would have implications for emotion research and theory more broadly.

7.1.2 Everyday Insight: Application of Findings

This thesis sees the collection of a large number of examples of everyday insight and problem solving. These could form the basis for a corpus of real-world problems that could be developed and presented in naturalistic cognitive tests, similarly to those that Gilhooly et al. (2007) presented to older adults (see section 3.4.1). The focus of Gilhooly et al.'s (2007) problems was interpersonal relationships, but equally pertinent would be intrapersonal problems seen in section 3.6.2. In addition, practical applications are highlighted below in relation to the situations identified in the everyday examples.

7.1.2.1 Learning and teaching

One aspect that is highlighted by this thesis is the role of insight in learning and teaching environments, with examples seen in these contexts in Chapter 2 and 3. This socially facilitated insight, discussed in section 2.4.4.3 and 2.4.5.3 can be seen as adaptive with the insight experiences described as leading to improved understanding. However, little is known of how insight moments operate within a learning context. Some research suggests that there are memory advantages to information identified through insight (Danek, Fraps, Müller, Grothe & Öllinger, 2013) and that this may be related to both the emotional component (Aha experience) and cognitive solving processes involved (Kizilirmak, Galvao Gomes da Silva, Imamoglu & Richardson-Klavehn, 2016). However, these are experimental studies with problems of lab. induced confounds. Further research might explore how and if advantages to insight occur in real-life learning and in what contexts this is adaptive. Everyday data collection methods such as those developed in this thesis (see below sections 7.2.1 and 7.2.2) but targeted to learning environments may be useful to further inform experimental studies by identifying how insight moments are experienced and judged as useful in a learning context. Such information may then be utilised to inform interventions to aid the recognition or experience of adaptive insight moments in a learning environment.

Alongside the development of interventions that aim to facilitate learning/ understanding, there would need to be reliable and validated measures of insight occurrence in every day settings such as the class room to test the effectiveness of the intervention. Self-reports could be sought, but these are reliant on participants making reports and further may be distracting in a class situation, taking focus away from the learning environment. As such the development of measures that capture behavioural or physiological markers could offer a distraction free alternative. This thesis presented preliminary findings of a somatic marker for insight. As discussed below (section 7.1.4) future work to identify a robust and reliable marker could then be applied to these situations and even could enable the exploration of insight within non-human animals.

7.1.2.2 Personal development and therapy.

A second avenue for application of findings in this thesis is that of therapeutic settings. The examples of Personal Insight identified in Chapter 2 (see section 2.4.4.2) can be related to counselling literature that centres on self-insight as a vehicle for therapeutic change. With help-seeking a consequence of problem-finding, it can be seen as an adaptive everyday behaviour outside of therapy. As discussed in section 3.6.2, future research could explore the relationship between negative insight and help-seeking in different populations (clinical versus non-clinical) and work to identify a model of Personal Insight as a healthy behaviour.

7.1.2.3 Workplace creativity.

The social aspects of creativity and insight in the workplace is perhaps the most explored everyday aspect (for example, Amabile, Barsade, Mueller & Staw, 2005, Csikszentmihalyi & Sawyer, 1995; Hargadon & Bechky, 2006). With creativity being highlighted as ever more important in the competitive, rapidly changing business environment (Baer, 2012; Puccio & Cabra, 2010, Cunningham and MacGregor, 2016). The work based and research related contexts highlighted in this thesis (Study 3 and 4) where participants describe insights relating to their working environment or the context of research (often relating to graduate research) again suggest that this be an area to develop in the future. Rigolizzo and Amabile (2015) discuss the importance of problem identification in entrepreneurial creativity in both newly established and longer running business settings. The role of negative insight as problem identification identified in this thesis would therefore need to be taken into consideration in models that propose such a stage.

7.1.2.4 Positive psychology.

Conner, DeYoung and Silvia (2016) recently identified an "upward spiral of wellbeing" (p. 6) in relation to everyday creativity, seeing lagged effects of positive mood and self-rated flourishing the day after reports of creative activity, the definition of which included "coming up with novel or original ideas" (p.3). This suggests that experience or recognition of everyday creativity, including mini-c creativity (intrapersonal insights) identified in this thesis, as insight could likewise have implications for wellbeing. As such this affords an avenue for impact, using the findings from this thesis to widen perception of what constitutes everyday creativity beyond little-c creativity such as painting or music, explicitly highlighting these links to positive wellbeing outcomes. Future research could look to compare the contributions of little-c and mini-c creativity to positive psychology measures such as positive affect and flourishing.

7.1.3 Individual Differences in Insight Prevalence and Phenomenology

Later studies in this programme of research built on findings regarding everyday experience of insight. One aspect identified was individual differences in in the experience of insight. This will firstly be discussed in terms of prevalence.

As identified in Chapter 4, some participants did not report any insight experiences over a week. De-brief interviews checked that this was not due to lack of reporting nor method of data collection, with one participant identifying that they had never experienced insight. At the same time, independent researchers using a questionnaire survey with a large sample likewise found that nearly twenty percent of their participants reported never experiencing insight (Ovington et al. 2015). Together these findings challenge the idea that insight is a universal experience. This thesis additionally offers face to face validation to the interpretation of Ovington et al.'s (2015) data. This has implications for both theory and applied fields.

Firstly in terms of theory, those who advocate a special process view of insight (e.g. Ball, Marsh, Litchfield, Cook & Booth, 2014; Subramaniam, Kounios, Parrish & Jung-Beeman, 2009), would need to explain this lack of experience in certain individuals. This could mean considering a deficit model, perhaps similar to the idea of alexithymia, which describes a lack of experience of emotion (Hogeveen, Bird, Chau, Krueger & Grafman, 2016). Such an assertion would then need to identify the neurological differences that underpin this deficit. For a business as usual view, the assertion that insight is a based on general underlying processes (e.g. Ollinger & Knoblich, 2009; Chein & Weisberg, 2013) would again lead to the question of what differences in these processes are seen between individuals who do and do not experience insight. For example, do these differences lie in cognitive aspects such as memory or attention or in emotional factors such as emotionality.

In applied fields, such individuals may need special consideration. For example in counselling contexts where insight is seen as central to the therapeutic process (see more detail in section 2.4.4.2 and 7.1.2.2) different theory or approaches may need to be taken with individuals who do not experience insight. Similarly in education and business, where creativity is seen as a desirable trait, there are implications for those whose creative experience contrasts to this ideal.

Recent attention has turned to individual differences in insight (e.g. Cunningham & MacGregor, 2014; 2016; Kounios et al., 2008; Ovington et al., 2016), which was seen in the identification of a congruent theme of Individual Differences in Chapter 4 of this thesis. This saw exploration of individual differences in terms of prevalence and experiential aspects (see section 4.4.1) and can be seen as offering validation to approaches that seek to measure these individual differences, either experimentally or in everyday experience. An alternative way to express this is assuming a trait or dispositional tendency to experience insight can be measured (this is the assumption Kounios et al., 2008 make). Whether this disposition is domain general (so sees consistent individual differences across tasks) or domain specific (with different experience and expression of insight according to context) is yet to be determined. In this thesis the proportion of insight levels for the two problem solving tasks were different. Furthermore no consistent pattern of tendency was seen within individuals across the tasks, so an individual reporting high levels of insight in Connect 4 did not similarly report high levels in the CRA. This may be suggestive of domain specific insight tendency patterns. However, as identified in section 7.2.3, the Connect 4 paradigm could be further developed. There were also problems with the approach taken by Kounios et al. (2008) in assuming performance on any lab-based problem solving task represents a general disposition towards insight seen in everyday life (see further discussion in 4.5.1). This led to inconclusive findings in relation to the further lab-based exploration of individual differences in dispositional insight.

Future research may look to compare the different measures for insight disposition including Ovington et al.'s (2016) Disposition of Insight Scale and Cunningham and MacGregor's (2014, 2016) Productive-Reproductive Thinking Inventory (P-R) and explore tendency to report insight across various lab-based insight tasks (following Kounios et al., 2008) in relation to actual measures of insight occurrence. As highlighted in this thesis (Study 3), lay perceptions of insight (the amount of insight an individual judges they themselves experience) overestimate what happens in actuality (as measured using event contingent ESM). As such any self-report measure must be validated with behavioural data.

Two further individual difference aspects were considered in relation to insight. These aimed to explore the relationship between emotion and insight so focused on individual differences in emotional experience, the rationale being that if these impacted on insight, associations would be seen relating them to insight experience. As summarised in Chapter 6, no associations were seen between interoception measured with the Heart Beat Counting task, emotional expressivity and tendency to experience insight. However as highlighted above there are questions regarding the tendency to experience insight measure used. Future research should not discount the relationship proposed in this thesis between individual differences in emotional experience and insight on the basis of a single set of null findings using poorly validated measures. Furthermore, other findings in this thesis are suggestive of a relationship: the identification and distinction of everyday insight solving by valence (positive and negative) and; somatic markers in insight consistent to those seen in emotional experience (both shown in this thesis for HR and discussed in section 1.2.5 in interpretation of neuroimaging results from other studies).

7.1.4 Biological Markers for Insight

Models that integrate emotion and cognition posit the involvement of physiological changes, for example the somatic marker hypothesis (Damasio, 1994). Accordingly examination of the biology of insight, with consideration to emotion literature was made. This identified complementary findings with regards to heart rate change during insight (Jausovec & Bakracevic,1995; Lackner et al., 2013), emotion elicitation (Bradley, Codispoti, Cuthbert & Lang, 2001) and detection of salient (or surprising) stimuli (Guerra et al., 2016) (for full outline of findings see section 5.1.3). This thesis identified a HR change over time that corresponded to previous findings but using within participant and within task comparisons to enable difference to be more confidently attributed to the solving type. A biphasic response was shown in Study 4 for both types of problem solving, with an initial deceleration towards the point of insight then seeing acceleration post solution. This was consistent with HR responses seen in both previous insight and emotion research (e.g. see Bradley et al., 2001; Lackner et al., 2013). In both the CRA task (Study 4) and Connect 4 (Study 5) less deceleration was seen for insight in comparison to search solving. This was again consistent with results for insight versus non-solving (Lackner et al., 2013) and emotional versus neutral images (Bradley et al., 2001). Together the results from this programme of study identify heart rate change as a potential somatic marker for insight and enable links to an emotion theory view of insight. Shen et al. (2016) recently demonstrated a difference in EDA between insight and search trials using the CRA. As speculated in section 6.1.6.2, the relationship between arousal and valence, with extremes of valence increasing in arousal might explain these corresponding HR results for insight, seen as more arousing than search solving. Future research might look to replicate findings with measures of both EDA and HR change in the CRA and across different solving contexts, for example using a refined version of Connect 4 (discussed below in section 7.2.3).

In terms of the applicability of these findings, this research (exploring somatic markers as in this thesis, also: Lackner et al., 2013 and Shen et al., 2016) is in its infancy. If a robust marker is quantified, it would first need to reliably discriminate between insight and search solving. Whilst this thesis did identify differences in HR, the effect size was small meaning the utility of such a difference may be limited. Such a signature could then be used in situations where self-reports of experience are either unreliable or impracticable. For example as discussed above in section 7.1.2.1. Further work could look to validate a signature in non-verbal populations, for example babies and infants or non-human animals. However, such a position is a long way off because the current research body, consisting of a few studies focusing on different measures and showing small effects does not demonstrate a robust difference on which to make such discrimination between solving types. More immediate complementary research might aim to explore other physiological and behavioural markers, for example facial expressions or other observable behaviours that map to insight. These could be combined to provide redundancy in any detection method developed.

7.2 Evaluation of Novel Methodology Developed for the Naturalistic Study of Insight Experience

In addition to the findings outlined above this programme of research also identified specific research problems to which novel methodological solutions were proposed. This section will provide a brief evaluation of these.

Firstly, the use of online questionnaires to collect open textual, qualitative accounts of participant's experience sees a departure from typical qualitative approaches. This methodology was applied to the collection of one-off snap shot accounts of everyday experience, but also in event contingent Experience Sampling Methodology. This will be explored in section 7.2.1

Secondly, in response to the circularity problems in insight research identified in section 2.11 it was decided that a qualitative approach should be taken in exploring everyday experience of insight. However, the subjectivity introduced by such methodology was seen as problematic in light of the influence of definitions on previous insight research. Therefore a methodology was developed to protect against these effects. Section 7.2.2 below explores this new methodology: Integrative Thematic Analysis.

Finally, the identification of negative insight presented a problem for existing paradigms of research where established insight elicitation tasks focus purely on positive insight. As such this programme of research aimed to identify and validate a new laboratory based task that would provide experiences of positive and negative insight and search solving echoing those seen in everyday life. It proposes that Connect 4 elicits this full range of solving types with a more naturalistic solving experience than previous methods. The efficacy of this method and further development opportunities are outlined below in 7.2.3.

7.2.1 Online Questionnaire Collection of Qualitative Textual Responses

Typical qualitative methods collect data using face to face semi-structured interviews, focus groups, observations, and review of documents and media of life (e.g. personal journals) (Braun, Clarke & Weate, 2016; Creswell, 2013). Study 1, 2 and 3 saw online collection of data using the Survey Monkey which is predominately set up for the collection of quantitative survey data. Online collection of qualitative data using a questionnaire is a new burgeoning qualitative data collection approach that is often overlooked in qualitative research (Toerien & Wilkinson, 2004). As such, this thesis presents an additional example of this methodology being successfully employed in the field of cognitive psychology.

In Study 1 and 2 textual responses were collected in response to open-ended questions aiming to capture participant's descriptions of a snapshot experience with as little leading bias as possible (e.g. offering of minimal or no definitions, questions to encourage description of experience and when it happened). As outlined in section 2.4.7 there were limitations to this method, with the responses given being more limited than in other qualitative methods (Braun & Clarke, 2013). For example in face to face interviews, participant' responses can be probed where it is not clear, or to encourage a more detailed explanation. Short or unclear responses given through an anonymous questionnaire therefore may remain ambiguous and wrongly interpreted without this opportunity to follow up responses.

However there are strengths to be highlighted as well. Firstly in the number and distribution of participants that an online survey can reach in comparison to face to face research. Additionally, the anonymity it affords can also be seen as advantageous. This thesis did not focus on a topic that was particularly sensitive (although anonymity may have contributed to the reporting of Personal Insights), but for other projects this may be an important consideration.

Study 4 additionally demonstrated an adopted version of the qualitative collection of insight experience, using the questionnaire format as a portal for participants to record their insight experiences as they occurred, following event elicited Experience Sampling Methodology (ESM) (Csikszentmihalyi & Larson, 1987; Moskowitz & Sadikaj, 2011). As such the benefits of the questionnaire were seen including: being a convenient medium for participants to make their reports (via their own smartphones or devices with online access); secure handling and storage of data and; time stamps to enable verification of reports. The addition of the face to face de-brief interview enabled probing of responses to check where information given was unclear, and to encourage elaboration of the experience. This highlights how the combination of collection methods, following methods outlined by Sun, Sharples and Makri (2011) who used it to validate a mobile phone application, could be useful in studies exploring everyday experience of psychological phenomena.

Finally, the use of qualitative methods within the questionnaire identified that participants' responses did not always relate to the definition given. As seen in the theme, Uh-oh no insight (section 3.3.1) in Study 2 and also in Study 3 (section 4.4.2), participants focused on one aspect of the insight definition, providing examples of an Uh-oh or Aha experience that did not represent a new understanding or idea. The de-brief interviews in Study 3 afforded confirmation that this was the case. This has important implications for all online research, highlighting the need to check that participants are describing what the researcher thinks they are and not to assume that in giving a definition it will be heeded. If, for example in this thesis it had been decided to collect quantitative data rather than qualitative, the proportion of participants who responded thinking about only the Aha or Uh-oh aspect of the definition would be unknown, and responses taken to represent insight when this may not be the case. Therefore a recommendation based on findings from this thesis would be to include qualitative open text responses in all questionnaires, regardless of approach (qualitative or quantitative) to check responses do relate to the phenomenon under investigation.

7.2.2 Integrative Thematic Analysis: Qualitative methodology

The thematic analysis methodology outlined by Braun and Clarke (2006) was adapted in this programme of research to protect against researcher subjectivity introduced by their necessary expert knowledge in the field being explored. For many situations where qualitative research is being used as a first-base exploratory tool or to reach a rich understanding of contextual, local-based knowledge this may not be a problem because reflexivity statements are included to acknowledge the position the researchers take. However this thesis was taking what Braun and Clarke (2013) categorise as small q qualitative research, aiming to inform quantitative research. However, because it was effectively informing the quantitative research after-the-effect, the existing body of knowledge would influence the analysis taken by the researcher. Specifically in the case of exploring everyday insight to validate experimental work, protection was needed to ensure continued circularity effect did not occur (see 2.1.1). As such a second researcher, naïve to the research area analysed the data in tandem to the first researcher and themes were integrated, a method this thesis termed Integrative Thematic Analysis (ITA).

Through the three studies that used ITA in this thesis a number of strengths of it as a methodology were demonstrated. In Study 2, the first researcher overlooked the theme, Time Away likely because it was identified in Study 1. The inclusion of a second researcher, not the same second researcher as in Study 1 meant that this omission was identified. In a reverse situation, the identification of a theme related to the research aims and literature review conducted by the first researcher (Gut Feelings) could be argued to be driven by this knowledge. The identification of a comparable theme by the second researcher offered reassurance that this was a genuine theme, rather than result of the first researcher's expert knowledge (see section 3.4.7). Both of these situations highlight how the data-driven contribution of a naïve researcher has advantages over the typical role of a second researcher offering a confirmatory review of analysis carried out. Following this approach, it is unlikely that the missed theme in Study 1 would have been identified through the review of themes and supporting data presented by the first researcher. Furthermore, a researcher with knowledge of the research field would be more likely to exhibit confirmatory bias, while the use of a naïve researcher, working independently to identify themes offers protection against this.

There are however some disadvantages to ITA to highlight. Particularly in terms of the additional resources required to follow this method. Over the three studies in this thesis using ITA this meant engaging a different second researcher for each analysis. Using the same second researcher over the series of studies would have meant that the discussion involved in the integration of themes from the previous study would have biased the subjectivity of the second researcher meaning they were not naïve in the follow up analysis. If the first researcher has been effective in disseminating findings from earlier research and so demonstrating impact, this too could have detrimental effects in finding a second researcher who was truly naïve. Fortunately in this programme of research, the first researcher was was able to locate appropriate naïve second researchers. This would likely be an even greater problem in large and specialist research teams who all work in the same field. As such the creative use of collaboration between researchers in different fields, but sharing qualitative methodologies could provide reciprocal second researchers to follow ITA.

In sum, while it may not be necessary in all research contexts, this thesis has demonstrated that ITA may be the method of choice where protection against subjectivity is particularly important, but qualitative methodology be seen as the best approach. In designing research using ITA analysis the role of a second researcher should be an appropriately naïve individual with the time to dedicate to the process.

7.2.3 Connect 4: Task to Elicit Naturalistic Laboratory Based Positive and Negative Problem Solving Experience

Section 6.4.1 sees an in-depth evaluation of Connect 4 as naturalistic laboratory based task to elicit experience of positive and negative solving experience. It is argued to be naturalistic in the same way as chess, a more established research tool used to explore decision making and problem solving (Charness, 1992; Connors, Burns & Campirelli, 2011; Gobet & Simon, 1996). Yet this thesis argues that the necessity of a level of knowledge in order to play chess places a constraint on its utility as a research tool for non-expert populations.

Connect 4 on the other hand has very simple rules, as demonstrated in this thesis, explainable in a short briefing session at the beginning of participation in research.

To summarise, the reliability and validity of Connect 4 as a problem solving elicitation tool was demonstrated in terms of it producing the expected range of solving experiences (positive and negative, insight and search) in the sample of participants recruited in Study 6. These were students and non-students, with no constraints in terms of language or experience of playing the game. As such this study demonstrates Connect 4 as being a task that is suitable for a general sample of adult participants. Furthermore, Connect 4 is recommended by its manufacturers as suitable for children over six years old. Future research could therefore explore the suitability of this task to elicit problem solving experience in children alongside adults to enable an exploration of developmental aspects in problem solving, insight and creativity. This is something that was highlighted by Guildford (1950) as an important area for investigation, and remains a matter of contemporary debate in terms of the extent that creativity is or is not seen in children (Russ & Fiorelli, 2010). Connect 4 could provide an experimental paradigm to elicit naturalistic solving experience across and through development into adult hood.

A current, major limitation was the version of the game used in this thesis. A computer based application, was downloaded as-is, in a format designed for casual game play rather than research. This meant that vital data collection opportunities were limited in terms of the amount of information that could be collected from the participant about each move. Furthermore, the short duration between each move created potential overlap that was problematic for the HR data collected, reducing the scope of analysis conducted. Finally, measurement of move quality through the game was not possible, as the moves made by the player and opponent were not recorded (see also above 7.1.1.2). As such a recommendation of this thesis would be for a purpose built research-focused version of Connect 4 be commissioned in order to improve control and data collection. This would provide more robust findings in relation to solving experience, adaptiveness of moves selected and factors such as physiological measures. Furthermore, the use of Connect 4 and the benefits of visuo-spatial methodologies to elicit insight perhaps demonstrate the need for openness to employing other novel methods to elicit insight that do not rely on specific abilities such as language skills.

7.3 Conclusion

In summary, this thesis has explored insight beyond the cognitive domain. Firstly, using qualitative data collection and analysis to characterise everyday insight experience. Through a series of studies novel aspects of insight including negative insight, as a problem finding process were identified. As a result this thesis proposed to re-define the insight moment as:

A sudden new understanding, realisation or idea that is accompanied by a positive feeling Aha moment, or negative feeling Uh-oh moment.

A quantitative approach was then taken to explore the aspects identified in the qualitative studies in this thesis and implicated through a review of previous insight and emotion research literature. Psychological and physiological aspects were measured as participants solved problems, firstly word puzzles (Compound Remote Associates [CRA]) and secondly whilst playing Connect 4. No association was seen between emotional expressivity or interoceptive accuracy (Heart Beat Counting) and solving performance (proportion solved through insight). A difference in heart rate (HR) was identified between solving labelled as insight and search in both CRA and Connect 4, with a greater decrease in HR in search solving than insight. A biphasic HR change was seen in the CRA solving, this was congruent to patterns of HR change shown in previous research in response to emotional stimuli and humorous, insight cartoons. Together this suggests that solving experienced as insight may be distinguishable from search through somatic measures such as heart rate. The successful elicitation of both positive and negative insight and search solving in a laboratory-based setting for the first time further validates the study of phenomenological and emotional aspects of insight. In addition it provides a novel methodology to use in the future investigation of insight phenomenology.

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Appendix 1 Participant details of experimental insight studies.

Study	Sample description	Age Mean	SD	Range
Bowden & Jung-Beeman 2003	students	na	a	
Bowers, Reghr, Balthazard & Parker, 1990	students	na	na	na
Cranford & Moss, 2010	students	na	na	na
Cranford & Moss, 2011	students	na	na	na
Cranford & Moss, 2012	students	na	na	na
Cunningham at al 2009	students	na	na	20-30
Cushen & Wiley 2011	students	18.76	1.08	
Daneck et al 2014	mainly Students	24.4	na	3.3
Duncker, 1945	mainly Students	na	na	
Fleck & Weisberg 2004	students	20.5	na	na
Fleck & Weisberg 2013	students	21.24	5.03	
Gilhooly and Fioratou 2009	students	22.64	6.38	18-35
Gilhooly et al. 2014	students	22.15	5.20	18-49
Isen, Daubman & Nowicki, 1987	students	na	na	na
Jarosz, Colflesh & Wiley, 2012	from university community	na	na	21-30
Jones, 2003	students			18-46
Jung-Beeman et al., 2004	na	na	na	na
MacGregor, Ormerod & Chronicle, 2001	study 1, 2, 3 & 5 students 4 visitors at uni. openday	na	na	na
Maier , 1931	students	na	na	na
Mednick 1962	students	na	na	
Metcalfe & Wiebe 1987	study 1 **volunteers** (n=26) study 2 - students (n=73)	na	na	na
Subramaniam et al 2009	na	na	na	
Weisberg & Alba, 1981	students	na	na	na

na = not available

Appendix 2. Pilot Study: CRA task

The aim of the pilot was firstly to assess language effects on performance, comparing performance for those with English as a first language to English additional language or bilingual (English plus another language spoken before age 7). Previous research has suggested that there might be effects of language experience on insight tasks (Cushen & Wiley, 2011). Additionally, the convenience student sample being utilised has a high proportion of international students making language experience effects a pertinent consideration. Secondly, the pilot was used to identify the word triads to be used in the main study. It aimed to identify triads of sufficient difficulty to promote problem solving experiences and render trials that elicited solutions reported as being insight and non-insight. A final aim of the pilot was to refine the protocols developed to run the experiment, particularly in relation to the computer programme delivering the task and output data produced

Method

Participants

Ten student participants (see Table A1 for breakdown of participants) were recruited from a convenience sample of University students with a range of language status (see section below). One participant withdrew from the study and so data was removed.

Table A1 Breakdown of pilot participants

	Number Female	Male	Age: Mean (Standard Deviation)
English	1	3	26.75 (7.09)
Bilingual[1]	2	1	36.00 (3.00)
English additional language[2]	2	0	33.50 (0.71)

[1] English spoken before age 7 [2] Originally three EAL participants, one withdrew data.

Materials

Compound Remote Associates task. Word triads were taken from Sandkühler and Bhattacharya (2008) who adapted the Compound Remote Associates task (CRA, Bowden & Jung-Beeman, 2003b) for a European, English speaking sample. The 45 triads which over 50% of Sandkühler and Bhattacharya's (2008) sample answered correctly were piloted, as such these triads represented the ones which were most successful at eliciting solution experiences. However, no feeling of insight ratings were recorded in this study, so the pilot aimed to check that triads produced solutions reported as both insight and non-insight. Three triads were selected for practice trials, these were the next three most successfully solved from Sandkühler and Bhattacharya's (2008) results.

Previous research using word triads (Remote Associates Test or CRA) have utilised different numbers of triads, as shown in Table A2. Studies that use neuroimaging techniques see the use of larger numbers of triads. For Study 3 which is not using neuroimaging, there will be an aim to identify a number of triads comparable with other non-neuroimaging studies, which range between 15 and 44 triads.

The problems were presented on a 330mm laptop monitor and typed responses and feelings of insight (insight or non-insight) collected. The task procedure was implemented using PsychoPy software version 1.80.03 (Peirce, 2007; 2008).

Table A2 Number of word Triads in studies using RAT/CRA

	Study	Number of Triads
Neuroimaging	Bowden & Jung-Beeman (2003a)	144
	Sandkühler & Bhattacharya (2008)	138
	Haarmann, George, Smaliy & Dien (2012)	124
	Cranford & Moss (2010, 2012): 60 triads	60
Non neuroimaging	Mednick (1962) original RAT	30
	MacGregor and Cunningham (2008)	20
	Jarosz, Coldflesh & Wiley (2012)	15
	Creswell, Dutcher, Klein, Harris & Levine (2013)	30
	Morris, Dontcheva, Finkelstein & Gerber (2013)	20
	McCarthy, Malony & Morrison (2013)	44
	Oppezzo & Schwartz (2014)	16

***Participant Feedback Questionnaire*.** A questionnaire was designed to gain qualitative feedback from participants about the pilot. They were asked a series of questions to assess: their understanding of the task; the usability of CRA task delivered via PsychoPy and a laptop; aspects of the task design (see Table A4 for list of questions).

Procedure

Participation in the study was on an individual basis conducted in a quiet, private location. On giving informed consent participants provided brief demographic information including their age, sex and language status. Language criteria were English as a first language [English]; early bilingual in English and another language (spoken before age of 7 years) [Bilingual]; late bilingual (English after age of 7 years)

[English additional language]. The age of seven was used by Cushen & Wiley (2011) in their study of the effects of bilingualism in insight, this was adopted in this pilot for consistency. The CRA task was verbally explained to the participant with the aid of written instructions. An example was also explored accompanied by its answer; the reason for it reviewed by the researcher to check that the participant understood the task. The participant was then asked to complete three practice trials on the laptop. The first of these was the example just given, to ensure that at least one practice trial resulted in the participant answering and trying out the full trial protocol. After attempting the further two practices the researcher again checked the participant's understanding and answered any questions they had. The participant then attempted to solve the 45 CRA trials, where they indicated that they had a solution, they were then prompted to type the answer and give a feeling of insight (either indicating that they solved it by insight or non-insight). On completion of the CRA task they were asked to complete the Participant Feedback Questionnaire and then de-briefed.

Results and Discussion

One participant from the bilingual sample appeared to have misunderstood the task: this was not noticed until examination of their data (some days after their participation). The participant answered all of the questions in a consistent yet incorrect way. This was despite reporting that they understood the instruction and not indicating otherwise in the feedback questionnaire. The data for this participant is not included in the results reported below.

Language effects on performance in the CRA task

By examining the performance of participants with different language status it can be seen that participants who spoke English from an early age, (English only speakers or early Bilingual) performed better than those with English as an Additional Language (see Figure A1). However, as highlighted above, one participant who was an early bilingual gave answers that suggested that they misunderstood the task instructions. In addition, a suggested improvement for the study was given by one participant suggesting the use of "images with the word for people who have English as an additional language". As well as the task being more difficult, the proportion of trials reported as insight appears much smaller for the participants' with English as an additional language. In sum it highlights that there may be differences in solving the CRA which is a language based task for those working in their non-native language.

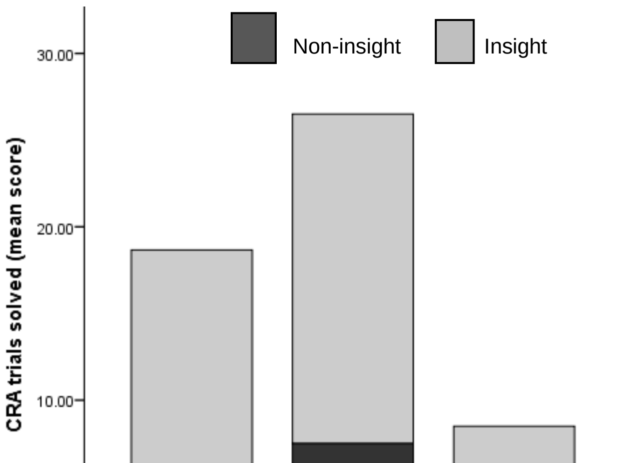

Figure A1 Graph to show mean correct insight and non-insight trails for different Language speakers: English, Bilingual (English before 7 years old) and English as an additional language (English after 7 years old).

Cushion and Wiley (2011) deliberately avoided language based tasks to control for basic language effects in their exploration of insight, selecting to use a series of spatial tasks, some demonstrated to elicit insight and other non-insightful analytic solving. But, as the within task elicitation of insight and non-insight solving seen in the CRA is central to the research rationale in Study 3 this is not an option. As the CRA is word based, and often uses colloquial phrases or compound words, it is unsurprising that participants with English as an additional language found the task harder. In addition, the original CRA and much of subsequent research has been conducted on U.S. colleague populations with a likely low proportion of non-native English speakers. As such, this pilot suggests that to enable comparison with other studies; and to maximise the likelihood of accurate responding and elicitation of problem solving episodes, that participants should have English as their first language.

Identification of the word triads to be used in Study 3

One participant indicated that they solved all of the word trials by insight. Their data was therefore excluded from the following analysis. Eight participants' responses were analysed and the frequency recorded for correct responses, insight and non-insight ratings, incorrect and timed-out (and so did not attempt to answer) trials. Table A3 shows this triad-by-triad breakdown of performance.

Study 3 required for trials that were challenging, but still meant that participants would be able to solve enough through both insight and search to measure related aspects such as heart rate. To reduce ceiling effects, the triads most often solved (by 75% or more of the pilot participants) were discounted (above solid line in Table A3). Likewise, triads which were too hard (solved by less than 25%) of participants were also removed (below solid line in Table A3). The remaining 26 triads were used for the CRA task in the main study. These can be seen to provide insight solutions (n=76) and search solutions (n=25) across the triads.

Table A3 Frequency counts of responses for each word triad.

Word1	Word2	Word3	Answer	Correct	Insight	Non insight	In-correct	Time out
cane	daddy	free	*sugar*	**7**	5	2	0	1
rocking	wheel	man	*chair*	**6**	5	1	1	1
house	grass	card	*green*	**6**	3	3	1	1
cry	walker	face	*baby*	**6**	5	1	0	2
flag	north	position	*pole*	**5**	5	0	1	2
night	wrist	stop	*watch*	**5**	3	2	1	2
fur	hanger	tail	*coat*	**5**	4	1	2	1
dust	cereal	toilet	*bowl*	**5**	3	2	1	2
sleeping	pipe	trash	*bag*	**5**	2	3	0	3
pad	trap	click	*mouse*	**5**	3	2	0	3
flake	mobile	fall	*snow*	**5**	2	3	0	3
high	mate	teacher	*school*	**4**	4	0	0	4
light	birthday	stick	*candle*	**4**	3	1	1	3
hard	drift	chopper	*wood*	**4**	4	0	2	2
river	note	account	*bank*	**4**	4	0	0	4
pain	serial	whale	*killer*	**4**	4	0	0	4
measure	worm	video	*tape*	**4**	3	1	1	3
polish	finger	head	*nail*	**4**	3	1	2	2
party	towel	ball	*beach*	**4**	2	2	2	2
bed	throat	point	*sore*	**4**	4	0	1	3
palm	line	house	*tree*	**3**	2	1	2	3
health	taker	child	*care*	**3**	3	0	1	4
tooth	stroke	hair	*brush*	**3**	3	0	0	5
safety	cushion	point	*pin*	**3**	3	0	2	3
equal	stop	language	*sign*	**3**	2	1	1	4
wise	work	alarm	*clock*	**3**	2	1	1	4
cottage	knife	cake	*cheese*	**3**	2	1	3	2
back	clip	wall	*paper*	**3**	2	1	2	3

water	mine	shaker	*salt*	**3**	2	1	1	4
fog	car	shoe	*horn*	**3**	2	1	1	4
sandwich	house	golf	*club*	**2**	2	0	3	3
pine	pie	juice	*apple*	**2**	2	0	1	5
chamber	mask	natural	*gas*	**2**	2	0	1	5
boat	limit	high	*speed*	**2**	1	1	1	5
dream	break	light	*day*	**2**	2	0	1	5
dew	moon	bee	*honey*	**2**	2	0	0	6
gun	puff	room	*powder*	**2**	1	1	3	3
end	line	brain	*dead*	**2**	2	0	1	5
fish	mine	rush	*gold*	**2**	2	0	0	6
wheel	hand	shopping	*cart*	**1**	1	0	3	4
fire	range	tropical	*forest*	**1**	0	1	3	4
carpet	alert	cross	*red*	**1**	1	0	2	5
date	alley	fold	*blind*	**1**	1	0	1	6
right	cat	carbon	*copy*	**0**	0	0	0	8
wet	law	case	*suit*	**0**	0	0	2	6

Development of protocols for Study 3

The final purpose of the pilot study was to determine whether the protocols developed for Study 3 worked and enabled the collection of data in controlled conditions. This first aspect was successful, with the collection of typed word responses, reaction time data (indicating solution point and key presses in typing the answers) and feeling of insight ratings. Qualitative feedback from participants was also collected to help identify improvements to methodology and to ensure that all of the instructions were clear and understandable (see Table A4).

Table A4 includes a summary of the participant qualitative comments in response to each of the questions.

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1. **Please give any general feedback regarding your participation which you feel may be important for the researchers to be aware of?**

2. **Please indicate any aspects of your participation where you were unclear on what was expected of you? How could this have been improved?**
3. **Please comment on the puzzles that you were asked to solve.**
4. **How easy was it to use the computer to indicate if you had solved a puzzle and then give your answer - what could be improved about this?**
5. **On solving a puzzle, did you find that it was useful to have the insight/ non insight solving descriptions displayed each time you indicated how you solved it? Please detail if/ how you used this information.**

From the feedback it can be seen that what was expected of participants was generally understood and instructions were clear. Participants suggested that being given definitions when making feeling of insight was generally helpful, although one highlighted that they were quite wordy. No major problems were highlighted other than in terms of the language status of participants discussed above.

In conclusion this pilot identified 26 CRA word triads to use in Study 3. It highlighted possible differences in performance of participants who speak English as an additional language, suggesting that for the word based, CRA task samples should be limited to native English speakers. Finally, it enabled research protocols to be tested, ensuring that the development of the CRA task on PsychoPy was fit for purpose and rendered appropriate data.

Appendix 3.

Sample size calculations for Study 4 (CRA) and Study 5 (Connect 4).

Effect sizes in previous comparable key studies

Jausovec & Bakracevic (1995). Not enough information given in this paper to calculate effect size.

Lackner et al. (2013). Lackner et al. (2013) reported effect sizes for their DV of HR change in relation to effects of time (η_p^2 = .52) and picture type [insight/non-insight] (η_p^2 = .16). Cohen's (1988) benchmarks for partial eta square are: small .0099, medium .0588, large .1379 (Richardson, 2011). Therefore these effects can be interpreted as large effects.

Pollatos, Herbert, Matthias and Schandry (2007). Pollatos et al. measured heart rate response to IAPS (International Affective Picture System) and interoceptivity (Heart Beat Counting task (HBC)). The authors report 2x2 ANOVA Picture content (positive/negative) versus HBC accuracy (high/low) with an effect size of (eta squared) $\eta^2 = 0.09$. This can be interpreted as a medium to large effect size (Cohen, 1988).

Sample size calculation

A priori power analysis was conducted using G*Power software to calculate the required sample size. Other assumptions were made according to recommendations by Cohen (1992), taking a significance criterion of 0.05 and power of 0.8.

For repeated measures ANOVA on HR change: Based on the above, it was assumed that there would be a large effect size for Heart Rate.

A conservative calculation was conducted using the G*Power function (see Table 1 and 2) for independent samples ANOVA this is following the advice of Miles (2013) who highlights that it is difficult to estimate the correlations between measures (as this is not reported in previous studies). As independent ANOVA has less power than repeated measures, he argues that using this as a conservative calculation would provide a solution to this problem.

Table 1. Summary of G*Power sample calculations for planned ANOVA analyses in Study 4

Study 4 : CRA	Numerator df	groups	Sample required
Main effect: solving type	1	22	53
Main effect: time	10	22	113
Interaction: solving x time	10	22	113

Table 1. Summary of G*Power sample calculations for planned ANOVA analyses in Study 5

Study 5: Connect 4	Numerator df	groups	Sample required
Main effect: solving type	1	44	58
Main effect: valance	1	44	58
Main effect: time	10	44	115
Interaction: 2 way - HR x valance	4	44	84
Interaction: 2 way - HR or valance x time	10	44	115
Interaction: 3 way - HR x Val x time	20	44	151

Correlations: HBC/ BEQ. Based on the above review of previous research calculations were conducted assuming a medium effect. G*power identifies that a sample of 64 would be necessary to detect a medium effect, with $\alpha = .05$, power = .80

Conclusion

Taking all of these into consideration, the sample required to detect the key aspects of interest would be up to 64, therefore it will be aimed to recruit 80 participants to ensure that with missing data, artefacts etc. on the HR signal that there is a large enough sample.

Some of the interactions do require larger samples, however, in light of these being less key, and in consideration of the conservative nature of the calculations (not taking into account the increased power of the repeated measures design) it was decided to aim for the lower sample size relating to the key comparisons.

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