IS IT THROUGH EMOTION THAT WE KNOW OURELVES: A PSYCHOPHYSIOLOGICAL INVESTIGATION INTO SELF-REFERENCE AND EMOTIONAL VALENCE

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Is it through emotion that we know ourselves?

A psychophysiological investigation into self-reference and emotional valence

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Declarations

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Abstract

Is it through emotion that we know ourselves? A psychophysiological investigation into self-reference and emotional valence.

The aims of the present thesis were two fold. The first aim was to investigate the relationship between self-referential and emotional processing. The second aim was to investigate the extent to which self-referential processing is altered as a function of mood. In order to address these two aims, a variety of behavioural and physiological measures were recorded and a new methodology was employed in the following experimental chapters.

The aim of experiment **one** was to investigate how non-dysphoric and dysphoric individuals evaluate the emotional valence and self-referential content of word stimuli at a behavioural level. A self-positivity bias was identified in non-dysphoric individuals, positive words were rated as self-referential and negative words were rated as non-self-referential. Compared to non-dysphoric individuals, dysphoric individuals' evaluations of self-reference but not emotional valence were altered. Event-related potentials (ERPs) were employed in experiment **two** to investigate self-referential processing at a neural level. A two stage model of processing was identified in which, an evaluation of emotional valence was found to occur prior to an interaction between self-reference and emotional valence. A self-positivity bias was identified in the ERP component known as the N400. ERP waves were more negative going to self negative and non-self-positive words when compared to self-positive and non-self-negative words. This bias was explained in terms of the semantic mismatch hypothesis. The aim of experiment **three** was to investigate how the neural processing of self-referential and emotional information is altered as a function of mood. Differences between non-dysphoric and dysphoric individuals were identified during the early stages of

processing in an emotion task. Between group differences were identified during the later stages of processing in a self-reference task, around 400 ms. Skin conductance and heart rate were employed in experiment **four** to examine autonomic responses during self-referential and emotional processing in healthy individuals. Both decision-making tasks were found to elicit similar physiological responses. These findings were taken to suggest that a large component of self-referential processing involves the processing of emotional information. Finally, the aim of experiment **five** was to investigate if person-referent processing was altered during the experience of a negative mood. The behavioural and neural responses of non-dysphoric and dysphoric individuals were compared across self-referent and other-referent decision-making tasks. Between group differences were specific to the self-reference task at the behavioural level. However, group differences were identified in both the self-referent and other-referent tasks at the neural level. The results provide partial support for the hypothesis that negative mood is associated with specific impairments in self-referential processing.

Overall the results of the present thesis illustrate that the processing of emotional information plays a large role in self-referential decision-making. Furthermore, the N400 was found be involved in this type of decision-making at the semantic level. Negative mood was associated with greater changes in self-referential processing than in other forms of emotional or person-referent processing. In the final chapter, a two stage model is proposed to account for self-referential processing. The implications of this model are discussed in terms of two macro-cognitive theories, interacting cognitive subsystems (ICS) and SPAARs. Finally, the limitations and future directions for developing this line of research are outlined.

Table of Contents

Chapter Outline

Chapter Three

Chapter Four

Chapter Seven

Chapter Eight

List of Figures

Chapter 6

Chapter 7

Chapter 8

List of Tables

Publications arising from the thesis

Published

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Watson, L., Drtischel, B., Obonsawin, M. C. (2008). Changes in the neural correlates of self-reference as a function of negative mood. *In preparation.*

- Chapter 1 -

Literature review

1.1: A theoretical investigation into the concept of self

The concept of self pervades everyday consciousness and pervades the discipline of psychology. If any individual walking down the street was asked, they would probably be able to give you a relatively good explanation of the term ‘self’ as they understand it. The Oxford English Dictionary (2000) defines the self as:

1. *a person’s essential being that distinguishes them from others.*
2. *a person’s particular nature or personality*

Although this definition seems straight forward, the notion of self has been a hotly debated issue in religion, philosophy and psychology for centuries. Therefore, it is important to begin by developing a working definition of the self which distinguishes the concept of self used in every day life from the concept that is used in the social sciences. In order to appreciate the modern scientific definition of self, we need to understand its origins.

1.2: The self: A historical review

The earliest discussions of self that are available to us are provided by the writings of the early classical Greek philosophers. Although the classical philosophers did not explicitly address the concept of self, Plato, Pythagoras and Socrates all proposed dualist theories as to how the mind or soul interacted with the body and controlled behaviour and action. Even Aristotle, who proposed that the brain was central to cooling the blood, suggested that men must have individual conscious awareness of the mind’s influence on bodily sensation (Popper & Eccles, 1977). These theories of consciousness acted as precursors which inspired the modern day conception and scientific study of self. After the introduction of Christianity into Europe, religious scholars also discussed the idea of self, often in terms of the soul which was created by, and answerable to God. However, these ideas referred to the self as an immaterial entity that could not be examined using scientific method. It was not until the 17^{th} century and the advent of modern western philosophy that the modern concept of self began to take form.

1.2.1: Modern conception of self: Early philosophical thoughts.

Rene Descartes (1596-1650) is acknowledged by many as the founder of modern western philosophy. Although psychology as a scientific discipline was not established until several centuries later, many of the early psychological theories of self were influenced by his theories in epistemology (Smith, 2001). As a rationalist, Descartes' project was to establish a set of principles, using logical reasoning alone, which could known to be true (Newman, 1999). It is in his first truth principle that Descartes raised the issue of the self[1]. He asserted that: 'I think, and my thoughts cannot be separated from me, therefore I exist' (Cottingham, Stoothoff & Murdoch, 1984). More commonly known in its revised form: *Cogito Ergo Sum* or 'I think therefore I am'(Descartes, 1644, part 1, article 7), this statement represents a definition of the self in its simplest form, I exist. It refers specifically to our conscious awareness of the immediate present. Descartes could only know the existence of his own mind; the existence of all other things, including the external world could be doubted. Descartes use of the term 'I' also highlights the individualistic and subjective character of experience.

[1] At this time, terms such as the mind, consciousness, soul and self were used interchangeably. Differences between these terms lead to great debate within epistemology and the development of a research area known as philosophy of mind. Although these questions are outwith the scope of the present thesis, these issues should be borne in mind throughout the following discussion.

Although Descartes did not discuss the self directly in this first principle, the concept '*Cogito Ergo Sum'* was taken up by later philosophers in the guise of self-consciousness. Self-consciousness represents the bare bones of the self as we know it today. The term is not taken to acknowledge the existence of a substantial self in terms of an individual's personal identity (Meditations II as cited in Newman, 2005). In his discussions of a substantial self, Descartes deferred to the notion of God. However, his ideas on immediate conscious awareness were employed by John Locke (1632-1704) and initiated the philosophy of self and theories regarding self-consciousness.

John Locke is cited as establishing the modern concept of self (Chappell, 1994). He revised Descartes' *'Cogito Ergo Sum'* in great detail.

Locke defines the self as:

'that conscious thinking thing, - whatever substance made up of, (whether spiritual, material, simple or compounded, it matters not)- which is sensible or conscious of pleasure and pain, capable of happiness or misery, and so is concerned for itself, as far as that consciousness extends.'

(Locke, 1690; chapter XXVII)

Where Descartes was concerned with establishing the existence of his own individual mind, Locke was more concerned with understanding the content of the mind and how we experience the external world. Lock developed Descartes conceptualisation of self-consciousness in three ways. He stressed that real life experience, extended memory and the existence of other selves were also important to a concept such as the self. Each of these points will be dealt with in turn.

Locke asserted that conscious awareness of real life experience was an important aspect of the self. As an empiricist, Locke believed that the mind was a *tabula rasa* on which experience writes its record. He stressed the importance of how we perceive the external world using our senses and generate ideas about the world from these senses. He also used a secondary term, ‘reflections’ to describe how we gain knowledge about ourselves by reflecting on our past experience. He suggested that it is by using these two processes of perception and reflection that we gain knowledge about the world and our place in it. In doing so he illustrated how conscious awareness of our own personal circumstances contributes to the way in which we experience and interpret the world.

Secondly, Locke illustrated the value of memory to the concept of self. He discussed personal identity at great length and believed that the self and consciousness are almost inseparable. Using several thought experiments Locke showed that personal identity of the self exists only to the extent that the self has conscious awareness of its past thoughts and actions and can be held responsible for them (Lowe, 1995). His introduction of memory was of paramount importance as it laid the groundwork for theories of personal identity in psychology and personal culpability within the justice system (Magee, 2000).

Finally, Locke stated that the concept of self is functional in that can be used to distinguish one individual mind from other thinking things:

> *‘For, since consciousness always accompanies thinking, and it is that which makes every one to be what he calls self, and thereby distinguishes himself from all other thinking things.’*
>
> Locke (1690; chapter XXVII)

Although this aspect of the self was not discussed further, or picked up by other philosophers of the time, the relationship between the self and other selves is fundamental to the modern day conception of self. The emphasis of this relationship has been particularly important for social psychologists, who devoted a great deal of research into the investigation of such relationships, as in, for example interpersonal and intergroup conflict.

Locke is known to be instrumental in establishing the self as a series of conscious events united through memory to create an awareness of previous thoughts and actions. However British empiricist, David Hume (1711-1776), discussed the self in a radically different way, possibly in response to Locke's unitary self (Bennett, 1971). Hume's admits in the Appendix of *A Treatise* that his discussion of the self is brief and his ideas are ill-formed. It is the extent to which his views differed from those held at the time, and the influence he had on his successors which make him worthy of mention.

Hume proposed that thinking consists of a succession of detached perceptions, a view he also held in relation to the self. Hume broke perception down into ideas and impressions, ideas being derived from our impressions. He discussed the concept of self in the following manner:

> *"But self or person is not any one impression, but that to which our several impressions and ideas are supposed to have a reference. If any impression gives rise to the idea of self, that impression must continue invariably the same, through the whole course of our lives; since self is supposed to exist after that manner. But there is no impression constant and invariable. Pain and pleasure, grief and joy, passions and sensations succeed each other, and never all exist at the same time. It cannot therefore be from any of these impressions, or from any other, that the idea of self is derived; consequently there is no such idea."*
>
> Hume (1739, Book I, Part 4, section 6)

Hume categorically stated that there is no idea of a unitary self as discussed by Locke. Although Descartes and Locke both stressed the importance of immediate conscious awareness to the self, they did not define it solely in these terms. They also acknowledged the unity of self over time. Although Hume stated that the self does not exist, ironically his beliefs were important to its study. Firstly, unlike Locke and Descartes, Hume's 'bundle theory of self' makes no reference to a self which exists beyond the life of the individual. Therefore, Hume developed previous ideas and placed the concept of self within nature, thus allowing the concept to be investigated empirically using the scientific method. Secondly, Hume questioned the unity of the self over time and in doing so opened up an avenue for discussion of the self as a divided concept. Due to the influence of religion at the time and the importance of the concept of self or soul to Christianity, this was a controversial statement (Morris, 2001). Nonetheless it was an important step, and the unitary self versus divided self argument has been a point of contention within psychology and philosophy ever since (for a review, see Markus & Cross, 1990).

Hume's work had a strong influence on his successors. The famous German philosopher Immanuel Kant (1724-1804) wrote that it was Hume's work that woke him from his 'dogmatic slumber' (Kui-Want & Klimowski, 2005). At that time, philosophers were divided into two philosophical positions as to how the mind perceived the world. The empiricists (such as Locke & Hume) believed that information about the world was provided by experience. In contrast, the rationalists (such as Descartes, Lebiniz & Spinoza) believed that knowledge was provided *a priori*, by some metaphysical source. Kant refuted both these positions and in doing so revolutionised philosophy of mind and the concept of self.

Kant placed the mind at the centre of knowledge. He stated that individuals receive information (perceptions) from experience through the senses. However, he also proposed that these perceptions are shaped by the construct and form of the mind using *a priori* categories (concepts) and organisation (McCormick, 2006). Where the empiricists and the rationalists viewed the mind as a passive recipient of information about the world, Kant introduced the idea that the mind is active in shaping perceived reality.

Kant proposed that 'transcendental unity of apperception' accounts for our conscious experience. He stated that the self which accompanies our conscious awareness arises as a construct of the activity of the mind when synthesising perceptions and concepts (or cognitions). Kant reacted against Hume's bundle theory of self, and stated that the self was more than the sum of an individual's sensations (Brook, 1996). In terms of consciousness, he stated that the self was *condito sine quâ non:* 'without which it could not be'.

Kant also separated two components of the self; 'transcendental apperception' and 'empirical self-consciousness'. Transcendental apperception is similar to Descartes 'I think', and was defined 'not how we appear, not how we inwardly are, only that we are'. In this context, Kant described the self as the subject of conscious experience. The empirical self provides us with an awareness of our inner psychological states (Brook, 1996). This aspect of self is the foundation on which knowledge about our selves as individuals can be built.

Overall Kant made two contributions to the growing philosophical debate surrounding the concept of self. Firstly, he attempted to combine the empiricist and rational perspectives of the time to show that the mind was an active participant in creating the world it perceives. Through this position, Kant identified the transcendental self. He stated that the self was more than the perceptions and cognitions of an individual. Secondly and more importantly, he explicitly divided the concept of self into two, the self which is the subject of conscious experience, and the self which is an object of this conscious experience and which has an awareness of the inner sense of the individual.

These modern western philosophers provided the foundation for the concepts of self which are used in psychology today. Descartes reintroduced the very basic concept of self, *cogito ergo sum,* into modern philosophy and begun debate on the question 'what constitutes the self?' As a response to this minimal self, Locke united the self across time as a function of memory and addressed issues of personal identity and other thinking things. Hume's ideas were also influential within the psychological definition of self, as they emphasised the importance of using experience and observable phenomenon in order to gain knowledge about the world. These ideas established the self as an object of empirical investigation, and removed the discussion of the self from methaphysical levels. Finally Kant divided the self into two components, the theoretical apperception, 'I as a subject' and the empirical self-consciousness, 'I as an object'.

1.2.2: The self within psychology: 19th century to William James

In the 19th century, experimental psychology began to develop as a scientific discipline. The work of Fechner and Helmholtz in psychophysics added validity to the notion that the workings of the mind could be studied using quantifiable measures (Coon, 2000). These experimental techniques were used to measure aspects of sensation, perception and thought. However concepts such as the self were still deemed too metaphysical to be observed using these methods.

At that time, the self and many other concepts within psychology were still placed within the realms of religious or moral philosophy. However William James' *Principles of Psychology* (1890) brought together the current literature in psychology, philosophy and physiology to form an arena for scientific investigation (Coon, 2000). Within this text James devoted the largest chapter to "The consciousness of self", while topics such as attention and memory remained minimal. This focus elegantly highlights how valuable James believed investigations into the concept of self and individual's subjective and objective experience were to psychology and the understanding of human experience.

James provided comprehensive theoretical accounts of what he regarded to be the constituent parts of the self. In a similar way to Kant, he divided the self into two main components, the 'empirical me' which is composed of the material, spiritual and social selves, and also the pure ego. The 'empirical me' encompasses what is today known as the substantial self. This discussion of self deviates from the concept of self utilised by the early philosophers; Descartes, Locke, Hume and Kant all stated that to understand and obtain knowledge about a substantial self was not possible. However, within the new discipline of psychology James stated that it was unnecessary for the researcher to explain the objective nature of the mind:

'About such ultimate puzzles he in the main need trouble himself no more than the geometer, the chemist, or the botanist do, who make precisely the same assumptions as he'.

James (1890; 184)

Although he did not conduct any experimental research on the self, in describing what he thought to be the elementary components of a substantial self, James provided a framework for the study of self within psychology. His ideas on personal identity, social selves and self-love were influential in social psychology. The material self, and spiritual self discussed aspects of personality theory and his section on malfunction of the self revealed the importance of individual case study research within psychopathology.

James is critical of each of the philosophical positions discussed previously, however his ideas on the self are clearly influenced by them. His position is similar to that of Locke and Kant. He proposed that the self provides unity to our thoughts and underlies our stream of consciousness across past, present and future. He also utilised Hume's associationist ideas to discuss the many selves that individuals show within the social world. The basic concept or concepts of self discussed by Willam James are largely similar to the way the self is discussed within contemporary psychology (Robin, Norem & Cheek, 1999).

This modern definition can be used as a working definition of self within the present thesis. The self represents a complex psychological construct which can be contemplated in many different ways. The core of the self consists of conscious awareness of the thought of an individual mind as distinguished from other minds. This thought can be unified across time by a stream of consciousness through past, present and future events. The identity of the self is also developed across time through memory for previous events. The substantial self consists of our knowledge about ourselves as objects within the world. This self is also identified through memory. However, unlike the unified stream of consciousness, it is adaptive and therefore can be modified by the social environment in which it is contained.

1.2.3: The self in the 20th century

As psychology began to utilise experimental methods, investigation into the self again became a point of contention. The self represented a complex psychological construct which was not amenable to investigation using the rigorous methods of the psychophysicists. The method of investigation into more complex aspects of psychology such as consciousness, self, understanding, expectation and belief was labelled systematic experimental introspection (Titchener, 1911). Early psychologists such as Wilhelm Wundt and Edward Titchener believed this technique could assess an individuals' phenomenal experience at an experimental level, in order to allow insight into the mental processes which underlie cognition (Hernstein & Boring, 1965).

In an early experiment into the self, Titchener asked several observers to introspect on the continuity of the self, its mode, and the conditions of its appearance. He found that the extent to which individuals were conscious of selfhood varied throughout the population sample. He postulated that the self represented an intermittent mode of conscious experience which occurred most frequently within a social context, when reference to self-knowledge was made conscious through either explicit or implicit modes of expression. From these results Titchener suggested that the constituent components of the self are not fully accessible through consciousness and that psychology could not be defined as a science of the self as conscious as previously stated (Calkins, 1910).

During the early 20th century, introspection came under scrutiny as its methods were subjective and the results showed great variability across participants. This caused researchers to become disillusioned with the subjective experimental technique, as it only provided information regarding aspects of mental processing which entered conscious awareness and could be semantically formulated (Bargh & Ferguson, 2000). Therefore, introspection failed to identify the underlying mechanisms involved in complex cognitive processing.

The doctrine of behaviourism formulated by Watson (1913) and Skinner (1938) proposed that all behaviours were a result of unconscious processes which could not be examined through subjective experience. It arose as a reaction to the difficulty in interpretation of the data generated through the introspective technique. Behaviourism postulated that mental processes are associated with behavioural analogues, and therefore in order to study the mind, psychology must become a science of behaviour (Lycan, 1990). Unfortunately its mechanistic account of behaviour as stimulus and response had no place for investigations into elusive concepts such as the self. During the reign of behaviourism, research focused on how conditioning could account for the shaping, extinction and differentiation of behaviours. The concept of self was hypothesised to be shaped by human experience and therefore was difficult to define solely in terms of rewards and punishments. This conceptualisation lead to the virtual disappearance of scientific investigations into the self within the psychological literature until the 1970s (Robins et al., 1999).

The cognitive revolution however, renewed interest in psychological states and internal mental processes as an explanation of human behaviour (Bargh & Ferguson, 2000). With cognitive psychology, in contrast to behaviourism, all behaviour requires explanation at the level of mental processes, taking into consideration mental representations, intentions and beliefs (Reber, 1995).

The rise of cognitive psychology placed the self back at the forefront of psychological research and the 1970s saw a dramatic rise in research into the concept of self. Since the beginning of the century the discipline of psychology had developed extensively and therefore the many aspects of the self were investigated across the diverse areas of psychological study (Robins et al., 1999). Social psychologists examined how the self differed across both social and cultural contexts (Tajfel, 1981, Zurcher, 1977). Cognitive psychologists examined the development and representation of self in memory and attention (Rogers, Kuiper & Kircher, 1977) and clinical psychologists examined the role of the self within psychopathology (Beck, 1967).

The scientific methods employed in the new area of cognitive psychology provided researchers with the tools to investigate the questions that remained at the forefront of investigations since the theories of self put forward by the early philosophers: what constitutes the self and how is it represented in the mind? By investigating if self-knowledge has influence over other mental processes such as memory and attention it is possible to determine if the self is a construct which is useful in explaining the functioning of the human mind.

1.3: The cognitive self: Experimental evidence

From 1975, the cognitive literature began to use schemata as an explanation for how information is structured in the mind (Bobrow & Norman, 1975). Schemata refer to cognitive structures which represent knowledge about a concept or type of stimulus, including its attributes and the relations among those attributes (Bargh & Ferguson, 1988). Markus (1977) stressed the importance of efficient information processing and suggested that a large amount of information processed by individuals is information that is related to their own thoughts and behaviours. She suggested that attempts to organise, evaluate and explain one's own behaviour would result in the formation and maintenance of cognitive structures specific to that information. These cognitive structures were referred to as self-schemata. It was hypothesised that to allow for the efficient processing of self-related material, information about the self may be represented differently from other types of information within the mind.

Markus (1977) conducted two studies in which she selected participants based on their descriptions of themselves in relation to the trait of independence. One third of the participants rated themselves as highly independent, a third as highly dependent and one third as aschematic, or as neither extremely independent nor dependent. In the first task, participants were presented with a set of trait descriptors which they were asked to rate as self- or non-self-descriptive. They were then provided with a set of behavioural descriptions and asked to cite past behaviours associated with the trait of independence. Finally they were given a set of behavioural descriptions and asked to predict how likely they were to behave in such a way in the future. In the second task participants completed a suggestibility questionnaire and then were provided with false information regarding their scores on the questionnaire. Independents were told they were highly suggestible and followers. Dependents were told they were non-suggestible and good leaders.

The results showed that individuals who rated themselves as highly independent or dependent endorsed more schema based trait adjectives as self-descriptive than aschematics. These participants also showed faster response times for schema-related words, provided more specific evidence for past behaviours and resisted incongruent schematic information to a larger extent than the aschematic groups. From these findings, Markus (1977) concluded that information associated with an individual’s self-concept is processed differently from other types of information. More specifically, Markus argued that self-schemata facilitate the processing of information about the self. This seminal paper led to interest into how the self functions as a cognitive construct within the mind.

Although this paper is of major importance to the psychological study of self-representation, it has limitations. It only investigates how individuals represent themselves on one specific trait, dependency. Therefore, it fails to identify how individuals represent and evaluate themselves across many different contexts and personality variables. Markus addressed this issue in later work that focused on the influence of culture on the self-concept (Markus & Kitayama, 1991; Markus & Wurf, 1987). Another series of studies which investigated the self-representation in a different way was conducted by Rogers, Kuiper and Kircher.

Rogers, Kuiper and Kircher (1977) were interested in investigating how self-schemata function on a more general level, with reference to more than one personality trait. They proposed that self-schemata function as an interaction between previous experience and incoming information. Specifically, they argued that the self acts as a superordinate schema at encoding, which elaborates new information within memory. They developed a paradigm which examined the relative strength of self-reference as an agent which facilitates information processing at encoding. If the self does act as a schema at encoding, then it was hypothesised that individuals would show better memory for information presented within a self-referential condition when compared to other memory encoding conditions. The experimental paradigm they employed is now known as the self-reference paradigm.

The self-reference paradigm was a modified version of Craik and Tulving's (1975) depth of processing paradigm. Within the self-reference paradigm, participants were asked to rate a set of personality adjectives within four different encoding conditions: structural (is the word presented in big letters?), phonemic (this word rhymes with XXXX?), semantic (this word means the same as YYYY?) and self-referent (this word describes you?). Using this method Rogers et al. (1977) were able to compare the processing of information across four different encoding conditions. In order to identify if there were any mnemonic advantages associated with self-reference when compared to other types of information, participants were asked to recall the adjectives that they had been presented with. It was hypothesised that if self-reference does function as a schema based elaborative agent at encoding, then self-reference would produce greater incidental recall within the depth of processing paradigm.

The results revealed that participants showed greatest recall of words presented within the self-reference condition, when compared to the semantic, structural and phonemic conditions. These results confirmed the findings of Markus

(1977) and led Rogers et al. (1977) to conclude that self-reference is a powerful encoding device which is facilitated by an underlying self-schema which elaborates incoming information.

However, the findings of this study were tentative. The self-reference condition differed from the other encoding conditions in terms of the level of person-related processing involved. Within the self-reference condition the participants were required to make person-related evaluative judgements regarding the extent to which they identified with the personality traits presented to them. Within the semantic, structural and phonemic conditions participants were asked to make descriptive factual decisions regarding the content of the personality traits. Therefore the mnemonic difference found within the study might have been the result of task-related differences in mnemonic processing rather than reflecting the existence of a cognitive self-schemata.

In order to address this problem Kuiper and Rogers (1979) conducted a set of experiments which expanded the original self-reference paradigm to include an other-referent condition in which participants were asked the question “Rate whether this word describes the experimenter”. This extra condition allowed Kuiper and Rogers compare self-referent processing to other types of information processing while controlling for components person-evaluation. In addition to the recall task, Kuiper and Rogers asked participants to provide difficulty ratings to determine how difficult participants found the decision-making task and confidence ratings to determine how confident participants were on the decisions made.

In the first experiment, participants showed greater recall within the self-referent condition when compared to the other-referent and semantic conditions. They also rated these decisions as easier and rated them with more confidence. It is interesting to note that words recalled from the self-reference condition had shorter response times than words recalled from the other-referent condition. Task difficulty was associated with increased reaction time. Therefore these results indicated that the better performance within the self-referent condition was not due to task difficulty inducing deeper processing. The results from the recall, reaction time at encoding, and the difficulty and confidence ratings led Kuiper and Rogers (1979) to conclude that individuals utilise different information processing mechanisms when processing self-referential information than when processing other types of information.

The increased recall found within the self-referent condition when compared to other-referent and semantic conditions is now labelled the self-reference effect and has been replicated using different stimuli, dependent variables and methodologies (Bower & Gilligan, 1979; Brown, Keenan & Potts; 1986; Maki & McCaul, 1985; Reeder, McCormick & Essleman, 1987).

Symons and Johnson (1997) conducted a review of the self-reference effect within memory. They found that overall, self-referential encoding does promote better recall on average than other types of encoding processes. They also found that the effect size was smaller when self-reference was compared to other-referent conditions as opposed to semantic conditions. The smaller effect size may be due to the differences in the level of evaluation and decision-making employed in the different conditions. There was also a smaller effect size for self-reference when nouns were used as stimuli rather than trait adjectives, and when imagery tasks were used rather than self-descriptive tasks. These findings suggest that the self-reference effect is highly susceptible to task manipulation. The results led Symons and Johnson to conclude that self-reference facilitates recall relative to semantic and other-reference due to elaborated and organised processing of encoded information. They state that processing information about the self is a uniquely efficient process, suggesting that information about the self forms a well organised and elaborated schema within memory.

These findings go some way towards answering the age old question of the philosophers ‘what constitutes the self and how is it represented in the mind?’. The results suggest that the self-schema represents a powerful, highly efficient and organised form of information processing. From this research, however, it is not possible to determine if the highly developed self-schema represents a unique and specialised form of processing, or if self-referent information is very well rehearsed and organised in well developed cognitive representations, such that self-schemata employ the same underlying mechanisms as other forms of information processing.

1.3.1: The neural basis of self-reference

The development of modern neuroimaging techniques has allowed researchers to take their investigations regarding the self and the self-reference effect to the neural level. A growing body of research aims to identify if there is a region or network within the brain which uniquely represents a self-schema by facilitating the processing of self-referential information. The comparison of neural activations associated with self-referential, other-referential and semantic conditions allows researchers to determine if these processes utilise separate functional networks within the brain. If separate functional networks were identified then this would provide further evidence to suggest that self-reference does in fact represent a unique and specialised form of cognitive processing.

Craik et al. (1999) used positron emission tomography (PET) to investigate the self-reference effect within Rogers, Kuiper and Kircher’s (1977) paradigm. The four conditions in which trait adjectives were presented were: self, other, general (how socially desirable is the trait described by the adjective?) and syllable (how many syllables does the adjective contain?). The results revealed increased frontal activations within the self-reference condition when compared to the other-referent, general and syllable conditions. More specifically, the statistical parametric mapping (SPM) analysis revealed an increase in activity within the right anterior cingulate cortex. The partial least squares (PLS) analysis revealed that activations specific to the self condition accounted for 15% of the variance within bilateral medial frontal lobes, right middle frontal gyrus and right inferior frontal gyrus. From these findings Craik et al. concluded that the concept of self was necessary for episodic retrieval and that its involvement was associated with neural activity in the right frontal lobe.

Subsequently, several other studies have identified activations within the prefrontal cortex, specifically within medial prefrontal cortex (mPFC) and posterior and anterior cingulate corticies, which are associated with self-referential processing (Johnson et al., 2002; Kelley et al., 2002; Zysset et al., 2003). These studies all use modifications of the self-reference paradigm. Other studies which utilised different stimuli - picture and word stimuli (Köhler, Winocur & McIntosh, 2000), faces (Kircher et al., 2000), one, two or three exemplar stimuli (Lepage, Habib, Cormier, Houle & McIntosh, 2000) and voices (Cabeza et al., 2004) - also found similar results. Table 1.1 provides a summarised account of the neural regions associated with self-reference as identified by previous neuroimaging studies (see p21). The consensus in results appears to indicate that self-reference is a unitary construct that is represented by activity in a network of brain structures within the mPFC and the cingulate cortex. This network is activated specifically during self-referential processing when the self-schema is hypothesised to be involved in facilitating information processing.

1.4: Self-Reference and emotional valence

The research discussed above presents a strong case that information about the self is organised into a self-schema and is represented by a specific set of regions within the brain. However, information about the self is usually embedded with other types of information. In the studies described above, the investigators did not separate the dimension of self-relevance from the dimension of emotional valence. This is very striking given that previous research, particularly in social and clinical psychology, has shown that the emotional valence of incoming information may be an important aspect of self-related processing.

1.4.1: The self-positivity bias

Many investigators have examined how people preferentially process and encode emotional information that is relevant to the self (Miall, 1986). Studies conducted across a range of different contexts show that individuals tend to view themselves through rose-tinted lenses (Alicke, Klotz, Breitenbecher, Yurak, & Vredenburg, 1995). A meta-analysis investigating this self-positivity bias in attribution research suggests that individuals tend to attribute positive traits and

Table 1.1: Table of neuroimaging studies investigating self-referential processing in healthy individuals.

Author	**Participants**	**Stimuli**	**Paradigm Used**	**Behavioural/Physiological measures**	**Activations associated with Self-reference conditions**
Fink et al. 1996	7 males	Auditory sentences (i) rest, (ii) impersonal, (iii) personal	Imagery task	PET	Increases in right hemisphere; hippocampal, parahippocampal, amgdaloid, anterior insula, posterior cingulate, tempropariental junction, prefrontal cortex. Decreases; bilateral lateral inferior parietal cortex, left inferior occipital cortex, right fusiform gyrus, left inferior frontal cortex.
Craik et al. 1999	4 males 4 females	Positive and negative personality trait adjectives (i) self, (ii) other, (iii) social desirability, (iv) syllables	Four choice judgement task	PET, reaction time, recognition	Increases in left hemisphere; **medial superior frontal gyrus**, inferior frontal gyrus. Decreases; left inferior parietal gyrus, right superior parietal lobule, left fusiform gyrus, right precentral gyrus.
Kircher et al. 2000 Exp I	6 males	Morphed faces (i) self, (ii) partner, (iii) other	Recognition task	fMRI, reaction time, recognition	Own face increases: right hippocampal formation, insula, anterior cingulate, superior/middle temporal, left inferior parietal, left middle, superior frontal gyrus, right precuneus, right subthalamic nucleus, cerebellum.
Kircher et al. 2000 Exp II	6 males	Self-descriptive personality traits, rated by participants earlier	Two choice judgement task	fMRI, reaction time, recognition	Left hemisphere increases; precuneus, superior parietal lobe, anterior cingulate gyrus, cingulum, anterior insula and inferior frontal gyrus, post central gyrus , putamen and medial geniculate body.
Johnson et al. 2002	7 males 4 females	Auditory self-evaluative statements	Two choice judgement task	fMRI, reaction time	Increases: anterior **medial prefrontal** cortex, posterior cingulate.
Zysset et al. 2002	8 males 5 females	Visual statements (i) evaluative, (ii) semantic, (iii) episodic, (iv)episodic, (vi) null events	Two choice judgement task	fMRI	Evaluative increases: left fronto-opercular cortex, **frontomedial cortex.** Episodic increases: Left and right superior frontal sulcus, right middle frontal gyrus, inferior precuneus, left and right intraparietal sulcus.
Kelley et al. 2002	13 males 11 females	Personality trait adjectives (i) self, (ii) other, (iii) letter case	Two choice judgement task	fMRI	Decreases: **medial prefrontal cortex**, posterior cingulate.
Fossati et al. 2003	6 males 8 females	Personality trait adjectives (i) self, (ii) other, (iii) target	Two choice judgement task	fMRI, reaction time	Increases: **dorsomedial prefrontal cortex**, left posterior cingulate.

		letter			Self-positive increases: right insula, temporal, occipital, inferior parietal regions. Self-negative decreases: left and right insula, left inferior parietal and right and left occipital cortex.
Zysset et al. 2003	7 males 11 females	Positive and negative sentences (i) semantic ,(ii) evaluative, (iii) baseline	Two choice judgement task	fMRI	Evaluative increases: dorsal and **ventral anteriomedial prefrontal cortex**, inferior precuneus, posterior cingulate cortex.
Cabeza et al. 2004	3 males 10 females	Photographs (i) taken by participant, (ii) taken by other participant	Recognition task	fMRI, recognition	**Medial prefrontal cortex**, parahippocampal regions, hippocampal formation.
Levine et al. 2004	2 males 3 females	Oral dialogues (i) personal semantic, (ii) personal episodic, (iii) other episodic, (iv) general semantic	Imagery generation	fMRI, rating of vividness	Increases: bilateral retrosplenial posterior cingulate cortex, precuneus, bilateral **anteromedial prefrontal** and dorsal paracingulate cortex. Decreases: **right ventromedial prefrontal cortex**, left superior temporal gyrus, left interior parietal cluster, left primary motor cortex, primary visual cortex.
Fossati et al. 2004	4 male 7 female	Positive and negative personality trait adjectives (i) self, (ii) other, (iii) target letter	Recognition task	fMRI, reaction time, recognition	Self-negative increases: right dorsolateral prefrontal cortex, right premotor cortex, right parietal, right extra-striate cortex, left caudate, right and left cerebellum. Self-positive increases: right anterior cingulate and **right medial prefrontal cortex.**
Johnson et al. 2005	9 male 8 female	Coloured squares (i) self-referential preference, (2) non-self preference, (3) non-self factual	Two choice judgement task	fMRI, reaction time	Increases: **anterior medial prefrontal cortex,** retiosplenial cortex, caudate bilaterally, left posterior temporal cortex, left anterior hippocampus.
Moran et al. 2006	17male 25 women	Positive and negative personality trait adjectives (i)self-reference	Two choice judgement task	fMRI, reaction time	Self-reference increases: **medial prefrontal cortex**, posterior cingulate and caudate bilaterally. Self-positive increases: ventral anterior cingulate cortex Self x Valence interaction increases: inferior prefrontal cortex, dorsal anterior cingulate supplementary motor area.

This table shows that out of the 12 studies conducted investigating self-referential processing 9 have identified changes in neural activations within the medial prefrontal cortex within the self condtion. Activations are also often identified within the anterior and posterior cingulate.

outcomes to internal, stable and global personal characteristics, whereas negative traits and outcomes are identified as unrelated to personal characteristics (Mezulis, Abramson, Hyde & Hankin, 2004). Individuals consistently view themselves as possessing more positive personality traits and exhibiting more positive behaviours and behavioural characteristics than other individuals. By the same token, individuals view themselves as having less negative personality traits and negative behavioural characteristics than other individuals (Allison, Messick & Goethals, 1989; Mesick, Bloom, Blodizar & Samuelson, 1985). This pheonomeon is known as the self-positivity bias (Heine, Lehman, Markus & Kitayama, 1999), and illustrates that a close relationship exists between self-reference and emotional valence.

Although the self-positivity bias is known to be a robust finding, its importance has not been discussed in relation to the cognitive construct of the self-schema. The self-positivity bias illustrates that most information individuals identify as self-referent is also universally identified as positive and most information that is identified as non-self-referent is universally identified as negative. None of the studies discussed previously, have addressed the possible role of emotional valence within self-referential processing. It is possible that the addition of a stimulus category such as emotional valence would act as a further organisational agent during information processing. Therefore, the emotional valence of stimuli within the self-referential condition may have facilitated information processing within the self-reference condition to a greater extent that in the other decision-making conditions. These differences may have contributed to the neural activations thought to be specific to self-referential processing.

More recently the self-positivity bias has been investigated in more detail. Pahl and Eiser (2005) investigated differences in the self-positivity bias in traits rated as extreme or moderate in emotional content. Sedikides and Green (2004) used recall tasks to investigate the underlying cognitive basis of the self-positivity bias. Finally several studies have attempted to identify the brain regions associated with self-related emotional processing.

1.4.2: Self-referential and emotional valence: neuroimaging studies

Fossati et al. (2003) carried out an fMRI study using the self-reference paradigm and conducted *post hoc* analyses on the emotional valance of stimuli both within the self-reference condition and across all conditions. As in previous neuroimaging studies (see Table 1.1), they found activations within the dorsomedial prefrontal cortex specific to the self-reference condition. The activation in this region was not found to be affected by emotional valence. No main effect of valence was identified. However reductions in response to negative words were identified within the self-reference condition in the left and right insula, temporal, occipital and inferior parietal regions. The authors suggest that these findings provide evidence that a widely distributed network of brain regions is involved in self-referential processing. They postulate that the medial prefrontal cortex mediates self-reference whereas other regions may be involved in other aspects of information processing, such as emotional valence, which are also important when evaluating self-reference.

The study conducted by Fossati. (2003) was the first attempt to address the issue of emotional valence within self-referential processing using neuroimaging techniques. Their findings provide preliminary evidence to suggest emotional valence is involved in the processing of self-referential information at a neural level. However, when the self-positivity bias is considered in relation to the self-reference paradigm commonly employed, one other factor needs to be addressed: the decision-making tasks involved. As discussed in Section 1.3 the self-reference paradigm compares participants' responses in a self-referential condition to their responses in an other-referent condition. Both conditions consist of a decision-making task (i.e., Does this word describe you?), therefore the participants are given the choice to make either a 'yes' or 'no' response. In the neuroimaging studies discussed, the influence of this decision-making task (the difference between the 'yes' & 'no' responses) was not considered. As the emotional valence of stimuli and participants' evaluation of self-reference are known to be highly correlated (see Section 1.4.1), it is unclear whether the activations identified by Fossati et al. are the result of emotional valence or whether they may in fact be the result of neural differences which occur when making decisions about self-referential information.

Moran et al. (2006) resolved this issue by analysing both self-evaluation ('like me' vs., 'not like me at all') and the emotional valence of the stimuli (positive vs. negative) within the self-reference decision-making task. They demonstrated a clear distinction between the processing of self-relevant information and the processing of emotional valence. The medial prefrontal cortex (mPFC) was found to respond preferentially to highly self-relevant (like me) material, as reported by Craik et al. (1999), Fossati et al. (2003) and Kelley et al. (2002). The emotional valence of self-relevant material (information evaluated as 'like me') activated an adjacent region, the ventral anterior cingulate cortex (vACC). Based on this apparent functional dissociation between the processing of self-relevance and emotional valence and the anatomical proximity of the two regions, Moran et al. suggested that a possible functional hierarchy may be involved in the processing of self-relevant and emotional information. They suggested that when information is first encountered, the mPFC signals the self-relevance of the information. After this step, information which is identified as highly self-relevant is then tagged for valence in the vACC. This functional hierarchy represents a tentative model of self-referential processing and therefore requires further investigation. One way to investigate this model further may be to employ another neurophysiological measure known as event-related potentials (ERPs).

Event-related potentials (ERPs), described in Section 2.4.1, are a physiological measure of the electrical activity in the brain which is time-locked to stimulus presentation. ERPs are a valuable psychophysiological measure as they provide a temporal record of the various stages of information processing. The functional hierarchy suggested by Moran et al. differentiates between two stages of processing: they hypothesise that the processing of self-relevance occurs prior to the processing of the emotional valence of information identified as highly self-referent. If a temporal dissociation between these two stages could be identified using ERPs then this would provide further support for Moran et al.'s functional hierarchal model of self-referential processing.

1.5: Aims and hypotheses (I)

Within the current literature, the relationship between self-reference and emotional valence is becoming more complex. Therefore, the first overall aim of the present thesis is to attempt to clarify this relationship. This will be done in two ways. Firstly, an alternative methodology will be devised to investigate the relationship between self-referential and emotional processing. Secondly, alternative physiological measures which are more suited to investigating all stages of information processing will be employed.

Within the self-reference paradigm, the role of emotional valence has previously been investigated by identifying the behavioural and neural activations which are associated with the presentation of positive and negative stimuli within a self-referent decision-making task (Fossati et al., 2003; Moran et al., 2006). However, research which has identified the self-positivity bias in healthy individuals illustrates that a close relationship exists between self-reference and emotional valence. Due to this close relationship, it is difficult to determine the extent to which self-reference and emotional valence contribute to the advantages of self-referential processing identified within the self-reference paradigm (see Section 1.4.1). In order to provide a comprehensive evaluation of the role of emotional processing within self-reference, it would be prudent to investigate the mechanisms underlying emotional processing itself. One way of exploring this further would be to ask participants to complete both an emotional decision-making task and a self-referential decision-making task. This methodology was employed in the research presented in the following experimental chapters (see Chapters Three, Five & Six).

By presenting participants with both self-referential and emotional decision-making tasks it will be possible to identify the behavioural and physiological correlates which are associated with each type of processing. If the correlates in each of the two decision-making tasks are similar then this would provide evidence to suggest that the processing of emotional valence is an important aspect of self-referential processing. However, if the behavioural and physiological correlates which are identified within the self-referential decision-making task differ to those identified in the emotional decision-making task then this would provide evidence to suggest that self-referent processing represents a specialised form of information processing.

The physiological measures employed in the following experiments also differ from the neuroimaging techniques employed in the previous research. To the author's knowledge, no previous studies have employed ERPs to investigate self-referential processing. By employing ERPs to investigate the processing of emotional valence *within* the self-reference task it may be possible to identify and separate these two variables temporally. If these two variables can be separated temporally then this would provide evidence to support the functional hierarchy model of self-referential processing proposed by Moran et al. (2006) (see Chapter Four). Furthermore, if the ERP correlates which are found to occur in the self-reference task do not occur in the emotional valence task then this would provide evidence to suggest that self-reference represents a specialised form of processing (see Chapters Five & Seven).

The relationship between self-reference and emotional valence has not been investigated to a large extent within the general population. However, due to the potential therapeutic benefits of understanding this relationship, a great deal of research has been done with clinical populations. The next section will provide a broad overview of some of the theories and experimental studies which have led research within this field.

1.6: Alterations in self-reference as a function of mood

1.6.1: A negative self-view: cognitive theories of depression

Negative thoughts about the self have been identified as one of the core features of depression (Hammen, 1997). Two of the most commonly used indexes for identifying depression, the diagnostic and statistical manual of mental disorders (DSM-IV) and the international classification of diseases (ICD-10), both list elements of a negative self-view, such as self-dislike, worthlessness and low self-esteem, as important indicators of a depressive episode. This negative self-view was identified by Aaron T. Beck in many of his depressed patients and formed the basis of one of the earliest and most widely researched cognitive theories of depression (Beck, 1967; 1978).

Based on the negative thought patterns identified in his patients, Beck proposed a schema theory of depression. He proposed that the experience of depression results from negative distortions in thought patterns within the 'cognitive triad'. The cognitive triad consists of the schemata that an individual holds about their self, the world they live in and their future. In his classical formulation of the theory, Beck (1967; 1978) proposed that negative distortions within the cognitive triad occur in early life. Individuals who possess a negative cognitive triad, or dysfunctional attitudes, are vulnerable to experiencing depressive episodes in later life. Environmental triggers can lead to a depressive episode when current circumstances activate the negative schemata held by the vulnerable individual.

On first inspection, Beck's schema theory seems concise and well supported by clinical observation. However, when put to the test by scientific research, several limitations have been identified. The theory was initially developed for use in clinical practice and not as a scientific explanation of the cognitive mechanisms underlying depression. Therefore, researchers found it difficult to define hypotheses and predictions which could be used to test the theory experimentally (Teasdale & Barnard, 1993).

As stated above, Beck stressed that the negative distortions present in the cognitive triad occur in early life and predispose individuals to depressive tendencies. If negative thinking is a precursor to depression then it should be possible to identify these negative thinking patterns in vulnerable individuals during periods of normal mood as well as during depressive episodes. However, research has found that the presence of dysfunctional attitudes is a poor indicator of future depressive episodes (Barnett & Gotlib, 1988, 1990; O'Hara, Rehm & Campbell, 1982). Furthermore, studies have shown that negative beliefs about the self are present during depressive episodes but not present during remission (Power, 1990). These findings suggest that negative thinking may in fact be a consequence of depression rather than a casual factor.

Another influential theory of depression proposed by Seligman (1975) and later modified by Abramson, Seligman and Teasdale (1978) and Petersen and Seligman (1984) is helplessness or hopelessness theory. This theory is based on more general theories concerned with attributional style. According to attribution theory, individuals intuitively form causal relationships between events which occur within their environment (Augoustinos & Walker, 1995). Hopelessness theory states that certain attributional styles are more likely to result in the occurrence of depression. Abramson et al. (1978) suggest that individuals who make internal attributions (in which individuals themselves are the cause) stable attributions (in which the cause is unchanging) and global attributions (in which the cause will occur in a wide variety of situations) are more vulnerable to depressive episodes.

A meta-analysis by Sweeny et al. (1986) involving over 100 experiments and 15,000 participants identified a correlation between this attributional style and depression. Furthermore, a longidutinal study by Nolen-Hoeksema, Girgus and Seligman (1992) showed that over a five year period attributional style predicted the occurrence of a depressive episode in children. One potential limitation of the theory, however, is that is focuses on the causes of events. Hopelessness theory fails to consider that the negative consequences of events, and the coping or social problem-solving skills employed to deal with these events may also be relevant to the onset and maintenance of depressive episodes (Power & Dalgleish, 1997).

Even in these early cognitive theories of depression, emotional biases within self are identified as central to the experience of a depressive episode. Many other theories of depression, also acknowledge the role of self to the onset and maintenance of depression. Ingram (1990), and Nolen-Hoeksema (1991), hypothesise that self-focused attention and rumination play a role in emotional disorders. Self-focused attention has been defined as “an awareness of self-referent internally generated information” (Ingram, 1990 p. 156) and rumination as the tendency to consistently focus on the implication of self-negative information (Lyubomirsky, Caldwell & Nolen-Hoeksema, 1998). Studies by Ingram (1990) and Mor and Winquist (2002) suggest that depressed individuals do in fact show higher levels of private self-focused attention and rumination when compared to anxious individuals.

These theoretical positions illustrate the importance of investigating the emotional component of self-referent processing as it may contribute to the development or maintenance of depression.

1.6.2: Self-referential processing in dysphoria and depression: experimental evidence

The earliest studies investigating self-reference in depression were done in order to investigate Beck’s negative self-schema concept. Several seminal studies utilised the self-reference paradigm devised by Rogers, Kuiper and Kircher (1977) to examine how emotional adjectives were processed by non-depressed and depressed individuals. Using depressed patients and non-depressed individuals, Bradley and Mathews (1983) found that depressed individuals recalled significantly more negative than positive adjectives within the self-referent task (a self-negativity bias) whereas, consistent with the self-positivity bias identified in the general population, non-depressed individuals showed the reverse effect. Studies by Derry and Kuiper (1981) and Mineka and Sutton (1992) found similar effects. The results of all three studies also suggest that emotional biases within the self-reference task occur for both recall and the number of adjectives endorsed as self-referential.

A study conducted by Kuiper and Derry (1982) employed a similar design to investigate differences between non-depressed and mildly depressed individuals. The results for non-depressed individuals were similar to the findings discussed above. Non-depressed individuals showed a self-positivity bias within memory. Mildly depressed individuals did not display a self-negativity bias. In fact, enhanced recall was found for both positive and negative adjectives within the self task when compared to the recall of stimuli presented in a semantic task. These findings were taken to suggest that the self-schema is markedly different in mildly depressed individuals when compared to non-depressed individuals. Even during states of mild of depression, individuals are beginning to incorporate negative information into their self-schema.

Although the results do provide evidence to suggest that self-referential processing is altered as a function of mood, the claim that these findings support Beck’s negative self-schema concept has been criticised. According to Beck’s theory, the memory bias for self-relevant negative information in depression is the result of the reactivation of an enduring self-negative schema. However, this self-negative bias may also be the result of differences in the selection strategies employed by depressed individuals or due to other information processing biases which facilitate the accessibility of negative information (Segal, 1988; Williams, Watts, MacLeod &

Mathews, 1997). Research by Kihlstrom and Cantor (1984) proposed that it may not only be the content of information which plays a role in self-schemata but also the interconnectedness between the information which is important.

A series of studies by Segal and colleagues (Segal, 1988; Segal, Hood, Shaw & Higgins, 1988; Segal & Vella, 1990; Segal, Gemar, Truchon, Guirguis & Horowitz, 1995) examined this hypothesis in depression. They utilised a modified version of the Stroop naming task. Prior to the colour naming task, individuals were presented with a prime which was either self-referential or non-self-referential in content. The amount of interference in colour naming the target was measured as an index of relatedness. Using this methodology, Segal et al. (1988) and Segal and Vella found that interference on the colour naming task was greatest for depressed individuals compared to normal individuals when the prime and target words were both self-referent. No differences in emotional valence were identified in these studies. In a further study, Segal et al. (1995) systematically manipulated the valence of the stimuli. Depressed individuals were found to exhibit the longest colour-naming latencies when self-referent negative information was primed with a similar self-referent negative stimulus. As in previous studies, these findings support the hypothesis that the self becomes more negative during depression. They suggest that the self-schema concept is still useful when attempting to understand emotional biases in depression and broaden our understanding of this concept. They illustrate that the definition of self-schema should consider both the content of and interconnectedness between emotional information (Ingram, Miranda, & Segal, 1998).

More recently, a comprehensive study by Dozois and Dobson (2001) examined the content and organisation of the self-schema in four groups: purely depressed individuals, depressed/anxious individuals, purely anxious individuals and non-psychiatric controls. Examining these groups allowed the authors to differentiate those aspects of the self-schema which are altered in emotional disorders from those alterations which are specific to the experience of depression. They employed two tasks to examine the content (self-reference task & emotional stroop) and two tasks to examine the cognitive organisation (redundancy card sorting, psychological distance scaling task) of the self-schema.

As in the previous studies, compared to non-psychiatric controls, depressed individuals endorsed more negative attributes as self-referential, recalled higher numbers of self-negative stimuli showed greater interconnectedness between self-negative information. However these biases in the self-negative schema were also present in all other psychiatric groups, suggesting that the self-negative bias is not specific to depression. More interestingly, biases in self-positive information were found to be specific to the depressed psychiatric groups. When compared to non-psychatric and anxious control groups, both depressed groups were found to endorse fewer and recall lower numbers of positive attributes and have less interconnectedness between self-positive information.

One limitation of this study is that the sample group consisted of only women. Therefore, these findings should not be generalised to the male population. Despite this restriction, this study represents an elegant investigation into the self-schema in depression. Although the concept of the self-schema has been altered since it was first proposed by Beck, research findings consistently illustrate that the highly elaborated and organised self-schema is dramatically altered during the experience of negative mood. Furthermore, research should consider not only self-negative information, but also the changes which occur during the processing of self-positive information.

1.7: Aims and hypotheses (II)

As stated previously, a close relationship is thought to exist between self-reference and emotional valence in healthy individuals. Due to this close relationship, it is possible that the self-reference task emphasises the emotional content of experimental stimuli to a greater extent than other decision-making tasks examined within the self-reference paradigm (see Section 1.4.1 for a review). Previous research has also identified that self-referential processing is altered as a function of mood (see Section 1.6.2). Due to this close relationship between self-reference and emotional valence within self-referential decision-making, it is not possible to determine from previous research if the changes in self-referential processing during negative mood are the result of specific changes in self-referential processing, or if they are the result of a more general bias in emotional processing.

The second aim of the present thesis is to investigate how self-referential processing is altered as a function of mood. The responses of individuals who are experiencing high levels of negative mood will be compared to the responses of individuals experiencing low levels of negative mood, in both self-referential and emotional decision-making tasks. Using these methods, it will be possible to examine if differences between the two groups occur in both self-referential and emotional decision-making tasks, or if emotional biases during the experience of negative mood are specific to self-referential processing. If differences identified between the two groups are specific to self-referential processing then this would provide stronger evidence to suggest that the emotional biases associated with negative mood occur specifically in the context of self-schema based processing.

The neuroimaging studies identified a functional hierarchy of self-referential processing in healthy individuals. To date, no research has employed neurophysiological techniques to examine changes in self-referential processing as a function of mood. By employing ERPs to investigate the changes in self-reference and emotional valence during negative mood, it would be possible to identify if the changes in these two types of processing at the behavioural level, are also evident within the brain. ERPs provide a temporal measure of electrical activity within the brain from stimulus onset until response. Recording ERPs within the present study would also be valuable as it would be possible to investigate between group differences at all stages of the decision-making process, including the early stages of processing which are not accessible to experimental investigation using behavioural measures alone.

1.8: Summary and Research Overview

The question of ‘What constitutes the self?’ has been of interest to religious scholars, philosophers and psychologists for centuries. Our conscious awareness and understanding of ourselves as living beings is what separates us from much of the animal kingdom. Our representation of ourselves as unique individuals separates us from each other, and the knowledge and understanding of this representation provides us with personal identity. Therefore, an understanding of concepts such as self-awareness and self-representation as discussed by Descartes, Locke and James are fundamental to psychology and knowledge of the human mind.

The work of early philosophers laid the foundation for the study of the self as a psychological construct within empirical science. The aim of the early research was to understand how the self was experienced using techniques such as introspection, however these methods were deemed too subjective to provide an accurate account of the concept of self.

After the cognitive revolution, investigation began into how the self functions within the mind. Studies by Markus (1977) and Rogers et al. (1977) suggest that information about the self is represented by a cognitive structure called a self-schema. Symons and Johnson (1997) show that this self-schema is a highly elaborated and organised structure which facilitates the processing of self-related information. More recent studies by Craik et al. (1999) sought to identify the mechanisms underlying this self-schema at a neural level in an attempt to establish if there is a brain region or network specific to the processing of self-related information. Using modern imaging techniques, these studies aimed to investigate the same questions that were asked by early philosophers: how is the self represented in the mind, and how does it function?

The results of these studies suggested that the medial prefrontal cortex (mPFC) and connecting regions, the anterior and posterior cingulate, may play a role in the processing of self-referential information. However, studies by Heine et al. (1999) and Mezulis et al. (2004), examining the emotional content of the self, suggest that emotional valence also plays a role within self-referential processing. The extent to which emotional valence plays a role in self-referent processing needs to be addressed before the neural correlates of self-related processing can be evaluated.

Fossati et al. (2003) and Moran et al. (2006) conducted studies which examined the neural relationship between self-reference and emotional valence. The findings of Moran et al. supported Craik et al. (1999) that the mPFC is involved in the processing of self-referent material. However, Moran et al. also identified regions specific to the processing of emotional valence within self-reference. Research should now focus on the investigating the extent to which emotional valence influences self-referential processing.

Studies conducted by Bradley and Mathews (1983) and more recent research by Dozois and Dobson (2001) identified that during depression, emotional biases are present within self-reference. These findings illustrate that, the self-positivity bias which exists in healthy individuals is altered as a function of mood. Further research is required to identify if alterations in self-reference are specifically related to self-referential processing or if they the are result of more general biases in the processing of emotional information.

1.8.1: General aims and hypotheses

In order to assess the extent to which emotional valence contributes to self-referential processing, it would be useful to identify the mechanisms associated with both types of processing. If decisions about emotional valence and self-reference are carried out by similar cognitive mechanisms, then both types of processing should elicit similar responses. However, if self-referential processing represents a unique cognitive mechanism, then responses elicited by self-reference should differ to those elicited by emotional valence.

In order to provide a full understanding of the nature of emotional and self-referential processing, several experiments will be conducted in which behavioural (word rating, frequency of response & response time), autonomic (heart rate, skin conductance) and neurophysiological (event-related potentials) measures will be recorded.

The studies done by Dozois and Dobson (2001) and Segal et al. (1988) illustrate that the relationship between self-reference and emotion is altered as a function of mood state. Therefore, investigating the relationship between these two variables during the experience of negative mood may help further clarify the relationship between self-reference and emotion and may also give us some insight into how this relationship is altered as a function of mood both behaviourally and psychophysiologically.

1.8.2: Outline of following chapters

Chapter Two is a reference chapter. It provides a brief explanation of all the questionnaires, physiological techniques and word stimuli employed within the following experimental chapters.

The aim of Chapter Three is to provide an experimental test of the stimuli employed within the following chapters. This first experiment presents a behavioural study of how non-dysphoric and dysphoric individuals evaluate information within both self-referential and emotional contexts. The results will be discussed in relation to the two overall aims of the thesis: (I) to clarify the relationship between self-reference and emotional valence, (II) to investigate how individuals' responses to self-referential and emotional information are altered as a function of mood.

The aim of Chapter Four is to identify if ERPs can be employed to investigate self-referential processing. To allow a comparison of the results of this study to the previous research conducted using neuroimaging techniques, a modified version of the self-reference paradigm is examined. Results are discussed in reference to the functional hierarchy model proposed by Moran et al. (2006) and previous research into the self-positivity bias. Some limitations of this paradigm are identified, in particular the extent to which this paradigm can be used to investigate aspects of emotional processing.

The two overall aims of the thesis are brought together in the fifth chapter. In this experiment, the behavioural and physiological (ERPs) responses of non-dysphoric and dysphoric individuals are recorded during both self-referential and emotional decision-making tasks. The results support the findings of the previous chapters and illustrate that neural activations within self-referential decision-making differ between non-dysphoric and dysphoric groups.

The aim of the sixth chapter is to investigate other physiological responses of non-dysphoric individuals within the two decision-making tasks. Participants' heart rate and skin conductance responses are recorded. These measures provide an index of the physiological emotional response which occurs in both self-referential and emotional decision-making tasks. The results are discussed in terms of the extent to which the self-referential and emotional decision-making tasks elicit similar autonomic responses.

The aim of Chapter Seven is to address the issue of person-evaluation processing. Non-dysphoric and dysphoric individuals' behavioural and physiological responses are recorded during both self-referential and other-referential decision-making tasks. The results are discussed in terms of the extent to which self-reference represents some form of person-referent processing.

Chapter Eight brings together the findings of all the previous experimental chapters. These findings are discussed in terms of the two overall aims of the thesis presented in this introduction. A theoretical model of self-referential processing is proposed. This model is then discussed in relation to two current models of psychopathology. Finally, some limitations of the present research are discussed alongside future directions for this research area.

- Chapter 2 -

Methodology

2.1: Introduction

The aim of the present chapter is to give an overview of the procedures and assessments that were used in the studies reported in subsequent experimental chapters. The first section will discuss the self-report measures used to assess the level of negative mood experienced by participants. It will also summarise the measures employed to examine control variables such as intellectual ability. The second section outlines the psychophysiological measures which were employed. In this section, discussion focuses around the underlying mechanism involved in each measure, the way in which it is recorded, and how it is used as a psychophysiological index. The third section outlines the word stimuli used in all experiments and the pilot study conducted to obtain this information.

2.2: Self-report measures: experimental variables

2.2.1: Revised Beck Depression Inventory II

The Revised Beck Depression Inventory II or, BDI-II (Beck, Steer, & Brown, 1996) measures the presence and severity of symptoms of depression in individuals aged 13+ (see Appendix I). It was developed to adhere to the criteria for diagnosing Major Depression as recommended by the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition* (DSM-IV, 1994). In line with these criteria, participants are asked to rate their experience of symptoms '*during the past two weeks, including today*'.

The inventory assesses a variety of symptoms of depression indicating pessimisim, loss of pleasure, punishment feelings, suicidal thoughts or wishes, indecisiveness, changes in sleeping pattern, agitation, tiredness and fatigue. The inventory consists of 21 items. Each item is measured on a 4 point scale; 0 indicates that the symptom is not present, *'I do not feel sad'* and 3 indicates that the symptom is strongly present, *'I am so sad or unhappy that I can't stand it'*. The range of scores can vary from 0 to 63. A higher score indicates a more severe form of depressive symptomatology.

The BDI-II is a revision of the Beck Depression Inventory (BDI), which was devised in 1961 (Beck, Ward, Mendelson, Mock, & Erbarugh, 1961). The BDI is one of the most widely used instruments for detecting and assessing the severity of depression in a variety of populations (Piotrowski & Keller, 1992).

Several studies have examined the factor structure of the BDI-II. Most studies find support for a two factor model consisting of cognitive-affective and somatic-vegetative factors. Generally the BDI is known to reflect the cognitive, affective, somatic and vegetative symptoms associated with depression and therefore provides an overall representation of the extent to which an individual is experiencing symptoms of depression (Osman et al., 1997; Steer, Ball, Ranieri, & Beck, 1999; Whisman, Perez, & Ramel, 2000; Storch, Roberti, & Roth, 2004; Ward, 2006).

The BDI is known to be one of the best instruments for assessing the extent to which individuals are experiencing symptoms of depression (Michalak et al., 2004). More recently, several studies have shown that the BDI-II also represents a valid and reliable screening instrument. The BDI-II has been shown to have high levels of test-retest stability with correlations ranging from 0.69 - 0.93 (Beck et al., 1996; Wiebe & Penley, 2005; Yin & Fan, 2000), suggesting that BDI scores remain relatively stable over time. The BDI-II has high internal consistency, with correlations ranging from 0.84 - 0.93 (Dozois, Dobson, & Ahnberg, 1998; Osman et al., 1997; Whisman et al., 2000; Wiebe & Penley, 2005; Yin & Fan, 2000). Finally, the BDI-II exhibits good convergence with other measures of depression: BDI-IA ($r = 0.93$), Hamilton Rating Scale for Depression ($r = 0.71$) (Beck et al., 1996), Depression Anxiety Stress Scales-Depression Scale ($r = 0.77$) (Osman et al., 1997) and divergent validity with measures of anxiety: Beck Anxiety Inventory ($r = 0.60$), Hamilton Rating Scale for Anxiety ($r = 0.47$) (Beck et al., 1996), Depression Anxiety Stress Scales-Anxiety Scale ($r = 0.44$) (Osman et al., 1997). Together these data support the use of the BDI-II as a valid and reliable measure for detecting and assessing levels of depressive symptomatology over time, independent of other psychopathologies.

2.3: Self-report measures: control variables

As word stimuli were employed in the present research, it was important to control for reading ability and general intellectual ability. This was done to ensure all participants could read and understand the words presented to them in the experiments. These measures also controlled for reading impairments such as dyslexia. The Test of Word Reading Efficiency (TOWRE) was employed with non-dysphoric participants as a simple measure of reading ability (see Section 2.3.1). Dysphoria and depression have been associated with slowed response times (Williams, Watts, MacLeod, & Mathews, 1997). As the TOWRE scores are based on speed of reading, the National Adult Reading Test was employed as an alternative test of reading ability for dysphoric participants (see Section 2.3.2).

2.3.1: Test of Word Reading Efficiency

The Test of Word Reading Efficiency (TOWRE) was devised to provide a norm-referenced measure of general reading ability in children and young adults (see Appendix II). The test itself consists of two components, a sight word efficiency subtest and a phonetic decoding efficiency subtest. The sight word test assesses the number of printed words that an individual can accurately identify within a 45 second time period. The phonetic decoding test assesses the number of printed non-words that can be decoded within the same time period. Either one or both subtests can be employed depending of the nature of the experimental procedure (Torgesen, Wagner, & Rashotte, 1999). In the present set of experiments the sight word test was employed. The test has shown adequate internal reliability ($\alpha = 0.90$) and test-retest reliability ($r = 0.83 - 0.96$) (Torgesen et al., 1999) and has been shown to distinguish dyslexic from non-dyslexic individuals within the student population (Carroll & Lles, 2006).

2.3.2: National Adult Reading Test

The national adult reading test (NART) was devised as a measure of premorbid intelligence levels within clinical populations, particularly dementia (see Appendix III). Estimates of general intelligence are often based on various factors within an indiviudal’s life history. However measures such as education level or occupation may not represent an accurate measure of overall intelligence. The NART provides objective and standardised measures of verbal performance and full-scale IQ (Nelson & Willison, 1991).

The NART consists of 50 words presented on individual cards. All 50 words are atypical of the common grapheme-phoneme and stress rules common within the

English lexicon. If the word is unfamiliar or not recognised by the participant, the irregular nature of the words should result in incorrect pronunciation. The words are presented in order of difficulty with *'chord'* being the easiest and *'campanile'* the most difficult. Individuals are asked to respond to each word even if they do not recognise it. The score consists of the total number of errors made. Scores can range from 0 - 50 and full-scale IQ can be predicted within the range 70 - 131 (Nelson, 1982).

The NART is a popular measure of general intelligence and its psychometric properties have been tested extensively. Several studies have shown high levels of inter-rater reliability (0.96 - 0.98), good test-retest reliability (r = 0.98) and construct validity (Crawford et al., 1989; O'Carroll, 1987; & Schlosser & Ivison, 1989). The NART has also been used in other populations as an index of general intelligence: depression (Evans & Katona, 1993; Tarbuck & Paykel, 1995; Watts et al., 2002) and bipolar disorder (Lebowitz et al., 2006).

2.4: Physiological Measures

2.4.1: Event-Related Potentials

Electroencephalography (EEG) is a non-invasive technique which allows researchers to record electrical activity generated in the brain from electrodes placed upon the scalp. EEG provides a continuous temporal measurement of the electrical activity which occurs at electrode sites during a testing session. This technique was originally devised by Hans Berger (1929), who was also the first person to suggest that electrical activity recorded from the scalp may be related to mental processes (Stern, Ray & Quigley, 2001). Since then, EEG has become a popular neurophysiological tool used to examine various psychological processes.

The advancement of computer technology has allowed for more refined analyses of EEG output. Therefore more recent research has focused on electrical activity which is time locked to specific known events. These events are defined as event-related potentials (ERPs). In terms of the relationship between ERPs and psychological processes, Fabiani, Gratton, & Coles (2000) define ERPs as:

'manifestations of brain activities that occur in preparation for, or in response to, discrete events, be they internal or external to the subject. Conceptually, ERPs are regarded as manifestations of specific psychological processes'.
Fabiani, Gratton, & Coles. (2000, p 53).

Recording ERPs within controlled experimental paradigms provides us with information about the electrical activity going on in the brain associated with a time-locked event. By manipulating experimental parameters we can then determine under what conditions these patterns of electrical activity vary. In this way, it is possible to identify patterns of activity which are associated with specific psychological processes. ERPs are also known to have excellent temporal resolution and can therefore provide us with information about the different stages of information processing. ERPs can provide us with information about what processes are important at different stages of information processing.

2.4.1.1: Underlying mechanism

It is generally accepted that ERPs reflect patterns of brain activity. It is thought that ERPs are the result of the post-synaptic potentials generated from populations of neurons (Allison, Wood, & McCarthy, 1986). However, there are two important features of these neuronal populations which need to be considered when recording ERP activity at the scalp. Firstly, a group of neurons must be active synchronously (all active at the same time), in order to generate enough activity to be recorded at the scalp. Secondly, the population of neurons must have an open field distribution. This means that the neurons must be geometrically organised in such a way that their summated activity can be recorded at the scalp (Coles & Rugg, 1995). Due to the parameters of ERP recording it is not possible to record electrical activity from all areas of the brain. In particular, neuronal populations deep within the brain or those with a closed-field organisation are not amenable to ERP recordings. Therefore careful attention is required when drawing inferences about the functional significance of ERP findings.

2.4.1.2: Recording ERPs

Time-locked ERPs are derived *post hoc* from continuous EEG recording during an experimental session. EEG is recorded by placing a number of electrodes on the scalp of a participant and recording the electrical activity generated at these electrode sites. The number of electrodes utilised is often defined by the research question being examined. However the standard placement of electrodes is taken from the international 10-20 system (Jasper, 1958). This system defines electrode placement in terms of distance from two main axes; the nasion-inion axis (anterior-posterior) and the left-right ear axis (left-right postauricular points), see Figure 2.1 (Coles & Rugg, 1995). The electrical activity from an active electrode is then compared to a reference electrode. There are a variety of reference methods which are employed. An average reference is utilised in the present set of experiments, whereby the voltage from the active electrode is calculated in relation to the mean electrode voltage across all electrodes on the scalp (Coles & Rugg, 1995).

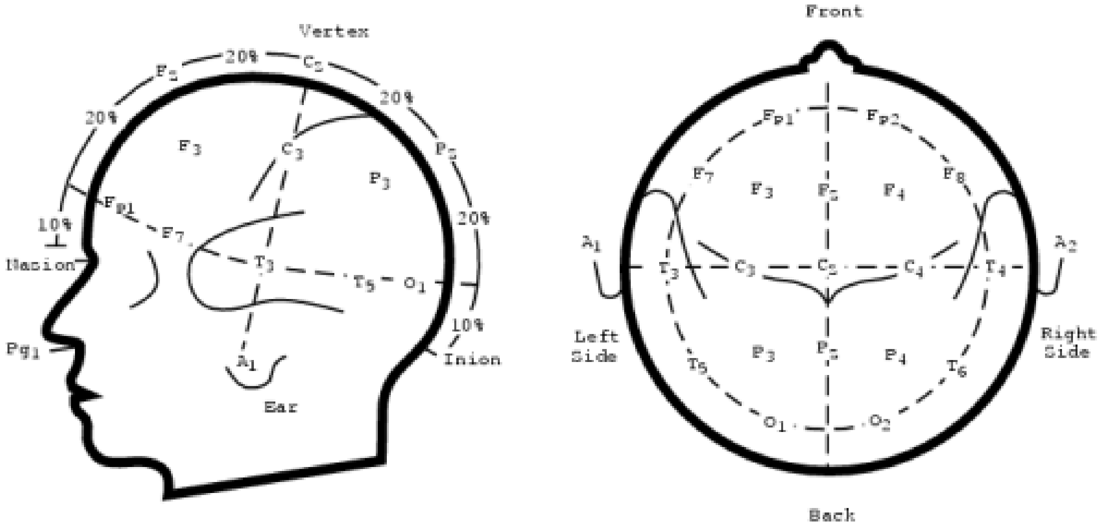


Figure 2.1: Electrode placement as defined by the international 10-20 system.
The right hemisphere is represented by even numbers and the left hemisphere is represented by odd numbers. The numbers increase in value as they move further away from the vertex and closer to the ear. The letters represent the brain region above which the electrodes are located F=frontal, C=central, P=parietal, O=occipital, T=temporal.

Taken from Kouri., & Lukes (2001)

During the recording of the EEG signal, event markers are recorded to indicate stimulus presentation and response. Epochs (i.e 100 ms pre-stimulus to 1500 ms post-stimulus) surrounding the event are then determined in order to identify ERPs. ERPs are relatively small (1-10 μV) in relation to the EEG signal (approx 100 μV). Therefore the data must be averaged over multiple trials in order to increase the signal-to-noise ratio. After averaging, random electrical noise is reduced and the ERP wave should represent the pattern of electrical activity associated with stimulus presentation.

An ERP is represented temporally by a wave function consisting of a number of components. These components describe the latency and polarity of voltage changes that occur in relation to an event. For example, components which have a negative polarity and occur around 200 ms are called N200 components, and components which have a positive polarity and occur around 300 ms are called P300 components (Figure 2.2). By comparing ERP waves under different experimental conditions it is possible to identify differences in the electrical activity of the brain in relation to psychological processes. Differences can occur in latency, where ERP components can occur earlier or later than in a comparison condition. Differences can also occur in amplitude whereby the amplitude of an ERP component may increase or decrease.

ERP researchers should be aware of several potential artefacts that may lead to distortions in ERP data. Electrical activity generated from sources other than the brain can be problematic. These sources include external electrical supplies, muscle movements, eye movements and eye blinks. Most of these problems can be resolved using high-pass or band-pass filters which allow the relevant electrical signal to be processed (i.e voltage of between 0.01-10 μV). To reduce the artefact caused by eye blinks and eye movements correction algorithms are often used (Fabiani et al., 2000).

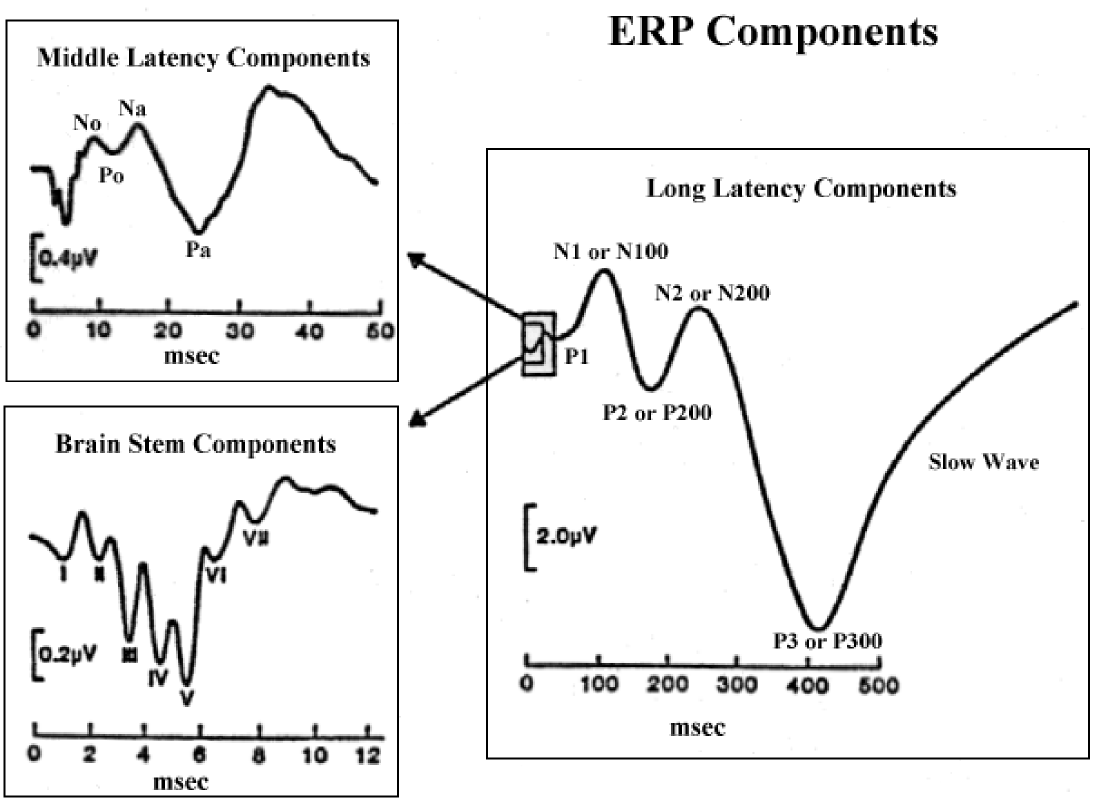


Figure 2.2: Examples of early, middle and late ERP components.

Taken from Doncin (1979)

2.4.1.3: ERPs as a psychological index

ERPs are of value as a psychological measure as they provide physiological correlates of psychological processes. Due to their excellent temporal resolution, ERPs can provide information about the timing and amplitude of different stages in information processing. ERP Components have been identified at various times after ERP onset and are hypothesised to index different cognitive processes.

Response-related potentials such as the lateralised readiness potential (LRP) and contingent negative variation (CNV) are found to occur in response to a warning signal. Prior to a required response, the LRP occurs over the motor cortex on the side of the brain contralateral to the side of the body on which a movement is required. (Coles & Rugg, 1995). The CNV occurs in response to a warning stimulus which indicates the onset of a second stimulus which requires a response. The CNV is thought to originate in the region of the thalamus (Nagai et al., 2004) These potentials are found to be associated with movement generation and preparation (Donchin, 1978; Kutas & Donchin, 1977). Early ERP components that occur from 100 to 300 ms (Figure 2.2) have been associated with selective attention, feature analysis and sensory memory (Fabiani et al., 2000). Finally late ERP components are endogenous, because they are solely influenced by an individual's perception or interpretation of an event. Two important components are the P300 and the N400. These components have been associated with memory and language processing respectively. The P300 is found to be sensitive to task-relevant stimulus probability (Dunan-Johnson & Donchin, 1977) and novelty (Friedman, Simpson, & Hamberger, 1993). Memory is subsequently found to be greater for items which elicit a larger P300. These findings led Donchin (1981) to suggest that the P300 is involved in the updating of environmental context. The N400 was identified by Kutas and Hillyard (1980) and occurs in a linguistic context, specifically when a semantically incongruous word is presented within the context of a sentence i.e ‘The pizza was too hot to *cry*.’ (Kutas & Van Petten, 1988). It is thought to be associated with the semantic integration process (Brown & Hagoort, 1993).

These findings illustrate the value of ERPs as a neurophysiological tool. ERPs provide a direct measure of the brain activity associated with different psychological processes . ERPs can also be useful in identifying what psychological processes are important at different stages of information processing.

2.4.2: Skin Conductance

By placing two electrodes on the skin and recording the current between them, Fére (1888) found that the skin momentarily becomes less resistant to the flow of an electrical current when presented with sensory or emotional stimulation (Dawson, Schell, & Filion, 2000). Fere’s experiment is thought to be one of the earliest experiments to illustrate that electrodermal activity (EDA) might be associated with psychological processes. This method became more popular in the 20th century with researchers such as Carl Jung (1907) suggesting that EDA can give us insight in to ‘the secrets of mental life’ (Stern et al., 2001). Since then EDA has become a popular physiological index of psychological processes. The advantages of EDA are that it is relatively simple and inexpensive to record, and more importantly, that it is responsive to events of psychological significance.

2.4.2.1: Underlying Mechanism

Several theories were put forward to account for changes in EDA. Secretory theory, initially attributed to Tarchonoff (1889, 1890) became generally accepted as providing the most accurate account of the underlying mechanism (Venables & Christie,1973). According to the secretory theory, changes in the levels of eccrine sweat glands result in changes in EDA. Skin conductance responses fail to occur in individuals after the removal of sweat glands (Quinton, 1983) and also when activity of the eccrine sweat glands is blocked pharmacologically using Atropine (Foster & Werner, 1970). Boucsein (1992; p 76) states that there is ‘ample empirical evidence that sweat gland activity in conjunction with the epidermal membrane processes plays a major role in the causation of electrodermal phenomena’.

The sympathetic component of the autonomic nervous system is known to regulate sweat gland activity, mainly through cholinergic innervation (Dawson et al., 2000). Therefore when the sympathetic nervous system is active, levels of sweat rise in the sweat glands generating an increase in skin conductance. Boucsein (1992) suggested two neural models which may underlie the various roles of sweat gland activity through the sympathetic nervous system. The first model suggests that the limbic system and hypothalamus are involved in thermoregulation and sweat gland activity in response to emotional stimuli. The second model suggests that the premotor system is involved when sweat glands are active in preparation of a motor action. Although little is known about the neural mechanisms underlying skin conductance, the strong relationship between EDA and psychological processes suggests that EDA can still be used as tool in order to further understand psychological processes.

2.4.2.2: Recording Skin Conductance

EDA can be measured in several ways such as skin conductance and skin resistance. However in recent research, the measure of skin conductance has been popular (Boucsein, 1992). Skin conductance will be recorded in the present study and therefore further discussion will focus specifically on this measure. Skin conductance is measured by passing a small direct current through a pair of electrodes placed on the surface of the skin. Ohm's law (Figure 2.3) states that the resistance of an electrical circuit (the two electrodes and the skin through which the electrical current is passed) is equal to the voltage applied between the two electrodes divided by the electrical current flowing through the conductor (the skin) (Dawson et al., 2000). Conductance is the reciprocal of resistance. Therefore, by using Ohm's law we can determine skin conductance.

R = V/I, *where R=resistance, V= voltage, I=current.*

Figure 2.3: Ohm's Law.

Adapted from Boucsein, (1992)

By measuring the current passing between the two electrodes (Figure 2.4) and holding the voltage constant we can record the conductance properties of the skin (Venables & Christie, 1973). The basic unit of measurement for skin conductance is micro Siemens (μS).

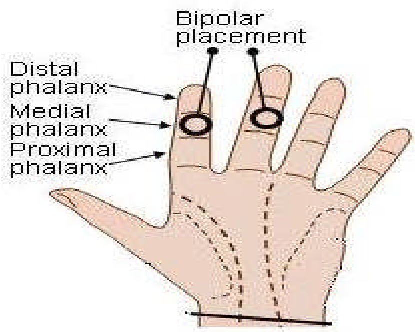


Figure 2.4: Skin Conductance electrode placement.

Skin conductance can be measured in two ways; skin conductance level and skin conductance response. Skin conductance level measures tonic activity. Tonic activity refers to general increases or decreases in skin conductance and is measured continuously through out an experimental session. Changes in amplitude commonly vary between 2 - 20 μS. Changes in skin conductance level across different experimental blocks can be compared using this measure. A second measure, skin conductance response, measures increases in skin conductance that are specifically linked to a known event, for example experimental stimulus. Skin conductance responses are short (1 - 3 seconds), relatively small (0.2 – 1.0 μS) increases in skin conductance which are recorded after stimulus onset within an experimental block. Changes in skin conductance in response to specific experimental stimuli both within and between experimental blocks can be compared in this way.

Sometimes non-specific changes in skin conductance also occur. These are small increases in skin conductance which occur spontaneously in response to some unknown event, these include various external and internally generated events (e.g., noises or thoughts). It is important to identify and control for such changes during experimental sessions. Non-specific changes in skin conductance sometimes occur due to physiological events such as a cough or a deep breath or sigh. Therefore it is also of value to record participants' respiration rate in order to provide additional information about non-specific changes in skin conductance.

2.4.2.3: Skin conductance response as a psychological index

Changes in skin conductance are associated with psychological phenomena, and vary in response to emotional stimuli and arousing events (Dawson et al., 2000). A large body of research conducted by Lang and colleagues at the Center for

Psychophysiology, University of Florida has provided an account of skin conductance as an index of emotional and arousing events (e.g., Lang, Bradley, & Cuthbert, 1997; Lang, Bradley, & Cuthbert, 1998; Bradley, Codispoti, Cuthbert, & Lang, 2001).

Humans are known to exhibit a wide variety of emotional responses. However Lang et al. (1997) suggested these emotional responses evolved as a system for motivated action or behaviour. They proposed emotional responses can be explained by a simple two factor model. One factor is represented by emotional valence and the other factor is represented by arousal. Emotional valence (positive – negative) is proposed to indicate the appetitive or defensive nature of a response, and arousal (calm – aroused) to indicate the degree to which an individual is motivated to carry out the response (Bradley et al., 2001). By controlling both the emotional valence and level of arousal of pictorial stimuli presented to participants, Bradley et al. (2001) found that skin conductance response increased with arousal but not with emotional valence. They conclude that skin conductance provides a useful measure of the motivational significance of stimuli.

2.4.3: Heart Rate

Willem Einthoven, the inventor of the modern electrocardiogram (ECG), designed early devices called string galvanometers which were used to measure the electrical activity of the heart muscle (Einthoven, 1895). This discovery furthered our understanding of how the heart functions and constituted an important step in modern medicine. For his work, Einthoven won the Nobel Prize for medicine in 1924 (Stern et al., 2001). The electrocardiogram has since been used extensively in medicine. However it has also been of value within psychophysiology.

2.4.3.1: Underlying mechanism

The heart (or myocardium) is a muscle which serves to pump blood round the body, providing oxygen and nutrients to different bodily systems. It generates its own electrical activity which causes constriction and relaxation of the 4 chambers in the heart in order to move blood through the body. The ECG measures the electrical activity of the heart during this action. Through a process of depolarization and repolarization of cells which make up the muscle surrounding the heart chambers, deoxygenated blood is pumped from the right atrium to the right ventricle, through the pulmonary system (the lungs) in which the blood is oxygenated. The oxygenated blood is then pumped through the left atrium into the left ventricle where it is pumped to the rest of the body (Brownley, Hurwitz, Schneiderman, 2000).

From this ECG output various changes in the electrical activity of the heart can be identified. Of particular interest to psychophysiologists is the measure of heart rate, which can be defined as the number of heart beats per unit time (which is usually recorded in minutes) (Stern et al., 2001).

2.4.3.2: Recording Heart Rate

ECG is measured through the placement of a number of unipolar electrodes on different locations on the body. Einthoven proposed a measurement triangle which is now known as “Einthoven’s triangle” as a standard system for electrode placement for use with ECG. This system is used today in psychophysiology (Brownley et al., 2000). A typical ECG electrode set up involves the placement of Silver-SilverChloride (Ag-AgCl) electrodes on the left and right arms and the left leg (Figure 2.5). These electrodes are then connected to an electrocardiogram in order to amplify and record the electrical activity of the heart.

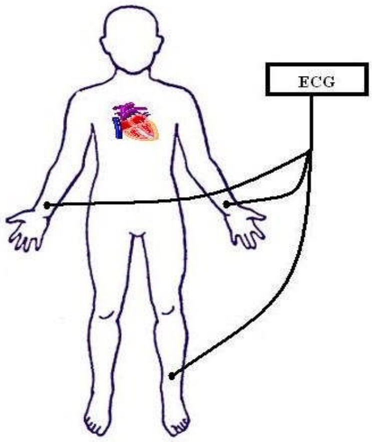


Figure 2.5: Standard electrode placement for ECG.

Heart rate is obtained from the ECG output. The interval between each cardiac cycle is calculated (interbeat interval), where a shorter interval indicates accelerated or increased heart rate and a longer interval indicates decelerated or decreased heart rate. Often the ECG output is filtered using a high-pass filter (30 - 35Hz) to reduce artefact created by external electrical appliances.

2.4.3.3: Heart Rate as a psychological index

The heart is responsible for circulating blood around the body and thus keeping us alive. To achieve this function, heart rate must be adaptive to various internal and external influences. It is responsive to changes in external stimulation such as changes in temperature or changes in air pressure. It is also responsive to internal action such as changes in motor activity (such as exercise) and digestion. However, of relevance here is that heart rate varies in relation to psychological stimuli and, in particular, emotional response.

In the series of studies mentioned above (Section 2.4.2.3), Lang and colleagues also examined event-related heart rate in relation to emotional and arousing pictorial stimuli. Greenwald, Cook III, & Lang, (1989) found accelerated heart rate in response to pleasant pictures and decelerated heart rate in response to unpleasant pictures regardless of arousal level. This early study provided a strong motivation for the use of heart rate as a measure of emotional response.

An early study by Lang & Hnatiow (1962) examined how heart rate changed across a five second time period. They found that when individuals view pictures, heart rate shows a triphasic response. The results of more recent studies have indicated that different components of this response are altered in relation to the pleasant and unpleasant content of the pictures being viewed. Bradley et al. (2001) found that in response to unpleasant pictures, individuals show an initial large and sustained deceleration in heart rate. In contrast, in response to pleasant pictures, the initial deceleration is smaller and a subsequent acceleration and secondary deceleration also occur. These findings suggest that there is not a linear relationship between the emotional content of pictures and heart rate, and illustrate that heart rate should be measured temporally from stimulus onset.

As heart rate changes in relation to emotional valence and not arousal, it may be useful to examine differences in heart rate in relation to self-referential and emotional stimuli in order to examine further the role of emotion in relation to self-reference. By measuring heart rate we can obtain information on how emotional valence is processed within both self-referential and emotional contexts. If heart rate is found to differ between positive and negative stimuli within both the self task and the emotion task, then this would provide evidence to suggest that emotional valence is important to both information processing tasks. However if differences are identified at between the two tasks then this would illustrate a difference in the processing of emotional information within a self-referential context.

2.5: Word Stimuli

All the research discussed in the present thesis employed word stimuli to investigate the relationship between self-reference and emotion. In order to obtain a set of appropriate stimuli a pilot study was conducted. The aim of this pilot study was to acquire a large set of word stimuli in which participant ratings of self-reference and emotional valence were known. To do this, a number of participants were presented with a questionnaire and simply asked to rate the self-referential and emotional content of words stimuli using a five-point Likert scale.

2.5.1: Method

2.5.1.1: Word database

Words were selected from experimental studies which previously controlled for emotional valence across positive, negative and neutral dimensions (Bradley & Lang, 1999; Brittlebank, Scott, & Williams, 1993; Green & McKenna, 1996; Ridout, 2005).

395 words were selected for use in the final questionnaires and information was collated on word frequency, word length and word type (see Appendix IV). These variables were not controlled for at this stage in order to provide the largest pool of words possible.

2.5.1.2: Questionnaires

To prevent fatigue effects, the 395 words were divided up into eight questionnaires, seven consisting of 50 words and one consisting of 45 words. To prevent order effects, two versions of each of the eight questionnaires were created.

Each version presented the words in a different randomised order, this lead to the construction of sixteen separate questionnaires.

Each word was rated on two five-point Likert scales, emotion and self-reference. On the emotion scale, the anchors ‘positive’, ‘negative’ were presented at the 1 or 5 endpoints and ‘neutral’ was maintained as a midpoint. Similarly, the anchors ‘like me’ and ‘not like me’ were presented at the 1 or 5 endpoints of the self-reference scale. These anchors were alternated between the one and five endpoints across words to prevent practice effects.

2.5.1.3: Participants

457 (341 female, mean age 20.03, s.d 3.71) participants took part in the pilot study, with a mean 55 participants completing each of the eight versions of the questionnaire. All participants were undergraduate psychology students from a number of Scottish universities. All participants spoke English to university entrance requirements.

2.5.1.4: Procedure

The questionnaires were completed within the students’ class time. A researcher introduced the topic area, the instructions and questionnaires were then handed out. The questionnaires took approximately ten minutes to complete. After completion, all participants were debriefed as to the nature of the pilot study and its use within future experiments.

2.5.2: Findings

2.5.2.1: Data analytic strategy

To obtain overall ratings of emotional content, the participants' scores for each word were averaged together. The same process was conducted on the participants' self-referential ratings for each word. A scatter plot was produced and a Pearson's correlation conducted, to identify the relationship between the self-referential and emotional content of each word. This was done in order to determine how the words should be categorised in future experiments.

2.5.2.2: The relationship between self-reference and emotion

The scatter plot (see Figure 2.6) suggests that a strong positive relationship exists between the emotional and self-referential variables. The Pearson's correlation supports this relationship, $r = 0.92$, $p < 0.001$. Emotionally negative words are identified as non-self-referential, while emotionally positive words are identified as self-referential.

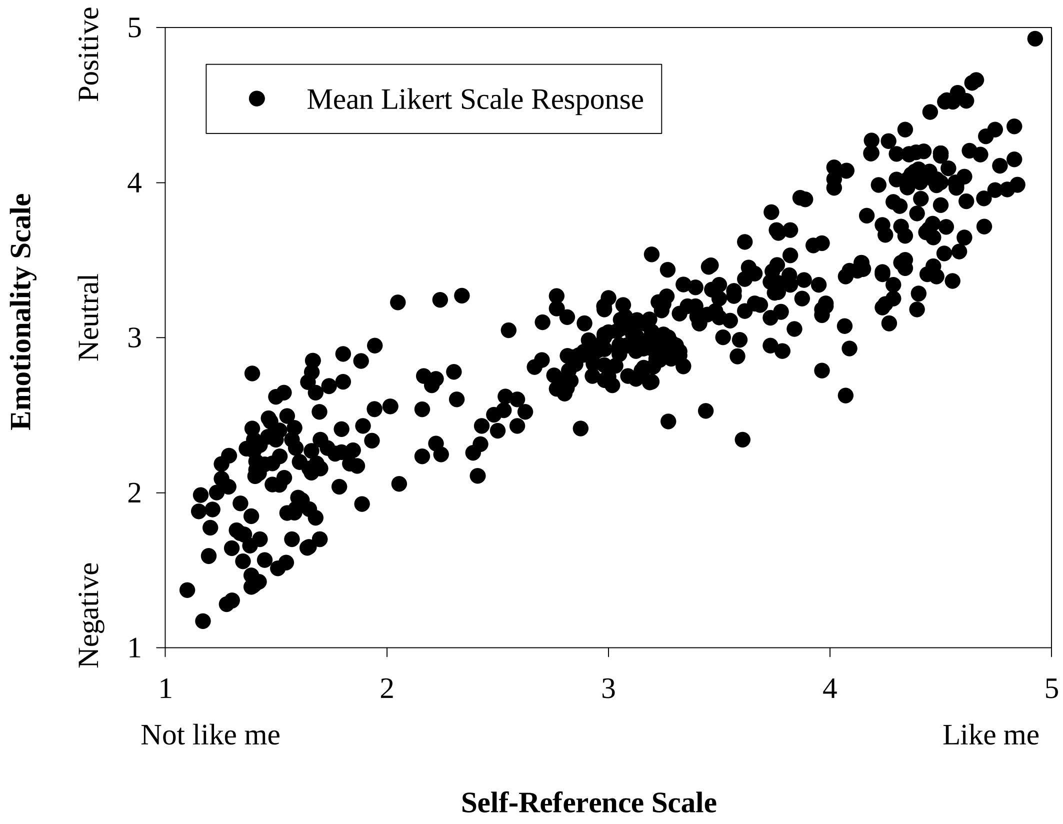


Figure 2.6: Relationship between self-reference and emotion.
A strong positive relationship exists between self-reference and emotion. Positive words are rated as like me and negative words are rated as not like me.

<u>*2.5.2.3: For use in the present thesis*</u>

This set of 395 words formed the database of word of stimuli employed in the present thesis. From the data shown in Figure 2.6 it is obvious that it was not possible to obtain sets of word stimuli which the general student population rated as self-referential and negative or non-self-referential and positive. Therefore for the present research, three word categories were defined (i) self-positive, (ii) non-self-negative and (iii) neutral. The self-positive word category consisted of all words rated between 3.5 – 5 on both the self-referential and emotional Likert scales. The non-self-negative word category consisted of all words rated between 1 – 2.5 on both Likert scales and the neutral word category consisted of all words rated between 2.5 – 3.5 on both Likert scales.

Once the word categories were identified, further selection was carried out to control for word length, word type and word frequency. Information about word frequency was obtained from the British National Corpus (http://www.natcorp.ox.ac.uk/). This left 80 words in each word category (see Appendix V). Two one-way ANOVAs revealed no significant differences in word frequency, $F(2, 239) = 1.51$, $p > 0.2$, or word length, $F(2, 239) = 0.51$, $p > 0.6$. A chi-square analysis revealed that there were no significant differences in word type, $\chi^2 < 1$, $df = 4$, $p > 0.9$

The way in which the word categories were employed varied across the experimental chapters. Discussion of how the word categories were utilised will be provided in the methods section of each experimental chapter as required.

- Chapter 3-

Experiment 1: Changes in the relationship between self-reference and emotional valence as a function of mood.

3.1: Introduction

As discussed in Section 1.4.1, healthy individuals present with a self-positivity bias across a variety of situations, such as academic and sports performance and the evaluation of future events (Alison et al., 1989; Mesick et al., 1985; Mezulis et al., 1999). Furthermore this bias has been found to be altered in clinical populations (see Section 1.6.2). Some studies have found a reduction in the self-positivity bias (Sweeny et al., 1986) where others have found a complete reversal (Bradley & Mathews, 1983).

One limitation of previous research into the relationship between self-reference and emotional valence is the way in which the stimuli are presented. In the self-reference paradigm, individuals are explicitly asked to rate the extent to which they identify with the presented information. The evaluation of this information represents a direct measure of self-reference. However, participants are not asked directly about the emotional valence of the information presented. Emotional valence is measured indirectly through pre-validated measures. With the role of emotional valence becoming increasingly central to the study of self (see Section 1.4.2) it is important to directly assess the extent to which both emotional valence and self-reference contribute to biases such as the self-positivity bias. This could be done by asking participants explicitly to rate experimental stimuli in terms of both self-reference and emotional valence (see Section 1.5).

To the author’s knowledge, self-reference *and* emotional valence have not been directly compared in any study to date. Therefore our understanding of the changes in the self-positivity bias during negative mood is limited. From the results presented by previous investigators (Bradley & Mathews, 1983; Sweeny et al., 1986) it has been difficult to distinguish between the possibilities that changes in the self-positivity bias as a function of mood are due to changes in individuals' processing of self-reference, changes in individuals processing of emotional valence, or possibly, changes in both in both these dimensions.

3.1.1: Present Study

The aims of the present study are twofold. The first aim is to provide a preliminary investigation into how self-reference and emotional valence are evaluated. The second aim is to investigate how the relationship between self-reference and emotional valence changes as a function of mood state. This second aim will be achieved by comparing the relationship between self-reference and emotional valence in individuals who are currently experiencing low levels of negative mood, to the relationship between self-reference and emotional valence in individuals who are currently experiencing high levels of negative mood. Individuals who are experiencing elevated levels of negative mood over a two-week period, but do not meet the clinical criteria for depression are said to be experiencing dysphoria. Therefore, the two groups will be labelled as non-dysphoric and dysphoric.

It is predicted that the relationship between the self-referential and the emotional content of words will differ across non-dysphoric and dysphoric groups. In non-dysphoric individuals, there is expected to be a strong positive relationship between words rated in a self-referential and emotional context, supporting the self-positivity bias identified in previous research (Alicke et al., 1995; Allison et al., 1989; Messick et al., 1985; Mezulis et al., 1999 & Moran et al., 2006). In dysphoric individuals, it is predicted that this relationship will be altered. Based on the previous literature, both strong and weak levels of this prediction can be made. According to the strong prediction the relationship between self-reference and emotional valence will be reversed in individuals experiencing elevated levels of negative mood (Bradley & Mathews, 1983; Sweeny et al., 1986), such that negative words will be rated as self-referent, and positive words will be rated as non-self-referent. According to the weak prediction, there will be no relationship between words presented in both a self-referential and emotional context (Kuiper & Derry, 1982; Mezulis et al., 1999).

3.2: Method

3.2.1: Design and Overview

The aim of the present study was to compare the responses of non-dysphoric and dysphoric individuals on a set of word stimuli rated for self-reference and emotional valence. All participants completed the Revised Beck Depression Inventory (BDI-II), see Section 2.2.1. Participants were asked to rate the set of word stimuli in terms of self-reference ('like me' – 'not like me at all') and emotional valence (positive – negative) of words using two separate five-point Likert scales.

3.2.2: Word Stimuli

Initially, a pilot study was conducted in order to obtain a set of word stimuli which varied across both self-reference ('like me' – 'not like me at all') and emotional valence (positive-negative) dimensions (see Section 2.5). The word ratings of dysphoric and non-dysphoric participants were compared across the three word categories identified in the pilot study (i) self-referential and positive, (ii) non-self-referential and negative, and (iii) neutral. Each word category consisted of 80 words.

A questionnaire booklet was developed with the 240 words. Each word was presented with two five-point Likert scales. The emotion scale was presented with the anchors ‘positive’ and ‘negative’. The self-reference scale was presented with the anchors ‘like me’ and ‘not like me at all’. These anchors were alternated between the one and five endpoints of the scales. Two versions of the questionnaire were created to control for word order effects.

3.2.3: Participants

Forty three participants initially took part in the experimental phase. Participants were classified into dysphoric and non-dysphoric groups on the basis of their score on the BDI-II questionnaire. Participants with a score below 7 were classified as non-dysphoric and participants with a score above 15 were classified as dysphoric (see Table 3.1). The fifteen participants who scored within the 7 - 15 range were excluded from further analyses. These high cut-off points were used in order to obtain purely non-dysphoric and dysphoric groups. Raising the cut off score reduces the number of false positive participants within a population sample (Beck, Steer, & Brown, 1999). All participants spoke English to university entrance requirements. All participants were fully debriefed as to the nature of the study and received payment (£4 per hour) for participation.

Table 3.1: Comparison of participant variables across non-dysphoric and dysphoric groups

	Non-dysphoric	Dysphoric
Number	10	18
Gender	8 female	14 female
Mean age (sd)	20.5 (2.82)	22.3 (6.49)
Mean BDI-II score	3.5	28.1
BDI-II Range	0 – 7	16 – 56

3.2.4:Procedure

Prior to taking part in the study, the experimental procedure was explained and participants provided informed consent. At this stage individuals were also asked for information concerning their age, gender and nationality. Participants were then provided with the booklet and instructed to rate each of the 240 words on two five point scales. Participants were first asked to rate the emotional content of each word (positive - negative), and were then asked to rate the self-referential content of each word ('like me' - 'not like me at all'). A general definition of self-reference was provided '*The word can relate to any aspect of your life, work, leisure, your past or it may explain a personality trait'*. All participants were debriefed as to the nature of the study on completion.

Half the participants completed the mood questionnaire (BDI-II) prior to the word rating task and half completed the questionnaire after the word rating task.

3.3: Results

3.3.1: Participant Variables

Statistical analyses were conducted to identify any possible confounds between the two groups in terms of participant variables. Chi-square analyses revealed no significant differences between non-dysphoric and dysphoric groups for gender, $\chi 2(1, N = 27) < 1$, or nationality, $\chi 2(3, N = 27) > 1$, $p > 0.6$. A one-way ANOVA revealed no significant age differences between non-dysphoric and dysphoric groups, $F(1,19) < 1$.

3.3.2: A comparison of the relationship between self-reference and emotional valence in non-dysphoric and dysphoric individuals.

In order to replicate the findings of previous studies and investigate the relationship between self-reference and emotional valence, the correlation coefficients for self-reference and emotional valence were calculated for each individual participant using Pearson's R. These coefficients were then transformed into z-statistics using the Fisher's r to z transformation. The mean correlation coefficient was then calculated for each group and converted back into r prior to comparison. The Fisher's r to z transformation was used as it has been found to reduce the variability associated with using multiple correlations (Corey, Dunlap, & Burke, 1998). A statistical comparison devised by Fisher (1921) was used to compare the two independent correlation coefficients. The method was taken from Howell (2002). The difference between the two correlations approached significance, $z = 1.36$, $p < 0.083$.

To examine this difference further, the correlations for each group were also examined independently. In the non-dysphoric group, a positive correlation was found between self-reference and emotional valence, $r(9) = 0.63$, $p < 0.05$. Positive words were more often rated as self-referent and negative words were more often rated as non-self-referent. No correlation was identified between self-reference and emotional valence in the dysphoric group, $r(16) = 0.10$.

3.3.3: Differences in the way in which non-dysphoric and dysphoric individuals identify with emotionally valenced information.

To examine the differences identified in the above correlations in more detail, two 2 (participant group) x 3 (word category) mixed ANOVAs were performed on the self-reference and emotion ratings, respectively. The factor 'participant group' consisted of two levels (dysphoric and non-dysphoric) and the factor 'word category' consisted of three levels (self-positive, neutral and non-self-negative).

3.3.3.1: Emotion

The results of the 2x3 mixed ANOVA for emotion identified a main effect of word category, $F(2, 52) = 69.01$, $p < 0.001$. A Bonferroni corrected one way ANOVA comparing the three word categories revealed that the mean word ratings of all three word categories significantly differed from each other. Both participant groups rated positive words (4.09) as highly positive and negative words (1.83) as highly negative compared to neutral (3.13) words. No other effects or interactions were identified (see Figure 3.1).

3.3.3.2: Self-Reference

The results of the 2x3 mixed ANOVA for self-reference show a main effect of word category, $F(2, 52) = 12.54$, $p < 0.001$ and an interaction between participant group and word category, $F(2,52) = 11.94$, $p < 0.001$ (see Figure 3.2).

To examine the main effect of word category a Bonferroni corrected one way ANOVA comparing the three word categories was conducted. The results reveal that positive words (3.27) are rated highly as 'like me' on the Likert scale and negative words (2.68) are rated as low, as 'not like me at all' on the Likert scale

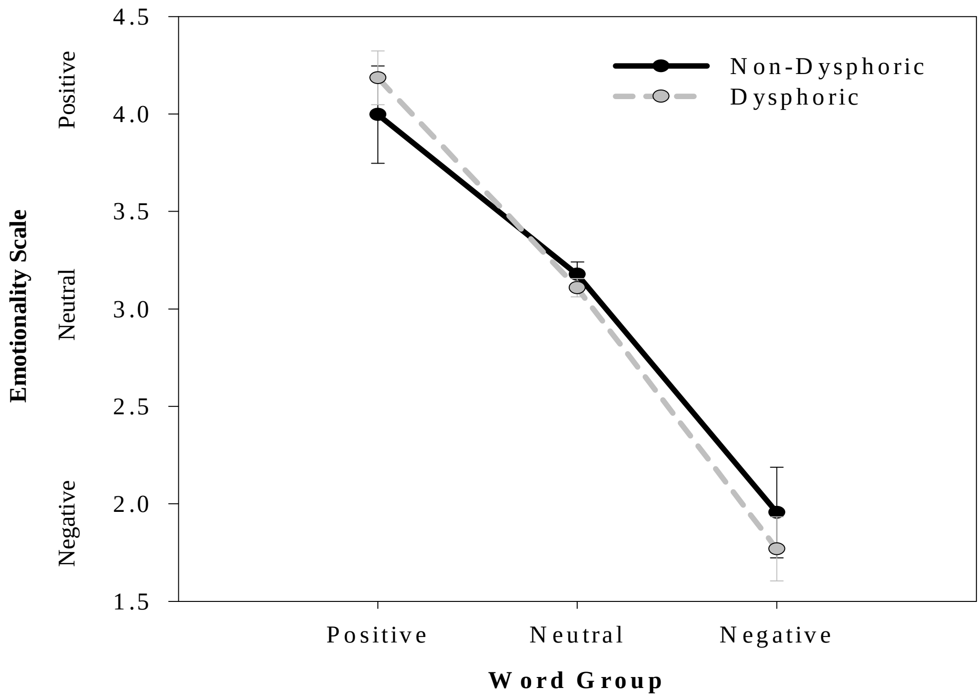


Figure 3.1: Non-dysphoric and dysphoric individuals' ratings of the emotionality of words.

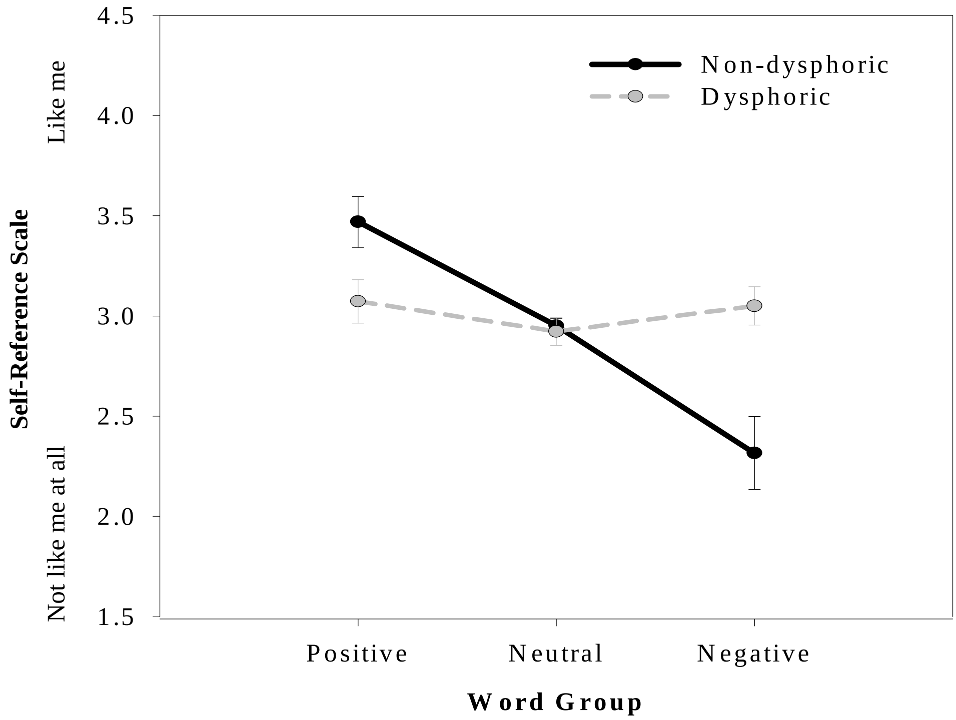


Figure 3.2: Non-dysphoric and dysphoric individuals' ratings of the self-referential content of words.

To examine the participant group x word category interaction, *post hoc* comparisons in the form of two within-group ANOVAs, were performed on the non-dysphoric and dysphoric participants' word ratings respectively. Non-dysphoric participants rated positive (3.47), neutral (2.95) and negative (2.32) word categories all as significantly different from each other, $F(2, 18) = 15.09$, $p < 0.05$. In contrast, no significant differences were identified between any of the three word groups for dysphoric individuals, $F(2, 34) < 1$ (see Figure 3.2).

3.4: Discussion

The behavioural results provide evidence to suggest that the methodology employed within the present study can be used in order to address the two main aims of the present thesis. In non-dysphoric individuals a positive correlation was identified between self-reference and emotional valence. As in previous studies (Alison et al., 1989; Messick et al., 1985; Mezulis et al., 1999), individuals rated positive information as self-referent and negative information as non-self-referent. As predicted, this finding provides evidence to suggest that emotional valence is highly involved in self-referential processing in healthy individuals. In terms of negative mood, the weak prediction was supported. No relationship was found to exist between self-reference and emotional valence in dysphoric individuals (Mezulis et al., 1999). Importantly, further analyses indicated that it is differences in the processing of self-reference, and not emotional valence, that is associated with differences in mood state. Both non-dysphoric and dysphoric individuals rate the emotional content of words in the same way. This finding suggests that dysphoric individuals can still identify the emotional valence of stimuli accurately. It is their evaluation of information with reference to their self-representation which is altered.

3.4.1: To clarify the relationship between self-reference and emotional valence

The finding that self-reference and emotional valence are correlated highlights the limitation of using the self-reference paradigm to investigate emotional valence. In all studies investigating self-reference, with the exception of Moran et al. 2006 the relationship between self-referential and emotional decision-making has been confounded. Based on previous findings, it is difficult to identify what elements of self-referential decision-making are linked to a possible unique mechanism involved in self-referential processing and, which elements are features of general emotional processing. By asking both non-dysphoric and dysphoric individuals to evaluate information in both a self-referential and emotional context it is possible to identify and separate these two types of processing. In the present study, the differences between the evaluation of self-referential and emotional information are particularly evident when comparing the responses of non-dysphoric and dysphoric individuals.

As predicted, a self-positivity bias was identified in non-dysphoric individuals. Therefore no differences were identified between self-referential and emotional processing in this group. These findings suggest that using a simple evaluation task only provides minimal information with regards to understanding the relationship between self-reference and emotional valence. To investigate this relationship in greater detail, further behavioural and physiological measures should also be examined. Physiological measures such as skin conductance and heart rate are known to differ in relation to the emotional response elicited by stimuli (see Section 2.4). Using these measures it would be possible to examine the extent to which stimuli presented in a self-referential decision-making task elicit a physiological emotional response. If the physiological responses identified in the self-referential decision-making task parallel the responses identified in the emotional decision-making task then this would provide evidence to suggest that self-referential processing is largely based on the processing of emotional information (see Chapter Six).

One possible limitation of the study is that the two ratings for the word stimuli were presented together, therefore it is possible that the correlation identified may be due to potential trial by trial carry over effects. This is unlikely to be the case as differences in evaluations were identified between non-dysphoric and dysphoric individuals. However, in order to reduce this potential bias in the future, it may be useful to present the trials in two separate tasks. In the self-reference task participants would only be asked to evaluate the self-referential nature of word stimuli and in the emotional task participants would only be asked to evaluate the emotional valence of word stimuli. This separation would reduce any carry over effects and optimise the two types of processing being investigated. Therefore the two decision-making tasks were completed separately in the following experimental chapters.

3.4.2: Alterations in the self-reference as a function of mood

As stated above, the weak prediction that no relationship would exist between self-reference and emotional valence for dysphorics was supported. Several studies also provide evidence to support the lack of an emotional association with self-identity in the context of dysphoria and depression. Kuiper and Derry (1982) found that recall within the self-referent condition, compared to the other-referent condition, was increased across both positive and negative stimuli. More recently, in a study of dysphorics, Smallwood (2004) utilised a word fragment task to examine self-reference and ambiguity. He found that dysphoric individuals used self-referent items to complete a word fragment task independently of the emotional tone of the stimuli. Finally, a study by Timbremont and Braet (2004) found that never depressed and remitted depressed children endorsed more positive adjectives as self-related whereas currently depressed children endorsed equal numbers of positive and negative traits. These findings, and those of the present study, indicate that the context of self-reference ('does this word describe me?') automatically activates the self-schema and that information processing *within* this context is altered in dysphoria. More generally, these findings may indicate that dysphoria is associated specifically with changes in the sense of self, rather than with changes in all aspects of emotional processing. Therefore, this finding highlights the importance of identifying and separating self-referential and emotional processing when investigating negative mood. Dysphoric individuals may not define their self-identity through emotion in the same way as non-dysphoric individuals.

Finally two methodological points need to be addressed. The first point is the distinction between self-negativity biases and attenuated self-positivity biases identified in previous research. As stated previously, Sweeny et al. (1986) identified a self-negativity attributional bias in depressed individuals. In contrast, Mezulis et al. (2004) examined attribution in psychopathology and found that overall, self-serving biases were attenuated rather than reversed. It is possible that these differences are due to the extent of depression measured. In the present study, dysphoric students were classified utilising a high score on the BDI-II. In this population the self-positivity bias was attenuated but not reversed, supporting the results of Mezulis et al. (2004). It is possible that individuals who have been diagnosed as clinically depressed would show a full negativity bias.

The second methodological issue to be examined is the use of the Likert scale within the construct of self-reference. This scale provided participants with two options when classifying stimuli as non-self-referent, they could either classify the item as neutral in relation to the self or as not related to the self at all. This neutral option allowed individuals to rate information as neutral in relation to the self rather than non-self-referent. Previous research into self-reference often utilised a two choice reaction time task (self/non-self) which does not include a neutral condition (Symons & Johnson, 1997; Williams et al., 1997). Therefore, it would be interesting for future research to attempt to include this neutral condition not only in studies examining emotional processing but also in studies investigating self-referential processing.

In conclusion, the results of the present study indicate that changes in mood states such as dysphoria are associated with changes in the relationship between self-reference and emotional valence. Although dysphoric individuals can identify the emotional valence of stimuli accurately, no relationship exists between the emotional content of the information and their ratings of self-reference. The study illustrates the importance of further investigating the role of self-reference within emotional disorders both within self-reference itself and also when comparing self-referent and emotional processing.

- Chapter 4 –

Experiment 2: Can ERPs be used as a tool to investigate the relationship between self-reference and emotion in the brain?

4.1: Introduction

The aim of the present study is to understand the complex relationship between self-reference and emotional valence at the neural level. This study aims to replicate the findings of the previous neuroimaging studies and extend these findings by employing an alternative neurophysiological measure: event-related potentials (ERPs).

Previous research (see Section 1.3), has shown that self-reference facilitates the processing of information from word stimuli. Furthermore, research using modern neuroimaging techniques has identified that activations specific to self-referential processing occur within the medial prefrontal cortex (mPFC), see Table 1.1. These recent findings appear to indicate that self-reference is a unitary construct, which is represented by activity in a network of brain structures within the mPFC and the cingulate cortex.

However, information about the self in word stimuli is usually embedded with other types of information, for example, if you are asked if the word ‘friendly’ describes you, the emotional valence of that word would play a role in your decision. Fossati et al. (2003) identified differences in neural activations to positive and negative words presented within a self-referential context. By further separating the self-referential judgements into ‘like me’ and ‘not like me’ categories Moran et al. (2006) demonstrated that distinct but closely related regions of the brain are involved in the processing of self-related (like me) and emotional information (see Section 1.4.2). Based on these findings, Moran et al. suggested a functional processing hierarchy may be involved in the processing of self-related information. They proposed that when information is identified, it is first processed in terms of self-relevance within the mPFC, then highly self-relevant information is tagged for valence in the ventral anterior cingulate cortex (vACC).

Until now, neuroimaging studies have taken advantage of the excellent spatial resolution provided by techniques such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI). These techniques were useful in identifying the brain structures involved in self-referential processing. However, these techniques are known to have poor temporal resolution and therefore do not provide any information with regards to the timing of events involved in the processing of self-referent information. If affective and cognitive components of the self do in fact represent separate and distinct aspects of self-referent processing as Moran et al. (2006) suggested, then these two types of information may be involved at different temporal stages of processing. If these two aspects of self-referential processing can be identified and separated temporally then this would provide further support for the functional processing hierarchy suggested by Moran et al.

4.1.1: The present study

To our knowledge, no previous studies have attempted to investigate the relationship between self-reference and emotional valence at an electrophysiological level. Electrophysiological methods like ERPs (see section 2.4.1), can demonstrate separate processing of different features of a stimulus when these features are processed at different times. The aim of the present study was to establish if electrophysiological measures can be used to investigate self-referential processing. More specifically if ERPs can be used to further clarify the temporal relationship between self-reference and emotional valence in word stimuli. To address this aim, ERPs were recorded while participants made explicit judgements about the self-referential content of emotional words. If ERPs are sensitive to differences in self-reference and emotional valence then it would be predicted, based on the functional hierarchal model, that differences should occur in the timing at which self-reference and emotional valence are important within self-referential processing.

4.2: Method

4.2.1: Participants

Sixteen participants (13 female, mean age: 21.2 years, SD 2.6 years, 16 right-handed) took part in a single session lasting approximately one and a half hours. The Beck Depression Inventory-II was completed by participants in order to control for negative mood (M = 8.3, SD = 4.1), see Section 2.2.1. All participants spoke English as their first language and scored within normal ranges on the TOWRE (see Section 2.3.1). All participants were fully debriefed as to the nature of the study and received payment (£8) for participation.

4.2.2: Stimuli and Apparatus

Word stimuli were presented using Experimental Run Time System (ERTS) software on a 17-inch CRT monitor controlled by a Pentium PC. Responses were recorded using two buttons mounted horizontally 10 cm apart on a response panel in front of the participant. Left and right key press responses were made with the index fingers of the left and right hand, respectively. The stimuli consisted of a selection of 160 affective words identified in an earlier pilot study (see Section 2.5). Only the self-positive and non-self-negative word categories were employed within the present experiment. Two words from each category were employed as practice trials. Therefore 78 words were presented as experimental trial stimuli from each word category. Words (letters 20 mm in height) and a fixation cross (6 x 6 mm) were presented centrally in white on black background. Approximately six characters subtended 1° of visual angle. Viewing distance was held constant at 75 cm.

4.2.3: Procedure

All participants were tested individually. On arrival, the experimental and EEG recording procedures were described to the participants. After the participants provided informed consent and information about age and gender, the EEG recording was set up.

The first section of the study consisted of a computer based task. Participants were asked to perform a two-choice judgement task to individually presented words in two instruction conditions: (1) an emotional judgement task (positive/negative), and (2) a self-referential judgement task (like me/not like me). The emotional judgement task was conducted as part of another study, the results of which will not be discussed presently (see Chapter Five). Participants were asked to indicate their choice by pressing the appropriate left or right key. The assignment of keys to response alternatives and the order of conditions were balanced across participants. Each trial started with the presentation of a fixation cross for 500 ms, followed by the word stimulus, which was presented until response. 1500 ms after response the next trial started. In each condition, four practice trials were followed by 156 experimental trials (presented in three blocks of 52 trials each) with words individually presented in random order. The same 156 word stimuli were used in both the self task and the emotion task.

After the computer based task, the electrophysiological recording equipment was removed and participants were asked to complete several questionnaires. Finally participants were debriefed, paid credit (£8) and thanked for participation.

4.2.4: Electrophysiological Recordings

Using a BIOSEMI Active-Two amplifier system, electroencephalographic (EEG) activity was continuously recorded from 70 Ag/AgCl electrodes over midline electrodes Fpz, AFz, Fz, FCz, Cz, CPz, POz, Oz and Iz and over the left hemisphere, from electrodes IO1, F1, AF3, AF7, F1, F3, F5, F7, F9, FC1, FC3, FC5, FT7, C1, C3, C5, M1, T7, CP1, CP5, TP7, P1, P3, P5, P7, P9, PO3, PO7 and O1 and from the homologue electrodes over the right hemisphere. Two additional electrodes (Common Mode Sense [CMS] active electrode and Driven Right Leg [DRL] passive electrode) were used as reference and ground electrodes respectively; cf. **http://www.biosemi/faq/cms&drl.htm**. EEG and EOG recordings were sampled at 256 Hz. Off-line trials containing blinks were corrected using a dipole approach (BESA 2000) and EEG activity was referenced to averaged reference. The analysis epoch started 200 ms prior to stimulus onset and lasted a total duration of 1500 ms. EEG and EOG activity were filtered (bandpass 0.01 - 10 Hz, 6 db/oct) and averaged time-locked to stimulus onset.

4.2.5: Data Analysis

Only trials without EEG or EOG artefacts were included in ERP data analysis. Analyses of variance (ANOVAs) were performed on RT and ERP data. Conservative Huynh-Feldt *F*–tests were used throughout. For *post-hoc* comparisons, Bonferonni corrected *t*-tests were applied.

4.3: Results

4.3.1: Behavioural Results

A two-way ANOVA was performed including the factors emotion (positive vs. negative), and self-reference (self vs. non-self). No main effects of self-reference or emotion in response time were identified, all *Fs* < 1. However, the interaction between the two variables was significant, $F(1,15) = 35.9$, $p < 0.001$. *Post hoc* comparisons revealed participants responded faster to words consistent with the self-positivity bias (self-positive 1095 ms; non-self-negative; 1098 ms), than to words that were not consistent with the self-positivity bias (self-negative; 1473 ms and non-self-positive 1398 ms), all *ts* > 4.0, all *ps* < 0.05 (see Figure 4.1). Table 4.1 also shows the number of items (on average) per condition (see Table 4.1).

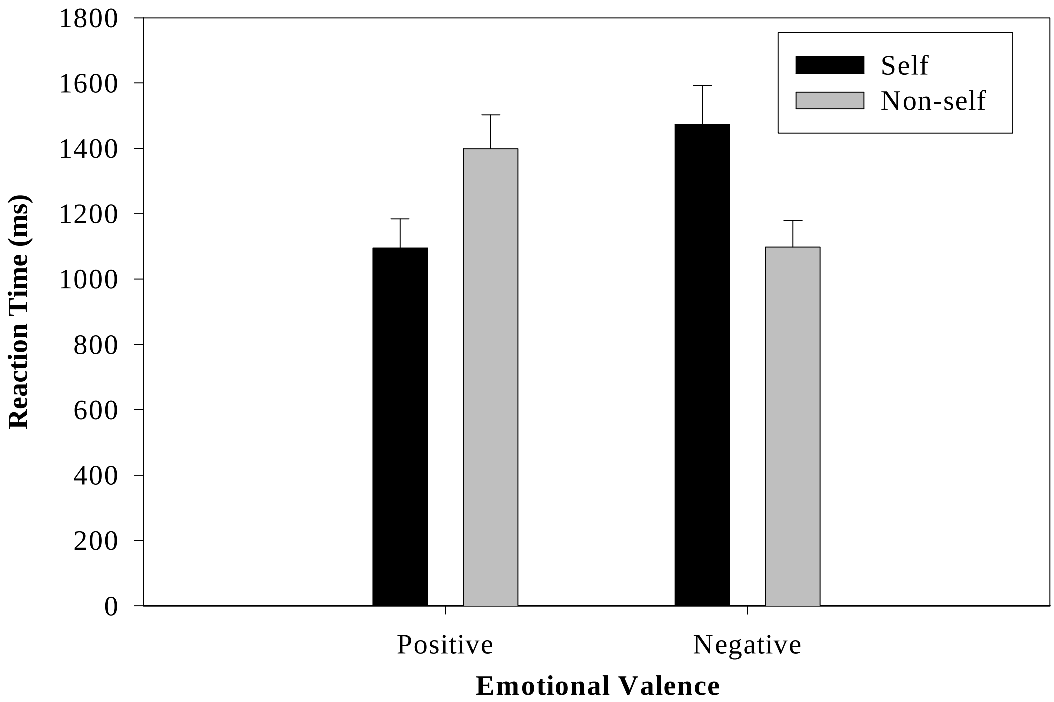


Figure 4.1: Responses (ms) to affective words presented in a self-referential context.

Table 4.1: Number of items (on average) per experimental condition

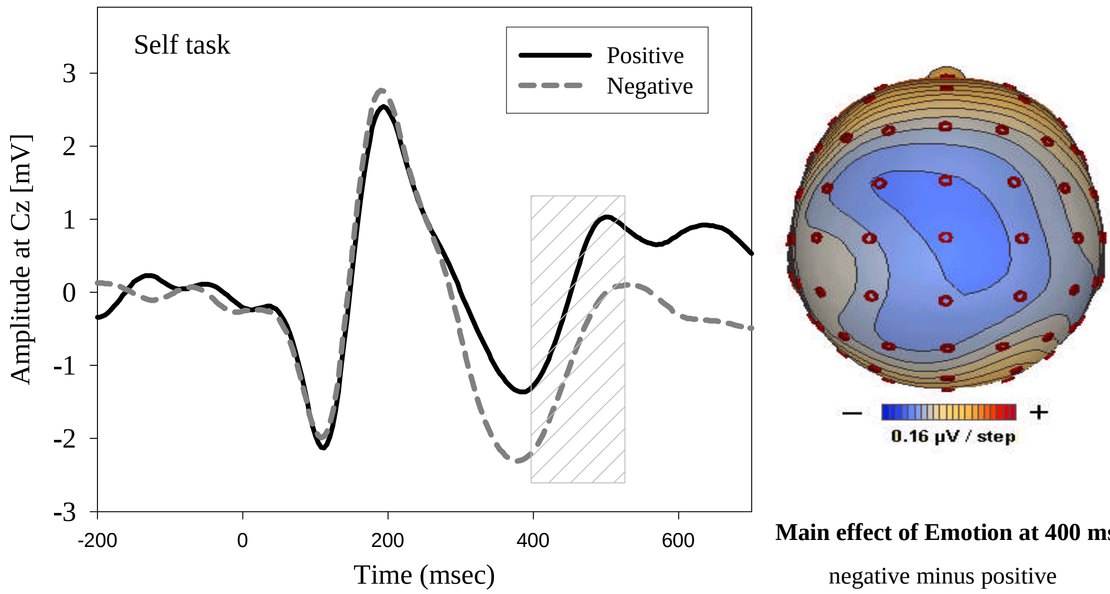
	Positive	**Negative**
Self	60.5	16.31
Non-self	17.31	61.56

78 items is the maximum number of items per experimental condition.

4.3.2: ERP Results

In order to provide information about the spatial location of any potential effects, ERP data from five specific regions was analysed (Mamassian et al., 2003): *frontal* (FP1, FP2, AF3, AF4, AF7, AF8, F1, F2, F3, F4, F5, F6, F7, F8, Fpz, Afz, Fz), *fronto-central* (FC1, FC2, FC3, FC4, FC5, FC6, C1, C2, C3, C4, C5, C6, FCz, Cz), *centro-parietal* (CP1, CP2, CP3, CP4, CP5, CP6, P1, P2, P3, P4, P5, P6, P7, P8), *temporal* (FT7, FT8, T7, T8, TP7, TP8), and *occipital* (O1, O2, PO3, PO4, PO7, PO8, P9, P10, POz, Oz, Iz). For each region, a three-way ANOVA including the factors emotion, self and electrode, was performed on subsequent ERP time segments. Mean ERP amplitudes were calculated for the P1 (80 – 120 ms), N1 (160 – 200 ms) and subsequent 50 ms time segments from 300 to 600 ms relative to stimulus onset. The two early time intervals were chosen around the peaks of the P1 and N1 components. These shorter 40 ms intervals were chosen due of the shorter duration of these early components. (Sprenglemeyer & Jentzsch, 2006). Previous research has employed 100 ms time intervals for analyses during later stages of processing (Schweinberger et al. 2002), 50 ms intervals were employed within the present study to obtain a more refined analysis of the temporal waveform. Only effects that were significant in at least two subsequent time intervals will be reported to reduce the probability of an alpha error. Other possible forms of spatial-temporal analysis of the ERP data, such as Principle Component Analysis (PCA) or Independent Component Analysis (ICA), were not employed. This was because the sample size used in the present study was not large enough to generate the level of statistical power required for procedures such as PCA (Chapman & McCrary, 1995).

No effects were significant in the early time interval. A main effect of emotion was significant at centro-parietal electrode sites in three subsequent time intervals from 400 to 550 ms, $Fs(1, 15) = 5.5$, 4.6, and 4.9, $ps < 0.05$. This effect was due to more negative amplitudes for negative as compared to positive word stimuli (see Figure 4.2). A significant three way interaction between self-reference, emotion and electrode site was revealed over occipital areas from 450 to 550 ms, $Fs(10, 150) = 2.2$, and 2.3, $ps < 0.05$, and fronto-central areas from 450 to 600 ms, $Fs(13, 195) = 2.6$, 2.4, and 2.1, $ps < 0.05$. *Post hoc* analysis revealed that the interaction between self and emotion was largest at FCz and Cz ($Fs > 4.6$, $ps < 0.05$). ERPs were more negative for words that did not fit within the self-positivity bias (see Figure 4.3), that is, to positive words rated as non-self-referential and negative words rated as self-referential.



Main effect of Emotion at 400 ms

negative minus positive

Figure 4.2: ERP waveforms at the CPz electrode and topographical scalp distribution (spline interpolated voltage map) depicting the main effect of emotion within the self-reference task. The waveforms for words representing positive and negative information are superimposed.

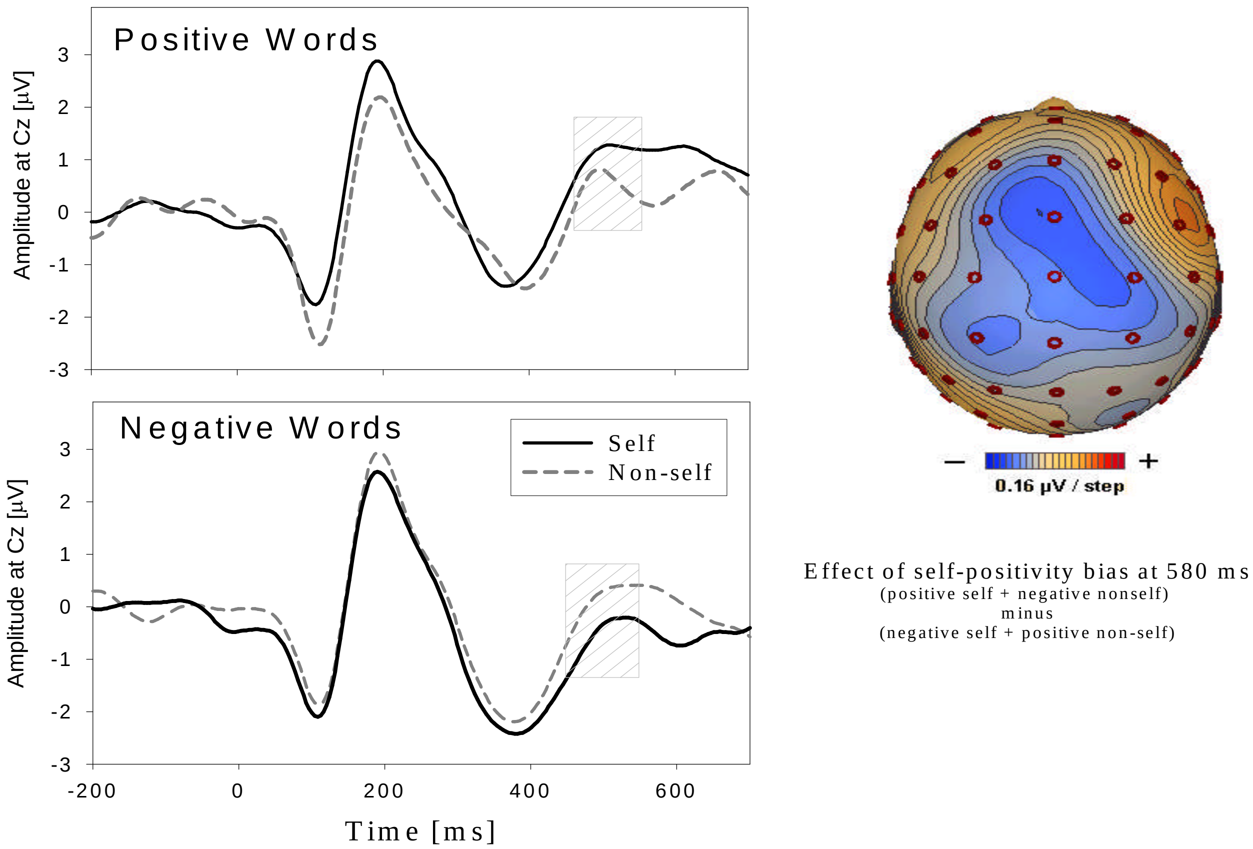


Figure 4.3: ERP waveforms at the Cz electrode and topographical scalp distribution (spline interpolated voltage map) depicting the self-reference x emotional valence. Within the self-reference, for positive words (top panel) and negative words (bottom panel). The waveforms for words representing self- and non-self related information are superimposed.

4.4: Discussion

The processing of both self-reference and emotional valence are important aspects of social and cognitive functioning (Mezulis et al., 2004). The aim of the present study was to examine if ERPs could be employed to investigate the role of these two dimensions within self-referential processing. Based on the functional hierarchy model suggested by Moran et al. (2006) it was predicted that differences should occur in the timing at which self-reference and emotional valence are processed during a self-referential decision-making task. The results provide partial support for this hypothesis. There is evidence of temporal and spatial differences in the processing of emotional valence and self-reference. These differences will be discussed in relation to the functional processing hierarchy proposed by Moran et al. Furthermore, there is also evidence that during the later stages of processing, self-reference and emotional valence are closely related. This interesting interaction will be discussed with reference to the self-positivity bias identified in previous literature (see Section 1.4.1). Importantly, these findings suggest that ERPs can be used as a neurophysiological tool to investigate aspects of self-referential processing.

4.4.1: The functional processing hierarchy as a model for self-reference

The results of the present study identified a main effect of emotional valence in ERPs from 400 to 550 ms at centro-parietal electrodes. This difference in emotional valence was found to be completely independent of self-reference. This effect was the result of more negative going ERP waves in response to negative when compared to positive words. Effects of self-reference were found to occur at different temporal and spatial locations. An interaction involving self-reference was identified slightly later, around 450 - 600 ms at fronto-central and occipital electrode locations. ERP waves were more negative going to words which did not fit the self positivity bias (self negative and non-self-positive) when compared to words which did fit this bias. These findings support the hypothesis that ERPs can be used to examine both temporal and spatial differences in the electrophysiological activity associated with self-referential processing.

Moran et al. (2006) identified a functional disassociation between the regions involved in the processing of self-reference (mPFC) and the regions involved in the processing of emotional valence for highly self-referent information (vACC). Based on these findings, they proposed that information is initially processed in relation to self-reference in the mPFC before highly self-relevant information is assessed for emotional valence in the vACC. On a temporal scale, Moran et al.'s model would predict a main effect of self-reference prior to an interaction between self-reference and emotional valence. Furthermore, the difference in emotional valence within the interaction would be specific to highly self-relevant material (material rated as ‘like me’). It is evident that although spatial and temporal differences were identified in ERPs, these differences were not in line with the functional hierarchy proposed by Moran et al.

It is possible that the difference in results is due in part, to the differences in spatial and temporal resolution of the neuroimaging measures employed in each study. The main effect of emotion identified in the present study occurred prior to any effects involving self-reference and was relatively short lasting, around 150 ms. It is possible that this effect, although identifiable using ERPs, was not evident in the Moran et al. (2006) study due the poor temporal resolution of fMRI. The interaction between self-reference and emotional valence, that differences were identified between words which fit the self-positivity bias (self-positive & non-self-negative) and words which do not fit this bias (self negative & non-self-positive), was identified by Moran et al. in the inferior frontal cortex, dorsal anterior cingulate cortex (dACC) and at the supplementary motor area regions (see Table 1.1). However this effect was not discussed with reference to the functional hierarchy model proposed.

Although the results of the present study differ to those identified by Moran et al. (2006) they are still of interest within a possible functional hierarchy model of self-referential processing. The results of the present study suggest that during a self-referential task, individuals process the emotional valence of presented information prior to, and independent of, any form of self-referential processing. This finding fits with the idea of a functional processing hierarchy on a temporal scale, suggesting that a general evaluation of the emotional valence of word stimuli occurs prior to any judgements involving self-reference. This model is attractive as individuals are faster to respond when making decisions about emotional valence when compared to decisions involving self-reference (see Chapter Five). The findings suggest that when making decisions involving self-reference, individuals may process the emotional valence of word stimuli at a slightly earlier stage in order to then facilitate the processing of self-reference.

It may be possible to examine this hypothesis further in two ways using the current methodology. If individuals are found to process the emotional valence of information faster than self-reference then this would provide some evidence to support the hypothesis that judgements about emotional valence occur prior to any form of self-referential processing. Furthermore, measures such as heart rate have been found to index individuals physiological emotional response to positive and negative stimuli (see Section 2.4.3), therefore if similar responses are found to occur in both an emotional valence task and a self-reference task then this would also provide support for the hypothesis that a general evaluation of the emotional content of word stimuli is a feature of self-referential processing.

4.4.2: Evidence of a self-positivity bias at the neural level

An interaction between self-reference and emotional valence was identified in the response time measure. This finding supports the behavioural results obtained by Moran et al. (2006). These results indicate that a close relationship exists between self-reference and emotional valence. This finding also confirms the self-positivity bias demonstrated by other investigators (Alicke, Klotz, Breitenbecher, Yurak, & Vredenburg, 1995; Mezulis et al., 2004, Pahl & Eiser, 2005; Weinstein, 1989).

As stated above, a significant interaction between self-reference and emotional valence was also identified in the ERP data. From 450 to 600 ms after stimulus onset, amplitudes over fronto-central scalp locations became more negative for self-negative and non-self-positive words as compared to ERPs responses to self-positive and non-self-negative words. This interaction supports the behavioural evidence provided by the response time data. One possible interpretation of this result is that the recognition of self-referent material relies on the recognition of emotional valence and that the two highly integrated processes may work together in order to assess the importance of incoming information.

The interaction identified in both the ERP and behavioural data occur in the same direction as the self-positivity bias identified in previous literature (Mezulis et al., 2004). The findings show that the ERP waveforms become more negative to words that are outwith the bias (self negative & non-self-positive) than to self-positive and non-self-negative words. Therefore the interaction identified provides evidence for the existence of the self-positivity bias at the neurophysiological level.

Having identified this interaction in the form of the self-positivity bias, it is worth speculating about the functional significance of this effect. Given the topography (fronto-central) and the latency of the observed ERP effect (starting at about 450 ms), it is possible that the differences identified in the present experiment are due to modulation of the N400 component. The N400 component was initially identified by Kutas and Hillyard (1980) in studies of language comprehension and has been found to index semantic mismatch. Differences in the amplitude of the N400 reflect the extent to which the lexical semantic content of a word matches the semantic specification of the context in which the word is presented. The component reflects aspects of a semantic integration process (e.g., Brown, & Hagoort, 1993). The results of the present study appear to indicate that the amplitude of the N400 reflects the extent to which self-referent information is discrepant with an individual's self-concept.

4.4.3: Some limitations?

The present study represents a good starting point in order to investigate the relationship between self-reference and emotion at a neural level. It provides a replication of the experimental paradigm used previously to investigate self-referential processing and illustrates the usefulness of using ERPs to investigate temporal differences in the processing of self-referential and emotional information. However, in order to fully clarify this relationship some potential limitations of this paradigm must be considered.

The modified version of the self-reference paradigm used in the present study presented participants with equal numbers of positive and negative words and asked them to make a self-referential judgement about those stimuli ('like me' vs. 'not like me at all'). Based on the self-positivity bias identified in Chapter 3, healthy individuals are known to be more likely to select positive words as self-referent, and negative words as non-self-referent. This bias may cause differences in the frequency with which participants select emotional words as 'like me' or 'not like me', such that a high numbers of positive words would be identified as 'like me' and high numbers of negative words would be identified as 'not like me. Conversely, low numbers of positive words would be identified as 'not like me' and low numbers of negative words would be identified as 'like me'. Therefore it is possible that the interaction identified in the response time and ERP analyses may be in fact be due to differences in the frequencies of the evaluative judgements made, rather than due to the self-positivity bias as initially suggested. Therefore an alternative experimental paradigm in which the frequency of evaluative judgements is taken into consideration is required before the relationship between self-reference and emotional valence can be fully understood (see Chapter Five).

A second limitation relates to the difference in presentation of self-reference (as explicit) and emotional valence (as implicit) within the modified self-reference paradigm. This issue has been discussed in Sections 1.5 and 3.4.1. Based on these considerations, an alternative methodology is required to further clarify the relationship between self-reference and emotional valence. One possibility is to directly compare only high frequency responses (responses to self-positive, and non-self-negative words) in self-referent ('like me' vs. 'not like me' judgement) and emotional (positive vs. negative judgement) decision-making tasks. In this way it would be possible to compare the processing of positive and negative stimuli in both a self-referential and emotional context. By asking participants to directly rate the self-referential and emotional valence of stimuli while recording the participants physiological activity we could learn two things. Firstly what physiological activity is associated with both self-referent and emotional processing, and secondly what physiological activity is unique to each process.

In conclusion, the present study has provided evidence for a two stage model of self-referential processing, in which a general evaluation of emotional valence occurs prior to any evaluations involving self-reference. The results also suggest that the processing of self-reference is carried out in association with the processing the emotional valence of the word, identified as an electrophysiological correlate of the self-positivity bias. This finding may have important consequences for research into normal cognitive function and processing of affective self-referential information. It may also contribute to research investigating the neural basis of affect and self-perception such as depression and anxiety.

- Chapter 5 –

Experiment 3: Does the neural processing of self-reference and emotion alter as a function of mood?

5.1: Introduction

Previous research has indicated that self-referential processing is altered as a function of mood (see Chapter Three & Section 1.6). The findings of Chapter Three suggest that at a behavioural level, it is evaluations about the self-referential nature and not the emotional valence of stimuli which are altered. The results of Chapter Four suggest that a possible neural correlate of the self-positivity bias can be identified using ERPs. Therefore one aim of the present study is to identify if the neural activations associated with self-referential processing are altered as a function of mood. The second aim is to identify if these differences are also evident during other forms of emotional decision-making.

5.1.1: The present study

Based on early theories of depression (Beck, 1967), more recent research (Dozois et al., 2001, see Section 1.6) and research conducted in this thesis (see Chapter Three), alterations of the self are found to be central to the experience of negative mood. The first aim of the present study was to investigate the processing of emotional information *within* the self-referential decision-making task. By recording the behavioural measures frequency of response and response time we can examine how non-dysphoric and dysphoric individuals respond within a self-referential context. By also recording participants' responses during an emotional decision-making task it will be possible to obtain a baseline measure of emotional decision-making. If non-dysphoric and dysphoric individuals differ from each other in self-referential but not emotional decision-making we can say with more certainty that the differences identified previously in self-referential processing are due specifically to alterations in the self-schema during the experience of negative mood.

Previous research (Chapter Four) found that a self-positivity bias can be identified at both behavioural and neural levels in non-dysphoric individuals. However this study also highlighted that the large differences in responses between conditions (high number of responses for self-positive and non-self-negative, low number of responses for self negative & non-self-positive) may act as a confounding factor. In order to control for this in the present study, the responses in the self-referential task can be compared to the responses in an emotional decision-making task. By comparing the responses individuals make within self-referential and emotional decision-making tasks it will be possible to determine the extent to which differences in response time are the result of differences in trial number.

From the previous research conducted in the present thesis several predictions can be made with regards to non-dysphoric and dysphoric responses within the self-reference task. Firstly, based on the findings of Chapter Four it is predicted that non-dysphoric individuals will show a self-positivity bias in both frequency of responses and response time measures. Secondly, based on findings from Chapter Three and previous research (Bradley & Mathews, 1983; Kuiper & Derry, 1982; Segal et al., 1995; Dozois & Dobson, 2001) it is predicted that dysphoric individuals will show a reduction in the self-positivity bias in both frequency of response and response time measures.

These group differences in the self-reference task will then be compared to the differences which occur between non-dysphoric and dysphoric individuals in the emotion task. If dysphoric individuals show impairments in both the emotion decision-making task and the self-reference task then this would suggest that negative mood is associated with generalised impairments in emotional decision-making. However if the differences between non-dysphoric and dysphoric individuals are specific to the self-reference task then this would provide further evidence to suggest that decision-making about self-referential information is specifically impaired during negative mood.

Using the current methodology in combination with ERP techniques (see Section 2.4.1) will allow an investigation into how these decision-making processes take place at the neural level. It may also allow us to identify at which stages of processing mood plays a role in both decision-making processes. The behavioural measures provide us with a good understanding of how information is processed *within* self-referential and emotional tasks. However in order to avoid the frequency of response limitation discussed in above, only two factors, task (self, emotion) and group (non-dysphoric, dysphoric) will be included in the ERP analyses. These analyses will provide us with information about how negative mood influences self-referential and emotional decision-making tasks within the brain.

In Chapter Four an ERP investigation of non-dysphoric individuals identified a neural correlate of the self-positivity bias from 450 to 600 ms at fronto-central and central electrodes. It is hypothesised that if this correlate does represent some aspect of self-related processing, then differences between the ERP responses of non-dysphoric and dysphoric individuals will occur at these temporal and spatial locations. If however, differences between non-dysphoric and dysphoric individuals are also identified at these temporal and spatial locations within the emotion task then this would suggest that the neural correlate identified previously may represent some more general aspect of emotional processing.

5.2: Method

5.2.1: Participants

Forty participants took part in the study. Participants' scores on the Beck Depression Inventory (BDI-II) were recorded (see Section 2.2.1). Scores on the BDI-II were used as a grouping variable to separate participants experiencing low mood (dysphoric) from participants with normal mood (non-dysphoric). Participants with a score lower than 12 were classified as non-dysphoric and participants with a score above 12 were classified as dysphoric (see Table 5.1). The high cut-off points employed in Chapter Three (see Section 3.2.3) were not utilised in this experiment or in experiment eight (see Chapter Five) due to the difficulty in obtaining a suitable number of participants who scored below 7 on the BDI-II questionnaire, furthermore previous research has shown that participants who score below 12 on the BDI-II are experiencing minimal levels of negative mood (Beck, Steer & Brown, 1996).

Table 5.1: Comparison of participant variables across non-dysphoric and dysphoric groups.

	Non-dysphoric	**Dysphoric**
Number	20	20
Gender	14 female	16 female
Handedness	19 right-handed	20 right handed
Mean Age (sd)	21.35 (2.74)	20.35 (1.80)
Mean BDI-II Score	5.6 (2.16)	23.05 (10.01)
BDI-II Range	3 – 10	12 – 48

All participants spoke English as their first language and scored within normal ranges on the Test of Word Reading Efficiency or the National Adult Reading Test (see Section 2.3). All participants were fully debriefed as to the nature of the study and received payment (£8) for participation.

5.2.2: Stimuli and Apparatus

The stimuli and apparatus used were identical to those employed in Chapter Four (see Section 4.2.2 for a review).

5.2.3: Procedure

The procedure used was identical the procedure employed in Chapter Four (see Section 4.2.3 for a review).

5.2.4: Electrophysiological Recordings

The set up of the electrophysiological recording was the same set up employed in Chapter Four (see Section 4.2.4 for a review).

5.3: Results

5.3.1: Participants Variables

Statistical analyses were conducted to identify any possible confounds between the two groups in terms the participant variables age and gender. Chi-square analysis revealed no significant differences between non-dysphoric and dysphoric groups for gender, $\chi 2(N = 40) > 1$. A one-way ANOVA revealed no significant age differences between non-dysphoric and dysphoric groups, $t(35) = 1.82$, $p > 0.2$.

5.3.2: Behavioural Results

5.3.2.1: Data Analysis

Two behavioural measures were analysed, frequency of response and response time. Frequency of response was measured as the number of times participants responded with a key press within each experimental condition. Responses were analysed as a percentage (%) of the overall number of stimuli presented. Response time was measured as the time taken from onset of stimuli until key press response. Response time was measured and analysed in milliseconds (ms).

All factors were analysed for each behavioural measure and two 4-way mixed ANOVAs were conducted, including one between groups factor and three within groups factors. The between groups factor was labelled group (non-dysphoric, dysphoric). The repeated measures factors were labelled as follows: task (self, emotion), evaluation (positive evaluation, negative evaluation) and valence (positive valence, negative valence). To clarify further, the evaluation factor encompasses the key press responses made by participants. This includes words rated by the participant as ‘like me’ and ‘not like me’ in the self task, and words rated as ‘positive’ and ‘negative’ in the emotion task. The valence factor identifies stimuli which have been previously rated as ‘positive’ or ‘negative’ through normative ratings (see Section 2.5). For *post hoc* comparisons, Bonferonni corrected *t*-tests were applied.

5.3.2.2: Frequency of response

No main effects were identified in the mixed ANOVA. However several interactions were revealed; an evaluation x valence interaction, $F(1, 38) = 522.41$, $p < 0.001$, an evaluation x valence x group interaction, $F(1, 38) = 6.13$, $p < 0.05$, a task x evaluation x valence interaction, $F(1, 38) = 19.58$, $p < 0.01$ and finally a four way task x evaluation x valence x group interaction, $F(1, 38) = 11.76$, $p < 0.001$ (see Figure 5.1).

This four way interaction was further evaluated using Bonferroni corrected *t*-tests. The interaction revealed no significant differences in the emotion task between non-dysphoric and dysphoric groups ($ts < 1.09$, $ps > 0.28$). Both groups rate emotional information in the same way. Positively valenced information is strongly evaluated as positive and negatively valenced information is strongly evaluated as negative (> 80 % of the time).

Significant differences were found between the two groups within the self task (ts > 2.76, $ps < 0.05$). Non-dysphorics rated most positive words as self-related (86.0 %) and most negative words as non-self-related (83.3 %). In contrast, dysphorics rated fewer words in this way; self-positive (67.2 %) and non-self-negative (68.1 %). Conversely, where non-dysphorics rate few negative words as self-related (16.6 %) and few positive words as non-self-related (13.3 %), dysphorics show increased responses within these conditions; self negative (33.7 %) and non-self-positive (29.4 %). These findings suggest that although dysphorics do show a self-positivity bias in their frequency of responding, this bias is reduced when compared to non-dysphoric individuals.

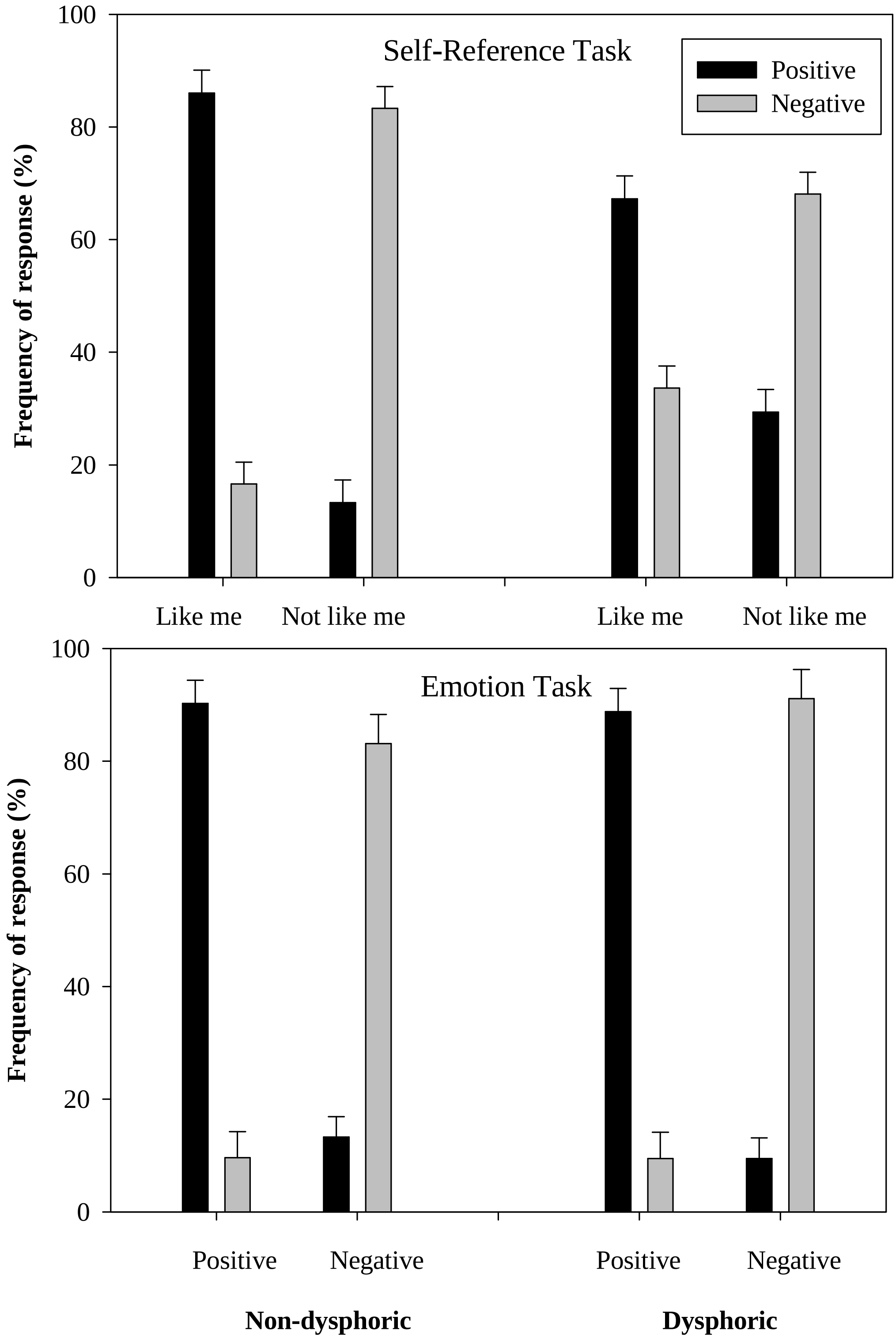


Figure 5.1: The frequency of responses (%) of non-dysphoric and dysphoric groups in all conditions. *The graph illustrates that differences between non-dysphoric and dysphoric individuals occur in the self task but not the emotion task.*

5.3.2.3: Response time

The analysis of response times revealed a main effect of task, $F(1, 38) = 30.99$, $p < 0.001$. Several interactions were also identified. An evaluation x valence interaction, $F(1, 38) = 25.40$, $p < 0.001$ and two three way interactions. The three way interactions were a task x evaluation x valence interaction, $F(1, 38) = 4.59$, $p < 0.05$, and a task x valence x group interaction, $F(1, 38) = 4.15$, $p < 0.05$ (see Figure 5.2). No four way interaction was identified.

The main effect of task illustrated that individuals were slower to respond in the self task (1320.2 ms) when compared to the emotion task (1071.4 ms). This difference suggests that regardless of group, the individuals were significantly faster during the emotion task when compared to the self task. No other main effects were revealed.

Bonferroni corrected *t*-tests were conducted to examine both three way interactions in more detail. The *post hoc* comparisons conducted on the task x evaluation x valence interaction illustrate that significant differences occurred in the evaluation x valence interaction within the self task but not the emotion task. Individuals showed faster responses to word which fit the self-positivity bias (self-positive 1167.2 ms; self negative 1141.5 ms) when compared to words which did not fit this bias (self negative 1433.0 ms; non-self-positive 1538.7 ms), ($ts > 3.37$, $ps < 0.05$). In the emotion task, this evaluation x valence interaction occurs in the same direction. However, these differences did not reach statistical significance ($ts < 2.17$, $ps > 0.2$).

Post hoc comparisons conducted on the task x valence x group interaction suggest a trend towards a difference between positive and negative stimuli within the self-reference task for non-dysphoric participants only ($t < 2.68$, $p = 0.1$). However the graph presented in Figure 5.2 seems suggest that this finding may be the result differences in non-dysphoric participants' responses to self negative and non-self-positive stimuli rather than due to a more general effect of emotional valence.

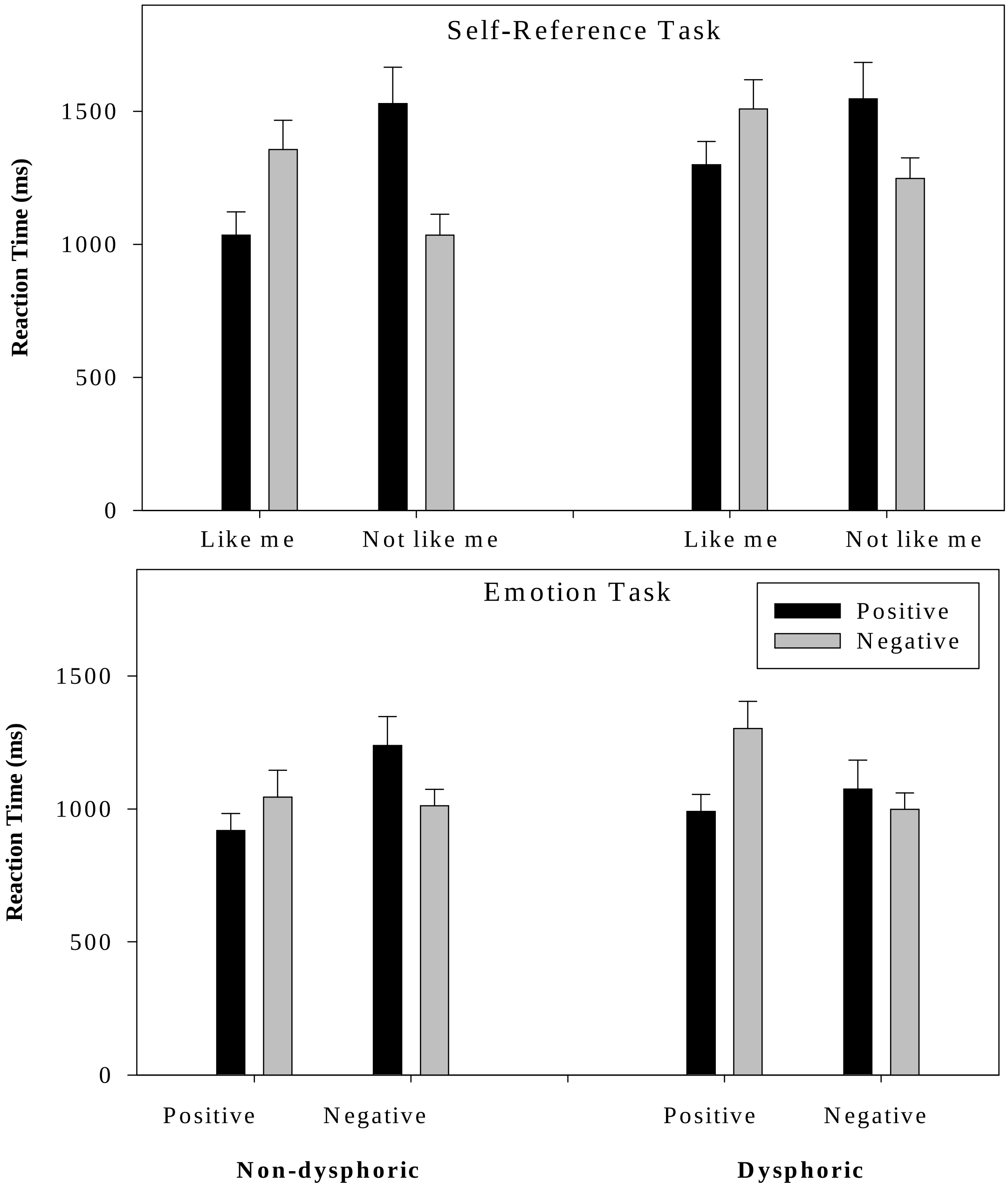


Figure 5.2: Response time (ms) responses of non-dysphoric and dysphoric groups in all conditions. *Significant differences occur between the evaluation and valence factors in the self task but not the emotion task.*

5.3.2.4: Behavioural results summary

The results of the frequency of response analysis provide support for the hypothesis that non-dysphoric and dysphoric individuals differ specifically during self-referential processing. As predicted, non-dysphoric individuals show a self-positivity bias. Positive information is more frequently rated as self-referential and negative information as non-self-referential. Dysphoric individuals also show a self-positivity bias. However, when compared to non-dysphoric individuals, the frequency of dysphoric individuals’ responses to self-positive and non-self-negative stimuli is reduced and the frequency of their responses to self negative and non-self-positive stimuli is increased.

Differences between the two groups were not identified in the emotional decision-making task. The finding that no group differences were identified in the emotion decision-making task suggests that changes in self-referential processing during negative mood are not present in other forms of emotional processing.

Several other effects in the response time analysis also highlight differences between self-referential and emotional decision-making. Firstly a main effect of task was identified. This effect suggests that individuals are not just using emotional information to guide their self-referential decision-making within the present experiment. Furthermore, a self-positivity bias was identified regardless of group. Individuals were faster to respond to self-positive and non-self-negative stimuli when compared to self negative and non-self-positive stimuli. No significant differences were identified in the emotional decision-making task suggesting that the positivity bias identified in response times is specific to self-referential processing.

5.3.3: ERP Results

5.3.3.1: Data Analysis

The overall aim of this experiment was to investigate if self-referential processing is altered as a function of mood. In order to control for the differences in trial number within the experimental tasks, the factors valence and evaluation were excluded from the analysis. From the self task, words which were rated as 'like me' and positive and 'not like me' and negative were included in the analysis. From the emotion task, words correctly identified as positive and negative were included in the analysis.

To investigate this using ERPs, three way ANOVAs were conducted including the between group factor group (non-dysphoric, dysphoric) and the repeated measures factors task (self, emotion) and electrode (see below). As in Section 4.2.4, only trials without EEG or EOG artefacts were included in the ERP data analysis. Conservative Huynh-Feldt *F*–tests were used throughout. For *post hoc* comparisons, Bonferonni corrected one way ANOVAs were applied.

ERP data from specific regions was analysed: *anterio-frontal* (FP1, FP2, AF3, AF4, AF7, AF8, Afz), *frontal* (F1, F2, F3, F4, F5, F6, F7, F8, Fpz), *fronto-central* (FC1, FC2, FC3, FC4, FC5, FC6), *central* (C1, C2, C3, C4, C5, C6), *centro parietal* (CP1, CP2, CP3, CP4, CP5, CP6), *parietal* (P1, P2, P3, P4, P5, P6, P7, P8), *temporal* (FT7, FT8, T7, T8, TP7, TP8), *occipital* (O1, O2, PO3, PO4, PO7, PO8, P9, P10, POz, Iz). In Chapter Four the ERP effects were largest across the midline electrodes FCz and Cz (see Section 4.3.2). Therefore, to provide a regional analysis of these electrodes, the *midline* electrodes (Fz, FCz, Cz, CPz, Pz, Oz) were analysed as an additional electrode group. For each region, a three-way ANOVA including the factors group, task and electrode, was performed on subsequent ERP time segments.

Mean ERP amplitudes were calculated for the P1 (100 – 140 ms), N1 (180 – 220 ms) and subsequent 50 ms time segments from 300 to 700 ms relative to stimulus onset.

5.3.3.2: Early Effects

The early effects identified are outlined in Table 5.2 below. The task x group interactions highlighted are most relevant to the experimental hypotheses.

Table 5.2: ANOVA table of early effects in the time window 100 – 220 ms.

Electrode site	**Effect**	**Time interval**	***F*-Value**	**Between group *Post Hoc* Comparisons**	
				Emotion task *F*-value	**Self task *F*-value**
Fronto-central	Group	100-140	4.43*		
Frontal	Group	180-220	>4*		
Midline	E x G	180-220	>3(*)		
Fronto-central	Task	100-220	>4*		
Occipital	Task	100-220	>4.5*		
Midline	**T x E x G**	**180-220**	**3.16***	**5.95****	**1.69**
Frontal	**T x G**	**180-220**	**4.07(*)**	**7.67****	**1.78**
Fronto-central	**T x G**	**180-220**	**8.64****	**4.27***	**0.98**
Occipital	**T x G**	**180-200**	**7.20***	**4.18***	**0.72**

T= task, E = electode and G = group, (*) = $p < 0.1$, * = $p < 0.05$, ** = $p < 0.01$

Figure 5.3 provides a graphical representation of these interaction effects. The interactions suggests that during the early time intervals the processing of emotional information differs across non-dysphoric and dysphoric groups. Figure 5.3 illustrates that dysphoric individuals ERP responses are larger than that of non-dysphoric individuals. At frontal sites where the ERP peak is positive between 180 - 220 ms dysphoric responses are more positive than non-dysphoric responses. At occipital sites where the ERP peak is negative, dysphoric responses are more negative than non-dysphoric individuals. This difference in polarity across the two electrode locations is labelled the average reference effect, this effect is due to the use of an average reference electrode as a baseline of general electrical activity in the brain within the present methodology.

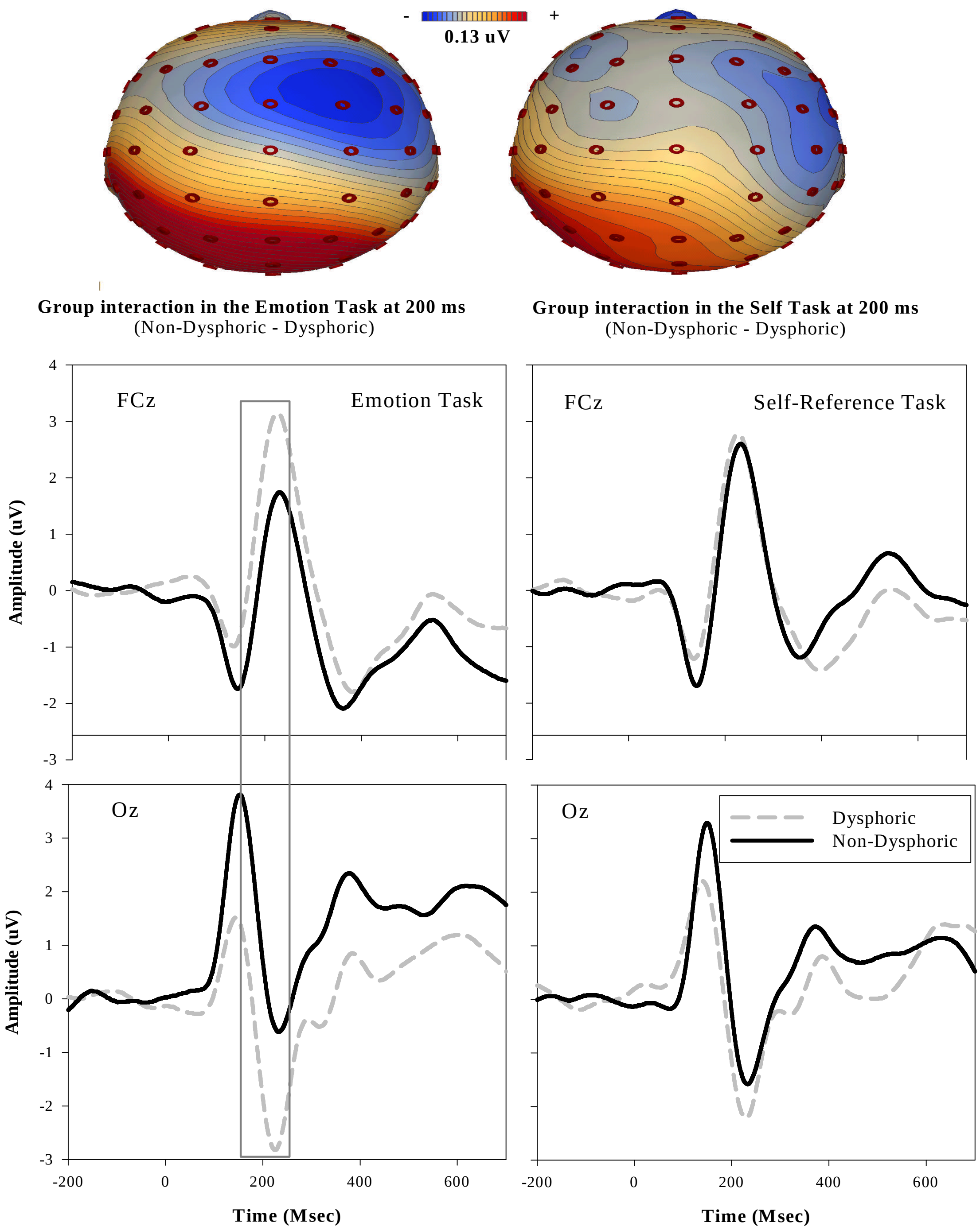


Figure 5.3: ERP waveforms at FCz and Oz electrodes and topographical scalp distribution (spline-interpolated voltage map) depicting the task x group interactions occurring during early processing. The waveforms for words representing non-dysphoric and dysphoric groups are superimposed.

<u>*5.3.3.3: Late effects*</u>

In the late time windows, robust main effects of task and task x electrode interactions were identified (see Table 5.3). In relation to the experimental hypothesis, a task x group interaction, outlined in bold, was also identified at midline electrodes, Figure 5.4. This effect occurred from 400 to 650 ms mainly as a significant trend, reaching significance between 400 – 450 ms, $F(1, 38) = 4.10$, $p < 0.05$, and 500 – 550 ms, $F(1, 38) = 4.61$, $p < 0.05$. *Post hoc* comparisons revealed a trend towards differences between non-dysphoric and dysphoric individuals within the self task, $F(38) = 3.90$, $p = 0.05$, but not in the emotion task, $F(38) < 1$. At this stage of processing dysphoric individuals ERP waves show reduced amplitude within the self task when compared to non-dysphoric individuals.

Table 5.3: ANOVA table of late effects in the time window 300 – 900 ms

Electrode Site	**Effect**	**Time Window**	***F*-Value (>)**
Midline	Task	300 – 400	5.0**
	T x E	350 – 700	8.0***
	T x G	**400 – 650**	**3.5***
Anterio-Frontal	Task	400 – 700	5.5**
	T x E	400 – 700	2.0**
Frontal	Task	350 – 700	6.5**
	T x E	550 – 700	2.5**
Parietal	Task	450 – 550	4.0**

T= task, E = electrode and G = group, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$

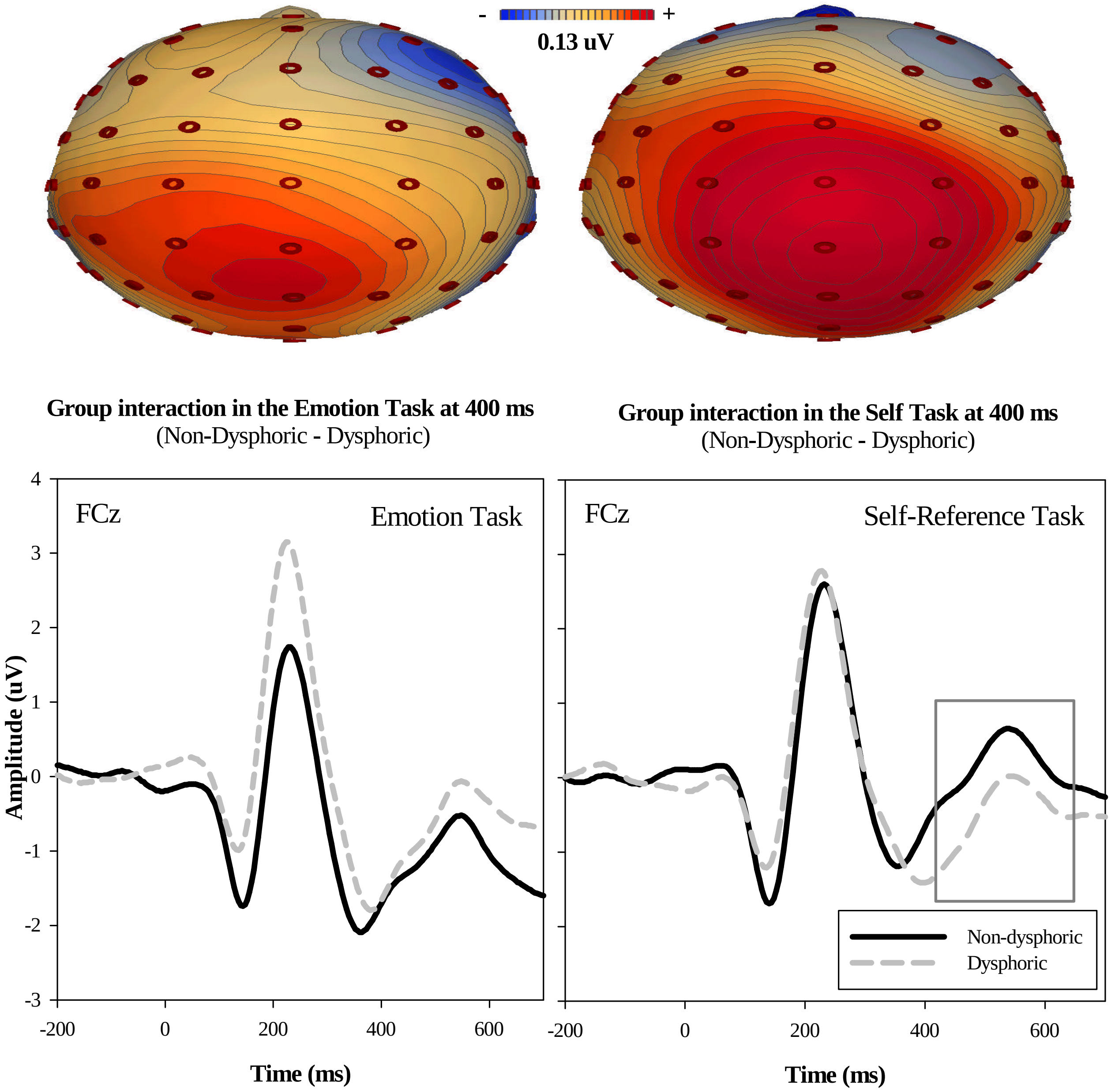


Figure 5.4: ERP waveforms at the FCz electrode and topographical scalp distribution (spline - interpolated voltage map) depicting the task x group interaction occurring during the late stages of processing. The waveforms for the non-dysphoric and dysphoric groups are superimposed.

5.3.3.4: ERP results summary

The results suggest that individuals, regardless of group differentiate between the self and emotion tasks at both early and late stages of processing. These effects are robust, long lasting and occur across several brain regions. Task x group interactions are also found to occur both at early and late stages of processing.

However the nature of these interactions differs across the different time intervals. At early stages, differences between non-dysphoric and dysphoric individuals occur in the emotion task and not the self task. Dysphoric individuals' ERPs are larger than non-dysphoric ERPs to emotional information. At the later stages of processing differences between non-dysphoric and dysphoric individuals occur in the self task but not the emotion task whereby dysphoric individuals ERP waves are more negative going than non-dysphoric individuals.

The task x group interaction identified in the later stages of processing supports the prediction that non-dysphoric and dysphoric individuals differentiate between self-referential information at midline electrodes from 400 to 650 ms.

5.4: Discussion

The overall aim of the present study was to investigate the extent to which self-referential processing is altered as a function of mood. The findings provide evidence to suggest that self-referential processing is indeed altered as a function of mood at both behavioural and neural levels.

5.4.1: Behavioural findings

5.4.1.1: Within the self task

The prediction that non-dysphoric individuals would show a self-positivity bias in frequency of responses and response time was supported. As previous research suggests (see Chapter Four, & Section 1.4.1), non-dysphoric individuals respond more frequently to, and have faster response times for positive information when rated as self-referential and negative information when rated as non-self-referential when compared to self negative and non-self-positive information.

The prediction that dysphoric individuals would show an alteration in the self-positivity bias was supported in the frequency of response but not the response time measure. As in previous studies, dysphoric individuals were found to endorse more negative traits and less positive traits as self-referential when compared to non-dysphoric individuals (Bradley & Mathews, 1983; Derry & Kuiper 1981; Mineka & Sutton, 1992; Dozois & Dobson, 2001, Dozois & Dobson, 2003). Although, this alteration in the self-positivity bias was not identified in response times, changes in self-referential processing in depression have been less consistent in the response time measure than in frequency of response or recall (Bradley & Mathews, 1983; Clifford & Hensley, 1987; Derry & Kuiper, 1981; Dobson & Shaw 1987; Dozois & Dobson, 2001).

The difference in self-referential processing identified between non-dysphoric and dysphoric groups provides strong evidence to suggest that this type of processing is altered as a function of mood. In dysphoric individuals a self-positivity bias was identified, however this bias was reduced in comparison to non-dysphoric individuals. This finding differs to studies of clinically depressed individuals where a self-negativity bias was identified (Bradley & Mathews, 1983; Segal et al. 1995). One similar study by Kuiper and Derry (1982) also failed to find a self-negativity bias. They found that recall of both positive and negative stimuli was enhanced in a self-referential encoding task when compared to a semantic encoding task. As in the present study Kuiper and Derry tested mildly depressed individuals. Therefore it is possible that changes in the self-positivity bias increase as a function of the severity of a depressive episode. It would be interesting to investigate this further by testing clinically depressed individuals. It may also be of interest to investigate if changes in self-referential processing increase as a function of the number of depressive episodes experienced. Both these studies would allow us to identify more fully how these self-referential biases alter as the severity of depression increases.

5.4.1.2: Self-referential versus emotional decision-making

Previous research employing the self-reference paradigm to investigate cognitive processing in mildly depressed or depressed individuals has identified differences in self-referential processing between these groups and healthy individuals (Bradley & Mathews, Kuiper & Derry; Dozios & Dobson, 2003). The results of the present study also identified differences between non-dysphoric and dysphoric groups during self-referential processing. Additionally, the responses of these two groups were compared during an emotional decision-making task. No differences between non-dysphoric and dysphoric individuals were identified during this task. This finding suggests that negative mood is not associated with changes in all forms of emotional decision-making. The results of the present study extend previous research as we can say with greater confidence that the changes in self-referential processing as a function of mood are not the result of a more general impairment in all forms of emotional decision-making.

Several other important effects warrant also some discussion. Firstly a main effect of task was documented. Regardless of group, individuals were found to be slower for the self task when compared to the emotion task. This effect is particularly important for the non-dysphoric group. In both the frequency of response and response time measures the pattern of responses made by non-dysphoric individuals in both the self-reference and emotional valence tasks were very similar. It may be suggested that non-dysphoric individuals are using the same decision-making processes within both self-referential and emotional decision-making tasks. However this main effect of task suggests that this is not the case. As expected, individuals were much faster at making simple decisions about the valence of stimuli than when asked to evaluate information as self-referential.

Secondly, a task x evaluation x valence interaction was identified. *Post hoc* comparisons revealed that individuals were faster to respond in conditions which fit the self positivity bias (self-positive & non-self-negative) when compared to conditions which did not fit this bias (self negative & non-self-positive). In the emotion task no such differences in response time were identified. One limitation of the study conducted in Chapter Four was that the differences in response time within the self task may be the result of differences in the frequency of responses between the conditions mentioned above. In the present experiment, the frequency of responses within the evaluation x valence conditions within the self task and the emotion task were similar, particularly for non-dysphoric individuals. The fact that no significant differences were identified within response times to the emotion task despite the large differences in frequency of responses across conditions suggests that the differences found within the response times in self-reference task do in fact represent a true self-positivity bias.

5.4.1.3: Summary

Overall the behavioural results of this study consistently support the findings of previous research. Non-dysphoric individuals show a strong self-positivity bias in both the information they endorse as self-referential and their response latencies. Dysphoric individuals also show a similar self-positivity bias in their response latencies, however this bias is significantly reduced in the frequency of response measure. Furthermore the addition of the emotional decision-making task extends previous research, illustrating that changes in the self-positivity bias as a function of mood are not the result of a generalised emotional processing bias.

5.4.2: ERP findings

The value of employing ERP techniques within the present experiment was twofold; firstly to investigate the neural correlate of the self-positivity bias in more detail and secondly to investigate how self-referential processing within the brain differs as a function of mood.

5.4.2.1: The neural correlate of the self-positivity bias

In Chapter Four differences in the self-positivity bias were identified in the brain at fronto-central and central electrodes from 450 to 600 ms. It was hypothesised that if behavioural differences were identified between non-dysphoric and dysphoric individuals then these differences should also be evident within the brain at the temporal and spatial locations mentioned above. The findings of the present study supported this hypothesis as differences between non-dysphoric and dysphoric individuals were identified at midline electrodes (including the fronto-central and central electrodes) from 400 to 650 ms. These findings are strengthened by the fact that no such differences were identified in the emotion processing task at these spatial and temporal locations. This suggests that the correlate identified is specifically related to self-reference and not the result of generalised differences in emotional processing. Group differences were identified in the emotion task at an earlier stage of processing. This effect will be discussed in a later section.

One potential limitation of the present study is that only words which fit the self-positivity bias (self-positive & non-self-negative) were examined in the ERP analysis. Due to the exclusion of the other two conditions the present study cannot provide a full picture of how self-referential processing takes place within the brain. It is interesting to note that despite this limitation, evidence for a neural correlate of the self-positivity bias was still identified. The present study does show that by comparing the ERP responses of dysphoric and non-dysphoric individuals within a self-referential task we can learn more about the neural correlates of self-referential processing.

5.4.2.2: In the brain: Self-referential processing as a function of mood

The second aim of the ERP analysis was to investigate, at the neural level, how self-referential processing is altered as a function of mood. The fact that a reduction in the amplitude of ERP responses of dysphoric when compared to non-dysphoric individuals was identified at locations previously found to be involved in self-referential processing, provides evidence to suggest that self-referential processing is altered both at the behavioural and neural levels.

It was put forward in Section 4.4 that the ERP differences between words which fit the self-positivity bias (self-positive, non-self-negative) and those words outwith the bias (self negative, non-self-positive) could be explained by semantic mismatch. That is, the N400 becomes more negative to stimuli which do not fit the current semantic context (Kutas & Hillyard, 1980). Within the self-referential task the semantic context consists of the current self-schema being used by the individual within the decision-making process. Based on this reasoning, the ERP waves of non-dysphoric individuals are less negative going than dysphoric individuals because the stimuli presented (self-positive & non-self-negative) are a better fit of the positive self-schema held by the individual. For dysphoric individuals the ERP wave is more negative going because the stimuli are a poorer fit of their more negative self-schema.

These findings support the suggestion that self-referential processing is altered as a result of negative mood and extend previous research by identifying these differences at the neural level. Furthermore, the semantic mismatch explanation of the changes in the N400 complement the previous scientific theory and behavioural evidence that the nature of the self-schema is altered as a function of mood.

5.4.2.3: Other ERP effects: early differences in emotional processing

As stated above (see section 5.4.2.1) differences between non-dysphoric and dysphoric individuals were identified in the emotional decision-making task during the early stages of processing. The results suggests that the ERP waves of dysphoric individuals are larger than the ERP waves of non-dysphoric individuals at midline, frontal, fronto-central and occipital regions from 180 to 220 ms. Although this effect is not relevant to the experimental hypothesis proposed in the study, it is interesting in its own right and therefore warrants some discussion.

The traditional stages of processing view suggests that early stages of information processing (pre 200 ms) are related to perceptual or sensory events (Fabiani et al., 2000). However more recent research suggests that relatively high level functions may also occur during this early time interval (Ortigue et al., 2004). During early time intervals (pre 200ms), ERPs have been found to differentiate between faces (Braeutigam et al., 2001), objects (Murray et al., 2002; Rousselet et al., 2002) and even word stimuli (see Pulvermùller, 1999 for a review). In line with the traditional stages of processing view, it is possible that these ERP differences are associated with visual-perceptual processes. However, these early differences have also been associated with the attributes of word stimuli commonly related to word meaning (Pulvermùller, 2001; Skrandies, 1998), syntax (Pulvermùller, 2001) and even emotional valence (Kissler et al, 2006).

The literature examining the influence of emotion at different stages processing is sparse, particularly studies looking at early time intervals (Kissler, Assadollahi & Herbert, 2006). However, a small number of studies have identified differences in affective processing around and prior to 200 ms. Most of these studies identified differences between affective word categories namely between emotional and neutral words. Begleiter and Platz (1969) found that ERP amplitudes were greater in response to taboo words than neutral words within the first 200 ms after stimulus presentation. Following this early study, Herbert et al. (2006), Kostandov and Arzumanov (1977), Ortigue et al. (2004), and Williamson, Harpur and Hare (1991) and have all identified similar differences between emotional and neutral words during early stage processing. Other studies have also identified differences between positive and negative stimuli, although these finding are less robust (Bernat, Bunce, & Shevrin 2001; Chapman, 1978; Kiehl et al., 1999; Kissler et al., 2006). These findings from multiple studies illustrate that the processing of emotional information occurs prior to 200 ms.

As stated above, the traditional stages of processing view states that early ERP components are associated with visual-perceptual processes. However, research into eye movements during reading has identified that the average time we fixate on a word during reading is 250 ms, this finding suggests that the processing of word meaning may occur earlier than previously thought (Sereno and Rayner, 2003). If the emotional valence of word stimuli was found to modulate the stages at which word meaning is accessed it could be said with greater certainty that emotional valence influences early stages of processing. Previous research has identified that the effects of word frequency are linked to the moment of lexical access (Sereno & Rayner, 2003), one recent study by Scott et al. (in press) examined the relationship between emotional valence and word frequency. They hypothesised that if the effects of word frequency on ERP components are modulated by emotional valence then this would support the idea that emotional valence is an important feature of lexical access during early stages of processing. As predicted, they identified word frequency x emotional valence interactions during the early stages of processing. This finding lead them to conclude, contrary to the traditional stages of processing view, that the emotional tone of a word does modulate early lexical processing. That these differences identified during the early stages of processing are not solely due to visual-perceptual processes.

All the studies discussed above relate to the processing of emotionally semantic information. During this type of processing, each word is evaluated individually and the averaged ERP responses relate to the emotional content of the presented words. In the present study, the task x group interaction occurs due to the context in which the words are presented. One study by Begleiter, Porjesz, and Garozzo (1979) examined task-related differences. They compared an emotional evaluation task to a vowel identification task and found that the N1 - P2 complex only differentiated between emotional and neutral words within the emotional evaluation task. Kanske and Kotz (2007) suggest that the task-related difference in the Begleiter et al. study occurs because attention is focued on the emotional connotation of the word stimuli in the emotional evaluation task. This explanation supports the present results to some extent, in that early differences in emotional processing were identified in an explicit emotion task but not an implicit emotion task (vowel identification task).

The task-related interactions in the present study revealed differences in the way in which non-dysphoric and dysphoric individuals make emotional evaluations at a neural level. Dysphoric individuals show larger ERP waves between 180-220 ms when making emotional evaluations when compared to non-dysphoric individuals. Again the literature in this area is limited. Clinical studies which investigate early stages of processing using ERPs consider anxious individuals or individuals who suffer from chronic pain (Kissler et al., 2006). Studies of depressed or dysphoric individuals generally limit their analyses to the later stages of processing (Dietrich et al., 2000; Dietrich et al., 2001). The present study provides evidence to suggest negative mood also alters early ERP components involved in simple emotional decisions during early time intervals. This finding suggests that further research should be conducted to investigate the influence of negative mood during the early stages of processing.

In conclusion, the results of the present study illustrate that self-referential and emotional decision-making do represent two distinct forms of processing. Furthermore, the results suggest that negative mood impairs self-referential processing both at the behavioural and neural level. In the brain, these impairments occur during the later stages of processing and can be explained with reference to the semantic mismatch hypothesis. Unexpectedly, differences in the emotional processing of non-dysphoric and dysphoric individuals were also identified during the early stages of emotional decision-making. Little research has been done in this area and our findings highlight the need to investigate the role of negative mood during these early stages of emotional processing in more detail.

- Chapter 6 -

Experiment 4: A comparison of self-referential and emotional processing in skin conductance and heart rate response.

6.1: Introduction

Previous chapters have identified that a self-positivity bias exists at both behavioural and neural levels in non-dysphoric individuals (see Chapters Three & Four). The experiment conducted in Chapter Five also illustrates the benefits of comparing the processing of information within the self-positivity bias (self-positive & non-self-negative) across explicitly self-referential and emotional tasks. This method allows a direct comparison of how the processing of emotionally valenced information differs within these two tasks, allowing us to determine the extent to which self-referential processing is associated with emotional processing. Furthermore it also enables us to identify which features of processing are specifically related to self-reference.

In the previous experiments conducted (Chapters Three, Four & Five) self-referential and emotional processing have been investigated by asking individuals to evaluate the content of word stimuli. It could be argued that this type of semantically based task may not elicit a true emotional response and therefore that these tasks may not accurately reflect emotional processing. Measures such as skin conductance and heart rate reflect how the brain recruits the peripheral nervous system (autonomic nervous system) in response to external events (see Section 2.4). Therefore, if the self-reference and emotional valence tasks presented in the previous experiments were found to elicit autonomic responses, it could be said with more certainty that these two tasks do reflect some form of emotional processing. As discussed below, these measures also have theoretical value. Skin conductance is known to index autonomic arousal and heart rate is known to index emotional valence (see Sections 2.4.2 & 2.4.3).

6.1.1: Skin conductance: a measure of motivational significance

Ever since Lacey (1967) proposed that changes in skin conductance could be used as an index of physiological arousal, many researchers have used skin conductance to investigate arousal. A series of studies by Lang et al. (Greenwald, Cook III, & Lang, 1989; Lang, Bradley, & Cuthbert, 1990, 1998; Lang, Greenwald, Bradley, & Hamm, 1993; Bradley, Cuthbert, & Lang, 1996; Bradley, Codispoti, Cuthbert, & Lang, 2001) investigated behavioural and physiological responses to emotional pictorial stimuli. Their common methodology was to present participants with a series of pictures which vary on the dimensions of valence (pleasant – unpleasant) and arousal (calm – excited). During the presentation of stimuli, physiological measures such as skin conductance, heart rate and facial myocardiographic activity were recorded. After presentation, participants were asked to rate the pictures for emotional valence and arousal using the self-assessment manikin (SAM). Lang and others found support for Lacey's hypothesis, that skin conductance consistently varies with arousal regardless of emotional valence.

Lang et al. (1990) hypothesise that physiological arousal represents the intensity of motivational activation experienced by an organism. As physiological arousal increases in an organism, their disposition to react also increases. Through these experiments, Lang et al. have found that arousal (as measured by participant ratings, skin conductance & startle blink) is greater for stimuli which have motivational significance for individuals in terms of survival, i.e pictures of sexual behaviour, human, and animal attack (Bradley et al., 2001).

Sedikides and Skowronski (1997) argue that the self-concept is also important for human survival. From an evolutionary perspective, they suggest that the self-concept is unique to humans and emerged in response to specific social and ecological pressures. The self-concept is proposed to have adaptive significance. It provides a mechanism by which we can assimilate and understand incoming information, organise and plan future behaviours and communicate at both the personal and group level. If the self-concept is important for survival, the processing of self-referent information should be of motivational significance.

Experimental studies have repeatedly indicated that individuals attend to, and have a better memory for self-referent information (Cacioppo, Petty, & Morris, 1985; Kihlstrom, Beer, & Klein, 2002; Markus, 1977; Symons, & Johnson, 1997;). These findings imply that self-referent information does have some degree of motivational significance for the individual. Following this line of reasoning, it can be hypothesised that self-relevant information should also elicit physiological arousal.

Two studies support this hypothesis to some extent. One study by Nikula, Klinger, and Larson-Gutman (1993) used skin conductance to determine if individuals find their own personal current concerns more arousing than those of other individuals. Nikula et al. presented participants with two sets of words. One set related to the participant’s own personal concerns (which had been identified previously) and the other set related to the concerns of another individual. Participants showed greater skin conductance responses to words which related to their own concerns when compared to words which related to the concerns of others. A very different study by Gronau, Ben-Shakar, and Cohen (2005) used an alternative version of the Stroop task to determine the extent to which skin conductance responses and response time distinguished between neutral and personally relevant information. They asked participants to name the colour of a series of non-personal (table, pen etc.) and personal (first & last names) words. They found that participants showed longer response time latencies and larger skin conductance responses to personal words when compared to non-personal words.

Both these studies provide preliminary evidence to suggest that individuals show greater physiological arousal to personally relevant information. In terms of the theory of arousal purported by Lang and others (1990), these findings indicate that self-referent information may be of greater motivational significance when compared to other types of information. In the studies discussed above, Nikula et al. (1993) only examined skin conductance responses to negative information and Gronau et al. (2005) did not evaluate emotional valence at all. Although these studies investigate self-reference, they fail to examine if the processing of self-referential information differs from the processing of emotional information. From these studies a key research question emerges as to whether individuals show different levels of physiological arousal when engaged in self-referential processing when compared to the physiological arousal experienced as a result of general emotional processing as previously shown by Lang et al.

As discussed in Chapter Four, within the self-referential task, individuals identify some types of information as ‘like me’ and some types of information as ‘not like me’. Therefore differences in physiological arousal may not only occur between self-referential and emotional tasks but also within the self-referential task itself. If this is the case we would expect that information rated as ‘like me’ would elicit greater physiological arousal than information rated as ‘not like me’ specifically within the self-referent task.

6.1.2: Heart rate: a measure of emotional valence

The results of Lang and others (1990) discussed above also consistently demonstrated that heart rate differentiates pictures of pleasant and unpleasant emotional valence. Early studies identified that cardiac acceleration was greater for pleasant pictures whereas cardiac deceleration was greater for unpleasant pictures (Greenwald et al., 1989).

More recently, studies have utilised a more detailed measure of heart rate due to the variability in mean heart rate response found across participants and task conditions (Greenwald et al., 1989). Bradley et al. (2001) measured how heart rate changes temporally after picture presentation. They identified a triphasic response which differed across emotional valence. In response to unpleasant pictures, Bradley et al. found a large initial increase in cardiac deceleration that was sustained through out the 6 second stimulus presentation period. In response to pleasant pictures the initial deceleration was smaller and a large peak acceleration occurred after the initial deceleration. These findings suggest the heart rate differs in response to emotional valence and that these responses differ over time. By measuring heart rate in this way it should be possible to examine the extent to which the emotional content of information is evaluated within a self-referential context. If emotional valence plays a large role in the processing of self-reference, then heart rate response within both self-referential and emotional tasks should be similar. However, if self-reference represents a unique form of stimulus processing then heart rate response within the two tasks should differ.

6.1.3: The present study

The aim of the present study was to investigate the extent to which emotional processing, as indexed by physiological measures, is involved in self-referential processing in non-dysphoric individuals.

The measure of skin conductance response has been found to be associated with arousal. Based on the research of Lang et al. (1990) and Sedikides and Skowronski (1997) it is hypothesised that self-referential information is of greater motivational significance and therefore will elicit greater physiological arousal than other types of information. Two predictions can be made with regards to this hypothesis. The first prediction is that skin conductance responses should be larger within the self-referent task when compared to the emotion task. The second prediction is that within the self-reference task itself, skin conductance responses should be larger to stimuli identified as ‘like me’ when compared to stimuli identified as ‘not like me’.

The measure of heart rate response has been found to differentiate between positive and negative valence. Therefore, heart rate can be used to provide a physiological measure of emotional processing. If decisions about the self-referential nature of information are heavily influenced by the emotional content of the stimulus then it would be predicted that differences in heart rate would be identified in both the self-referential and emotion tasks. However, if self-referential processing represents a unique form of stimulus processing, then it would be predicted that differences in heart rate would only be present in the emotion task.

Behavioural measures such as frequency of response and response time were also recorded for all participants. It is hypothesised that the results of the present study will replicate the behavioural results identified in Chapter Five for non-dysphoric individuals. In the frequency of response measure an evaluation x valence interaction is predicted. In the response time measure a task x evaluation x valence interaction is predicted. This replication would lend support to finding that the self-positivity bias identified in the response time measure is not simply due to the frequency of trial responses within the experimental conditions.

6.2: Method

6.2.1: Participants

Thirty eight participants (26 female, mean age: 20.76 years, SD: 3.05 years) were initially recruited from the University of Strathclyde. All participants took part in a single session lasting approximately 90 minutes. The language requirements were the same as in Section 4.2.1.

Participants completed the Beck Depression inventory-II (BDI-II), see Section 2.2.1. On the basis of their scores on the inventory, 11 participants were excluded from further analyses as their scores were greater than 12. A further 2 participants were excluded due technical errors during physiological recording. The responses of 25 participants (15 female, mean age: 20.68 years, SD: 3.00 years) were included in further analyses. All participants were fully debriefed as to the nature of the study and were given a choice of payment (£4 per hour) or class credit for participation.

6.2.2: Stimuli and Apparatus

Word stimuli were presented using Experimental Run Time System (ERTS) software on a 17-inch CRT monitor controlled by a Pentium PC. Responses were recorded using two buttons mounted on two separate response panels placed in front of the participant. Left and right key press responses were made with the index and middle fingers of the participant's preferred hand. The stimuli were identical to those used in Chapter Four (see Section 4.2.2 for a review).

6.2.3: Procedure

On arrival participants were asked to wash their hands to ensure a baseline level of sanitation required for measuring skin conductance response. After the participants provided informed consent, information about age and gender was obtained, recording electrodes and a respiration strap were secured onto the participant and the participant was familiarised with the experimental procedure.

The instructions and tasks completed in the first section of the study were the same as in Section 4.2.3. However the experimental trials were set up differently to allow for differences in the physiological measures being recorded (see Section 6.2.4) below. Each trial began with the presentation of a fixation cross for 0.5 seconds, followed by the word stimulus, which was presented until response. Five seconds after stimulus onset, the next trial began. In each condition, four practice trials were followed by 156 experimental trials (presented in three blocks of 52 trials each) with words individually presented in random order. The same 156 word stimuli were used in both the self task and the emotion task.

After the computer based task, the electrophysiological recording equipment was removed and participants were asked to complete several questionnaires. Finally participants were debriefed, paid credit and thanked for participation.

6.2.4: Electrophysiological recordings and data analysis

The physiological measures recorded were; heart rate (from the electrocardiogram, or ECG), autonomic skin conductance response (SCR), and respiration rate (RR). All physiological measures were recorded and analysed using Biopac MP150 hardware system and AcqKnowledge software.

6.2.4.1: Heart rate response

Biopac EL258 (8 mm) unipolar Ag-AgCl electrodes were placed on the palmer surface of the right and left wrist and anterior surface of the ankle opposite the preferred hand in accordance with Einthoven's triangle using the Lead I and Lead II system (see Section 2.4.3.2). Each electrode was filled with Sigma Gel electrolyte (Parker Laboratories Inc) and secured with a length of surgical tape. The ECG signal was amplified using a Biopac model ECG100B amplifier, with a high pass filter at 50 Hz. To cancel out electrical activity associated with movement and muscle artefact a Band Pass filter of between 10 - 40 Hz was also used.

Heart rate was calculated from the ECG signal and any further distortions within the heart rate data were transformed using a point to point smoothing function. Within the self-reference task, a heart rate waveform was calculated for positive words rated as self-referent, and negative words rated as non-self referent by the participant. In the emotion task, a heart rate waveform was calculated for words correctly identified as positive and negative. Change in heart rate was calculated in reference to a baseline of the average heart rate in the 0.5 seconds prior to stimulus onset.

6.2.4.2: Skin conductance response

Biopac TSD203 (6 mm) bipolar Ag-AgCl Skin Conductance Electrodes were placed on the palmer surface of the medial phalanx of the middle and index fingers of the non-preferred hand. Prior to placement, each electrode was filled with a standard electrolyte cream (Med Associates Inc, Vermont, U.S.A) of approx 0.05 m NaCl to facilitate conduction of the electrical signal. Responses were amplified using a Biopac model SCR 100 amplifier and sampled at 200 Hz and expressed in micro-ohms ($\mu\Omega$).

The SCR data was collected in accordance with general guidelines for SCR provided by Venables and Christie (1973). A response was identified as the maximal change in conductance activity within a specified time period. Within the present study, responses were only recorded if the onset of response began 1- 4 seconds after stimulus presentation, and peaked no later than 4.5 seconds (Venables & Christie, 1973). A peak to peak measure from onset of response until peak of response was measured. Any response in which the slope of the conductance activity was negative was removed from analysis. Any response which contained irregular conductance activity, or an associated respiration was also removed from analysis. Respiration rate (RR) was recorded for this purpose.

6.4.2.3: Respiration rate

RR was measured using a Biopac TSD201 respiratory effort transducer which measures changes in thoracic or abdominal circumference associated with breathing. The hardware consists of a Velcro strap and a transducer which are secured around the chest approximately one inch above the sternum. The RR signal was amplified using a biopac RSP100C respiration amplifier.

Large intakes of breath are found to be associated with changes in autonomic arousal (Venables & Christie, 1973). Therefore RR was calculated in order to control for SCR responses which are directly related to breathing activity and not related to stimulus-response. During analysis of SCR, every trial in which a large respiration occurred within the 3 sec period after stimulus onset was removed from further analysis. RR will not be discussed further.

6.3: Results

6.3.1: Data analytic strategy

The behavioural and physiological responses recorded for both HR and SCR measures were analysed, and will be presented separately. This was done for two main reasons. Firstly, HR was recorded for all twenty-five participants. In contrast, SCR was only recorded for seventeen of these participants (due to movement artefact or lack of physiological responses). To provide behavioural information which corresponds to the physiological measures analysed, behavioural responses were also analysed separately for each group.

Secondly, HR was analysed for all word stimuli in the conditions with high amounts of trials (see Section 4.4.1 & Section 5.3.3.1). However, due to the effects of habituation (see Section 6.3.3) skin conductance responses were only analysed for the first 20 words in each condition with high amounts of trials. These differences in the physiological analyses are also reflected in the corresponding behavioural analyses. As stated above, only conditions with high amounts of trials were included in the physiological analyses. From the self task this included the self-positive and non-self-negative conditions, and from the emotion task this included the positively evaluated positive valence, and negatively evaluated negative valence conditions

6.3.2: Heart Rate

6.3.2.1: Behavioural Results

In line with the behavioural analyses conducted in Chapter Five, Section 5.3.2.1, all factors were included in the present analyses. Two three way repeated measures ANOVAs were conducted employing the factors task (self, emotion), evaluation (positive evaluation, negative evaluation) and valence (positive valence, negative valence). Frequency of response and response time data were analysed (see section 5.3.2.1).

- Frequency of response

As predicted, the repeated measures ANOVA revealed an interaction between evaluation and valence, $F\ (24) = 105.52$, $p < 0.001$. In the self-reference and emotion tasks positively valenced words were more frequently evaluated as ‘like me’ and positive respectively, $t(24) = 8.21$, $p < 0.05$. Negatively valenced words were more frequently evaluated as ‘not like me’ and negative, $t(24) = 10.18$, $p < 0.05$ (see Figure 6.1). No further main effects or interactions were identified.

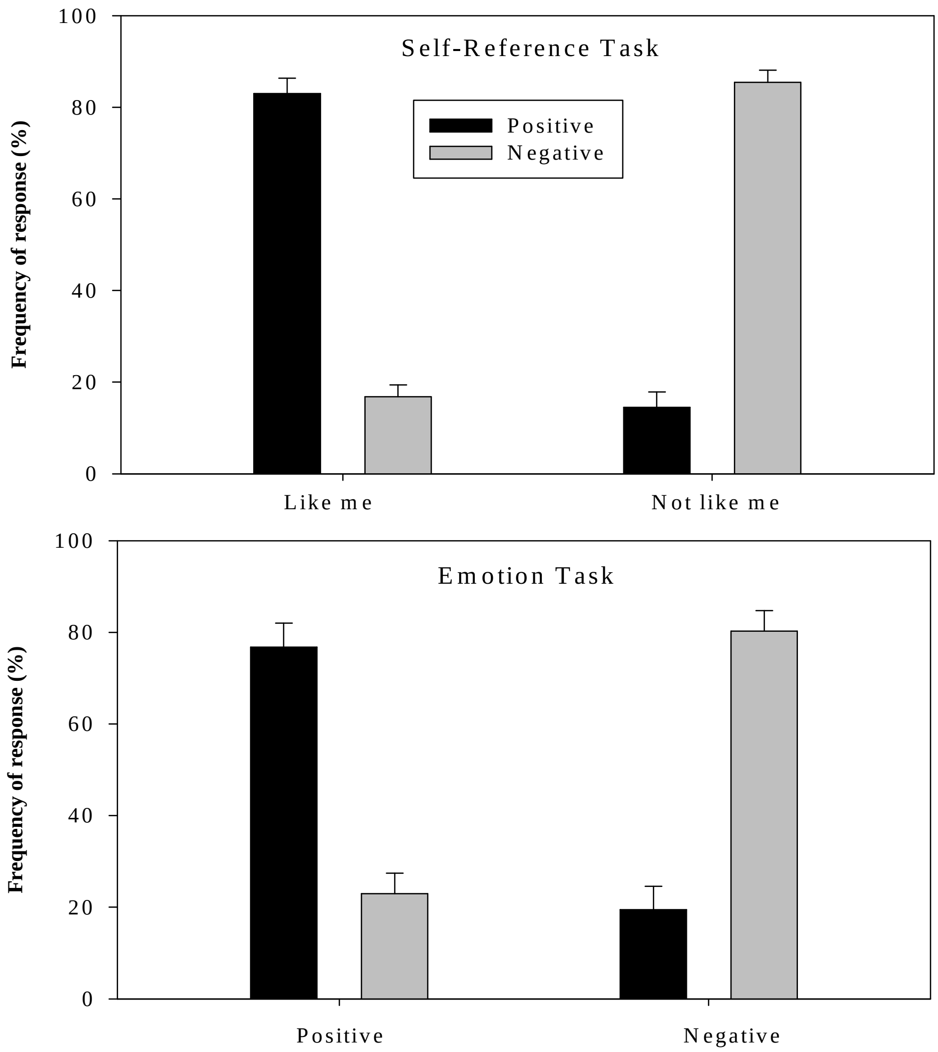


Figure 6.1: Frequency of participants' responses (%) in all conditions. *Participants more frequently rate positive words as 'like me' and positive and negative words as 'not like me' and negative.*

- Response time

No main effects were identified in the repeated measures ANOVA. However several interactions were revealed. Task x valence, $F(24) = 5.22$, $p < 0.005$; judgement x valence, $F(24) = 76.96$, $p < 0.001$ and finally as predicted, a task x judgement x valence interaction, $F(24) = 26.14$, $p < 0.001$ (see Figure 6.2). *Post hoc* comparisons show that in the self task, individuals are significantly faster when responding to positive words as 'like me' and negative words as 'not like me' than when responding to negative words as ‘like me’ and positive words as ‘not like me’, $ts(24) > 5.15$, $ps < 0.05$. In the emotion task, the difference between negatively evaluated positive and negative words did not reach statistical significance, $t(24) = 2.69$, $p > 0.1$.

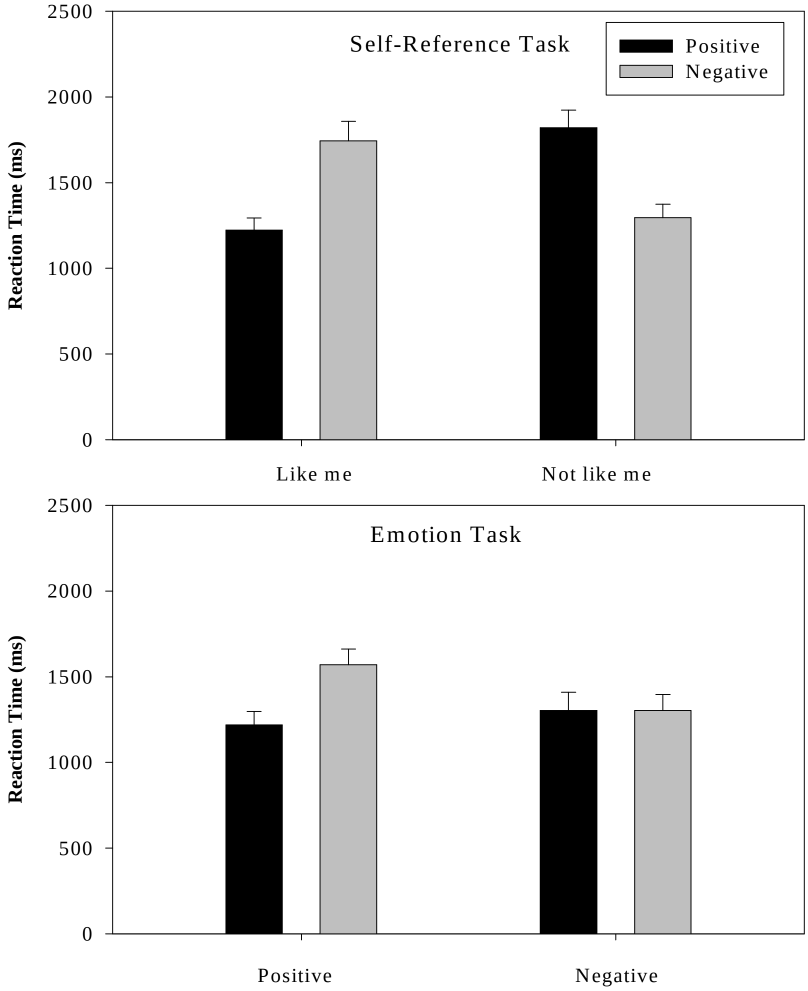


Figure 6.2: Response times (ms) of participants’ in all conditions. *In the self task, individuals are significantly faster when responding to positive words as ‘like me’ and negative words as ‘not like me’.*

6.3.2.2: Heart rate results

On inspection of the data, HR was found develop through four stages. Initally HR decreased between 0 – 1.5 seconds. The lowest point occurred between 1.5 – 2.5 seconds. HR then began to accelerate between 2.5 – 4 seconds and a second positive peak occurred between 4 -5 seconds (see Figure 6.3). In order to investigate the four stages of the HR response, the factor time was divided into four epochs; time 1 = 0 – 1.5 seconds, time 2 = 1.5 – 2.5 seconds, time 3 = 2.5 – 4 seconds and time 4 = 4 – 5 seconds. A 3 way ANOVA including the factors task (self, emotion), valence (positive, negative) and time (time 1, time 2, time 3, time 4) was performed.

The analysis revealed a main effect of valence, $F\ (1, 24) = 6.09$, $p < 0.05$, a main effect of time, $F\ (3, 72) = 25.30$, $p < 0.001$, and as predicted, a significant time x valence interaction, $F\ (1.37, 72) = 3.82$, $p < 0.05$. Bonferroni corrected pairwise comparisons conducted on the time x valence interaction revealed that HR significantly differed at time 2, $t(24) = 2.82$, $p < 0.05$ (positive -1.84 & negative -2.41), and time 3, $t(24) = 2.80$, $p < 0.05$, (positive -0.53 & negative -1.41) but not at time 1 or time 4, all *ts* > 1 (see Figure 6.3). No further main effects of task, or interactions were identified.

The graph illustrates a possible task x valence interaction occurring at time 4 although this difference did not reach statistical significance. The graph suggests that the valence difference is larger and more sustained within the emotion task when compared to the self task. A *post hoc* power analysis was conducted using the statistical software G*Power. The result suggested that the statistical power to detect medium sized effects was found to be low in the present study ($1\text{-}\beta = 0.10$) due to a relatively small sample size.

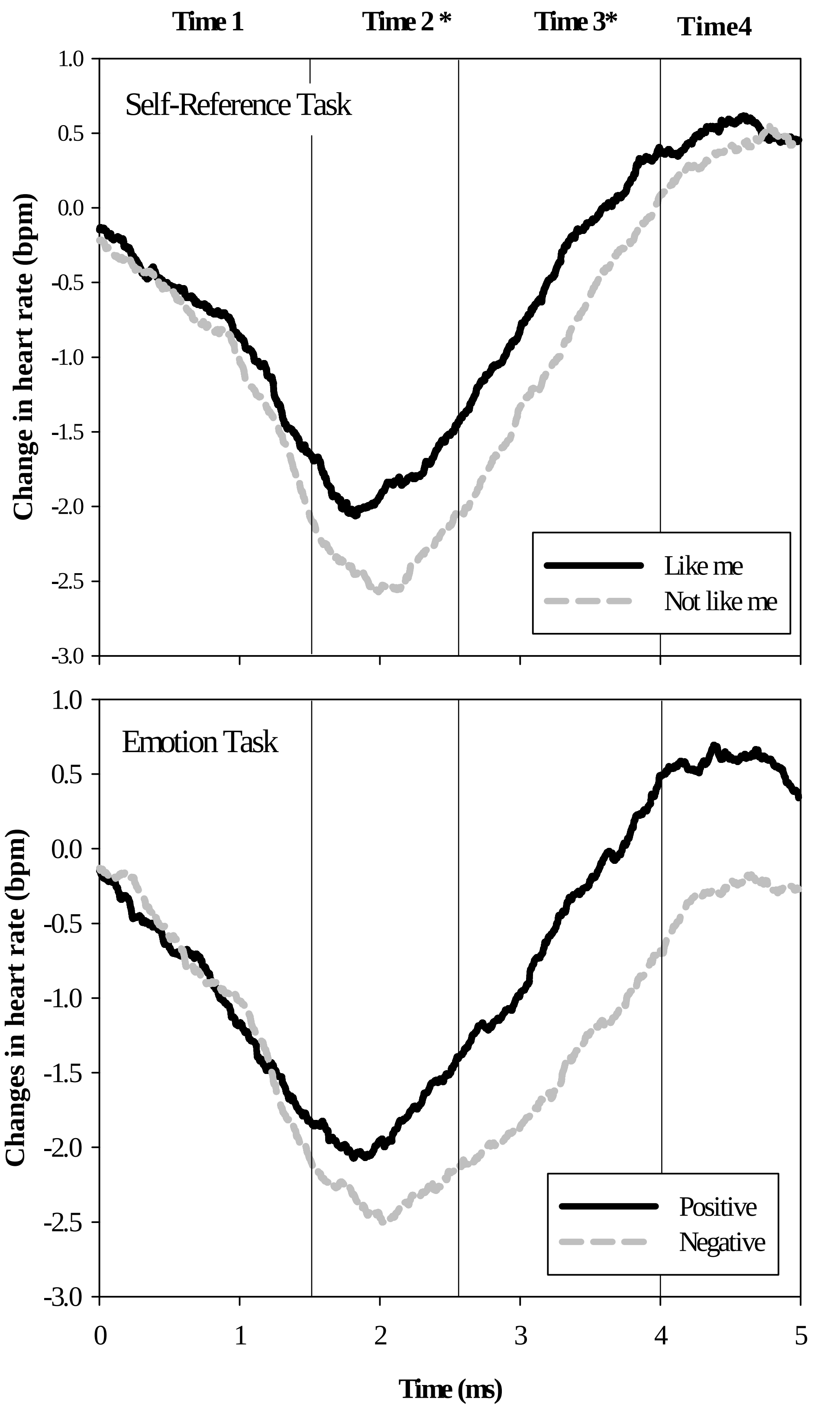


Figure 6.3: Phasic heart rate response (bpm) of all participants across a 5 second period. Significant differences between positive and negative words occur in both the self-reference task and the emotion task at time 2 and time 3

6.3.3. Skin Conductance Results

Responses were analysed from 17 participants (11 female, mean age: 20.70 years, SD: 2.75). Independent *t*-tests revealed no significant differences in age, $t(40) < 1$, or BDI-II scores, $t(40) < 1$, between all participants and the SCR group. A chi-square analysis identified that there were no significant differences in gender between all participants and the SCR group, $\chi\,(1) < 1$.

SCR was recorded for the 156 words presented in each experimental condition. However, SCR becomes habituated during experimental tasks (Bradley, Cuthbert, & Lang, 1996). Therefore the analysis was completed on the first 20 words in each condition. Within the self task, the first 20 positive words rated as self and the first 20 negative words rated as non-self were analysed. In the emotion task the first 20 positive words correctly identified as positive and the first 20 negative words correctly identified as negative were analysed. The behavioural analyses were conducted in the same way to provide a comparative analysis of behavioural responses.

6.3.3.1 Behavioural Results

- Response time

The repeated measures ANOVA for response time revealed a main effect of valence within the response times $F\,(1, 16) = 6.95$, $p < 0.01$. Participants were faster to respond to positive words (1352.4), see Figure 6.4 when compared to negative words (1491.2), regardless of experimental task. This effect was not predicted in the experimental hypotheses and was not present in the full behavioural analysis of all twenty five participants. No further main effects or interactions were identified.

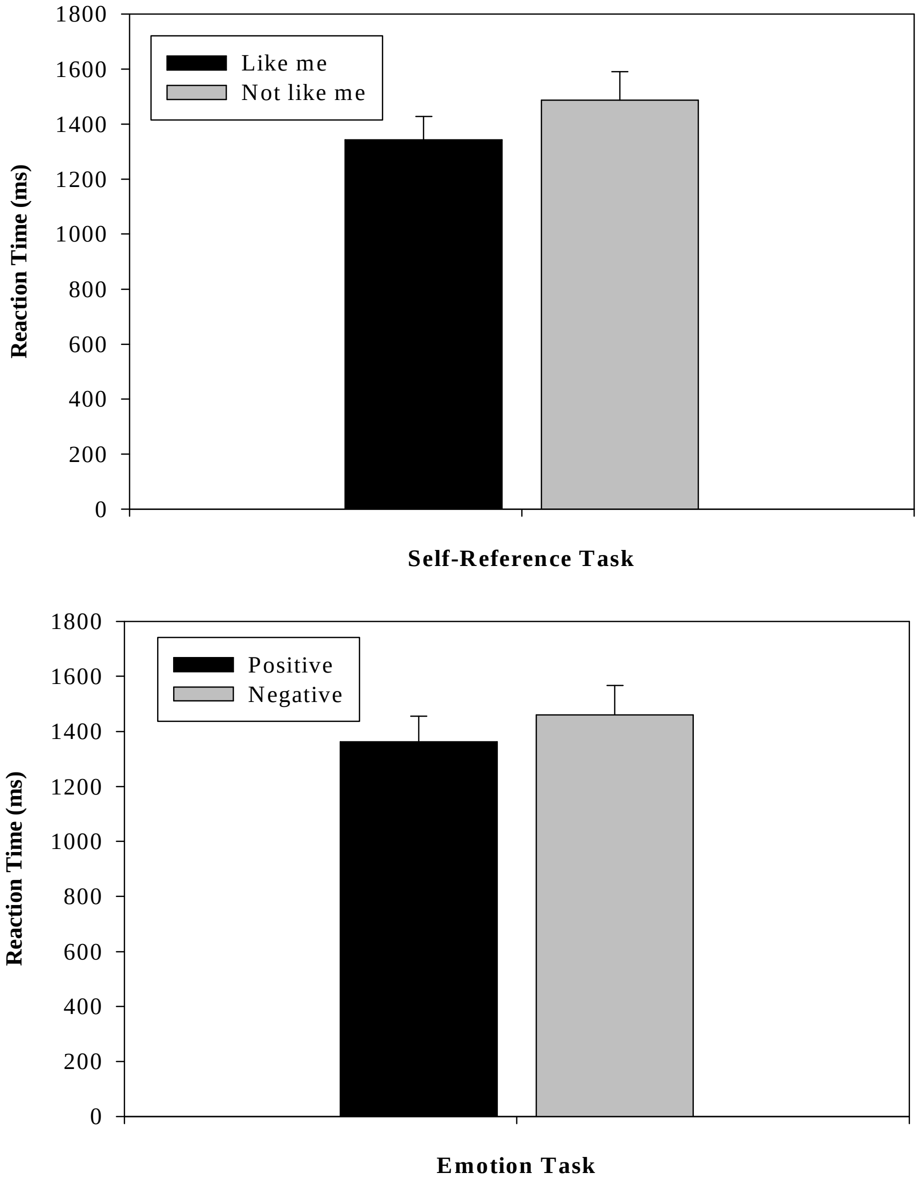


Figure 6.4: SCR participants' response times (ms). *The graph shows a main effect of valence regardless of experimental task in participants' response times.*

<u>6.3.3.2: Skin conductance responses</u>

A 2 x 2 (task, valence) ANOVA was completed on the participants SCRs. A significant main effect of valence was identified, F (1, 16) = 7.39, $p < 0.05$. The main effect suggests that participants show significantly greater SCR to positive words (0.060 $\mu\Omega$) when compared to negative words (0.047 $\mu\Omega$), regardless of experimental task (see Figure 6.5). Contrary to predictions, no effects of task were identified, although interestingly the numerically largest SCR was elicited in the self-referential task, ‘like me’ condition.

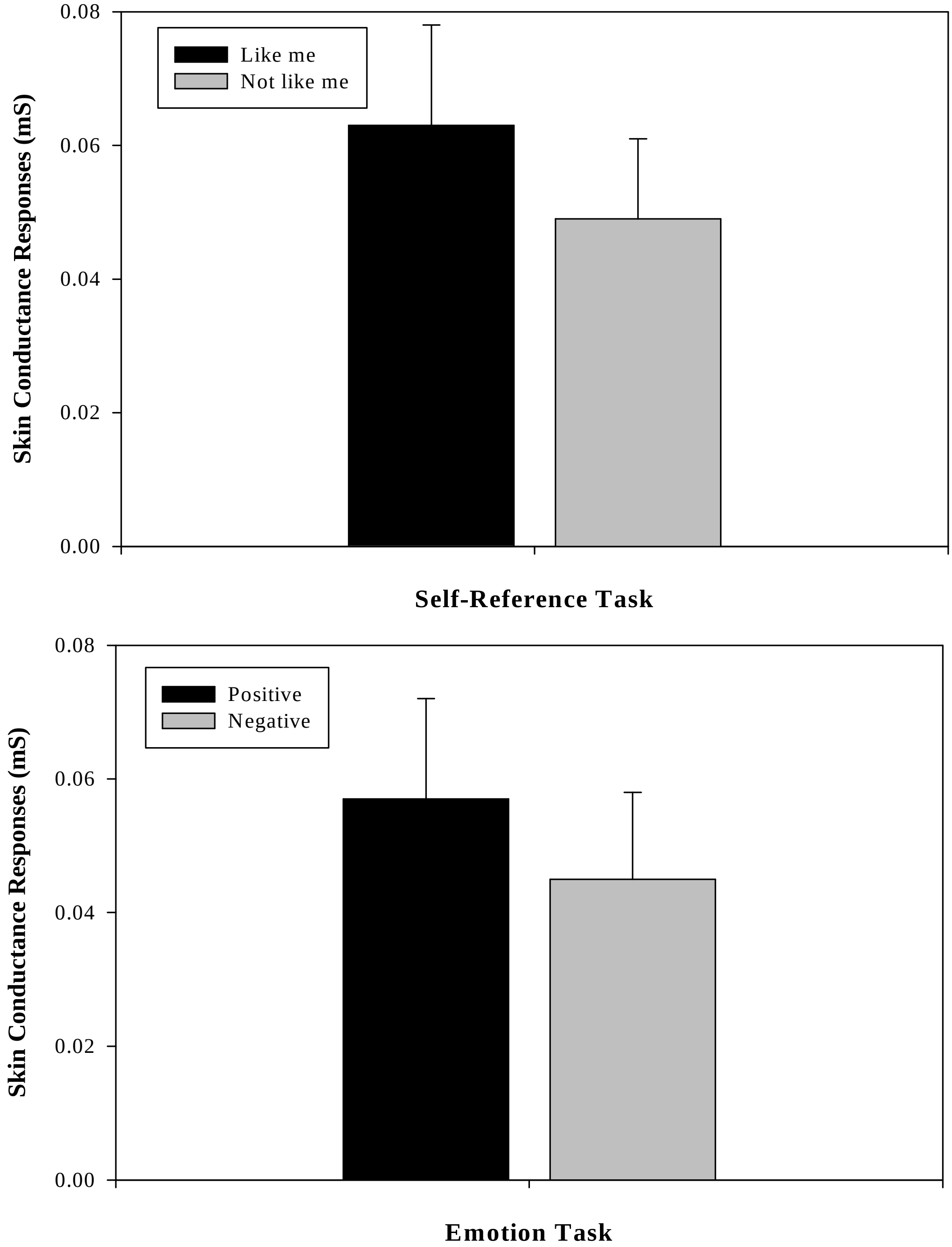


Figure 6.5: Participants skin conductance responses (mS). *The graph shows a statistically significant main effect of valence regardless of experimental task in the participants’ skin conductance responses.*

6.4: Discussion

In terms of the experimental hypotheses, support was found for the predictions concerning behavioural and heart rate responses. The hypothesis regarding task related differences in skin conductance responses was not supported. These findings illustrate that emotional valence has a larger impact on autonomic response than task-related processing.

One potential limitation of the research conducted in the previous chapters is that the effects identified in the self-reference and emotion tasks may represent some bias at a semantic level. It could be argued that in Chapters Three, Four and Five that the participants may have been rating the emotional and self-referential content of information without experiencing an emotional response in relation to the word stimuli. This experiment provides convincing evidence to suggest that individuals do experience some form of physiological emotional reaction when performing both types of decision-making task.

6.4.1: Replication of the Self-positivity bias in the behavioural measures

As predicted, a task x evaluation x valence interaction was identified in the response time measure. The results suggest that individuals are significantly faster when responding to words which elicit a self-positivity bias (self-positive & non-self-negative) when compared to words outwith this bias (self negative & non-self-positive). This finding provides support for the behavioural experimental hypothesis and replicates the self-positivity bias identified in Chapter Four and Five in non-dysphoric individuals.

One potential confound identified in Chapter Four was that the experimental conditions in which the response time differences were identified also show large differences in number of items per condition (see Figure 6.1). Therefore it is possible that the self-positivity bias identified in response time was the result of differences in item number and did not represent a true effect. However, in Chapter Five it was found that despite similar frequencies of items across the experimental conditions, the response time differences found in the self-reference task were not reflected in the emotion task. The replication of this effect in the present study provides further evidence to suggest that the self-positivity bias identified within response times does represent a true self-positivity bias and is not the result of differences in item frequency.

In Chapter Five a strong main effect of task was also identified. This effect did not occur within the present study. Failure to replicate this effect may be due to slight differences in the methodologies employed. In Chapter Five, the maximum stimulus presentation and response time was 2 seconds. In the present experiment, stimuli were presented for a maximum of 5 seconds. This difference was due to the longer response time required for skin conductance responses to reach their peak. Although participants in both experiments were told to respond as fast as possible, it may be that the longer response period in the present experiment lead to participants taking longer to respond during both experimental tasks. These longer response times may have lead to a reduction in the potential to identify a main effect of task within the response time measure. In order to determine if a main effect of task could be identified, the stimulus presentation and response times could be limited to 1500 ms within the present study. This could be done by replacing the stimulus with a fixation cross after 2 seconds, until the end of the 5 seconds trial period required for measuring skin conductance responses.

6.4.2: Physiological measures

6.4.2.1: Heart rate response

As predicted, heart rate was found to differentiate between positive and negative valence regardless of experimental task. The findings illustrate that heart rate was lower in response to negative words. This effect was evident in both experimental tasks and was greatest from 1.5 to 4 seconds. This finding supports the hypothesis that self-referential processing is heavily influenced by emotional valence, illustrating that a close relationship exists between self-referential and emotional processing. This result supports the behavioural findings of the previous chapters. In particular Chapter Three, in which participants showed very similar behavioural responses when rating a set of words as both emotional and self-referential and Chapter Four where a main effect of valence was identified within the self-reference task from 400 to 550 ms at centro-parietal electrodes.

When the results were plotted on a graph (Figure 6.3) the data also reveal a possible difference in task within the fourth time window (4 -5 seconds). This difference was not statistically significant. However it seems to suggest that although the self-reference task does elicit an emotional response, the emotional response is larger and sustained for longer within the emotion task. A *post hoc* power analysis revealed that the statistical power of the analysis was low thereby increasing the risk of type two errors.

The non-significant task-related difference is interesting as it would provide further support for the temporal functional hierarchical model of self-referential processing presented in Chapter Four. Within the self-reference task, the heart rate response reveals an effect of valence early within the response waveform. Unlike in the emotion task, this difference between the word categories seems to disappear in later time intervals. This later task-related difference would be predicted by the functional hierarchical model. In this model, emotional processing is involved in the early stages of self-referential processing, whereas the later stages are devoted to the processing of self-referential contextual information. This would cause a reduction in the effect of emotional valence within the self-reference task at later time intervals as seen in the heart rate response and the ERP responses presented in Chapter Four.

In order to determine if this task-related difference is reliable, the statistical power of the analysis would need to be increased. Although thirty eight participants were initially tested, only twenty five were included in the final analyses. A large number of participants were excluded due to their high BDI-II score. In line with the other experiments conducted in the present thesis, the BDI-II questionnaire was presented at the end of the experimental study in order to avoid any potential mood biases which may occur as a result of completing the questionnaire. To obtain a larger sample size and thus increase statistical power in future experiments, it may be more effective to screen participants using the BDI-II prior to conducting the experimental study itself. Preventative measures could be employed to avoid any potential effects of mood caused by completing the BDI-II. A pre-test BDI-II could be completed a week prior to the experimental session allowing time for the potential mood effects to dissipate. Secondly, the BDI-II could be completed within a set of other psychological questionnaires which do not assess levels of mood, this would avoid the influence of any potential demand characteristics which may occur if the BDI-II was to be completed prior to the two decision-making tasks.

6.4.2.2: Skin conductance response

Two predictions were made with regard to changes in skin conductance response during the experimental task. Firstly, it was predicted that skin conductance responses would be larger when individuals were engaged in self-referential processing when compared to general emotional processing. Contrary to this prediction, no task-related differences were identified in skin conductance response. The second prediction stated that within the self-reference task, individuals would show larger responses to stimuli rated as ‘like me’ when compared to stimuli rated as ‘not like me’. The analysis revealed a main effect of emotional valence such that larger skin conductance responses were identified to positive when compared to negative words in both decision-making tasks. This effect partially supports the experimental prediction as larger skin conductance responses were identified for ‘like me’ when compared to ‘not like me’ words within the self-reference task. However unexpectedly, this difference was also identified in the emotion task such that, individuals showed larger skin conductance responses to positive when compared to negative words.

These results replicate the findings of Gronau et al. (2005) and Nikula et al. (1993) such that skin conductance responses were greater for personally relevant information (‘like me’) when compared to non-personally relevant information (‘not like me’). However, the fact that this difference was also identified in the emotion task, again highlights the close relationship that exists between self-reference and emotional valence. As in previous chapters, this finding illustrates the importance of assessing emotional valence when investigating self-referential processing. Based on these results and the results of previous research, it is not possible to determine if the differences identified in skin conductance response are the result of increased arousal to the self-referential content of the information or the result of differences in physiological arousal across the positive and negative stimuli presented.

As stated above, the experimental hypotheses that task-related differences would be identified between self-referential and emotional decision-making tasks was not supported. Previous research has investigated physiological arousal from an evolutionary perspective, suggesting that arousal responses such as the orienting response and the habituation response are essential for survival, as part of the fight or flight response systems. Differences in physiological arousal in response to different experimental stimuli have been identified across a wide variety of species (Boucsein, 1992). In fact, much of what is know regarding the brain structures involved in fear responses comes from research involving rats (LeDoux, 1990). Because differences in physiological arousal can be identified relatively far back in the evolutionary chain, it is possible that changes in physiological arousal, such as changes in skin conductance, may be based on an automatic response system which occurs during early stages of processing. It is possible that task-related differences were not identified by skin conductance response as these differences may occur during later stages of processing which are under greater cognitive control. Some tentative evidence for this hypothesis is provided by the apparent task-related difference in heart rate response which, as stated previously, requires further investigation.

The unexpected main effect of valence identified by the skin conductance response is somewhat difficult to interpret without further investigation. Two different explanations are possible. Based on the findings of Nikula et al. (1993) and Groanu et al. (2005) one hypothesis would be that the effect is the result of increased arousal to stimuli identified as self-referential. According to this hypothesis, the difference in skin conductance response between positive and negative words during an emotional decision indicates that individuals show greater arousal to self-referent material regardless of the decision-making context being examined. Although individuals must decide on the emotional valence of the word during the emotional valence decision task, the positive words are mostly self-referential, and the negative words are mostly not self-referential, and the greater skin conductance response to the positive words may indicate implicit processing of the self-referential dimension of these words.

An alternative explanation may be that the effect is the result of a confounding dimension between the level of arousal and the emotional valence of stimuli selected for use within the present study. The word stimuli employed within the present study have not been previously assessed for arousal. Therefore, the alternative hypothesis would be that the positive words selected for use in the present study may be higher in their level of arousal than the negative words selected. Based on previous research this alternate hypothesis seems unlikely. In studies where individuals were asked to rate the emotional valence and arousal of picture and word stimuli using the self-assessment manikin (SAM) it has been found that individuals tend to rate negative stimuli as more arousing than positive stimuli. Therefore, the relationship between emotional valence and self-rated arousal identified in the previous research occurs in the opposite direction than the results of the present study.

One way to distinguish between these two hypotheses would be to focus more specifically on one aspect of the self-construct. In the early study conducted by Markus, (1977) she focused on the trait dimension of independence/dependence. By focusing on one specific trait it may be possible to identify both a number of positive and negative traits or behaviours associated with this dimension. Examples of positive and negative behaviours associated with independence would be ‘is able to accept her own mistakes and learn from them' and 'doesn't always listen to the opinion of other people'. If self-referent information does elicit physiological arousal then individuals who identify themselves as independent would show increased arousal to stimuli associated with the independence, regardless of emotional valence. In contrast, individuals who identify themselves as dependent would show increased arousal to stimuli associated with dependence. Furthermore, by asking participants to provide an evaluation of the emotion valence and also level of arousal associated with the stimuli then both these measures could be taken into consideration using techniques such as structural equation modelling.

In conclusion, the results of the present study provide evidence to suggest that self-referential processing is heavily influenced by emotional information. Autonomic measures such as heart rate and skin conductance response seem to indicate that emotional processing is a relatively automatic process which may be involved during the early stages of many more complex decision-making processes such as self-referential processing. No task-related effects were identified using autonomic measures. The self-referential effects which were identified in Chapters Four and Five occur during the later consciously controlled states of processing. Therefore one possible explanation for the lack of task-related effects in the present study is that, some aspects of self-referential processing represent complex cognitive processes which occur during conscious components of the decision-making process.

– Chapter 7 –

Experiment 5: Does the neural processing of self-referential and other-referential information differ as a function of mood?

7.1: Introduction

In the previous chapters, evidence for a neural correlate of the self-positivity bias was strengthened. In line with behavioural findings, a difference in ERP responses within a self-referential decision-making task was identified between non-dysphoric and dysphoric individuals. This difference suggests that the self-schema employed by dysphoric individuals is less positive and more negative than that of non-dysphoric individuals and that this bias in processing is reflected in the neural correlate of the self-positivity bias at midline from 400 to 650 ms. The finding also suggests that these biases are specific to the self-referential decision-making task and are not the result of generalised biases in emotional processing.

The evidence presented in the previous chapters suggests that changes in the self-positivity bias associated with negative mood seem to be specific to self-referential processing. However differences between self-referent and other-referent processing also need to be investigated. If alterations in the self-positivity bias associated with negative mood are specific to self-referential processing, then these changes should not be evident in other forms of person-referent processing.

7.1.1: The relationship between self and person-referent processing

Early studies (Rogers, Kuiper and Kircher, 1977) compared the self-reference task to semantic, structural and phonetic tasks. From the finding that individuals showed superior recall in this self-reference task Rogers et al. concluded that the self is represented by a unique cognitive schema. This conclusion was criticised due to the control tasks employed within the experiment. Several researchers proposed that enhanced recall within the self-reference task may be due to the cognitive organisation and elaboration of all person-referent information rather than due to the functioning of a specialised self-schema (Bower & Gilligan, 1979; Symons & Johnson, 1997; see Chapter One, Section 1.3).

In response to this criticism, Kuiper and Rogers (1979) conducted a series of experiments employing a similar experimental design to the previous studies. In these studies an other-referent encoding task was also included (Does this word describe the experimenter?). In the first experiment, they found significant differences in rating task and recall between the self-referent and other-referent encoding tasks. These results provided further evidence for the concept of a specialised self-schema. However in subsequent experiments, differences in recall between self-referential and other-referential tasks were not identified.

Other differences between the two tasks were observed. During the self-referential and other-referential decision-making tasks participants were asked to rate how confident they were when making their decision and also how easy they found these decisions to make. Differences in participants' responses to these rating tasks across self-reference and other-reference suggested that individuals were more confident when making self-referential decisions and also found these decisions easier to make. More interestingly, when response time and recall responses were considered together, Kuiper and Rogers (1979), found that in the self-reference task, individuals were more likely to recall words which elicited fast responses whereas in the other-reference task individuals were more likely to recall words which elicited longer responses. Although the self-reference effect in memory recall was not consistently identified within this set of experiments, evidence from the other behavioural measures suggested that the cognitive strategies employed to process and encode self-referential information were different to those involved in other-referential processing.

7.1.2: The role of familiarity in person-referent processing

In the set of experiments conducted by Kuiper and Rogers (1979), the other-referent target employed was the experimenter involved in running the study. One issue which was also investigated in this set of experiments was the level of familiarity with the other-referent target. Throughout the four experiments conducted, the experimenter was employed as the other-referent target and the same group of participants were used. The experimenter running the studies was also the lab instructor for the undergraduate psychology classes taken by the students, therefore the level of familiarity between the students and the experimenter increased across the four experimental sessions. The participants' responses in the rating tasks, and encoding tasks in experiment four replicated the pattern of results discussed above. However, a comparison of memory recall for the self and other-referent tasks across the four experimental sessions revealed that while levels of self-referent recall remained the same, recall of other-referent information increased across the four sessions. These findings illustrated that recall of other-referent information is influenced by the level of familiarity with the other-referent target. Importantly differences in recall between other-referent and self-referent information were found to disappear as levels of familiarity increased.

Kuiper and Rogers (1979) conducted one final study to ensure that the differences observed in experiment four were the result of changes in the level of familiarity with the other-referent target and not the result of increased familiarity with the experimental paradigm itself. To do this Kuiper and Rogers tested a separate group of students, with no knowledge of the experimental paradigm but with similar levels of familiarity with the experimenter running the study. The results from this experiment replicated the results from the previous study and provided further support for the need to assess the level of familiarity associated with the other-referent target.

Although the study by Kuiper and Rogers (1979) highlighted the importance of assessing the level of familiarity of the other-referent target, the other-referent target employed within their experiments was still relatively unknown to the participants taking part. In fact, during experiment four, participants' responses on familiarity ratings indicated that they knew the other-referent only a little less than a "casual acquaintance". It is possible that when using a relatively unfamiliar other as an other-referent target participants may use different cognitive strategies to process this information when compared to self-referent processing. However it is possible that as familiarity with the other-referent increases, the amount of information known about the other-referent also increases.

Researchers suggest that individuals frequently use knowledge about the self to organise and interpret incoming information, however the same may be true of knowledge about close friends and family. Individuals may also use their knowledge of the personal experiences and information about their friends and family in order to understand the environment around them. Therefore the differences between the self-referent and other-referent processing may decrease further as the knowledge about the other-referent increases.

The role of familiarity within self versus other-referent processing was further examined in a meta-analysis conducted by Symons and Johnson (1997) including over 250 studies. They found that the self-reference effect was reduced when and other-referent target was used as a comparison task. However the effect was still present, for other-referent targets of both high and low familiarity. From this it can be concluded that self-reference remains a uniquely efficient information processing construct.

7.1.3: Neural evidence for differences in self and other-referential processing

At a neural level, several studies have found differences in neural processing between self and other referent tasks. Both Craik et al. (1999) and Kelley et al. (2002) found significant differences between self-referent and other-referent tasks at medial frontal prefrontal locations. Fossati et al. (2003) also found task related differences that this location. Furthermore, Fossati et al. found that regions of the lateral prefrontal cortex were active during both types of processing.

These findings suggest that neural activations specific to self-referential processing can be identified within the brain. However the three studies discussed above all use the same other-referent comparison figure, the current prime minister of the country in which the study was conducted. Based on the findings of behavioural studies (see Section 7.1.2), the level of familiarity associated with the other-referent target is an important aspect of person-referent processing. Although it is likely that the prime minister would be known to all individuals taking part in the studies, the level of familiarity with this other-referent target is relatively low. It is unlikely that participants would use their knowledge of the personal experiences of the prime minister to learn more about the world around them, in the same way that they may do with self-referent information or indeed information about a close friend or family member. Therefore, to examine if self-referential processing differs from person-referential processing at a neural level it would be valuable to employ an other-referent figure such as a family member or a close friend. If task-related differences were identified between self and other-referent processing it would then be possible to say with more certainty that these differences are not the result of some other factor such as differences in familiarity.

7.1.4: Self and other-referential processing as a function of negative mood.

Research discussed in the previous chapter has identified that self-referential processing is altered as a function of negative mood, however some research has also considered if negative mood influences other-referential processing. The studies discussed previously by Bradley and Mathews (1983) and Kuiper and Derry (1982) identified biases towards negative information specifically within the self-reference task. When considering the other-referential conditions Bradley and Mathews found that both non-depressed and depressed individuals exhibited the same bias towards recalling positive information. Kuiper and Derry found no differences in the recall of non-depressed adjectives between the self and other-referent conditions. Both these studies suggest that the negative biases associated with negative mood are specific to self-referential processing.

A study conducted by Bargh and Tota (1988) aimed to investigate the automatic nature of the negative self-schema in depression. They argued that if the association between self-reference and negative emotional valence was strong during depression, then the processing of this type of information would be automatic. If the activation of negative information during self-referential processing was automatic, then it would involve minimal attentional resources. The allocation of attentional resources was measured by the extent to which a concurrent cognitive load task (keeping in mind six digits) increased response time latencies during decision-making, when compared to the response time latencies during decision-making with no cognitive load task. If negative self-representations are automatically activated during depression, then the slowing of depressed participants' response latencies to negative information should be minimal when compared to the slowing of response latencies to positive information during self-referential decision-making when comparing the cognitive load and no cognitive load conditions.

Bargh & Tota (1988) asked non-dysphoric and dysphoric students to complete self-referent and other-referent decision-making tasks during cognitive load, or no cognitive load conditions. The responses of depressed individuals were compared during self-referential processing, across cognitive load and no cognitive load conditions. As predicted, the results revealed that the cognitive load condition resulted in less slowing of response latencies to negative than positive information. The reverse was found to occur for non-depressed individuals. They showed less slowing of response latencies to positive than negative information. These findings found support for the automatic activation of self-negative representations during depression and self-positive representations as part of healthy cognition.

Bargh and Tota (1988) also examined the influence of a cognitive load task during other-referent decision-making. This was done in order to determine if depressed individuals were impaired in self-referential processing, or if these impairments were also evident in more general social-perceptual constructs. Differences between non-dysphoric and dysphoric individuals were not identified during other-referential processing. Both groups showed less slowing of response latencies to positive than negative words during other-referential decision-making. The results illustrate that emotional biases during self-referential processing seem to be due to the automatic activation of a positive self-schema during healthy cognition and negative self-schema during depression. Importantly this study also found that between group differences do not occur in other tasks which involve person-evaluation such as other-referent decision-making. This study used an average-other as a comparison individual. Therefore the same limitation of the other-referent can be applied here as in the neuroimaging studies discussed above, namely that the other-referent is less similar than the self-referent target. It would be valuable to employ a more familiar other in a comparison task in order to further examine the role of person-evaluation in negative mood.

7.1.5: The present study

The overall aim of the present study was to examine how self-referential and other-referential processing differ as a function of mood. Previous research suggests that the advantages of self-referential processing are minimised when the control task employs a similar social comparison figure. The effects of self-reference may not be due to the functioning of a specialised self-schema but the result of a highly practiced and commonly employed form of person-referential processing. It is possible that the effects identified at both the behavioural and neural levels in Chapters Four and Five may also be present in other forms of person-referent processing. In order to examine this possibility further, both non-dysphoric and dysphoric individuals took part in self-referential and other-referential decision-making tasks. During these two tasks behavioural and neural responses were recorded. One limitation of the previous neuroimaging and clinical studies is that they commonly use a non-familiar other as the other-referent target. In order to provide a strict test of person-referent processing ‘a close friend’ has been selected for use as the other-referent target within the present study.

Based on previous research into the self-reference effect (Symons & Johnson, 1997) and the results of previous chapters, it is hypothesised that differences between non-dysphoric and dysphoric individuals will be identified within the self-reference task. In the behavioural measures it is predicted that a self-positivity bias will occur for both non-dysphoric and dysphoric individuals, however that this bias will be significantly reduced for dysphoric individuals. If changes in the self-positivity bias associated with negative mood are specific to self-referential processing then these differences should not be evident in other-referent processing even when a familiar other is employed as the other-referent target. Based on the findings of Bargh and Tota (1988), it is predicted that no such differences will be identified in other-referent processing and positivity bias will be identified for both non-dysphoric and dysphoric individuals.

The findings of Chapters Four identified a neural correlate of the self-positivity bias in ERP responses at fronto-central midline electrodes from 400 to 600 ms. The results of Chapter Five suggested that this correlate is altered as a function of mood within self-referential decision-making. In the present experiment it is predicted that a task x group, or task x group x electrode interaction will occur at fronto-central electrodes from 450 to 600 ms, such that differences between non-dysphoric and dysphoric individuals will be identified at these temporal and spatial locations within the self-reference task but not within the other-reference task.

If differences are identified between dysphoric and non-dysphoric individuals within the self-reference task and not the other-reference task then this will allow us to say with more certainty that the reduction in the self-positivity bias during negative mood, is specific to self-referential processing.

7.2: Methods

7.2.1: Participants

Forty participants took part in the study. Non-dysphoric and dysphoric participants were classified in the same way as in Section 5.2.1. See Table 7.1 for participant information.

Table 7.1: Comparison of participant variables across non-dysphoric and dysphoric groups.

	Non-dysphoric	**Dysphoric**
Number	20	20
Gender	11 female	15 female
Handedness	19 right-handed	20 right-handed
Mean Age	21.81	20.25
Mean BDI-II Score	5	20.6
BDI-II Range	0-9	12-39

7.2.2: Stimuli and Apparatus

Stimuli and apparatus were identical to those used in Chapter Four (see Section 4.2.2 for a review).

7.2.3: Procedure

The experimental procedure employed was similar to the procedure employed in Chapters Four and Five (see Chapter Four, Section 4.2.3 for a review). The emotion decision-making task was replaced with an other-referent decision-making task. This decision-making task was altered by changing the instructions provided to participants. Prior to beginning the other-referential decision-making task participants were provided with the following instructions:

"In this section of the study you will be presented with a series of words and asked the question 'Is this word personally relevant to my best friend?' Prior to beginning this task please think of one individual, somebody close to you, such as a family member or a close friend. Please rate all the words in relation to this individual."

All other aspects of the procedure were identical to those outlined in Section 4.2.3.

7.2.4: Electrophysiological Recordings

The set up of the electrophysiological recording was the same set up employed in Chapter Four (see Section 4.2.4 for a review).

7.3: Results

7.3.1: Participants Variables

As in Section 3.3.3.1 and Section 5.3.1, statistical analyses were conducted to identify any possible confounds between the two groups in terms of participant variables. Chi-square analysis revealed no significant differences between non-dysphoric and dysphoric groups for gender, $\chi_2(1, N = 40) = 1.28$, $p > 0.2$. A one-way ANOVA revealed no significant differences in age between non-dysphoric and dysphoric groups, $t(28) = 1.23$, $p > 0.2$

7.3.2: Behavioural Results

7.3.2.1: Data Analysis

The behavioural analysis was identical to the analysis conducted in Chapter Five (see Section 5.3.2.1).

7.3.2.2: Frequency of response

The mixed ANOVA revealed no main effects however, several interactions were identified, an evaluation x valence interaction, $F(1, 38) = 428.28$, $p < 0.0001$, and a task x evaluation interaction, $F(1, 38) = 7.19$, $p < 0.01$. Finally, as predicted a four way group x task x evaluation x valence interaction was identified, $F(1, 38) = 4.40$, $p < 0.05$ (see Figure 7.1).

The four-way interaction was further evaluated using Bonferroni corrected *t*-tests. Comparisons between non-dysphoric and dysphoric individuals were conducted within self-referential and other-referential processing in order to investigate if these two types of processing were altered as a function of mood. Because the predictions are based on the findings of the previous experimental chapters and the expected direction of the effects are known, one-tailed comparisons were employed. The *post hoc* comparisons revealed significant differences between the responses of non-dysphoric and dysphoric individuals within the self task (all $ts > 1.8$, all $ps < 0.05$). Non-dysphoric individuals rated most positive words as self-related (82.5 %) and most negative words as non-self-related (83.0 %). In contrast, dysphoric individuals rated fewer words in this way; self-positive (71.7 %) and non-self-negative (70.6 %). Conversely, where non-dysphoric individuals rate few negative words as self-related (17.0 %) and few positive words as non-self related (17.4 %), dysphoric individuals show increased responses within these conditions; self negative (29.7 %) and non-self-positive (28.2 %). This result replicates the findings of Chapter Four and illustrates that although dysphoric individuals do show a self-positivity bias, this bias is reduced when compared to non-dysphoric individuals.

The *post hoc* comparisons conducted in the other-referent task revealed no significant differences between the non-dysphoric and dysphoric individuals in the other-referent task (all *ts* < 1). The four way interaction identified supports the prediction that changes in the self-positivity as a function of mood are specific to self-referential processing and do not occur in other forms of person-reference such as other-referent processing.

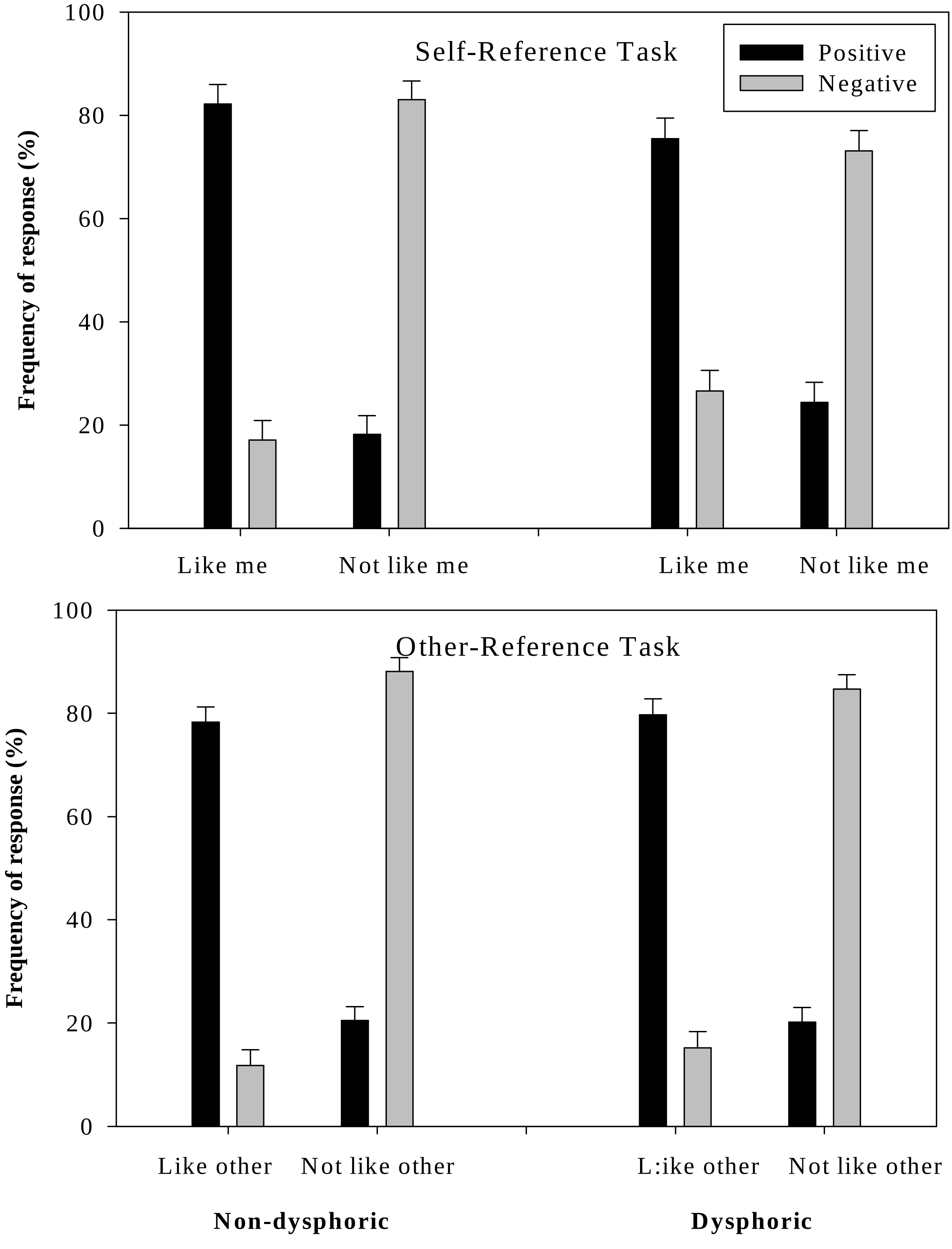


Figure 7.1: The frequency of responses (%) of non-dysphoric and dysphoric groups in all conditions. *Individuals rate positive words as 'like' and negative words as 'not like in both the self-referent and other-referent conditions.'*

7.3.2.3: Response time

No main effects, and only one interaction reached statistical significance in the response time analysis. Similar to the effects in the frequency of response analysis, an evaluation x valence interaction, $F = 97.45$, $p < 0.001$ was identified (see Figure 7.2). Individuals were found to respond faster to positive words rated as ‘like me’ or ‘like them’ (1049.4 ms) and negative words rated as ‘not like me’ or ‘not like them’ (1050.2 ms) when compared to negative words rated as ‘like me’ or ‘like them’ (1399.8 ms) and positive words rated as ‘not like me’ or ‘not like them’ (1360.4 ms), all $ts > 7.59$, $ps < 0.001$. No effects involving task or group were identified.

7.3.2.4: Behavioural results summary

Differences were identified between self-referential and other-referential tasks in the frequency of response analysis, but not the response time analysis. The frequency of response results illustrate that differences between self-referential and other-referential processing can be identified, but only during the experience of negative mood. These findings provide evidence to suggest that self-referential processing represents a specialised form of processing which is specifically altered as a function of mood. This result was not replicated in the response time measure, providing evidence to suggest that differences between self-referent and other-referent processing are not evident across all behavioural measures.

A positivity bias was identified in response times, in both the self-referent and other-referent decision-making tasks. This finding suggests that the positivity bias identified in response times is not specific to self-referential processing but also occurs in other forms of person-referent processing.

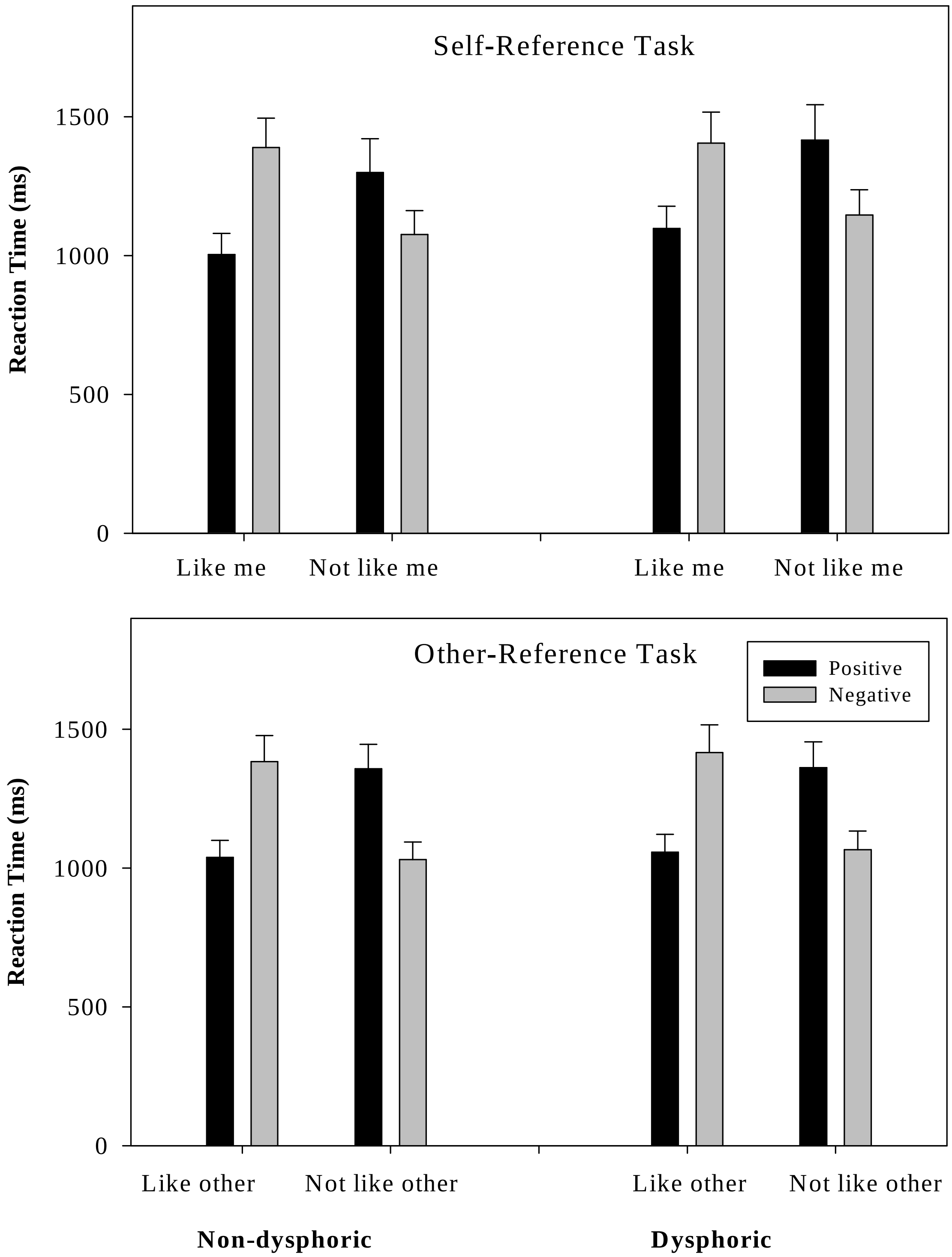


Figure 7.2: Response times (ms) of non-dysphoric and dysphoric groups in all conditions. *Individuals were fastest to respond to positive words rated as 'like' and negative words rated as 'not like'.*

7.3.3: ERP results

7.3.3.1: Data Analysis

Three way ANOVAs were conducted on the ERP data, including the between subjects factor group (non-dysphoric, dysphoric) and the repeated measures factors task (self, other) and electrode. For further information on how this analysis was conducted (see Chapter Five, Section 5.3.3.1).

7.3.3.2: Early effects

A task x electrode interaction was identified at *midline* electrodes from 180 to 220 ms. This task x electrode interaction was largest at the Pz electrode during early time intervals, $F = 5.32$, $p < 0.05$ (see Figure 7.3). This effect illustrates an early difference between self-referent and other-referent processing at the neural level. No significant task x group, or task x group x electrode interactions were identified during the early time intervals.

7.3.3.3: Late effects

Similar to the task effects identified during the early time interval, a task x electrode interaction was identified at *midline* electrodes from 300 to 400 ms, All *Fs* > 3.05 and all *ps* < 0.05. This effect suggests that differences between self-referent and other-referent processing are evident at the neural level (see Figure 7.3).

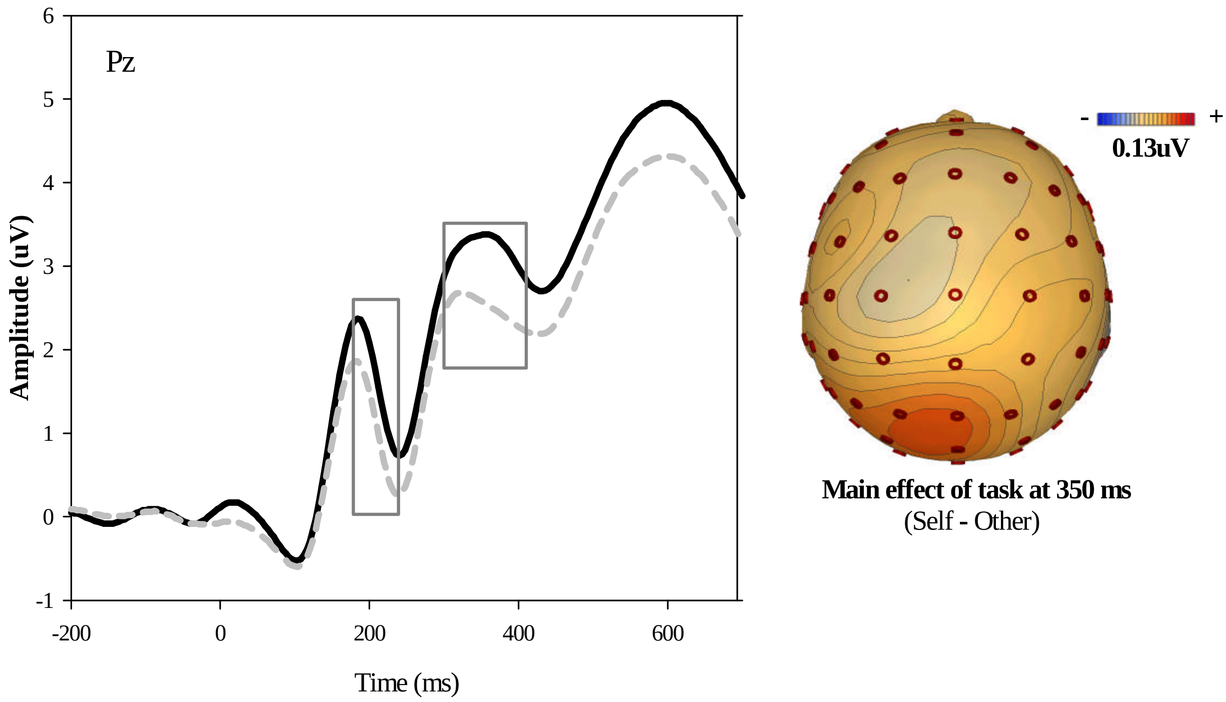


Figure 7.3: ERP waveforms at Pz electrode and topographical scalp distribution (spline-interpolated voltage map) depicting the main effect of task occurring during early and late processing. The waveforms for words representing self-referent and other-referent decision-making are superimposed.

In order to find support for the hypothesis that the neural activations associated with self-referential processing are specifically altered as a function of mood, task x group or task x group x electrode interactions should be identified within the ERP analysis. No such task x group interactions were identified. However, a group x electrode interaction was found to occur. This interaction was evident at fronto-central electrodes from 350 to 500 ms, all *Fs* > 3.97, all *ps* < 0.05 (see Figure 7.4). The interaction, which is maximal over the left hemisphere (FC3 & FC5), suggests that ERP waves of dysphoric individuals are more negative going than the ERP waves of non-dysphoric individuals, regardless of experimental task. As no group x electrode interactions were observed in any other spatial locations no further post hoc analyses were performed. In terms of the predicted spatial and temporal locations, the interaction identified occurred slightly earlier than 400 - 600 ms, and was also identified at fronto-central electrodes over left hemisphere rather than fronto-central midline electrodes as predicted.

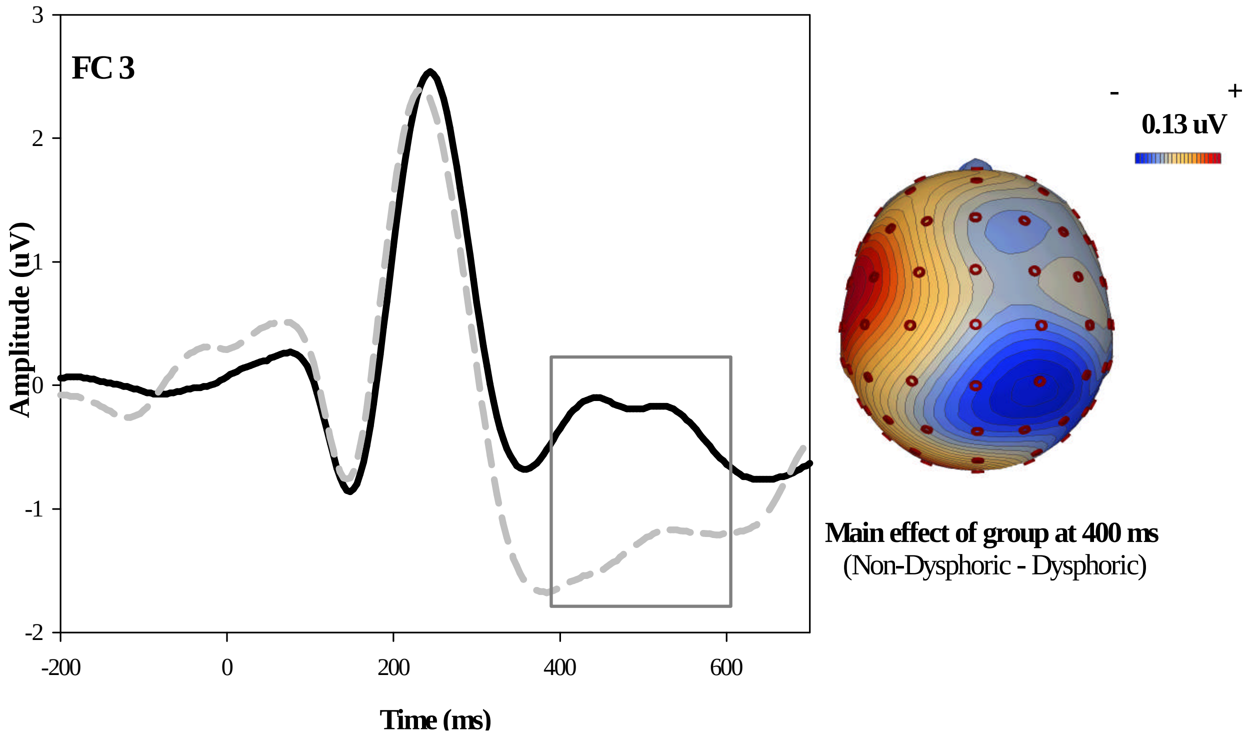


Figure 7.4: ERP waveforms at FC electrode and topographical scalp distribution (spline-interpolated voltage map) depicting the main effect of group occurring during late processing. The waveforms for words representing non-dysphoric and dysphoric groups are superimposed.

7.3.3.4: ERP summary

Main effects of task were identified at frontal and midline electrodes during both the early and late stages of processing. These findings suggest that self-referential and other-referential processing are represented by different levels neural activity.

Although task x group differences were identified at the behavioural level, no such differences were identified in the ERP analysis. However, a group x electrode interaction was identified at fronto-central electrodes from 350 to 500 ms. This finding suggests that mood influences both self-referent and other-referent processing at the neural level. Contrary to predictions, mood causes impairments in all forms of person-referent processing, not just self-reference.

7.4: Discussion

The overall aim of the present study was to examine how self-referential and other-referential processing differ as a function of mood. By employing both behavioural and ERP techniques the goal was to provide a broad representation of the cognitive processes underlying the two tasks. By testing both non-dysphoric and dysphoric individuals, the goal was to investigate how these cognitive processes differ as a function of mood. Initial discussion will focus on the main hypothesis that changes in the self-positivity bias as a function of mood are specific to self-referential processing. Further discussion will focus on effects identified within the ERP analysis which do not support this hypothesis. Finally task-related differences between self-referential and other-referential processing will be examined.

7.4.1: Changes in the self-positivity bias as a function of mood.

The hypothesis investigated in the present study stated that changes in the self-positivity bias during negative mood were specific to self-referential processing and, that these differences would not occur in other forms of person-referent processing. Evidence from the behavioural measure frequency of response provides some support for this hypothesis. Within the frequency of response measure significant differences were identified between non-dysphoric and dysphoric individuals within the self-reference task. Although both groups of individuals did show a self-positivity in the frequency of response measure, this bias was reduced in dysphoric individuals. When compared to non-dysphoric individuals, dysphoric individuals responded less frequently to positive words as self-referential and negative words as non-self-referential, and more frequently to negative words as self-referential and positive words as non-self-referential. This finding replicates results identified in previous chapters (Chapters Three & Five) and provides further evidence to suggest that self-referential processing is altered as a function of mood (see Chapter Five for a review).

Importantly, differences between non-dysphoric and dysphoric individuals were not identified within the other-referential decision-making task. Both dysphoric and non-dysphoric individuals responded more frequently to positive information as other-referential and negative information as non-other-referential when compared to the frequency with which they evaluated negative information as other-referential and positive information as non-other-referential. This finding replicates previous research by Bargh and Tota (1988) in that negative mood was associated with specific alterations in self-referential processing while other-referential processing remained unchanged. In the study conducted by Bargh and Tota the other-referent target employed was an average other. Therefore the results of the present study extend these findings by illustrating that other-referent processing is not influenced by negative mood, even when a familiar other such as a close friend is employed as the other-referent target. However, it could still be argued that even a familiar other-referent is less familiar than the self-referent target.

7.4.2: The positivity bias in self and other-referent processing

Although differences were identified in the frequency of response measure, no interactions involving task x group differences were identified in the response time measure. This finding replicated the results of previous research as no between group differences in self-referential processing were identified in the response time measure in Chapter Five. As stated previously, changes in self-referential processing during negative mood have been less consistent in response time than in frequency of response or recall measures (see Chapter Five, Section 5.4.1.1).

In previous chapters, (Chapters Four, Five & Six) the faster responses to self-positive and non-self-negative stimuli when compared to non-self-positive and self negative stimuli in response times has been taken as evidence for the existence of a self-positivity bias in response times. The finding that this bias was not identified within the emotional decision-making task contributed to this conclusion. However in the present study, this positivity bias was also identified in both non-dysphoric and dysphoric individuals during other-referential decision-making. Two possible explanations for the observation of the positivity bias in both self-referent and other-referent processing will be put forward.

One possibility is that individuals hold a positively biased schema which is involved in the processing of information about close friends and family members. This would suggest that the schema held about familiar others is similar in emotional valence to the positive self-schema associated with healthy cognitive processing. Previous research has shown that self-serving biases such as the above-average effect are reduced when a familiar other is used as the other-referent target. These findings support the results of the present study in that the evaluations of other-referent targets are positive when a familiar other-referent is used as a comparison figure (Sedikides & Strube, 1997; Alicke, et al., 1995). In previous chapters, the faster response times and changes in the ERP correlate known as the N400, have been explained in terms of the semantic mismatch hypothesis. It was suggested that the context of the self-reference decision-making task activates the positive self-referent schema held by healthy individuals. Therefore incoming information which does not fit this positive self-schema elicits longer response times and more negative going N400 responses when compared to information which does fit the positive self-schema. The results of the present study suggest that this explanation of the difference in response times could also be used to explain differences in the response times associated with other-referent processing. However, an alternative explanation is that the differences in response times in both self-referent and other-referent processing are the result of a more general match to context effect.

Within both self-referent and other-referent processing, incoming information is evaluated on two dimensions which have been found to be highly correlated during normal cognitive processing; person-reference and emotional valence. It is possible that the differences in response time identified within the present study are the result of more general differences in cognitive processing, such that faster response times are elicited to information which is correlated on both dimensions (i.e self/other positive & non-self/non-other negative) when compared to information which is not correlated on both dimensions (i.e self/other negative & non-self/non-other positive). This explanation would also account for the differences between response times across the self-referential and emotional decision-making tasks. The emotional decision-making task only focuses on one dimension (positive-negative valence) therefore the lack of a positivity bias identified within the emotion task may be due to the fact that this task did not involve a comparison between two highly correlated dimensions. This alternative explanation highlights that it is important to consider the differences identified within the present study in the context of more general cognitive processing, rather than focusing on specific forms of person-referent processing.

7.4.3: Group differences identified in ERPs

Group differences in self-referential but not other-referential decision-making were identified at the behavioural level. However no interactions involving task x group differences were identified in ERP responses. Surprisingly, a main effect of group was identified for both self-referent and other-referent decision-making tasks from 350 to 500 ms at fronto-central locations over the left hemisphere. The results of the present study partially replicated the findings of Chapter Five. The ERP responses of non-dysphoric and dysphoric individuals were found to differ during self-referential decision-making. However these group differences were more lateralised over the left hemisphere. Furthermore, similar between group differences were also identified within the other-referential decision-making task. One explanation for the lack of task-related effects within the ERP analyses is that the statistical power of the study was too low. However this is unlikely as task-related effects were identified in the study conducted in Chapter Five which employed the same number of participants and the same statistical analyses. Overall, these findings provide evidence too suggest that negative mood is associated with changes in both self-referential and other-referential processing at the neural level.

In previous chapters, the neural correlate identified in self-referential decision-making has been discussed in terms of the N400 and the semantic mismatch hypothesis. In Chapter Four, ERP responses in the self-reference task were more negative-going to words which did not fit the positive self-schema employed by non-dysphoric individuals. In Chapter Five, ERP responses within the self-reference task were more negative-going for dysphoric than non-dysphoric individuals. This difference between the two groups can be explained in terms semantic expectancy. Due to the positive self-schema held by non-dysphoric individuals, a semantic expectancy is set up in the self-reference task. Positive words are likely to be identified as self-referent and negative words are likely to be identified as non-self-referent. Because the self-schema employed by dysphoric individuals is more negative than that of non-dysphoric individuals, there is a reduced correlation between self-reference and emotional valence (see Chapter Three). As this correlation is reduced, the expectancy that positive information will be self-referent and negative information will be non-self-referent is reduced in dysphoric individuals. Based on this rationale, task x group differences would also be expected at the neural level within the present study. Because group differences were identified in ERPs responses in both the self-referent and other-referent decision-making tasks it is difficult to explain the findings of the present study in relation to the more negative self-schema held by dysphoric individuals. This lack of task differences within the present study suggest that the group differences identified are not in line with the explanation involving the N400, or the semantic mismatch hypothesis employed to explain differences between non-dysphoric and dysphoric individuals in Chapter Five.

Previous research has indicated that the N400 occurs around 400 ms at fronto-central and central electrodes. Curran, Tucker, Kutas and Posner (1993) investigated the topography of this effect in a semantic expectancy paradigm during which participants were presented with sentences ending in semantically congruous or incongruous words. They found that the N400 is relatively symmetrical across the two hemispheres. The between group differences in ERP responses within the present study are lateralised; they are only evident in the left hemisphere. Therefore one possible explanation is that the ERP differences identified presently may not reflect the same neural correlate of the self-positivity bias identified in previous chapters. Furthermore, as the ERP effects identified in Chapters Four and Five were found to occur on the midline electrodes, the ERP responses across hemisphere were not included as separate regions of spatial analysis within the present study. In light of the lateralised group x electrode effect identified presently it may be useful in future research to examine the lateralisation of effects in more detail.

In their study of healthy individuals; Craik et al. (1999) compared neural processing during self-referent, other-referent, general and syllable encoding tasks (see section 1.3.1). They found that increases in activations in the left prefrontal cortex occurred in self-reference, other-reference and general encoding tasks when compared to a syllable encoding task. They hypothesised that these left-sided activations were involved in the meaningful processing of individual words. This finding is in line with previous research conducted in relation to the hemispheric encoding/ retrieval model (HERA) put forward by Tulving, Kapur, Craik, Moscovitch, and Houle (1994).

In relation to the present study, the left sided activations identified by Craik et al. (1999) suggest that the left hemispheric differences in ERP responses between non-dysphoric and dysphoric individuals may be the result of general impairments in the processing of meaningful word stimuli. Other research has identified that the processing of meaning in the left prefrontal cortex is associated with a good episodic memory for processed events (Kapur et al., 1994; Petersen, Fox, Posner, Mintun, & Raichle, 1988). Although memory performance was not recorded within the present study, previous research has repeatedly indicated that negative mood is associated with poor memory for both episodic and autobiographical retrieval (Williams et al., 1997; Williams et al., 2007). These findings provide some support for the possibility that the differences in left lateralised activations are the result of general differences in the processing of meaningful stimuli during negative mood. This explanation is tentative, however it would be interesting to investigate this potential relationship between left hemispheric activation, the processing of meaningful stimuli, memory and mood further. Again these findings highlight the need to consider the results of the present findings outwith the context of self-referent or person-referent processing.

7.4.4: Task-related differences in self and other-referential processing

The results of the present study illustrate that during normal mood, the processing of self-referent and other-referent information represent similar decision-making processes. It is only during the experience of negative mood that the differences between the two types of decision-making task are evident at the behavioural level. However, further evidence for differences between self-referent and other-referent processing was provided by the analysis of ERP responses. Differences within the brain between the self-referent and other-referent tasks were identified at frontal and midline locations at both the early and late stages of processing. These differences occurred for both non-dysphoric and dysphoric individuals. Although task-related differences were not evident at the behavioural level in non-dysphoric individuals, this finding illustrates that decisions involving self-reference elicit significantly different levels of neural activity than when compared to other forms of person-referent processing supporting the findings of previous neuroimaging studies done by Craik et al. (1999), Fossati et al. (2003) and Kelley et al. (2002). These studies found that different regions were active during self and other-referent processing using a non-familiar other as an other-referent target. The results of the present study extend the previous research by illustrating that differences in the neural activations associated with self-referent and other-referent processing remain even when familiarity is controlled for.

In conclusion, the present research provides partial support for the proposition that negative mood is associated with specific impairments in self-referential processing. At the behavioural level, high levels of negative mood result in an alterations within self-referential but not other-referential decision-making. This difference between self-referential and other-referential processing as a function of mood was not identified in the brain as in previous research. It was proposed that the group differences identified in both person-referent processing tasks may be the result of impairments in the way that dysphoric individuals process all forms of meaningful word stimuli. The results of the present study extend the findings of previous research as differences between the self-referent and other-referent tasks were identified at both behavioural and neural levels, even when a familiar other target is employed.

- Chapter 8 –

Discussion

8.1: Introduction

The two main aims of the present research were to clarify the relationship between self-reference and emotional valence in more detail, and to investigate changes in self-referential processing as a function of mood. The present research employed a novel methodology to conduct a comprehensive investigation of both self-referential and emotional processing across behavioural, neurophysiological and autonomic responses. Using this methodology we have learned about the extent to which both cognitive and affective systems are involved in each type of processing. Furthermore, we have identified that changes in self-referential processing as a function of mood are not only evident at the behavioural level, but also at the neural level. These findings lead the way to developing a comprehensive framework of self-referential processing which considers the role of emotional information, is informed by each level of the physiological response system and is relevant to both healthy and disordered cognition.

The next section will present a brief overview of the experimental findings in relation to the two main aims of the research. Based on these findings, a possible theoretical model of self-referential processing will be proposed. This model will then be compared to two other general theories of cognition and emotional disorder. Finally some limitations of the research will be discussed and future directions will be proposed.

8.2: Overview of experimental findings

8.2.1: Investigating the relationship between self-reference and emotional valence

The results of the present research replicated previous findings that a close relationship exists between self-reference and emotional valence (Alicke et al., 1995; Alison et al., 1989; Mezulis et al., 2004). For non-dysphoric individuals, a self-positivity bias was identified in all experimental chapters when individuals were asked to make evaluations about self-reference. This positivity bias was identified at the behavioural level using Likert scale, frequency of response and response time measures. The results of the experiment reported in Chapter Four extended this research by using ERPs to identify a neurophysiological correlate of this self-positivity bias.

Chapter Four provided supporting evidence for a two stage model of self-reference. That is, ERP data revealed a main effect of emotional valence beginning prior to, and at different spatial locations from, an interaction between self-reference and emotional valence. This finding indicates that a general evaluation of emotional valence begins prior to any evaluations involving self-reference. Using a very different methodology to asses the physiological affective system, the experiment conducted in Chapter Six revealed that individuals' autonomic responses (heart rate & skin conductance) were very similar during both self-referential and emotional decision-making. This result illustrates that the processing of self-referential information elicits a similar form of emotional response as the processing of emotional information. These results provide further evidence to suggest that the processing of emotional information represents a large component of self-reference. These results illustrate that the recognition of self-referent material relies on the recognition of emotional valence and these two highly integrated processes work together in order to assess the importance of incoming information.

8.2.2: Investigating changes in self-referential processing as a function of mood

As stated above, the self-positivity bias was consistently identified during self-referential processing. However, changes in self-referential processing as a function of mood were just as consistent. No relationship between self-reference and emotional valence was identified for dysphoric individuals in Chapter Three. In Chapters Five and Seven dysphoric individuals more frequently rated negative information as self-referent, and positive information as non-self-referent when compared to non-dysphoric individuals. The experiments conducted in Chapters Five and Seven represent the first investigations into changes in self-referential processing as a function of mood at the neural level. Clear differences between non-dysphoric and dysphoric individuals were identified during self-referential processing in the ERP data.

In order to investigate whether mood was associated with more general changes in emotional processing, the responses of non-dysphoric and dysphoric individuals during self-referential decision-making were then compared to their responses when engaged in an emotional decision-making task. In the experiment reported in Chapter Five, the behavioural differences between non-dysphoric and dysphoric individuals identified during self-reference were not evident during the emotion task. Between group differences were identified at the neural level. However these differences were found to occur at different spatial and temporal locations from the differences identified during self-reference. When self-referent and other-referent decision-making were compared to investigate changes in person-referent processing, similar between group differences in self-reference but not other-reference were identified at the behavioural level. However, no such task-related differences were identified in the ERP data. Differences between non-dysphoric and dysphoric individuals were identified at the same spatial and temporal locations during both types of decision-making.

One possible explanation for the difference in neural activations between self-reference and other-reference when compared to the emotion task may be the amount of complex processing involved. The emotion task represents a simple form of processing, whereas both self-referent and other-referent decision-making represent more complex forms of processing. It is possible that differences in decision-making as a function of mood occur during the early stages of simple cognitive processing and during the later stages of complex cognitive processing. Despite the behavioural evidence that negative mood results in changes in unique features of self-reference, the findings from the ERP data provide evidence to suggest that negative mood is associated with changes in both simple and complex forms of cognitive processing.

8.3: A theoretical model of self-referential processing

The present set of studies is the only body of research to date that has employed both psychophysiological and behavioural methods to investigate self-referential processing. The use of this methodology presented two unique opportunities. The first opportunity was to examine self-referential processing on a temporal scale. Using ERPs and autonomic responses it was possible to access various stages of self-referential processing across a variety of psychophysiological systems. Second, the present research represents the only investigation into changes in self-referential processing as a function of mood within the brain. Importantly, the results of the present research identified components of self-referential processing in both cognitive and affective systems which could not have been identified using behavioural methods alone. These findings should now be incorporated into the existing literature, in order to create a more comprehensive understanding of self-referential processing that encompasses the psychophysiological system.

At a broad level, the results of the present research provide further evidence to support several established findings. Early behavioural and neuroimaging research identified that the self is a highly elaborated and organised representation, which is served by a widely distributed network of brain regions (Craik et al., 1999; Symons & Johnson, 1997). In the present research, differences were identified between the self-referent task and both other-referent and emotion tasks across a number of spatial and temporal locations within the brain.

This finding provides support for the existence of such a self-representation, served by a distributed network of brain regions. The results of the present research also replicated previous research which identified that a self-positivity bias is present during low levels of negative mood and altered during high levels of negative mood (Bradley & Mathews, 1983; Dozois & Dobson., 2001; Mezulis et al., 2004). It is important to replicate these previous research findings using different stimuli and methodologies in order to ensure the reliability and validity of these effects. However, some of these findings have been established for almost a decade, and very little has been done to bring together these findings in order to develop a theoretical framework of self-referential processing. Such a framework should attempt to provide a comprehensive explanation of the psychological processes which underlie self-reference.

More recently using fMRI, Moran et al. (2006) investigated the relationship between self-reference and emotional valence within the brain. Activations specific to self-reference, independent of emotional valence were identified within the medial prefrontal cortex (mPFC). Furthermore, activations specific to the processing of self-referent (like me) positive words were identified within the adjacent region, the ventral anterior cingulate cortex (vACC). Based on the spatial proximity of these regions, Moran et al. proposed the first functional hierarchy of self-referential processing. Within this hierarchy, it was suggested that incoming information is initially assessed for self-reference within the mPFC before information identified as highly self-referent (like me) was then tagged for emotional valence within the vACC. Although this was an important step towards the development of a theoretical framework for self-referential processing, the findings were very limited. Moran et al. focused specifically on self-referential processing, with little discussion of the wider context of general emotional processing. Furthermore although the sequence of processing was described on a temporal scale, no measures of temporal processing were analysed. The results of the present thesis make a substantial contribution within this area. Based on the two stage model of self-referential processing identified on a temporal scale, and the changes identified in self-reference as a function of mood, a tentative model of self-referential processing will be proposed. This model is the first theoretical framework of self-referential processing, informed by both psychophysiological and behavioural responses. In order to place this model within the wider context of emotional processing, the model will then be compared to two current multilevel theories of cognitive and emotional processing.

8.3.1: Self-reference

The studies reported in the present thesis employed relatively simple self-referent, other-referent and emotional decision-making tasks to investigate self-referential processing. As stated above, the results suggest that self-reference represents a complex form of processing. Figure 8.1 illustrates a tentative model of self-reference identified on a temporal scale within the present research. Firstly, the model will be discussed in terms of how it relates to the empirical effects observed within the present thesis. Secondly, the model will be discussed in relation to how it relates to a broader range of real life phenomenon such as goal attainment and social and environmental cues.

8.3.1.1: The model of self-reference: empirical effects

Figure 8.1 represents a basic default model of self-referential processing in healthy individuals. The psychophysiological measures employed within the present research examine different components of the physiological response system. ERPs access cognitive processes at a neural level, whereas autonomic measures are responsive to emotional information (See Section 2.4). Within the present model these components were divided into two systems and labelled as the Cognitive and Affective Systems respectively. The value of recording psychophysiological responses is that they access information processing at both preconscious and conscious stages. These temporal changes in physiological response are represented on the vertical axis of the model, beginning with Incoming information and continuing in a linear fashion with a number processes occurring in parallel across the two Systems until the Response output.

As stated above, the neural responses identified in relation to self-referential processing are reflected in the Cognitive System. In Chapter Four, during the later stages of processing, two components of a self-referential evaluation were identified. A general evaluation of emotional valence was found to occur prior to, and at different spatial locations from an evaluation of both self-reference and emotional valence. These two stages are reflected in the Cognitive System within the model of self-reference. In Chapter Six autonomic measures such as heart rate and skin conductance also differentiated between positive and negative information. This finding is reflected in the Affective System, this system directly influences the evaluation of the emotional valence of information in combination with the Cognitive System. This model of self-referential processing adequately deals with the psychophysiological responses identified in the previous experimental chapters. Behavioural responses are based on information from both the Cognitive and Affective systems, within the present set of experiments a self-positivity bias was identified consistently in both the frequency of response and response time measures. This bias is reflected in the elaboration of self-reference and emotional valence stage, during which, information about the emotional valence of information from the Cognitive and Affective Systems is integrated with self-referential information.

8.3.1.2: The model of self-reference: within a broader context

The studies reported in the present thesis employed relatively simple self-referent, other-referent and emotional decision-making tasks to investigate self-referential processing. As stated above, the results suggest that self-reference represents a complex form of processing. Figure 8.1 illustrates a tentative model of self-reference identified on a temporal scale within the present research. It is proposed that this model represents a basic default system of self-reference in healthy individuals. In this system, information is evaluated for emotional valence prior to being integrated with self-referent information at later temporal stages.

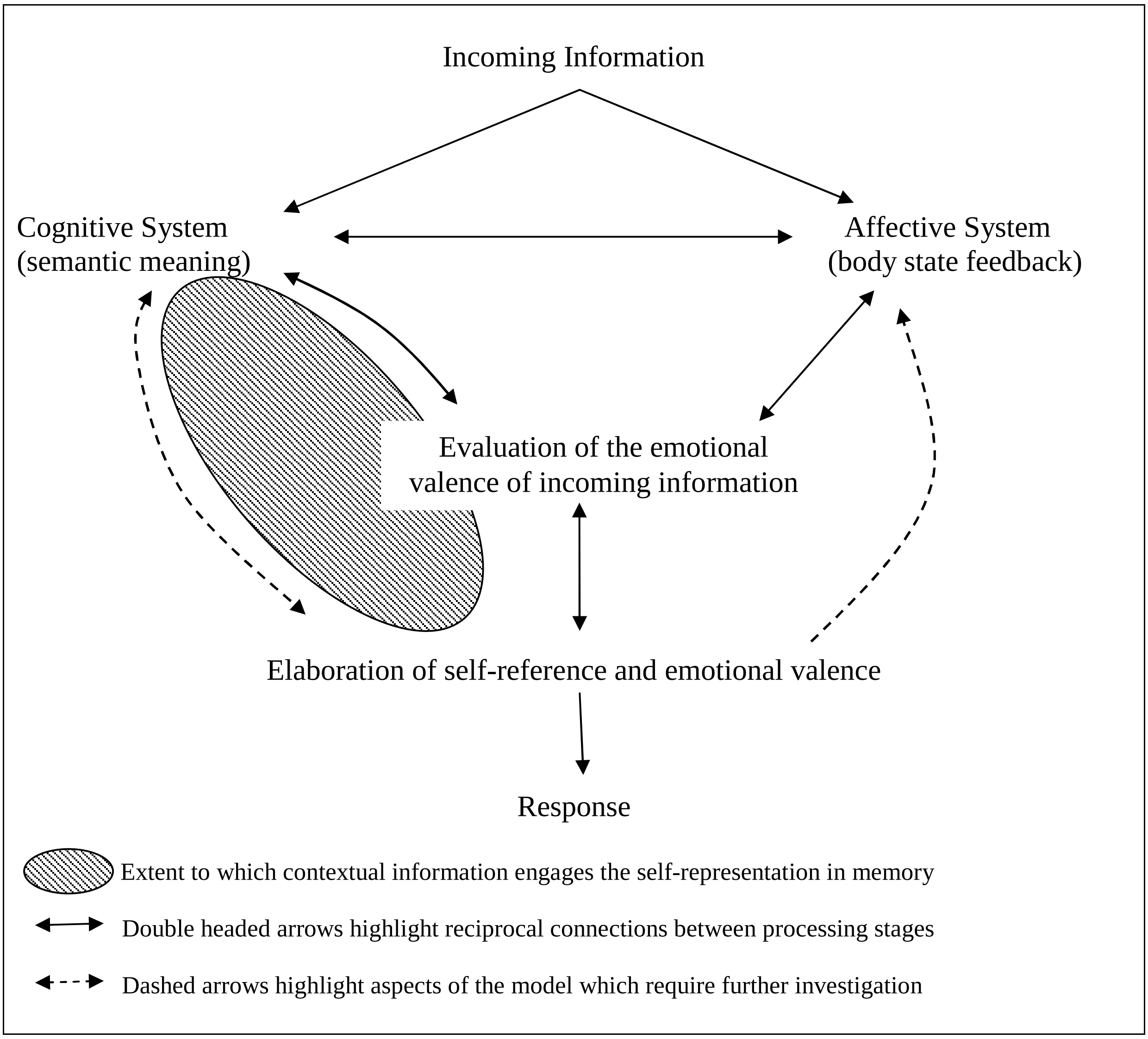


Figure 8.1: The default system of self-referential processing in healthy individuals

In the present set of experiments participants were asked to make decisions about the extent to which a word stimulus was personally relevant to them. This task was done in a darkened room with minimal feedback from the environment. In this situation individuals would receive minimal feedback from their cognitive and affective systems. In situations with minimal contextual information it would be advantageous for self-referential processing to be based on a default system which relies on basic processing of emotional information. This would allow individuals in unfamiliar situations to identify appetitive, and avoid aversive outcomes in relation to their own goals. This situational context sets up a close relationship between the processing of emotional information and the self-representation. Therefore, the outcome of this basic default system explains the self-positivity bias identified at both the behavioural and neural level (Chapter Four, Moran et al., 2006). This system would also be useful in other forms of person referent processing, although further research is required. Previous research has shown that the positivity bias is strongest for familiar others (Alicke et al., 1995). The default system of complex processing of emotional information may also be applied to familiar in-group members. In situations with minimal context, a close relationship between other-reference and emotional information would enhance the representation of a familiar other. This may facilitate team work to achieve desirable outcomes for a group.

The diagram in Figure 8.1 illustrates that, as the self-representation is engaged to a greater extent by richer contextual information, the decisions about self-reference may become less dependent on the emotional valence of incoming information, within the cognitive system. Under these circumstances, it is possible to speculate that as richer contextual information facilitates access to the self-representation, self-referential processing would become less dependent on automatic processes, and make greater use of episodic memory and previously employed problem-solving techniques. This would lead to self-referential processing becoming less reliant on the emotional valence of incoming information. Engaging these processes could be termed engaging the cognitive components of the self-representation. It would be predicted that in situations with higher levels of contextual information, while the general evaluation of emotional valence would remain, the relationship between self-reference and emotional valence would be reduced as specific autobiographical memory is engaged. Although tentative, this component of the model is testable at both the behavioural and neural levels. Possible future directions will be discussed in following sections (see Section 8.6).

8.3.2: Self-reference and depression

The results of the present thesis identified changes in self-referential processing as a function of mood. These behavioural and neural changes are reflected in the self-positivity bias, indicating that negative mood is associated with changes in self-referential processing during the final stage, when self-referent decisions begin to incorporate emotional information. The self-positivity bias at this stage was found to be reduced but not reversed during the experience of negative mood. This finding suggests that the self-positivity bias may serve as a protective mechanism against incoming negative information or short term negative events. It is possible that negative moods become more enduring or depressive episodes occur, when this reserve of self-positive information is depleted.

Based on the changes in self-reference which occur during the experience of negative mood and depression (Chapter Five, Chapter Seven, Dozois & Dobson, 2001), a model of self-referential processing should also consider how this system is altered during the experience of depression. Figure 8.2 presents a speculative model of how a depressive episode is maintained within this model. In Chapter Five and Seven, differences between non-dysphoric and dysphoric individuals were identified in the self-reference task during the later stages of processing. These differences were found to occur in similar spatial and temporal locations to the self-positivity bias identified in the ERP responses of non-dysphoric individuals in Chapter Four. It is proposed that the main changes in self-referential processing as a function of mood are associated with alterations in the engagement of the self-representation within the cognitive system. Although the terminology differs, these alterations in self-reference are similar to those proposed by two more general theories of cognition and emotional disorder, the integration vs. elaboration model (Williams et al., 1988, 1997) and Interacting Cognitive Subsystems (ICS, Teasdale & Barnard, 1993). The relevant components of each model will be discussed respectively.

Williams et al. (1997) suggest that information processing can be separated into two main stages. A relatively simple and automatic integration stage, where information is integrated into schematic representations, and a later more strategically controlled elaboration stage, in which the new relationships formed between new and old information within the self-representation activate other aspects of the self-representation in memory. Williams et al. proposed that anxiety is associated with impairments during the attention or integration stage whereas depression is associated with impairments during the strategic elaborative stage. In relation to the current model, both the integration and elaboration stages would occur within the cognitive system. However within this model, it is proposed that it is the reciprocal relationship between these two processes which are disrupted within the cognitive system during the experience of depression. This disruption causes depressed individuals to get caught within this stage of the cognitive system leading to the cognitive symptoms of depression specified in Figure 8.2.

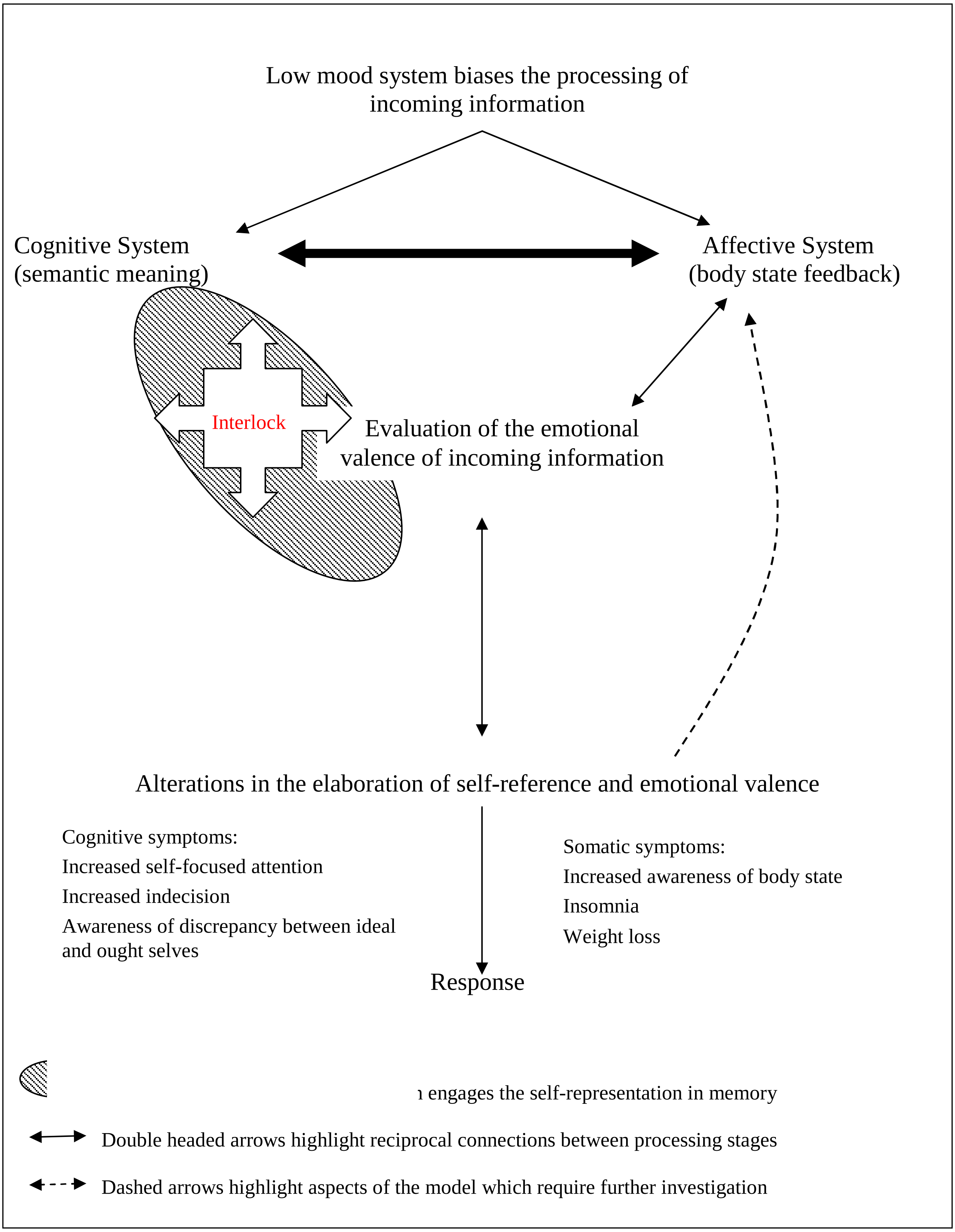


Figure 8.2: The model of self-referential processing during a depressive episode

The disruption in the model is similar to the "depressive interlock" proposed by Teasdale and Barnard (1993) in which individuals who are experiencing negative mood process new information in a negative context due their negative cognitions, this circular pattern of thinking leads to the maintenance of the negative mood. This interlock occurs within the two subsystems which work at the highest level of abstraction in the interacting cognitive subsystems model (ICS), see Figure 8.3. This model will be discussed in more detail within section 8.4. The depressive interlock occurs between the propositional subsystem which processes the semantic meaning of information, and the implicational subsystem which co-ordinates information from the basic sensory subsystems and propositional subsystem to create a "holistic sense of knowing". In this model, the holistic representation of self at the implicational level leads to the generation of negative truth statements (i.e I am a hopeless individual) at the propositional level. These propositions are then used to generate feedback to the self-representation at the implicational level. In this model, a depressive episode occurs as the reciprocal connections between the two systems become interlocked. This depressive interlock provides a parsimonious account of the changes which occur during self-referential processing as a function of mood.

When processing incoming information during the early stages of a depressive episode, individuals can still make accurate evaluations about the emotional valence of information. However as negative mood biases their cognitive system, negative self-representations are activated. At this stage, the discrepancy between the negative self-representation and the emotional valence of incoming information becomes apparent. In an attempt to resolve this discrepancy, two processes may occur. One possibility is that the depressed individual searches within their cognitive self-representation. This extended search may lead to some of the cognitive symptoms of depression, such as increased self-focused attention in the form of rumination, increased indecision and a slowing of responses. If the discrepancy cannot be resolved then it would lead to the maintenance and consolidation of the negative self-representation within memory. If this discrepancy cannot be resolved within the cognitive system, then the depressed individual may search for other sources of information within the affective system in an attempt to facilitate the process. This search of the affective system may lead to more of the somatic symptoms of depression, for example, increased awareness of physiological stress. If this discrepancy can be resolved using these two search processes then flexibility within self-reference would be maintained. This may lead to a reduction in the activation of the negative self-representation and consequently the experience of negative mood. However, if the discrepancy cannot be resolved, then the negative self-representation would be maintained. After the completion of the decision-making process, feedback loops within the system would lead to further biases in both the cognitive and affective systems.

The commonalities between this model of self-representation and two current multilevel theories of cognition and emotional disorder will be discussed within the following section (see Section 8.4). Overall this model illustrates that a depressive episode is maintained when individuals identify a discrepancy between the emotional valence of incoming information and their self-representation. Furthermore this model is maintained through an interlock within the cognitive subsystem and the reciprocal relations between this system and other components of the psychophysiological system as a whole.

8.3.3: Other models of self-referential processing

Moran et al. (2006) identified that the medial prefrontal cortex (mPFC) was active during the processing of self-referential information regardless of emotional valence. In contrast to this result, evaluations involving self-reference were not found to be independent of emotional valence within the present research. This difference in findings may be due in part, to the differences in spatial and temporal resolution of the neuroimaging measures utilised. It is important to consider the results of both studies as complementary. It is possible that the alternative measures employed highlight different components of the same functional hierarchy of self-referential processing, or that the differences in experimental design activated different components of the cognitive system. However as no general evaluation of self-reference was identified on a temporal scale, it is not possible to determine at what stage this general evaluation of self-reference would occur. It is important to note that the results of the present research do not rule out the possibility that a general evaluation of self-reference occurs at some point during self-referential processing.

It is important to reiterate that this model, although currently specific to self-referential processing, may also represent other forms of complex emotional processing. Further research is required to identify if this is the case. From the results of the present research, an obvious choice of comparative complex emotional processing would be other-reference. If a similar pattern of findings was identified on a temporal scale during healthy cognition then this would provide evidence to suggest that all forms of complex processing of emotional information are based on similar mechanisms.

8.4: Commonalities and Differences to other theoretical models

As discussed previously, only one other study has attempted to develop a theoretical framework for self-referential processing. However, the model of self-reference presented above shares a number of similarities with other more general theories of cognition and emotional disorder. The following section will present a brief discussion of the similarities and the differences between this model and two multilevel theories of cogntion. The interacting cognitive subsystems model discussed previously (Teasdale and Barnard, 1993) and the SPAARS model (Power & Dalgleish, 1997).

8.4.1: Overview of ICS

Interacting Cognitive Subsystems (ICS) is a macro theory of cognition proposed by Teasdale and Barnard (1993) in order to account for a broad range of laboratory and real life phenomenon associated with human cognition. On first inspection ICS appears to be a relatively complex account of cognition. It consists of nine subsystems which work together, through a series of reciprocal relations, to process incoming sensory and proprioceptive information, integrate this information with previous knowledge, abstract higher levels of meaning and provide the contextually appropriate output for real world situations. This single, but complex model provides a more parsimonious account of a range of cognitive phenomenon when compared to a combination of limited cognitive theories which only attempt to explain selected components of cognitive experience (Barnard, 2004).

ICS is represented in Figure 8.3. The nine subsystems illustrated are each involved in processing qualitatively distinct forms of information (i.e., sound, meaning, movement). Each subsystem is based on the same design in which two main processes occur. After relevant information is collected in the information array, a copy of this information is stored within the subsystems in its original form as an image record. Another process transforms the information collected in the information array to allow further processing by other subsystems within the model.

The nine subsystems can be further subdivided based on the type of information they encode. Three of the subsystems deal with sensory information taken directly from the external world; the acoustic (sounds), visual (dimensions of light) and body state (touch, smell) subsystems. Two subsystems encode intermediate structural descriptions. These subsystems identify recurring patterns of information detected in the sensory subsystems and abstract these patterns and the relationships between these patterns; the morpholexical subsystem deals with relationships in sounds space and the object subsystem with relationships in visual space.

The two subsystems, discussed previously (see Section 8.3.2), which work at the highest level of abstraction are the propositional and implicational subsystems. These two subsystems deal with the more complex concept of meaning. Both subsystems work on the principle of abstraction; they process the relationship between information presented in the information array in a more generic format than the previous level. The propositional subsystem deals with semantic meaning, such as true or false statements i.e., monkeys have tails. This system provides us with semantic knowledge. The implicational subsystem co-ordinates low-level and high-level information from the sensory and propositional subsystems. Teasdale and Barnard (1993) propose that it is an interlock between these two systems which leads to the onset and maintenance of a depressive episode.

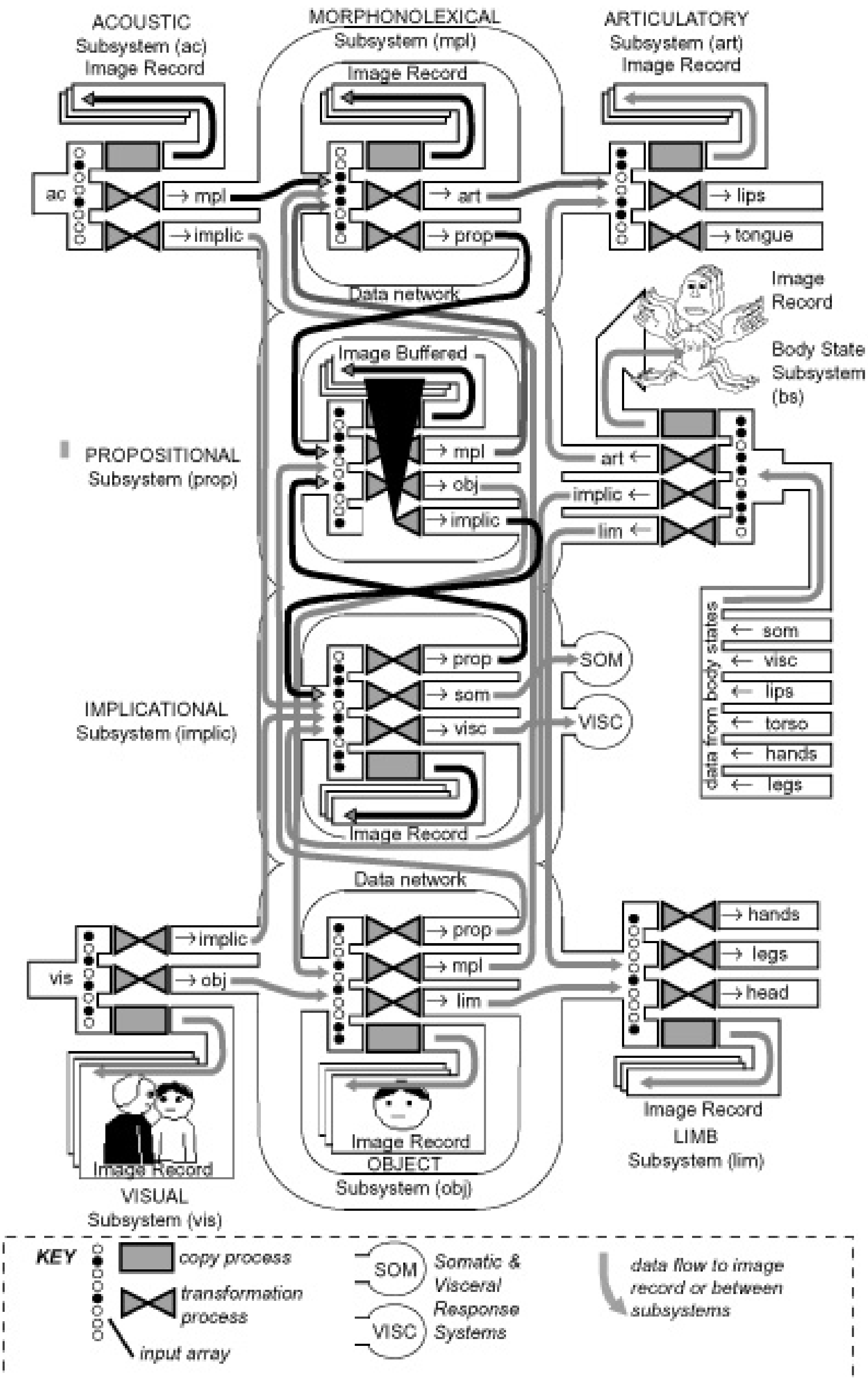


Figure 8.3: The Interacting Cognitive Subsystems Model (Teasdale and Barnard, 1993)
Taken from http://www.mrc-cbu.cam.ac.uk/~philb/

Using this abstracted information, the subsystem creates contextual schemata which provide us with a broad knowledge base without specific linguistic referents. This base forms what is known as our “holistic sense of knowing”. Importantly, Teasdale and Barnard (1993) propose that it is the relations between these two subsystems that form the main crux of cognitive experience and that emotional experience only results from activity within the implicational subsystem. The final two subsystems are involved in system output. The articulatory and limb subsystems prepare information for suitable vocal or movement action. In relation to previous research, this model can competently deal with both cognitive and affective forms of processing. It can explain phenomena such as mood congruent and incongruent memory, memory for autobiographical events and evaluations and attributions of success and failure (for a review see Teasdale and Barnard, 1993).

8.4.2: ICS and the self-referential model

The model of self-referential processing represents a micro-theory of cognition in that is seeks to explain only one specific type of cognitive process, self-reference. However some of the principles on which this model is built parallel those which underlie more complex macro-theories of cognition such as ICS. Firstly, both models recognise that a model of cognition should first set out to understand normal cognitive function and the underlying psychological processes involved before seeking to explain the alterations in these models which are associated with disordered cognition (Barnard, 2004). In the present set of experiments a two stage model of self-referential processing was identified on a temporal scale in healthy individuals prior to any investigations into alterations in this model during the experience of negative mood.

Second, both models incorporate information from the psychophysiological system as a whole and the reciprocal relations between the subsystems. ICS is composed of a set of nine subsystems which work together in parallel at a number of levels. This framework generates a powerful system which acknowledges the richness of the contextual information obtained from the environment, and also the elaboration of this information in relation to previous knowledge. Both these processes lead to the experience of our conscious awareness and sense of self (Barnard, 2003). The model of self-reference also acknowledges the information obtained from the psychophysiological system as a whole and the reciprocal relations within this system, as evidenced by the division of the cognitive and affective systems. Further evidence is required to examine self-referential processing in relation to other forms of sensory feedback, such as visual information from facial responses or auditory information from tone of voice.

At a more theoretical level, Barnard (2004) states that the self-model in the implicational subsystem at the highest level of abstraction generates propositions with specific meanings, and that those propositional meanings are fed back into the implicational model to regenerate the self-model (see Figure 8.3). Although the results of the present research cannot untangle these two subsystems, this explanation provides a parsimonious explanation of the processes which may occur within the cognitive system within self-reference (see Figure 8.1). The results of the present research identified a neural correlate of the self-positivity bias in the same spatial and temporal locations as the N400. In previous research, the N400 has been identified as a correlate of semantic processing. Therefore, in terms of the ICS model this finding may provide evidence that our self-representation at the implicational level (i.e., our general bias to view ourselves as positive) does generate truth statements in the propositional subsystem at the semantic level. Furthermore, the interlock within the cognitive system parallels the depressive interlock in ICS and importantly the notion that this interlock may be heightened by reciprocal links with other body state subsystems.

One limitation of macro-theories of cognition and their power to explain a variety of real life phenomenon is the difficulty in developing hypotheses which can be tested experimentally in order to evaluate these models (Williams et al., 1997). The parallels between some aspects of the micro-theory of self-reference and the macro ICS model illustrate that both types of theoretical model are valuable at different levels of explanation. It is useful to develop a micro theory of self-reference which can be tested experimentally. In turn the results of the present research suggest that these models can then be incorporated in to a larger macro-theory of cognition. Theoretical explanations at both micro and macro levels may ultimately result in more powerful macro-theories of cognition. This will lead to a better understanding of much broader concepts, such as our implicit sense of self which are difficult to understand using micro-theories alone.

8.4.3: Schematic, Propositional, Analogical, and Associative Representation System (the SPAARs Approach)

A more recent macro-theory of cognition and emotion was proposed by Power and Dalgleish (1997). This model has strong parallels in terms of its structure with the structure of the ICS model proposed by Teasdale and Barnard (1993). Both models attempt to explain a broad range of both healthy and disordered cognition. Both models are based on a set of subsystems which process mental representations at different levels of abstraction. The levels of abstraction in the SPAARs approach are the schematic level, the propositional level and the analogue level. Although the processes differ, the output from these three levels are largely similar to the implicational level, the propositional level and the sensory levels respectively in ICS. One further level of abstraction proposed in the SPAARs approach is the associative level. Unlike in ICS, this level represents a direct association between contextual information and previous information, such that an automatic emotional response can be generated without the need for further cognitive elaboration at the level of schematic representations.

At first glance, this direct route to emotional processing in the SPAARs approach seems like a major difference between the two models. However, a direct link between the body state subsystem and the implicational system is present in the ICS account of cognition. This direct link serves the same function as the associative level in the SPAARs approach. In both models this direct link to emotional processing is based on the automatic physiological responses as indexed by the affective system in the current model (see Figure 8.1). These similarities between the two macro-theories and the current model of self-reference illustrate that this model fits comfortably in the context of more general theories of emotional processing.

Although both models address the functionality of the experience of emotion within the cognitive system, a unique feature of the SPAARs model is that it identifies a set of five basic emotions which occur through a process of interpretation and appraisal at the schematic level. Power and Dalgleish (1997) propose a sequential process of emotional experience (see Figure 8.4):

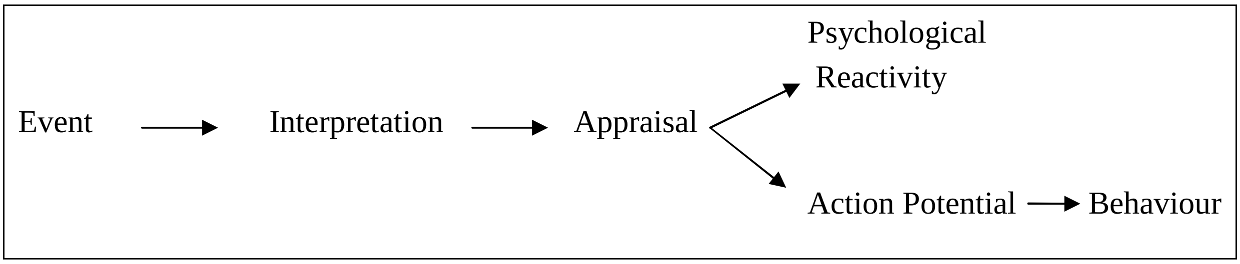


Figure 8.4: Emotional appraisal in SPAARs

Modified from Power and Dalgleish (1997, p150)

The appraisal stage of this process is an important feature of emotional processing within the model. It assesses incoming information in relation to the current roles or goals of the individual. The value of the incoming information in relation to these roles or goals is then reflected in the emotion experienced. For example, an individual may experience sadness in response to finding out that his hiking partner is ill the weekend that they had planned to go away hiking.

Power and Dalgleish (1997), state that individuals may have complementary or conflicting roles or goals in three domains, self, others and world. The appraisal of emotional experience in relation to the current roles or goals of the individual is not a feature of the model of self-referential processing at this stage of development. However, this difference between the two models is an interesting point of discussion. The goals of the individuals who took part in the present research were not assessed within the experiments conducted. Therefore, it is not possible to determine whether individuals were working towards goals, if they were trying to maintain a positive self-view, if they were showing the experimenter they could keep on task, or even if they were simply trying not to fall asleep. It is possible that the robust self-positivity bias occurs in this experimental situation across a variety of goals, all of which may have contributed to keeping participants on task. As with ICS, as a macro-cognitive theory, it is difficult to create testable hypotheses with regards the SPAARs model which can be tested experimentally.

Within the current model of self-referential processing it is the reciprocal relations between the self-representation and the incoming information which serve to alter or maintain the currently held self-representation which is important to healthy cognition, rather than the roles and goals themselves. Despite this position, the SPAARs model highlights limitation of the current model of self-referential processing to assess the value of specific features of the self-representation. Within the current model, it is proposed that the roles and goals of an individual are a very important part of the cognitive self-representation. These features are commonly employed in a socio-cognitive setting and are reflexive to the needs of the individual and the constraints of the situational circumstances. An important point for future research may be to identify how alterations in specific features of the self-representation (i.e., failure to obtain a promotion at work) may spread to other components of the self-representation during the experience of negative mood.

8.6: Some limitations

Although the psychological construct of self has been investigated for almost a century, the present thesis represents the first systematic investigation into self-referential processing using psychophysiological methods. As with all exploratory investigations, some aspects of the methodology employed were successful and some were not. Using this methodology we learned more about self-referential processing on a temporal scale, and also about how self-reference is altered as a function of mood at the neural level. However limitations of the research were also identified. In the following section some of these limitations will be discussed in order to constrain the theoretical framework proposed and inform future directions.

8.6.1: Differences in trial number within frequency of response

The results of the present study consistently identified differences in trial numbers within the frequency of response measure. In line with previous research, the self-positivity bias was evident such that individuals responded to self-positive and non-self-negative information frequently (approx > 80% of trials) when compared to self negative and non-self-positive information (approx < 20% of trials). This difference in trial number was problematic at several stages of the research. During the testing phase of the study conducted in Chapter Three, it was difficult to find participants who responded frequently enough on the non-self-positive and self negative trials in order to control for the inter subject variability which is high in ERP responses to conditions with low trials numbers. During the analysis and interpretation stages, it was difficult to determine if the differences identified in response times and the ERP data, were due to this difference between the high and low trial conditions, or the result of an actual self-positivity bias. In order to avoid this limitation in the following experimental chapters only the conditions with high trial numbers (self-positive & non-self-negative) were included in the analyses of psychophysiological responses.

The one of the aims of the ERP experiment conducted in Chapter Five was to identify if changes in self-reference as a function of mood could be identified at the neural level. The analysis of the ERP data revealed that differences between non-dysphoric and dysphoric individuals could be identified within the brain. However, the generalisability of these findings is limited to the processing of self-positive and non-self-negative information. Based on this finding, and the temporal and spatial locations at which this difference was identified, it was proposed that this difference may be be due to an alteration in the N400 during negative mood, within a self-referential context. However this difference was also identified in the neural responses to an other-referent decision-making task in Chapter Seven, despite no between group differences at the behavioural level.

The difference identified at the neural level in the other-referent task puts into question the interpretation of the between group difference identified within self-referential processing in Chapter Five. Based on the findings of the present research, it is not possible to clarify if these differences are specific to changes in the positivity bias identified in both self-referent and other-referent decision-making or, if this difference is the result of more general changes tasks which involve complex decision-making. One way of investigating this issue would be to conduct a full analysis of the ERP data including all the factors analysed at the behavioural level. However, due to the difficulty in finding participants who respond in both the high and low trial conditions, and also the increase in statistical power required for such an analysis, a much larger participant group of both non-dysphoric and dysphoric individuals would need to be tested. An alternative method would be to develop a decision-making task of similar complexity (using two highly correlated dimensions) with no emotional component. If between group differences were identified in this task, then the evidence would suggest that negative mood is associated with changes in all forms of complex decision-making.

8.6.2: Validity of the experimental decision-making tasks and word stimuli employed

The results of the present thesis illustrate that it is useful to examine psychological processes across a variety of psychophysiological systems. Self-reference and emotion tasks and self-reference and other-referent tasks were compared in using this method. However it is also important to discuss the value of comparing self-reference to other forms of emotional decision-making.

One issue relates to the level of complexity of the emotion task when compared to the self-reference task. As discussed in Chapter Seven, the emotion task involves individuals making decisions on one dimension (emotional valence), whereas two dimensions are involved in the self-reference task (self-reference & emotional valence). It is possible that some of the task-related differences identified between the two tasks may be related to the level of complexity of the decision-making task, rather than due to the involvement of a self-schema. Within the present research an other-referent task was compared to the self-reference task in Chapter Seven, this task controlled for the complexity of emotional decision-making. However the comparison between these tasks raises a question about the value of comparing self-reference to a more basic emotion task.

It was outlined in the general introduction in Chapter One that it would be useful to compare self-reference to an emotion task in order to identify the processes which are similar in each task and the processes which differ. In non-dysphoric individuals, differences between the self-reference and emotion tasks were identified in the reaction time measure and in the ERP data. It is possible that these differences are due to differences in the level of complexity of the two decision-making tasks. However, in the frequency of response measure and both autonomic measures (heart rate & skin conductance) no differences were identified between the two tasks. These findings illustrate that it is beneficial to identify similarities between self-reference and emotion tasks despite the differences in complexity, the similarity in the responses suggests that the self-reference task does involve some form of emotional decision-making.

In Chapter Three, the self-reference task was not compared to any other form of emotional processing. This focus on the self-reference task was to allow a comparison between the results of the experimental study to previous neuroimaging research. The model of self-reference discussed above suggests that a general evaluation of emotional valence occurs prior to the interaction between self-reference and emotional valence. If this general evaluation of emotional valence was also evident in more basic forms of emotional processing such as the emotion task, it would be possible to say with greater certainty that the initial evaluation of emotional valence is based on a more basic form of emotional processing. This line of research also highlights the benefit of comparing self-reference to a more basic form of emotional processing on a temporal scale, and argues that comparisons between self-referent and simple emotional decision-making should be employed in the future.

8.6.2.1: The role of environmental context and word content

The research conducted in experimental chapters three to seven all employed the same word stimuli. The use of word stimuli within the present set of experiments raised some issues about how word meaning can be interpreted, both in relation to the context in which words are presented and also in relation to the content of the words themselves. In the main, words were presented in either a self-referential or emotional context. Within these two contexts, participants were asked to rate words on either a 5-point Likert scale, or a two choice decision making task. Both these evaluation methods are relatively simple and address self-reference and emotionality as uni-dimensional constructs. Although it is useful to begin experimental research with simple tasks in order to establish a strong foundation for future research, it is possible that these methodologies may fail to capture the richness of such complex evaluations. For example, as discussed in chapter six (see sections 6.1.1 & 6.4.2.2), an emotional evaluation involves both emotional valence (whether the stimuli is positive or negative) and arousal (motivational significance for the individual). This arousal component of emotional evaluations was not taken into consideration in other studies presented within the thesis. It is important for future research to consider both emotionality and self-reference as multi-faceted constructs which are rich, both in quality and quantity of information processing.

When considering self-reference and emotionality as multi-faceted constructs, these constructs can be influenced by a number of factors. Within the emotion task it is important to note that the emotionality of a word can be influenced by the context in which it is presented. For example, if the word “hospital“ is presented to someone with a broken arm they may view the word as positive. Conversely, if the word is presented to someone who has recently experienced a death in the family, “hospital” may be viewed in a more negative light. As the number of word stimuli employed within the present thesis was relatively large (78 words per condition) and the participant sample was relatively homogeneous (student population, aged between 18 & 25 approximatley), it could be argued that the variability in responses caused by such differences in contextual interpretation would minimised. In the future, experimental research should consider the role of contextual interpretation in more detail. Employing a task in which the success or failure of a participant is experimentally manipulated (i.e solvable versus unsolvable anagrams) would be one way to examine the extent to which emotional judgements are influenced by contextual interpretation. Equally, socially relevant contextual information may also bias the interpretation of word meaning within the self-reference task. If a particular social identity is made salient, for example if the word “black” is presented to a non-coloured individual who has been primed with a racial identity task, it is possible that an evaluation of “not like me” would be of greater similarity to a “like them” judgement than when compared to an evaluation of self-reference without a racial identity prime.

Finally, one question which was raised by the research conducted presently is why are some words identified as self-referential and some words identified as non-self-referential? The results of the present research suggest that the emotionality of word stimuli strongly influences this type of evaluation. The issues discussed above suggest that the social and environmental context in which stimuli are presented also play a role. However, features of the word stimuli itself are also important. Previous research has shown that the familiarity of a word, and word type influence self-reference (Symons & Johnson, 1997), such features were controlled for in the present research (See section 2.5). However, one feature of the word stimuli which was not controlled for was the ease with which words can relate to the construct of self. For example the words “fun” and “tank were words which were employed as self-positive and non-self-negative respectively. It is clear from this example that it is relatively easy to identify the word “fun” as self-related, whereas it is much more difficult to relate the word “tank” to the self. Future research into self-reference should also include a measure which can asses how easily participants can relate stimuli to their self-construct. Importantly ease of relatedness to self should be controlled for across positive and negative stimuli.

8.6.3: Use of a dysphoric student sample

The second aim of the present study was to investigate changes in self-referential processing as a function of mood. As the experimental studies were only conducted with non-dysphoric and dysphoric student samples it is not possible to generalise the findings of this research to the experience of a depressive episode. It is possible that the mechanisms which underlie transitory mood states and clinical disorders such as depression differ (Wenzlaff, Rude, Talyor & Stultz, 2001). In order to control for this as much as possible, several practices were put in place to obtain a relatively stable dysphoric population. During the experimental design phase of the research, the DSM-IV criteria for a depressive episode were discussed. The minimal criteria for a depressive episode are feelings of negative mood, or loss of pleasure or interest in normally enjoyable activities for a minimum period of two weeks. Participants were contacted with this criteria in mind, these two criteria were stated clearly on both poster and e-mail advertisements which were placed through out the university campus. Furthermore, on first contact with participants (usually via e-mail) these selection criteria were restated. Secondly scores on the Beck Depression Inventory-II were recorded during the experimental session as an index of negative mood. This questionnaire asks participants to evaluate their mood over a two week period and questions were formulated to concur with the DSM-IV diagnostic criteria for a depressive episode. Despite these control procedures, these experiments should be replicated with a clinically depressed sample before any further conclusions can be drawn.

It is interesting to note that differences between non-dysphoric and dysphoric individuals were identified during complex processing, indicating that these changes are not dependent on the experience of clinical depression. Investigating psychological processes across populations which increase in the severity of the negative mood being experienced would help clarify if depression is a spectrum disorder or a specific form of psychopathology.

Therefore it is important to consider findings from experiments conducted with all three populations when discussing clinical depression. It would be expected that if the present set of experiments were conducted with a clinically depressed population then these individuals would show even greater changes in self-referential processing, with a possible reversal of the self-positivity bias. It is also expected that these individuals would also show changes in other forms of emotional processing not just self-reference.

As stated above, the BDI-II was employed as a measure of negative mood within the present study. The BDI-II shows good divergent validity with some measures of other psychopathologies, such as anxiety (Beck et al., 1996; Osman et al., 1997). However, other indices of anxiety have shown a moderate correlation with the BDI-II; for example, the Beck Anxiety Inventory (r = 0.60) (Beck et al., 1996). As no measure of anxiety was recorded within the present research, it is not possible to determine if the differences between non-dysphoric and dysphoric individuals are the result of changes in ruminative or anxiety based thinking, or indeed, a combination of changes in both types of thinking. Williams et al., (1997) proposed that anxiety is associated with impairments during the early stages of processing, whereas depression is associated with impairments during the later stages of processing. Therefore, this restriction is particularly relevant to the finding that differences in the ERP waveforms of non-dysphoric and dysphoric individuals were identified during both early and late time intervals. Further research investigating differences in non-dysphoric and dysphoric individuals should employ measures of both negative mood and anxiety. This type of research is important for two reasons. Firstly, it would help clarify whether it is negative mood or high levels of anxiety which are driving the behavioural and ERP effects identified within the present research. Secondly, it would also help clarify if the differences identified within ERP waveforms at both early and late time intervals have common origins, or if they are influenced by different aspects of a dysphoric mood.

8.7: Future Directions

The results of the research and the theoretical framework presented lead to the formulation of future research questions. This section will present a number of future research directions which could extend this line of research further.

8.7.1: An evaluation of the model of self-referential processing

One important direction for future research is to evaluate the model of self-referential processing proposed within the present thesis. The research conducted within the present thesis represents the first set of experiments to use ERPs to investigate self-referential processing. In order to ensure the reliability and validity of the findings identified presently, these findings should be replicated. This would provide further evidence to support the two stage model of self-referential processing identified, and the changes in this model associated with negative mood.

In Figure 8.1 two dashed lines represent features of the model which were not examined within the present thesis. One of these features is the engagement of the self-representation in a contextually rich environment. In the model of self-referential processing it was proposed that as higher levels of attention are devoted to decision-making, or greater feedback is provided by the environment, self-referential processing should become less dependent on the emotional valence of incoming information. This could be tested by comparing two groups of participants on a self-referential decision-making task and asking one group to explicitly attend to their self-representation. An experiment could be conducted in which one group of participants are asked to make self-referential decisions to personality adjectives and also supplement this decision with three behavioural examples from their memory. In this experiment, the model would predict that a reduction in the self-positivity bias would be evident for the engagement group when compared to group who were not asked to explicitly engage with their self-representation.

A second component of the self-reference model which has not been investigated is the feedback loop from the elaboration of self-reference and emotional valence to the physiological responses within the affective system. As discussed in Chapter Six (see Section 6.4.2.2), although no differences between physiological responses were identified across the self-reference and emotion tasks, individuals did show increased skin conductance responses to words rated as 'like me' and positive in the self-reference and emotional valence tasks respectively. Based on previous research, this finding provides some tentative evidence that information from the self-representation is fed back into the affective system. However, it would be interesting to investigate this result in more detail. As discussed in Chapter Six one way of investigating this would be to focus on one specific dimension of the self-representation such as independence. By asking individuals who identify with trait of independence it would be possible to identify if these individuals show increased physiological arousal to word stimuli which have been incorporated into their self-representation. If independent individuals showed greater arousal to independence related adjectives, whereas dependent individuals showed greater arousal to dependence related adjectives then this would provide some evidence to suggest that information from the self-representation is fed back into basic emotional responses within the affective system.

8.7.2: An evaluation of the model of self-referential processing in depression

As stated in Section 8.6, the tentative model of self-referential processing during depression is based on the differences identified during self-referential processing between non-dysphoric and dysphoric individuals. Therefore, before any further conclusions can be drawn, the experiments conducted within the present thesis should also be examined in individuals who are currently classified as experiencing a depressive episode. This research would not only tell us more about the representation of self during depression, it would also provide us with a continuum of ordered to disorder cognition.

It would also be useful to further investigate the neural mechanisms which underlie the self-positivity bias using self-focus or mood induction procedures. Using these techniques it would be possible to identify the parameters of the neural correlate of the self-positivity bias. Would a positive mood induction lead to an enhancement of this bias and a negative mood induction result in an impairment? In this way it would be possible to investigate the effects of transitory mood states on the self-positivity bias. If these findings were then compared to research conducted with clinically depressed individuals it may be possible to separate the effects of transitory mood states and stable mood states on both the behavioural and psychophysiological correlates of the self-positivity bias.

8.8: General Conclusions

This final chapter presented an overall view of the results obtained in the previous experimental chapters. Based on these results, a model of self-referential processing was proposed, which considered the responses made during self-referential processing across several levels of the psychophysiological system. This model was developed to account for the experience of self-referential processing during normal mood and also during the experience of negative mood. This model was then compared to a number of more general theories of cognition and emotional experience. This comparison illustrated that the model is in line with the current explanations of cognitive processing within a broad psychophysiological system. Furthermore it highlighted the reciprocal relationship between micro and macro theories of cognition. The current model of self-referential processing can be employed to develop testable experimental hypotheses in relation to self-representation which can then be used to further inform macro theories of cognition. In contrast, macro theories of cognition can provide a powerful explanation of the core of our conscious experience and an overall understanding of our sense of self.

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List of Appendices

Appendix I

The Revised Beck Depression Inventory – II
(See overleaf)

Due to copyright issues the BDI-II has not been included in the electronic version of the present thesis. For further information regarding this questionnaire see the following reference:

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *BDII-manual.* New York: The Psychological Corporation.

Appendix II

Test of Word Reading Efficiency: Subtest 1
(See overleaf)

1. Is	27. Work	53. Crowd	79. Uniform
2. Up	28. Jump	54. Better	80. Necessary
3. Cat	29. Part	55. Inside	81. Problems
4. Red	30. Fast	56. Plane	82. Absentee
5. Me	31. Fine	57. Pretty	83. advertise
6. To	32. Milk	58. Famous	84. Pleasant
7. No	33. Back	59. Children	85. Property
8. We	34. Lost	60. Without	86. Distress
9. He	35. Find	61. Finally	87. Information
10. The	36. Paper	62. Strange	88. Recession
11. And	37. Open	63. Budget	89. Understand
12. Yes	38. Kind	64. Repress	90. Emphasis
13. Of	39. Able	65. Contain	91. Confident
14. Him	40. Shoes	66. Justice	92. Intuition
15. As	41. Money	67. Morning	93. Boisterous
16. Book	42. Great	68. Resolve	94. Plausible
17. Was	43. Father	69. Describe	95. Courageous
18. Help	44. River	70. Garment	96. Alienate
19. Then	45. Space	71. Business	97. Extinguish
20. Time	46. Short	72. Qualify	98. Prairie
21. Wood	47. Left	73. Potent	99. Limousine
22. Let	48. People	74. Collapse	100. Valentine
23. Men	49. Almost	75. Elements	101. Detective
24. Baby	50. Waves	76. Pioneer	102. Recently
25. New	51. Child	77. Remember	103. Instruction
26. Stop	52. Strong	78. Dangerous	104. Transient

Number of word read correctly _______

If examinee finishes list before 45 seconds, not time to finish ________

Appendix III

The word stimuli presented in the National Adult Reading Test

Word
1. CHORD
2. ACHE
3. DEPOT
4. AISLE
5. BOUQUET
6. PSALM
7. CAPON
8. DENY
9. NAUSEA
10. DEBT
11. COURTEOUS
12. RAREFY
13. EQUIVOCAL
14. NAÏVE
15. CATACOMB
16. GAOLED
17. THYME
18. HEIR
19. RADIX
20. ASSIGNATE
21. HIATUS
22. SUBTLE
23. PROCREATE
24. GIST
25. GOUGE

Word
26. SUPERFLUOUS
27. SIMILE
28. BANAL
29. QUADRUPED
30. CELLIST
31. FAÇADE
32. ZEALOT
33. DRACHM
34. AEON
35. PLACEBO
36. ABSTEMIOUS
37. DÉTENTE
38. IDYLL
39. PUERPERAL
40. AVER
41. GAUCHE
42. TOPIARY
43. LEVIATHAN
44. BEATIFY
45. PRELATE
46. SIDEREAL
47. DEMESNE
48. SYNCOPE
49. LABILE
50. CAMPANILE

Words are presented to the participants on individual cards, in order of difficulty from word number one to word number fifty.

Appendix IV

395 words selected from previous research for use in the pilot study

Word	Valence
Accident	Negative
Agony	Negative
Ashamed	Negative
Awful	Negative
Bad	Negative
Betray	Negative
Blackmail	Negative
Blame	Negative
Bored	Negative
Boring	Negative
Coward	Negative
Death	Negative
Debt	Negative
Defeated	Negative
Depressed	Negative
Despise	Negative
Discourage	Negative
Disgusted	Negative
Disliked	Negative
Displeased	Negative
Distressed	Negative
Dreadful	Negative
Dreary	Negative
Drown	Negative
Dumb	Negative
Enraged	Negative
Fault	Negative

Word	Valence
Hurt	Negative
Immature	Negative
Inadequate	Negative
Incapable	Negative
Incompetent	Negative
Inferior	Negative
Insecure	Negative
Isolated	Negative
Jail	Negative
Jealousy	Negative
Leprosy	Negative
Loneliness	Negative
Lonely	Negative
Mad	Negative
Malaria	Negative
Massacre	Negative
Miserable	Negative
Misery	Negative
Mistake	Negative
Nervous	Negative
Obesity	Negative
Pathetic	Negative
Pollute	Negative
Prison	Negative
Punishment	Negative
Pus	Negative
Rabies	Negative

Fearful	Negative
Foolish	Negative
Foul	Negative
Germs	Negative
Gloom	Negative
Gloomy	Negative
Grave	Negative
Guilty	Negative
Helpless	Negative
Hopeless	Negative
Hostage	Negative
Humiliate	Negative
Humiliated	Negative
Humiliation	Negative
Word	**Valence**
Terrified	Negative
Tired	Negative
Toxic	Negative
Toothache	Negative
Torture	Negative
Tragic	Negative
Traitor	Negative
Ugly	Negative
Ulcer	Negative
Uneasy	Negative
Unhappy	Negative
Unpopular	Negative
Unwanted	Negative
Upset	Negative
Useless	Negative
Weakness	Negative
Wicked	Negative
Worse	Negative
Worthless	Negative
Abrupt	Neutral
Absence	Neutral
Adjusted	Neutral
Anxious	Neutral
Appliance	Neutral
Banner	Neutral
Bathe	Neutral
Bench	Neutral
Bereavement	Neutral
Bland	Neutral
Bread	Neutral
Bunch	Neutral

Rage	Negative
Regretful	Negative
Rejected	Negative
Sad	Negative
Seasick	Negative
Silly	Negative
Sinful	Negative
Slum	Negative
Smallpox	Negative
Solemn	Negative
Stupid	Negative
Suffering	Negative
Suffocate	Negative
Sulking	Negative
Word	**Valence**
Context	Neutral
Cork	Neutral
Corner	Neutral
Corridor	Neutral
Costly	Neutral
Deputy	Neutral
Desolate	Neutral
Door	Neutral
Engine	Neutral
Entirely	Neutral
Equivalent	Neutral
Expert	Neutral
Extreme	Neutral
Fabric	Neutral
Fashion	Neutral
Finger	Neutral
Foot	Neutral
Furnishing	Neutral
Gene	Neutral
Gigantic	Neutral
Graphite	Neutral
Grass	Neutral
Habit	Neutral
Hairdryer	Neutral
Hay	Neutral
Headquarters	Neutral
Hospital	Neutral
Hydrant	Neutral
Icebox	Neutral
Imperative	Neutral
Imported	Neutral

Butter	Neutral
Cabinet	Neutral
Catalogue	Neutral
Causal	Neutral
Chin	Neutral
Civilian	Neutral
Clock	Neutral
Closer	Neutral
Clumsy	Neutral
Coast	Neutral
Cohesive	Neutral
Column	Neutral
Composite	Neutral
Consoled	Neutral
Word	**Valence**
Lawn	Neutral
Lazy	Neutral
Library	Neutral
Lion	Neutral
Locker	Neutral
Lodge	Neutral
Manner	Neutral
Mantel	Neutral
Material	Neutral
Medicine	Neutral
Medium	Neutral
Mild	Neutral
Moderate	Neutral
Monastic	Neutral
Muddy	Neutral
Museum	Neutral
Mysterious	Neutral
Naval	Neutral
Nearest	Neutral
Noisy	Neutral
Nonchalant	Neutral
Nursery	Neutral
Obey	Neutral
Occasion	Neutral
Office	Neutral
Okay	Neutral
Onion	Neutral
Package	Neutral
Pamphlet	Neutral
Part	Neutral
Pedestrian	Neutral

Incorporate	Neutral
Inflated	Neutral
Initial	Neutral
Ink	Neutral
Inorganic	Neutral
Internal	Neutral
Item	Neutral
Jelly	Neutral
Kerosene	Neutral
Ketchup	Neutral
Kettle	Neutral
Kitchen	Neutral
Ladder	Neutral
Lantern	Neutral
Word	**Valence**
Reprint	Neutral
Reserved	Neutral
Resident	Neutral
Resistant	Neutral
Revised	Neutral
Rhythm	Neutral
Rough	Neutral
Runner	Neutral
Scissors	Neutral
Search	Neutral
Seated	Neutral
Serviette	Neutral
Shallow	Neutral
Short	Neutral
Shy	Neutral
Sideboard	Neutral
Slush	Neutral
Sometimes	Neutral
Spacious	Neutral
Spray	Neutral
Stagnant	Neutral
Startled	Neutral
Statue	Neutral
Stiff	Neutral
Street	Neutral
Table	Neutral
Tamper	Neutral
Tank	Neutral
Teacher	Neutral
Terminology	Neutral
Theatre	Neutral

Pencil	Neutral
Pendulum	Neutral
Pertinent	Neutral
Phase	Neutral
Pianist	Neutral
Pig	Neutral
Pottery	Neutral
Primitive	Neutral
Quart	Neutral
Raincoat	Neutral
Rapid	Neutral
Recipe	Neutral
Refund	Neutral
Related	Neutral
Word	**Valence**
Yellow	Neutral
Youngest	Neutral
Achievement	Neutral
Admirable	Neutral
Admired	Positive
Alert	Positive
Amazed	Positive
Amusing	Positive
Applause	Positive
Aroused	Positive
Attentive	Positive
Attractive	Positive
Bath	Positive
Bright	Positive
Cake	Positive
Calm	Positive
Capable	Positive
Car	Positive
Carefree	Positive
Careful	Positive
Caring	Positive
Cash	Positive
Champ	Positive
Champion	Positive
Charming	Positive
Cheer	Positive
Cheerful	Positive
Clever	Positive
Competent	Positive
Confident	Positive
Considerate	Positive

Thermometer	Neutral
Totally	Neutral
Trumpet	Neutral
Trunk	Neutral
Twelve	Neutral
Umbrella	Neutral
Uncle	Neutral
Upright	Neutral
Vanity	Neutral
Village	Neutral
Wagon	Neutral
Whistle	Neutral
Wildlife	Neutral
Window	Neutral
Word	**Valence**
Euphoric	Positive
Excellence	Positive
Excited	Positive
Exhilarated	Positive
Flirt	Positive
Freedom	Positive
Friendly	Positive
Fun	Positive
Generous	Positive
Glorious	Positive
Glory	Positive
Good	Positive
Grateful	Positive
Greet	Positive
Happy	Positive
Honour	Positive
Hopeful	Positive
House	Positive
Incentive	Positive
Intelligent	Positive
Intimate	Positive
Joke	Positive
Jolly	Positive
Joy	Positive
Jubilant	Positive
Kind	Positive
Kiss	Positive
Knowledge	Positive
Laughter	Positive
Lively	Positive
Love	Positive

Cosy	Positive
Creative	Positive
Dazzle	Positive
Desire	Positive
Devoted	Positive
Diamond	Positive
Dog	Positive
Eager	Positive
Easy	Positive
Elated	Positive
Eloquent	Positive
Enjoyment	Positive
Entertaining	Positive
Enthusiastic	Positive
Word	**Valence**
Popular	Positive
Pretty	Positive
Profit	Positive
Promotion	Positive
Proud	Positive
Rainbow	Positive
Relieved	Positive
Saviour	Positive
Scholar	Positive
Sexy	Positive
Ski	Positive
Skilful	Positive
Sky	Positive
Smart	Positive
Smile	Positive
Snuggle	Positive
Soothe	Positive
Spirit	Positive
Spouse	Positive
Star	Positive
Success	Positive
Successful	Positive
Sunny	Positive
Sunrise	Positive
Sweetheart	Positive
Talent	Positive
Tender	Positive
Terrific	Positive
Toy	Positive
Triumphant	Positive
Trophy	Positive

Loveable	Positive
Loving	Positive
Lucky	Positive
Luscious	Positive
Masterful	Positive
Memories	Positive
Merry	Positive
Orgasm	Positive
Outdoors	Positive
Paradise	Positive
Peaceful	Positive
Pillow	Positive
Pleasant	Positive
Pleased	Positive

Trustworthy	Positive
Unselfish	Positive
Untroubled	Positive
Wealthy	Positive
Win	Positive
Wit	Positive
Witty	Positive

Appendix V

Characteristics of the three word categories employed within the experimental chapters

Words	**Word Category**	**Word Length**	**Word Frequency (occurrences per million)**	**Word Type**	**Self-Rating**	**Emotion Rating**
Absence	ns-neg	7	5.78	Noun	2.43	1.89
Accident	ns-neg	8	6.399	Noun	2.4	1.88
Agony	ns-neg	5	0.914	Noun	2.03	1.25
Anxious	ns-neg	7	3.083	Verb	1.89	1.89
Bereavement	ns-neg	11	0.337	Noun	1.64	1.64
Betray	ns-neg	6	0.256	Verb	1.7	1.43
Blackmail	ns-neg	9	0.242	noun	1.81	1.55
Blame	ns-neg	5	0.777	noun	2.49	1.7
Bored	ns-neg	5	0.832	verb	2.45	1.95
Coward	ns-neg	6	0.161	noun	2.34	1.57
Death	ns-neg	5	20.061	noun	2.09	1.54
Debt	ns-neg	4	4.798	noun	2.44	1.54
Despise	ns-neg	7	0.075	verb	2.24	1.29
Discourage	ns-neg	10	0.411	verb	2.27	1.85
Disliked	ns-neg	8	0.44	noun	2.29	1.59
Displeased	ns-neg	10	0.063	verb	2.15	1.67
Distress	ns-neg	10	0.214	verb	2.46	1.47
Drown	ns-neg	5	0.289	verb	1.28	1.28
Germs	ns-neg	5	0.11	noun	1.89	1.59
Gloom	ns-neg	5	0.816	noun	2.11	1.41
Grave	ns-neg	5	0.75	noun	2.15	1.65
Hospital	ns-neg	8	13.79	noun	2.25	2.25

Hostage	ns-neg	7	0.276	noun	2.05	1.42
Humiliated	ns-neg	10	0.108	noun	2.19	1.4
Humiliation	ns-neg	11	0.587	noun	2.25	1.37
Isolated	ns-neg	8	2.813	adjective	1.4	1.4
Jail	ns-neg	4	1.068	noun	1.46	1.39
Jealousy	ns-neg	8	0.713	noun	2.46	1.39
Lazy	ns-neg	6	0.802	adjective	2.47	1.74
Leprosy	ns-neg	7	0.071	noun	1.3	1.3
Loneliness	ns-neg	10	0.571	adjective	1.39	1.39
Lonely	ns-neg	8	1.753	adjective	2.36	1.46
Mad	ns-neg	3	3.149	adjective	2.35	2.22
Massacre	ns-neg	8	0.51	noun	1.54	1.45
Miserable	ns-neg	9	1.193	adjective	1.4	1.4
Misery	ns-neg	6	1.266	noun	2	1.23
Muddy	ns-neg	5	0.633	adjective	2.49	2.32
Obesity	ns-neg	7	0.189	noun	1.7	1.36
Pathetic	ns-neg	8	0.635	adjective	1.42	1.42
Pig	ns-neg	3	1.047	noun	2.11	2.41
Primitive	ns-neg	9	1.149	adjective	2.25	2.39
Prison	ns-neg	6	6.421	noun	1.55	1.55
Pus	ns-neg	3	0.091	noun	1.8	1.68
Rabies	ns-neg	6	0.082	noun	1.68	1.34
Rage	ns-neg	4	1.063	noun	2.37	1.49
Regretful	ns-neg	9	0.063	adjective	2.41	1.8
Rejected	ns-neg	8	0.17	adjective	1.17	1.17
Rough	ns-neg	5	3.311	adjective	2.23	2.16
Sad	ns-neg	3	3.439	adjective	2.4	1.52
Seasick	ns-neg	7	0.041	adjective	1.7	1.7
Shallow	ns-neg	7	1.406	adjective	2.07	1.41
Short	ns-neg	6	13.547	adjective	2.43	2.43
Shy	ns-neg	3	1.072	adjective	2.11	2.3
Sinful	ns-neg	6	0.185	adjective	1.7	1.7
Slum	ns-neg	4	0.279	noun	1.84	1.58
Smallpox	ns-neg	8	0.16	noun	1.69	1.32
Solemn	ns-neg	6	0.474	adjective	2.32	2.49
Stagnant	ns-neg	5	0.226	adjective	2.49	2.16
Startled	ns-neg	6	0.2	adjective	2.31	2.22
Stupid	ns-neg	6	3.207	adjective	1.51	1.51
Suffering	ns-neg	9	2.663	noun	1.81	1.15

Tamper	ns-neg	8	0.038	noun	2.32	2.2
Terrified	ns-neg	9	0.161	adjective	2.27	1.66
Toothache	ns-neg	9	0.092	noun	1.95	1.48
Toxic	ns-neg	5	1.177	adjective	1.4	1.4
Tragic	ns-neg	6	1.216	adjective	1.98	1.16
Traitor	ns-neg	7	0.241	noun	1.59	1.2
Ugly	ns-neg	4	1.365	adjective	2.48	1.47
Ulcer	ns-neg	5	0.991	noun	1.56	1.35
Uneasy	ns-neg	7	0.978	adjective	2.22	1.68
Unhappy	ns-neg	7	1.901	adjective	1.78	1.39
Unpopular	ns-neg	9	0.642	adjective	2.34	1.4
Unwanted	neutral	8	0.81	adjective	2.3	1.43
Upset	ns-neg	5	0.408	adjective	2.49	1.55
Useless	ns-neg	7	1.305	adjective	2.34	1.5
Vanity	ns-neg	5	0.334	noun	2.47	2.02
Weakness	ns-neg	8	1.727	adjective	2.34	1.7
Wicked	ns-neg	6	1.046	adjective	1.89	1.65
Worse	ns-neg	5	6.258	adjective	2.41	1.39
Worthless	ns-neg	9	0.356	adjective	1.61	1.3
Banner	neutral	6	0.531	noun	2.96	3.2
Bath	neutral	4	2.655	noun	3.46	3.46
Bench	neutral	5	1.667	noun	2.82	3.03
Bread	neutral	5	3.179	noun	2.88	3.32
Bunch	neutral	4	1.194	verb	2.81	3.08
Butter	neutral	6	1.977	verb	2.75	2.93
Causal	neutral	6	1.163	adjective	2.96	2.98
Chin	neutral	4	1.569	noun	2.92	2.98
Clock	neutral	8	2.785	noun	2.94	3.13
Composite	neutral	9	0.591	adjective	2.93	2.98
Context	neutral	7	8.453	noun	2.82	2.84
Cork	neutral	4	0.266	noun	2.81	3.34
Corner	neutral	8	7.177	noun	2.53	2.53
Door	neutral	4	25.36	adjective	2.95	3.13
Easy	neutral	4	1.089	adjective	3.03	3.4
Engine	neutral	6	5.005	noun	3.06	3.06
Equivalent	neutral	6	1.448	adjective	2.96	3.29
Extreme	neutral	7	3.062	adjective	3.08	3.08
Finger	neutral	6	3.209	verb	2.96	3.16
Foot	neutral	4	7.141	noun	2.84	2.87

Gigantic	neutral	8	0.391	adjective	2.53	3.19
Habit	neutral	6	2.314	noun	3.16	2.77
Imperative	neutral	10	0.237	adjective	2.72	2.85
Imported	neutral	8	0.507	verb	2.85	3.05
Incorporated	neutral	11	0.052	verb	2.93	2.91
Initial	neutral	7	4.371	adjective	3.02	3.25
Ink	neutral	3	0.63	noun	2.7	3
Inorganic	neutral	9	0.22	adjective	2.57	2.54
Internal	neutral	8	6.721	adjective	3.2	3
Kitchen	neutral	8	8.244	noun	2.8	3.16
Lantern	neutral	7	0.218	noun	2.9	3.27
Library	neutral	7	8.206	noun	2.71	2.92
Lion	neutral	4	0.96	noun	2.75	3.09
Locker	neutral	8	0.239	noun	2.94	2.94
Manner	neutral	6	6.063	noun	3.31	3.47
Material	neutral	8	11.084	adjective	3.18	2.98
Mild	neutral	4	1.444	adjective	3.26	3.26
Moderate	neutral	8	0.79	adjective	2.95	3.21
Monastic	neutral	8	0.435	adjective	2.58	2.67
Mysterious	neutral	10	1.336	adjective	2.88	3.58
Naval	neutral	5	1.5	adjective	2.89	3.2
Nearest	neutral	7	1.988	adjective	3.07	3.5
Noisy	neutral	5	1.023	adjective	3.05	2.55
Nonchalant	neutral	10	0.065	adjective	2.92	2.97
Obey	neutral	4	0.158	verb	3.07	2.77
Okay	neutral	5	1.334	adjective	3.54	3.2
Onion	neutral	5	0.657	noun	2.66	2.79
Pedestrian	neutral	10	0.485	adjective	3.06	3.06
Pencil	neutral	6	1.146	noun	3.04	3.04
Pendulum	neutral	6	0.216	noun	2.89	2.89
Pertinent	neutral	9	0.269	adjective	2.96	2.98
Phase	neutral	6	4.628	noun	2.93	2.7
Pianist	neutral	7	0.325	noun	2.71	3.32
Raincoat	neutral	8	0.255	noun	2.89	3
Rapid	neutral	5	3.417	adjective	2.9	3.31
Related	neutral	7	2.155	adjective	3.32	3.39
Reprint	neutral	7	0.05	noun	2.68	2.78
Reserved	neutral	8	0.22	adjective	2.91	2.89
Resident	neutral	10	0.851	noun	2.82	3.05

Resistant	neutral	9	0.002	adjective	2.85	2.7
Search	neutral	6	4.363	verb	3.15	3.32
Seated	neutral	6	0.136	noun	3.15	3.07
Silly	neutral	5	2.828	adjective	3.09	2.89
Slush	neutral	5	0.06	noun	2.52	2.63
Sometime	neutral	9	20.517	adjective	3.13	2.81
Spray	neutral	5	0.673	noun	2.81	2.93
Statue	neutral	6	0.823	noun	2.86	3.22
Stiff	neutral	7	0.827	adjective	2.5	2.59
Street	neutral	6	9.511	noun	3.02	3.11
Thermometer	neutral	11	0.137	noun	2.76	3.2
Totally	neutral	7	5.807	verb	3.17	3.48
Trophy	neutral	6	0.905	noun	2.95	3.5
Trumpet	neutral	7	0.264	noun	2.53	3.44
Trunk	neutral	5	0.659	noun	2.63	2.83
Upright	neutral	7	0.307	adjective	3.25	3.5
Village	neutral	7	10.31	noun	2.88	3.16
Wagon	neutral	5	0.476	noun	2.82	2.98
Youngest	neutral	8	1.183	adjective	3.21	3.25
Achievement	self-pos	11	3.031	noun	4.3	4.7
Adjusted	self-pos	8	0.256	verb	3.51	3.66
Admirable	self-pos	9	0.457	adjective	3.51	4.47
Admired	self-pos	7	0.569	verb	3.52	4.44
Alert	self-pos	5	0.676	adjective	3.51	3.82
Amazed	self-pos	7	0.334	verb	3.61	3.77
Amusing	self-pos	7	0.618	adjective	4.26	4.26
Applause	self-pos	8	0.485	noun	3.7	4.31
Aroused	self-pos	7	0.376	verb	3.5	4.34
Attentive	self-pos	9	0.255	adjective	3.78	4.17
Attractive	self-pos	10	5.152	adjective	3.51	4.39
Bathe	self-pos	5	0.099	verb	3.56	3.62
Bright	self-pos	4	5.442	adjective	4.04	4.39
Cake	self-pos	4	2.796	noun	3.56	3.88
Calm	self-pos	6	1.011	adjective	3.87	4.29
Capable	self-pos	7	4.943	adjective	4	4.5
Car	self-pos	3	7.798	noun	3.62	3.62
Carefree	self-pos	8	0.178	adjective	3.67	3.77
Careful	self-pos	7	5.218	adjective	3.61	3.96
Caring	self-pos	6	1.011	verb	3.87	4.45

Cash	self-pos	4	8.125	noun	3.54	3.96
Charming	self-pos	8	1.376	adjective	3.67	4.24
Cheer	self-pos	5	0.244	noun	3.73	4.46
Cheerful	self-pos	8	1.144	adjective	3.95	4.75
Clever	self-pos	6	2.357	adjective	4.19	4.5
Closer	self-pos	6	2.333	adjective	3.89	3.89
Coast	self-pos	5	3.736	noun	3.63	3.73
Competent	self-pos	9	0.131	adjective	3.66	4.25
Confident	self-pos	9	3.242	adjective	4.64	4.64
Consider	self-pos	11	0.216	adjective	4.09	4.54
Consoled	self-pos	8	0.066	verb	3.54	3.57
Cosy	self-pos	4	0.63	adjective	3.95	4.4
Creative	self-pos	8	2.444	adjective	3.5	4.34
Dazzle	self-pos	6	0.058	verb	3.51	3.84
Desire	self-pos	6	4.91	noun	4.02	4.02
Devoted	self-pos	7	0.544	adjective	3.89	4.41
Diamond	self-pos	7	1.061	noun	3.56	4.29
Eager	self-pos	5	1.432	adjective	4.02	4.02
Elated	self-pos	6	0.049	adjective	3.76	4.13
Eloquent	self-pos	11	0.211	adjective	3.74	3.74
Enjoyment	self-pos	9	1.026	noun	4.18	4.68
Entertainment	self-pos	12	0.136	adjective	4.19	4.5
Enthusiastic	self-pos	12	1.419	adjective	3.83	4.69
Euphoric	self-pos	8	0.08	adjective	3.98	4.48
Excellent	self-pos	10	0.704	noun	3.54	4.55
Excited	self-pos	7	0.525	adjective	4.34	4.34
Exhilarated	self-pos	11	0.027	adjective	3.56	4.25
Expert	self-pos	6	1.206	noun	4.19	4.19
Faithful	self-pos	8	0.95	adjective	4.18	4.36
Fantasy	self-pos	7	1.252	noun	3.96	4.02
Festive	self-pos	7	0.39	adjective	3.98	4.57
Flirt	self-pos	5	0.036	adjective	3.53	3.76
Freedom	self-pos	7	6.042	adjective	4	4.57
Friendly	self-pos	8	4.058	adjective	4.29	4.83
Fun	self-pos	3	2.376	noun	3.98	4.85
Generous	self-pos	8	2.307	adjective	3.95	4.47
Honour	self-pos	6	1.95	noun	3.71	4.53
Joke	self-pos	4	2.019	noun	4.19	4.19
Joy	self-pos	3	2.392	noun	4.58	4.58

Kiss	self-pos	4	1.355	noun	4.04	4.61
Knowledge	self-pos	9	14.586	noun	3.7	4.45
Love	self-pos	4	12.093	noun	4.31	4.62
Loving	self-pos	6	0.518	noun	4.93	4.93
Medicine	self-pos	8	2.344	noun	3.54	3.74
Memories	self-pos	8	2.633	noun	3.77	3.87
Occasion	self-pos	8	5.274	noun	3.5	3.57
Profit	self-pos	6	5.39	noun	3.65	4.15
Promotion	self-pos	9	3.142	noun	4.45	4.45
Rainbow	self-pos	7	0.421	noun	3.56	4.32
Rhythm	self-pos	6	1.475	noun	3.64	3.82
Runner	self-pos	6	0.644	noun	3.52	3.52
Scholar	self-pos	7	0.704	noun	3.61	3.77
Sky	self-pos	3	4.956	noun	3.56	3.88
Smile	self-pos	5	6.124	noun	4.11	4.36
Spirit	self-pos	6	6.473	noun	4.07	4.07
Sweetheart	self-pos	9	0.144	noun	3.55	4.58
Talent	self-pos	6	2.095	noun	4.02	4.48
Tender	self-pos	6	1.116	noun	4.08	4.08
Toy	self-pos	3	0.524	noun	3.74	3.95
Wildlife	self-pos	8	1.956	noun	3.52	3.98

Ns-neg = non-self-negative word category, self-pos = self-positive word category. Emotionality and Self-Reference ratings were obtained from the pilot study (see Section 2.5). Word Frequency information taken from the British National Corpus (http://www.natcorp.ox.ac.uk/).