# Heideggerian Phenomenology and the Electrophysiological Correlates of Consciousness

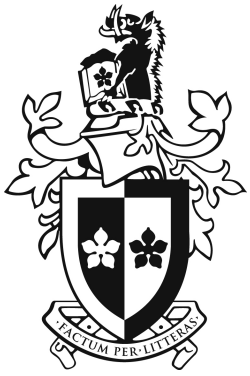
# Heideggerian Phenomenology and the Electrophysiological Correlates of Consciousness

A thesis submitted for the degree of Doctor of Philosophy

by

Kaelasha Cameron David Tyler

Centre for Human Psychopharmacology
Swinburne University of Technology
Melbourne, Victoria, Australia
2019



# Abstract

Over recent years, numerous theoretical and empirical approaches have sought to situate consciousness within an understanding of the spatially extended physical processes of nature. However, such approaches often begin with a naïve phenomenology and proceed to base scientific theory and empirical research around this. As such, much of the science has imported philosophical assumptions and biases about the nature and existence of consciousness into its research paradigms. Even while decrying Cartesian dualism, the brain sciences throughout the later twentieth century have continued to entrench a characterization of consciousness as being a unit of subjectivity that is enclosed within the psychical domain of its own representations.

This thesis draws on the works of Heidegger in order to examine and provide alternatives to this traditional characterization of consciousness. Heidegger presents human experience as existing in such a way that dissolves the traditionally conceived dichotomies between self and world, within and without, and ultimately between ipseity and alterity. On this basis Heideggerian thought is drawn on to motivate a theoretical approach to qualitative experience. Broadly qualitative human experience is suggested to exist as a unified gestalt of conscious and non-conscious content and processes arising as a singular phenomenon. Within this theoretical orientation, qualitative experience is hypothesized to exist in a way that is representationally opaque or evasive. That is, it is suggested that qualitative experience is not itself able to be treated as any sort of object that could be represented 'in consciousness' in its entirety. Problematic issues that arise when using Heidegger to motivate consciousness theory are also addressed.

Four experiments are constructed in an attempt to provide evidence in support of such a hypothesis. Experiments 1 and 2 take an initial step towards using the mathematics of nonlinear dynamical systems and circular causality. Circular causality is treated as a mathematical analogue to the model of qualitative experience as a reciprocally causal relationship between conscious and non-conscious processes. As an initial step, these experiments examine the EEG time-locked to the emergence of a perceptual event for the presence of Alpha-Beta synchrony, a proxy of non-linearity. The strength of Alpha-Beta synchrony in the EEG is compared between conditions in which a visual stimulus is either perceived or not perceived. Results of these experiments revealed an increase in alpha-beta synchrony in the EEG for perceived compared to not perceived conditions in line with our contention that the non-linear architecture of brain activity is modified in response to conscious perception.

Experiments 3 and 4 examine the interaction of conscious and non-conscious processes during a time window of neural activity that correlates with conscious perception. The basis for such a temporal window is taken from the Global Neuronal Work Space (GNWS) model. According to this model, consciousness correlates with an abrupt nonlinear and categorical transition between early feed forward non-conscious processes, and a late amplified re-entrant loop of global cortical activity which occurs around 300 ms after the presentation of a given stimulus. In contrast to previous attempts, experiments 3 and 4 examine the interaction between simultaneously occurring conscious and nonconscious processes. Experiment 3 was a behavioural experiment that examined the interaction of the semantic content of conscious and non-conscious processes in terms of reaction times and error rates. Experiment 4 examined the interaction of the semantic content of conscious and non-conscious processes through use of an N400 evoked field paradigm. Invisible masked prime words were paired with visible target pictures in conditions for which the word-picture pair was either semantically congruent or semantically incongruent.

The results of experiment 3 revealed that reaction times and error rates did not differ across conditions, and therefore provided no evidence of any interaction between the semantic content of conscious and non-conscious processes. In contrast, the electrophysiological results of experiment 4 did show some evidence for such an effect. Significant increases in the amplitude of the evoked fields were observed in the case of semantically incongruent stimuli pairs when compared to semantically congruent pairings, when utilising a cluster based permutation analysis ($p = 0.04$). When comparing neuronal activity generated in the Congruent and Incongruent conditions, recorded over left hemisphere sensors, a cluster based permutation analysis found one significant negative cluster ($p=0.04$). Specifically, this effect was observed in activity recorded over the left hemisphere in response to the simultaneous presentation of visible and invisible stimuli pairs. This N400 effect is most parsimoniously explained as having arisen from the interactions of simultaneously occurring conscious and non-conscious processes.

These results present some support for a view in which the structure of qualitative experience could be thought to cross or subsume the division between what is traditionally conceptualised as conscious and non-conscious processes. In this way, some steps are taken towards validating a view in which qualitative experience exhibits its non-conscious ontologically primary conditions, in its way of existing *as* experience. Such findings argue against a conceptualisation of consciousness as an isolated unit of subjectivity that stands ontologically apart from a non-conscious material 'reality' and merely represents that objective 'reality' within itself.

# Acknowledgments

I'd like to acknowledge the patience and support of my primary supervisor Professor David Liley, without whom this thesis would not have come to completion. I am genuinely grateful for David's willingness to support my interest in pursuing the particular topic of this thesis and have always found David to be a good friend and ally.

I would also like to thank Dr Muhammad Kamal, one of my secondary supervisors who has provide me with much sought after but hard to find expertise on Heideggerian philosophy.

My thanks also go to Professor David Crewther, who has provided his support and expertise for the experimentation and visual neuroscience contained in this work.

These acknowledgements would not be complete without expressing my humble gratitude in particular to my partner Josette, and also my children Jade, Dante and Mietta, who have put up with my absentmindedness along with the many ramifications of having a partner and father who never quite seems to finish his PhD thesis. Well, not until today at least!

Thank you so much for your support, belief, encouragement and willingness for me to begin and now complete this thesis.

# Declaration

This thesis contains no material that has been accepted for the award of any other degree or diploma. To the best of my knowledge this thesis contains no material previously published or written by another person except where due reference is made in the thesis text.

Kaelasha Tyler

14th February 2019

# Table of Contents

# List of Figures

# List of Tables

# Definitions

| Abbreviation | Meaning |
|---|---|
| **AMPA** | $\alpha$-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid |
| **ECG** | Electrocardiogram |
| **EEG** | Electroencephalography |
| **EOG** | Electro-oculargram |
| **ER** | Error rate |
| **ERF** | Event related field |
| **FFA** | Fusiform face area |
| **GNWS** | Global Neuronal Work Space theory |
| **HREC** | Human Research Ethics Committee |
| **IIT** | Integrated Information |
| **LCMV** | Linear Constrained Mean Variance |
| **MEG** | Magnetoencephalography |
| **MNI** | Montreal Neurological Institute |
| **MRI** | Magnetic Resonance Imaging |
| **MTL** | Medial Temporal Lobe |
| **NCC** | Neural Correlates of Consciousness |
| **NMDA** | N-methyl-D-aspartate |
| **PFC** | Pre Frontal Cortex |
| **PSC** | Physical Substrate of Consciousness |
| **RT** | Reaction Time |
| **SOA** | Stimulus Onset Asynchrony |

# Introduction

Consciousness represents that aspect of nature against which the mechanisms of science have foundered. The philosophical antecedents and mechanisms of science have led to a view of nature in which qualitative human experience has been expunged. Science is capable of sequencing an individual's DNA and new subatomic particles continue to be discovered and their theoretical significance increasingly understood. However, our collective body of scientific theories essentially describes a universe in which we ourselves don't exist. That is, our best scientific knowledge conspicuously lacks any complete explanation for the fact of our own sentience.

Over recent years however, the problem of consciousness has come to be recognized as a significant scientific problem. Numerous approaches have sought to reconcile the existence of consciousness with that of physical or material processes (Chalmers, 1996; Crick & Koch 2003; Deacon, 2012; Alter, 2015; Tononi et al., 2016). As part of this effort, the scientific study of consciousness has produced many insights into the workings of the nervous system and it's relationship to the mercurial phenomenon of qualitative human experience (Del Cul, Baillet & Dehaene, 2007; Kouider & Dehaene, 2007; Dehaene & Changeux 2011).

However, the science of consciousness often begins with a naïve phenomenology and proceeds to base scientific theory and empirical research around this. As such, much of the science has imported problematic philosophical assumptions and biases about the nature and existence of consciousness that have been present for much of the trajectory of Western thought. For example, approaches such as the Integrated Information Theory (Tononi et al., 2016) or the Global Neuronal Work Space theory (Dehaene & Changeux, 2011) all begin with the assumption that we can first imagine the existence of consciousness in and of itself, and then relate such an existence back to that of matter and material processes after the fact. Inherent in such an approach, an a priori conceptual division

between consciousness and matter has already taken place. These neurobiological approaches take concepts such as subjectivity or qualia for example as a starting point with little investigation into the dualism already inherent in these concepts. In doing so, these approaches fail to envisage the structure of what we think of as 'consciousness' in a way that could possibly incorporate domains traditionally thought to be outside of, or ontologically prior to consciousness. Even while decrying Cartesian dualism, the problem of consciousness has often been approached as the question of how to relate an inherently Cartesian preconception about what consciousness is, to our preconceptions about the existence of matter and material processes. This thesis identifies this unexamined philosophical orientation as a central problem within much of the current science of consciousness and seeks to examine an alternative philosophical basis for research.

Heidegger traces the roots of this philosophical orientation, and in doing so unravels some of the biases and assumptions that he saw as shaping the contours of Western thought. In following Heidegger's critique, we can begin to see how we have arrived at a view of consciousness as an internal and self-enclosed unit of subjectivity separate from the world. In doing so, we can see that such a view of consciousness is arbitrary and that other ways of grasping the phenomenon are possible. This approach is taken in order to inform alternative theoretical frameworks regarding consciousness within the neurosciences.

Heidegger looks ultimately to Plato for the origins of the modern concept of subjective consciousness as an internal representation of an external spatially extended material world. It was in Platonic thought that Heidegger saw these two domains as first being conceptualized essentially independently of each other. In Plato's theory of Forms for example, a dichotomy is established between the timeless unchanging Ideal essences, and the changing and mutable manifest Real existence (Plato, *Phaedo, 100c9-d8*). Heidegger saw this Platonic dichotomy between underlying *essence* and manifest *existence* as shaping the trajectory and possibilities of successive centuries of Western thought.

It follows from this Platonic separation between essence and existence that human experience is thought to be somehow internal, in contrast to the supposed external or objective existence of the 'world' or of material processes. The idea that an immaterial rational blue

print must precede and shape the way in which 'reality' manifests, leads to a view that the domain of the rational mental subject is an immaterial and internal domain. In this, the privacy of the contents of consciousness is conflated with the idea that the very way of existing that consciousness has is somehow as an enclosed and internalised unit of mental 'stuff'. Heidegger discussed the way in which throughout Western thought, human existence is conceived of in one way or another as internal, enclosed and in this sense 'boxlike' in nature (Heidegger, 1984, p. 161). Conceptual mechanisms such as Kant's epistemological transcendence are then required to link this internal domain, to the external domain conceived to exist beyond or outside human existence (Kant, 1855). Complicit in such an attitude is the view of human experience as existing in a characteristically enclosed, intrinsic and internal manner, as opposed to the characteristically external existence of the 'world' (Heidegger, 1984, p. 161).

Heidegger also critically examines the philosophical origins of the concept of self-consciousness as being entirely self-transparent and as having an immediacy of epistemic access to itself. This is the assumed view in which qualitative experience is understood as a collection of positive phenomenal facts, that is, as 'consciousness' and as "the most familiar thing in the world"(Chalmers, 1996). Again, for Heidegger, the origins of such an understanding come about in a Platonic separation of the Ideal and the Real or essence and existence. It was with this separation that Heidegger saw Western thought first begin to take an object-oriented approach towards existence or Being. This object-oriented approach to existence is one that treats existence only in terms of beings or substances. That is, to exist, means to be an object or 'thing' of some sort. This is carried through in Aristotle's treatment of existence in terms of *Hypokeimenon* or primary substances, -a substantial material substrate that depends on nothing else for it's existence (Aristotle, 1995). Again, such a view informs Descartes substantialist treatment of consciousness as *Res Cogito*, literally, a 'thinking thing' or 'thinking substance' (Descartes, 1924). When this substantialist or object-oriented approach is turned on our own existence, we come to conceive of the existence of human experience also as an object, albeit as a mental object or self-contained unit of subjectivity viz 'subjective consciousness'. It is precisely when conceived of as this type of self-contained atomic entity that qualitative experience can itself be explicitly represented 'in consciousness'. That is, when

conceived of as 'subjective consciousness', we think that qualitative human experience is just what is known and what is phenomenally apparent i.e. that consciousness is 'the most familiar thing in the world'(Chalmers, 1996).

Underneath this substantialist or object-oriented approach, Heidegger identified a desire within Western thought to characterize all existence and natural phenomena as implicitly amenable to mental representation. It was the desire to understand and control all phenomena explicitly, that underlay what Heidegger saw as a Platonic portrayal of existence as a collection of dissociable, positively circumscribed entities or atomic facts all relating to each other on the basis of a set of explicit rules. In this sense, the traditional aim of Western Philosophy could be characterized from a Heideggerian perspective, as one of seeking Truth through the annihilation of ambiguity (Heidegger, 1977a, Heidegger, 1977b). Inherent in such an approach is the belief that it is desirable and possible to step back from existence and mentally represent any given phenomena explicitly. It was believed that such an approach always yields the most accurate truth in all domains. This was a position that Heidegger was deeply critical of. Characterizing qualitative human experience as a unit of subjective consciousness was part of this desire to treat all phenomena as implicitly amenable to mental representation.

Against the Cartesian overtones of a view of human experience as 'subjective consciousness', this thesis draws on Heidegger's description of human existence to motivate an alternative approach to consciousness theory. Heidegger did not concern himself with the relationship between consciousness and matter per se. Nevertheless, because the perceived separation between essence and existence plays out in the difficulty of conceptually reconciling consciousness and matter, it is informative for approaches within the science of consciousness to see how Heidegger dealt with this perceived dichotomy. Heidegger's project can be grasped as one of seeking to dissolve this dichotomy between the Real and the Ideal or between existence and essence, in our apprehension of existence and human meaning. Heidegger sought to bring together Being and Time. That is, Heidegger sought to explain Being, from within the context of everyday historical contextual human existence. The approach that Heidegger took ultimately lead to a fundamentally different understanding of

human experience than that implicit in the concept of 'subjective consciousness'. This is discussed below in Chapters One and Two and used as a basis for experimentation in Chapters Four through to Six.

In contrast to a view of subjective experience as standing apart from the world, and merely representing it, Heidegger tried to show that the phenomenon that was the original impetus for the concept of 'reality' and of 'world' was in fact something that manifest *within* what human experience is, not outside of it. For example, Heidegger suggests that when Being is approached via the lens of substantialism, it is incorrectly interpreted as 'Reality', i.e. as the sum total of things (Latin *res*). Heidegger replaces the duality that then necessarily arises between a perceiving subject and a perceived 'reality' with a relationship between Dasein (human existence) and Being. However, in this case, Dasein does not perceive, witness or internally represent Being. Rather, Dasein is itself a revealing of Being. Heidegger writes "Understanding Being is a definite characteristic of Dasein's Being" (Heidegger, 1962, p. 32). In this way, Heidegger reinterprets the mode of human existence such that a domain that is traditionally viewed as an alterity or an outwardness and otherness (e.g. the 'world') when viewed through the lens of substantialism, reveals itself as internal to and as actually informing the existence of human experience. In this way Dasein was not viewed as a passive witnessing consciousness that merely beholds existence or Being. Rather, human experience is portrayed by Heidegger as an engaged dynamic in which existence or Being is already manifest.

Following through Heidegger's thinking leads to a very different characterization of the qualities and existence of human experience. Rather than grasping human experience as any sort of mental thing, who's way of existing is somehow 'internal', Heidegger presents human experience as an existential openness or outwardness. It is through describing the structure of human existence in a way that incorporates domains that are traditionally viewed as outside of subjectivity, that Heidegger incorporates the sense of exteriority, alterity or outwardness traditionally associated with these domains, into humans own way of existing. For example, Heidegger writes that - "the 'world' is in a certain sense precisely 'the beyond' within [human] existence and for it" (Heidegger, 1977a, p. 229). Human existence so described, now itself incorporates a type of 'beyond-ness' rather than solely being an instance

of ipseity or self-hood . Heidegger defines Dasein in terms of an existential horizon. However, Dasien is not defined as what is within this horizon as opposed to that which is beyond, be that Being, the nothingness or the world. Rather, it is a 'being-beyond' or a transcending of this horizon between ipseity and alterity that is precisely what Dasein or human existence is (Heidegger, 1984, p. 135). In this way, rather than being thought of as characteristically enclosed, intrinsic or internal, Heidegger describes human existence in terms of being a qualitative outwardness or openness which he terms *offenheit*.

There are several ways in which the secondary literature interprets Heidegger's writings on *offenheit* or openness. By one interpretation, best exemplified in Dreyfus (Dreyfus, 1991), Heidegger's discussion of openness is interpreted as suggesting that meaningful human behaviour is not the product of an intellectual agent who exists separately from the world. By this reading, meaningful behaviour does not come about on the basis of an intellectual agent who exists as an internal psychical entity, who represents that world internally, and who then forms a rational plan to guide subsequent behaviour. Rather, Heidegger's discussion of openness is interpreted as portraying meaningful human behaviour as arising on the basis of implicitly grasped, shared contexts and social practices without any explicit mental representation or isolated mental agency. In this sense, human existence is not parsed separately from the world, but exists as an openness that incorporates context, environment and culture.

This can be made clearer through an example of how these views have come to be reflected in the recent cognitive neurosciences. For example, Heidegger's discussion of openness is reflected in theories of embodied and extended cognition. Over recent decades, empirical support for the notion of embodied cognition has increasingly undermined the strong distinctions between 'inner' and 'outer', in an understanding of mental processes. Findings in the psychologies, cognitive sciences and robotics have all lent support to the notion that cognition does not occur purely in the domain of the mind and brain but rather arises inseparably from perceptuo-motor processes and an engaged interaction with the environment (Kirsh & Maglio, 1994; Clark, 1997; Beer, 2000; Bridgeman & Tseng, 2011; Hotton, 2011; Lowers, 2011). Kirsh & Maglio (1994) for example have demonstrated the way in which

participant's engaged motor activity can be shown to be part of the computational process relied on to solve the cognitive and perceptual tasks involved in a game of 'Tetris'. Likewise, Clark (1997) describes the humanly structured environments of a factory, office or workshop as informing and 'scaffolding' individual cognitive processes. Strong impetus for embodied and extended theories of cognition have also been provided by the increasing recognition of the relevance of dynamical systems analysis to describe the processes of the brain and mind (Kelso, 1995; Kelso, 2006). Such an approach for example has sought to explain the relationship between an organism and its environment in terms of being coupled dynamical systems (Beer, 2000; 2003; Warren, 2006; Hotton, 2011). Over the last several decades, there has been increasing evidence for and awareness of the way in which the body and the world operate alongside the central nervous system, in forming the machinery underlying various mental states and contents (Clark & Chalmers, 1998; Clark, 2007). This understanding of extended cognition reflects the type of openness that Heidegger discusses where by the strong distinction between an internal mental subject and an external objective environment is undermined.

However, Heidegger's term *offenheit* or openness has also been interpreted as having significance to the being structure of consciousness rather than merely being a commentary on cognition and behavior (Olafson 1975). Openness for example can be understood in the sense that qualitative human experience is not treated as an enclosed subjective sphere. Rather, human experience is treated as an openness by Heidegger in that its being structure incorporates that which is beyond, outside of, or hidden from a traditionally conceived subjective consciousness. That which is beyond or outside of a traditional Cartesian subjectivity is dealt with by Heidegger primarily in terms of his discussion of Being. Being is described by Heidegger as neither mentally representable nor able to be explicitly cognitively grasped. In this sense, Being is absent from the positive phenomenal facts of a traditionally understood Cartesian subjective consciousness. Nevertheless, by Heidegger's account a precognitive and a-phenomenal grasp of the meaning of Being is part of what qualitative human experience *is*. In this way the being structure of human experience viz consciousness, incorporates that which cannot be represented in consciousness. It is in this sense that the existence of human experience is described by Heidegger as an openness because it consists

in part as that which cannot be represented in consciousness, and is therefore a type of absence. Human existence so described transgresses the traditionally conceived boundaries between ipseity and alterity. For example, Heidegger writes that human existence contains a 'beyond within itself' (Heidegger, 1977a, p 229). It is precisely in his discussion *of openness* that Heidegger tries to characterize that which is unique about the luminous existence of human experience, as compared to the inert existence of an inanimate object.

In this sense, Heideggerian philosophy has been compared to themes in Zen and Taoist thought (Parkes, 1987). The type of non-substantialist interpretation of Being and Dasein (human existence) that Heidegger points to is at times highly reminiscent of the treatment of the *Tao* in the classic Chinese text, *Tao Te Ching.* For example, Heidegger discusses human existence as an openness because it cannot be wholly defined as an explicit object, 'thing' or substance but incorporates a sense of absence and groundlessness in its essential proximity to Being. Similarly, in invoking a non-substantialist grasp of the Tao, the *Tao Te Ching* points allegorically to the way in which absence can be central to the existence of certain concrete things- "Pots are fashioned from clay, But it's the hollow that makes a pot work" (Tzu, 2017). This comparison to the *Tao Te Ching* can shed some light on what Heidegger inferred in characterising human existence as an openness, rather than as the enclosed Cartesian substance of the *Res Cogito*.

This characterization of human existence as incorporating domains that are traditionally viewed as outside of or ontologically prior to consciousness, is also closely related to Heidegger's description of Dasein as cognitively evasive or as characteristically hidden from itself. In contrast to a traditional Cartesian view of human experience as a consciousness that has immediate epistemic access to itself, Heidegger presents human existence as partially obscure and hidden from itself. For Heidegger, human existence is a play between *Alethia* (un-concealment) and *Lethia* (concealment) (Heidegger, 1977b, pp. 127-137). In his description of Being, Heidegger seeks to evoke a non-substantialist understanding of what it means for something to exist. Dasien is precisely the revealing or showing of Being. As such, Heidegger presents a non-substantialist understanding of both Being and Dasien. That is, neither can be thought of as a self-contained 'thing' that is amenable to mental

representation. Therefore, human experience cannot be treated as any sort of object that could itself be represented 'in consciousness' and therefore be fully transparent to itself. The way of existing that human experience has is not as a substance or any sort of 'thing', but closer to a 'no-thing', an openness or nothingness from the perspective of mental or conscious representation. In this way, human experience is described by Heidegger as partially hidden or concealed from itself. This contrasts directly with a traditional Cartesian view of human experience as a consciousness that by definition has immediate epistemic access to itself.

The language and terminology used to refer to consciousness in this thesis should be noted here. The focus of theory and philosophy in the first two chapters and throughout this thesis is on qualitative human experience, typically referred to as qualia and thought of as the content of consciousness or the 'what it is like' to be any particular experiencing being (Aru, Bachmann, Singer, & Melloni, 2012; Block, 2005; David J. Chalmers, 2010; Tononi et al., 2016). However, the main theoretical claim presented in this thesis is that this state of 'consciousness' cannot be explicitly separated from a background of non-representational and cognitively impenetrable processes. In this sense, non-conscious processes are suggested to form an essential part of the phenomenal structure of any particular 'conscious' state. This claim is explored even as far as to view physical processes, thought of as a-phenomenal and non-conscious, as forming an essential part of this phenomenal structure. Because the term 'consciousness' is laden with Cartesian implications and is typically used in the literature to refer to processes that are mutually distinct from 'non-conscious' processes, the term 'qualitative human experience' is used in this thesis instead. However, the phenomenon under discussion remains the 'what it is like' to be any experiencing being, and this phenomenon is that which is typically referred to in the literature as qualia or 'consciousness' (Aru, Bachmann, Singer, & Melloni, 2012; Block, 2005; Chalmers, 2010; Tononi et al., 2016).

These ideas represent a small selection of only some of the concerns that Heidegger dealt with throughout his writings. To briefly summarize, Heidegger has presented an understanding of human experience that in its existential structure did not stand separate from 'reality' and merely passively witness or behold existence. Rather, by Heidegger's account the original impetus for the concept of 'reality' was in fact something that manifest

within what human existence is, not outside of it. In other words, Heidegger laid out an analysis of human experience that undermined the dualism between essence and existence that he saw as originating in Platonic thought. Following from this, Heidegger can be interpreted as presenting human existence or consciousness as an openness or outwardness rather than as a type of interiorized subjective entity. Lastly, by such an account, human existence is inherently hidden and opaque to itself, rather than being an explicitly self-representable or objectifiable 'thing'.

The central hypothesis contained in this work is a claim about the phenomenology and being structure of consciousness. This is not a theory of consciousness in the sense that it is not a theory about how matter could combine to create consciousness. Rather, Heideggerian thought is drawn on to present a hypothesis about what consciousness *is*- it's structure and way of existing. This is explicitly contrasted with the way in which a traditionally Cartesian consciousness or *Res Cogito* is imagined to exist. This hypothesis is then used as the basis of experimentation that examines the types of neural activity that may underlie and instantiate human experience. That is, rather than seeking the neural correlates of 'consciousness' understood essentially as a *Res Cogito*, the experiments in Chapters Four through to Six explore the possible neural correlates of what Heidegger termed *lichtung* (lightening) or *offenheit* (openness). Summarised very simply, the central hypothesis of this work is that qualitative human experience exists as a dynamic relationship between conscious sand non-conscious processes arising as a singular phenomenon. In other words, qualitative human experience is hypothesised to exist in a manner that is not able to be entirely and explicitly represented 'in consciousness'. This is further presented as one avenue to reconcile the existence of consciousness with the existence of non-conscious physical or material processes.

The approach taken in this thesis is largely one of seeking alternative approaches to what has been referred to as the 'Easy Problem of Consciousness' (Chalmers, 1997). That is, rather than seeking the Neural Correlates of Consciousness, where consciousness is understood as a type of Cartesian *Res Cogito*, this thesis looks to characterise the types of neural activity that could underlie human experience understood as a Heideggerian 'being-beyond' or 'lighting of Being' (Heidegger, 1977b, p 211).

However, underlying such an approach, this theoretical orientation is also intended to comment on the 'Hard Problem of Consciousness' (Chalmers, 1997). That is, this thesis is put forward as relevant to the question of how to develop a shared ontology that incorporates both the existence of consciousness and the existence of matter and non-conscious physical processes. The theoretical position presented here steps back from an assumption that we can first imagine the existence of consciousness in and of itself and then relate such an existence back to what we know of matter and material processes after the fact. Rather, the view is put forward that the structure of what we think of as 'consciousness' already incorporates domains traditionally thought to be outside of or ontologically prior to consciousness. The way in which such an approach leads us away from a Cartesian characterisation of consciousness is examined in Chapter Two. The implication of this theoretical orientation to the 'Hard Problem' of consciousness has not been able to be taken up explicitly in the experimentation outlined in Chapters Four through to Six. Nevertheless, these theoretical considerations contained in the initial two chapters are presented as an avenue to make some progress towards the deeper problematic that consciousness presents us with. Broadly, the approach presented in this thesis is treated as relevant to both the 'Hard' and the 'Easy' problems of consciousness (Chalmers, 1997).

The initial two chapters deal with the philosophical basis of the thesis. **Chapter One** follows elements in Heidegger's writings in tracing the origin of the view of human existence as an isolated unit of subjective consciousness. This chapter begins with an examination of the separation of *essence* and *existence* in Platonic thought and traces this conceptual orientation through to evidence of Cartesianism within the contemporary science of consciousness. **Chapter Two** presents an alternative characterization of qualitative human experience motivated by elements of Heideggerian thought. This is framed as a hypothesis or theory about the structure of qualitative experience. At its most simplified, chapter two presents a hypothesis that qualitative human experience can be thought of as a dynamic gestalt of conscious and non-conscious processes arising as a singular phenomenon.

The remaining four chapters deal with four experiments that seek to provide empirical evidence in support of such a hypothesis. **Chapter Three** transitions from purely

philosophical and theoretical concerns to experimental ones. This chapter outlines the ways in which the theoretical and philosophical issues presented in the previous two chapters will be translated into empirically verifiable experimental questions. **Chapter Four** details two electroencephalographic studies and takes an initial step towards using the mathematics of nonlinear dynamical systems and circular causality. Circular causality is presented as a mathematical analogue to the model of qualitative experience as a reciprocally causal relationship between conscious and non-conscious processes. As an initial step towards employing the theory of circular causality, these experiments examine the EEG time-locked to the emergence of a perceptual event for the presence of Alpha-Beta synchrony, a proxy of non-linearity. The strength of Alpha-Beta synchrony in the EEG is compared between conditions in which a visual stimulus is either perceived or not perceived. The results of these experiments revealed an increase in alpha-beta synchrony in the EEG for perceived compared to not perceived conditions in line with our contention that the non-linear architecture of brain activity is modified in response to conscious perception. These results contribute to evidence supporting the use of the mathematics of nonlinear dynamical systems in characterising the EEG associated with perception. Further exploration of the use of Circular causality to model qualitative experience is considered warranted. In **Chapter Five** the hypothesis of such a gestalt is approached experimentally in a behavioural study. Through examining behavioural responses, the level of interaction between liminal and subliminal processes within a temporal window of neural activity associated with conscious perception is examined. The basis for such a temporal window is taken from the Global Neuronal Work Space (GNWS) model (Dehaene & Changuex, 2011). According to this model, consciousness correlates with an abrupt nonlinear and categorical transition between early feed forward non-conscious processes, and a late amplified re-entrant loop of global cortical activity which occurs around 300 ms after the presentation of a given stimulus. The experiment in this chapter examines whether behavioural responses to a consciously perceived stimulus can be impacted on by simultaneously occurring processing of a non-consciously perceived stimulus. The impact of non-consciously perceived stimuli on subsequently presented target stimuli is a well-validated effect (Ortells, Frings, & Plaza-Ayllón, 2012; 2006; Van den Bussche & Reynvoet, 2007). However, the novelty in the methods used in experiment three and four (Chapters Five and Six) is that the stimulus onset a-synchrony is designed such that the neural processing of

the masked prime occurs simultaneous to, rather than prior to, the neural processing of the target stimulus. Methodologically, this required that the masked prime be presented after the target stimulus. A positive result in these studies would provide some support for a view in which qualitative experience be considered a gestalt of foreground supraliminal phenomenal content and background subliminal phenomenal content, rather than as 'consciousness' per se. The results of the behavioural study presented in Chapter Five did not provide any evidence of an interaction between liminal and subliminal processes. That is, the results of this experiment did not support the broader hypothesis of qualitative experience arising as a gestalt of conscious and non-conscious content and processes.

**Chapter Six** details a Magnetoencephalographic study which examined the interaction of the semantic content of conscious and non-conscious processes through use of an N400 evoked field paradigm. Invisible masked prime words were paired with visible target pictures in conditions for which the word-picture pair was either semantically congruent or semantically incongruent. This study was designed such that the liminal and subliminal neural processes associated with the visible and invisible stimuli respectively, both took place during the temporal window of activity associated with the GNWS. In this way, the GNWS was examined as a cluster of neural activity that would represent a relationship between conscious and nonconscious processes, rather than demarcating the correlates of consciousness exclusively. In contrast to the results presented in Chapter Five, the magnetophysiological results presented in Chapter Six did show some evidence for such an effect. Significant increases in the amplitude of the evoked fields were observed in the case of semantically incongruent stimuli pairs when compared to semantically congruent pairings, when utilising a cluster based permutation analysis ($p = 0.04$). When comparing neuronal activity generated in the Congruent and Incongruent conditions, recorded over left hemisphere sensors, a cluster based permutation analysis found one significant negative cluster ($p=0.04$). Specifically, this effect was observed in activity recorded over the left hemisphere in response to the simultaneous neural processing of visible and invisible stimuli pairs. This N400 effect is most parsimoniously explained as having arisen from the interactions of simultaneously occurring conscious and non-conscious processes. In this way, some support was provided for a hypothetical approached towards qualitative human

experience as a dynamic gestalt of conscious and non-conscious content and processes. The thesis presents its final experimental and theoretical conclusions in **Chapter Seven**.

# Chapter 1
## The Philosophical Origins of the Concept of 'Consciousness'

### 1.1 Introduction

This chapter seeks to examine the antecedent philosophical attitudes that have shaped the way in which we have come to imagine consciousness to exist and fit within a broader theory of the world. Martin Heidegger's critique of Western thought in particular is drawn on. This is done in order to highlight some of the origins of the tendency in Western thought to characterize qualitative human experience in terms of being a mental subject enclosed in the psychical domain of its own representations. In examining some of the ways such a tendency of thought took root, the purpose is to underscore that such a characterization is largely arbitrary, and that fundamentally different ways of apprehending the existence of consciousness and human experience are possible. The thesis then continues in Chapter Two with a specifically Heideggerian perspective on the existence of human experience. This is ultimately done in service of motivating alternative theoretical frameworks in the neuroscience of consciousness.

Heidegger contended that Western cultures' way of understanding human existence, from Plato onwards had increasingly calcified around a characterisation in terms of being a unit of 'subjective consciousness'. Heidegger's central discussion of a loss of understanding of Being in Western thought is closely wed to a narrative he builds up of the way in which human existence has become increasingly conceptualised as a rational calculative unit of mental stuff, isolated from the broader context of the world. This chapter follows this narrative through from its inception in Platonic thought, to its ramifications in the contemporary neuroscience and philosophy of consciousness. The purpose of tracing this narrative is to highlight the way in which such a characterisation is the result of particular line of philosophical enquiry characteristic of Western thought. The possibility is then raised that if the current conception of human subjectivity originated and took shape at certain points in history, then other ways of characterising the existence of qualitative human experience may

also be possible. This is taken up in the following chapters and used as an alternative basis for consciousness theory.

The chapter begins with an investigation of the way in which *essence* and *existence* become separate in Platonic thought and some of the ramifications this has for an understanding of human existence. The Aristotelian notion of *hylomorphism* is dealt with and the way in which this lead directly to a Cartesian distinction between a thinking mental substance (*res cogito)* and a spatially extended physical substance (*res extensio*). The way in which the ontology implicit in Platonism has led to a number of psychological assumptions about the nature of the mind is then also examined. This is seen in the cases of Logical Positivism and 20th Century Cognitive Science where not only the natural world, but also human mental processes are understood in terms of being constructed of atomic components relating together via a set of formal operations. In distinction to such a trend, some of the ways in which recent cognitive sciences exhibit elements of Heideggerian thought are also highlighted. The chapter then goes on to examine several dominant approaches in the contemporary neuroscience and philosophy of consciousness. Some of the ways in which implicit Cartesian and Platonic biases and assumptions are imported into these research paradigms are then examined. The chapter concludes by addressing the use of Heideggerian philosophy to inform consciousness theory. Elements in the secondary literature specifically disavow that Heideggerian philosophy concerns itself in any way with the question of consciousness. Contrary to this, the position taken in this thesis is that the phenomenon of the felt existence of the human being does remain an important locus of Heideggerian thought. The concluding section of this chapter outlines some of the justifications for this position.

## 1.2. Platonism, Cartesianism and Subjective Consciousness

Heidegger identified in Platonism the seeds of a mode of thinking that he saw as coming to shape the way in which we imagine human experience to exist as an isolated unit of subjectivity. It was a Platonic distinction between Being (Forms or Ideas) on the one hand, and Time- the temporal reality of existence on the other, that Heidegger saw as seminal in shaping an understanding of human existence as being a unit of subjective consciousness

distinct from the world. Plato's theory of Forms or Essences maintains that what informs and defines the objects of the world that we perceive are their underlying essences. What defines redness for example, or a triangle, or a horse, is the transcendent Ideal Form of redness, triangle-ness or horse-ness, in which they imperfectly participate. Importantly, these Forms or Essences were understood as able to be known or contacted directly by the mind of the trained philosopher as a form of higher truth. Conversely, the actual objects we interact with in the world around us are treated as merely the fabled shadows on the wall of Plato's cave, the light having been emitted by the higher and truer existence of the Forms themselves. In this way, the Forms or Essences are understood as somehow mind-like, perfect, eternal and unchanging. These are contrasted and distinguished ontologically from the changing, mutable and imperfect objects of a world governed by time. Such a theoretical orientation sets up a division between the mind, and the changing world of manifest physical objects and of the body. The word 'essence' cannot be treated as synonymous with the word 'consciousness'. Nevertheless, the modern difficulty understanding how consciousness relates to matter can be seen to be a legacy of this Platonic theory of Forms. In *Letter on Humanism* Heidegger writes "the differentiation of *essentia* (essentiality) and *existentia* (actuality) completely dominates the destiny of Western history." (Heidegger, 1977b, p. 208). Throughout Western thought, 'essence' was able to be posited as informing the domain of the mind, soul or rational spirit. This in turn allows the conception of an internal unit of subjectivity or personhood who's way of existing is distinguished from and contrasted ontologically with that of the world around them.

By contrast, in Heidegger's view, the earlier pre-Socratic experience which he saw expressed for example in Parmenides and Heraclitus, was one of a direct revealing or partaking in existence or Being (Heidegger, 1997a, pp 130). In Heidegger's telling, the pre-Socratic understanding of 'Being' –of what it meant for something to exist- was such that there were not two different ways of existing that could be applied on the one hand to a human's *felt* existence and on the other, to the *manifest* existence of the world. However, with Plato's theory of Forms, the possibilities of existence become defined in terms of either the timeless unchanging Ideal essences, or the mutable and manifest worldly existence. It was in this that Heidegger saw the germination of a modern concept of subjectivity.

It was with Platonic thought that Heidegger identified the origins of the Western ontological and epistemological traditions. These were approaches that treated Being – or existence, in a substantialist manner. That is, by Heidegger's account, Plato's approach was an object oriented one in which Being came to be understood solely in terms of beings or 'things'. With Plato, Being came to be understood as a collection of independent atomic substances and their rule-governed interactions. It was in this way that the separation of *essence* and *existence* in Platonic thought can be posited as the inception of a theoretical approach to existence. Plato's theory of Forms allowed that the universe existed as a collection of context free components, that there are underlying rules-Forms or essences-governing these components, and that one could therefore comprehend the universe in a detached manner by discovering these underlying formal laws. Such an approach allowed a theoretical orientation towards existence and this has justifiably been likened in its cultural significance to the advent of fire and language (Dreyfus, 1991. p. 1). It is this approach which Heidegger points to as resulting in a treatment of human experience as an isolated unit of subjectivity, who's relationship with the broader existence is considered to be primarily epistemic in nature. That is, we have come to assume that our primary relationship to reality through *knowing* it. This continually establishes our way of existing as a mind-like beholding, differentiated from the reality which is beheld rather than fundamentally part of that reality.

This should be understood against Heidegger's interpretation of a pre-Socratic understanding of Being and the possibilities that such a grasp of Being afforded human existence of that age. Heidegger presented his interpretation of a pre-Socratic understanding of Being, not in terms of substantial entities, but as a hidden revelation pivotal to the way in which human experience exists and takes place. Being in this way was an event that was illusive to mental representation, but also active in our experience of entities, the environment and ourselves. Heidegger maintained that the pre-Socratic humans did not conceive or experience themselves as a mind or conscious subject within but separate to a world of objects. By this account, for the pre-Socratics there was no separation between *essence* and *existence*. Such an account turns on its head the supposition that human beings, as subjects, merely internally represent the external world within themselves. Heidegger writes,

> That which is, does not come into being at all through the fact that man first looks upon it, in the sense of a representing that has the character of subjective perception. Rather, man is the one who is looked upon by that which is. To be beheld by that which is, to be included and maintained within its openness …that is the essence of man in the great age of the Greeks. (Heidegger. 1977b, p. 131)

In this way Heidegger described the pre-Socratic experience as fundamentally different from the modern conception of a unit of subjective consciousness, isolated from the world by being enclosed within the domain of its own representations.

Throughout his writings, Heidegger's central concern was with Being and he drew on this pre-Socratic sense of the term and the ramifications that it had for an understanding of human existence. Heidegger's project can be grasped as one of seeking to dissolve this dichotomy between the Real and the Ideal or between existence and essence, in our apprehension of existence and human meaning. Heidegger sought to bring together Being and Time. That is, Heidegger sought to explain Being, from within the context of everyday historical contextual human existence and this project forms the basis of his magnum opus *Being and Time* (Heidegger, 1962). Such an approach led to a fundamentally different understanding of human existence than that implicit in the concept of 'subjective consciousness'. This is an idea that will be developed more fully in Chapter Two.

Heidegger contended that with Platonic thought, this more elusive pre-Socratic grasp of Being was replaced by the object-oriented mode of thinking in which Being is understood only in the concrete terms of beings, 'things' or substances. He saw this as a comparatively diminutive understanding of Being that has led to a correspondingly diminutive concept of human experience as a unit of subjective consciousness, separate from the existence around it. That is, when this object-oriented ontology is turned on our own existence, we come to conceive of the existence of human experience also as an object, albeit as a mental object or self-contained unit of subjectivity viz 'subjective consciousness'. This is seen later in Descartes' *res cogito* that carries through this sense of being an independent substance that did not depend on anything else for its existence. In this case, Descartes has reified human existence

as the *res cogito*, which translates literally as 'thinking thing' or 'thinking substance' (Descartes, 1968). The *res cogito*, was considered as an isolated, independent entity, and as the foundational fact on which an accurate knowledge of the world can be based. In his *Meditations*, Descartes famously establishes his *res cogito* as the sole fact of existence which cannot be doubted, and upon which accurate knowledge of reality could thus be founded (Descartes, 1968).

From the vantage point of contemporary thought, essence or soul is not thought to inform or be reflected in material existence. Nevertheless, Platonism is present in that the theoretical attitude is prioritized over the practical as a means of grasping the true nature of reality. For example, while the scientific method begins with the perturbation and observation of nature, the model of scientific knowledge itself is one in which accurate knowledge of existence is thought to be found through taking a theoretical stance as though standing outside of reality, and then establishing a mental or mathematical representation of that reality. Direct involvement or participation in the substance of the world by one's mind is not thought to be possible. This conceptual assumption derives from the Platonic separation between the Ideal and the Real, or between essence and existence (Heidegger, 1977b).

That is, with this Platonic treatment human's primary relationship with the universe became conceived of as epistemic in nature. Human experience became construed as a self-contained subjectivity whose primary way of relating to reality is by knowing it, that is by grasping its laws and representing it in consciousness. In this, the existence of the world is imagined to take place beyond, that is-differently from- the existence of human experience. By Heidegger's account, the loss of a pre-Socratic understandings led to qualitative human experience no longer being grasped as a direct partaking in existence or openness to Being in which *essence* and *existence* are non-separate. Rather Heidegger critiques the trajectory of Western thought as being increasingly a case of treating human existence as a consciousness that merely witnesses objective 'reality' and therefore stands apart from that reality in its own way of existing.

It can be seen also that this Platonic ontology carries with it an epistemological implication in that Being, thought of in in terms of substances and entities, is just the type of existence that is available to pure contemplation or beholding. That is, when Being is thought of as the sum total of factual 'things', anything that exists, is conceived to do so in a manner that is perfectly amenable to mental representation. Heidegger writes that understood in this way, "Being acquires the meaning of 'Reality'" (Heidegger, 1962, p. 245), rather than the more primordial revelation intrinsic to existence and experience that Heidegger points to in Pre-Socratic thought. Further, characterizing traditional Western metaphysics pejoratively Heidegger writes, "It has long been held that the way to grasp the 'Real' is by that kind of knowing which is characterized by beholding" (Heidegger, 1962 p 246). That is, when Being is understood exclusively in terms of the sum total of 'things', the scope and possibility of existence is reduced to facts that can be grasped by calculative thinking or mental representation.

This representational account of meaningful behaviour and its underlying ontological assumptions are closely wed to a subjectivist account of human existence. When Being or existence is thought of in terms of substance, this is the type of existence that is available to representation or pure beholding. In this case the assumption arises that beholding is the primary type of relationship that human experience has with 'reality' (Heidegger, 1962 p 246). This implicitly characterizes human experience as a mental witness or 'internal' subject in its very way of existing. When Being is understood as the totality of 'things' it becomes able to be characterized as 'Reality' rather than an event central to humans own way of existing as Heidegger suggests (Heidegger, 1977a, p. 204). In this case, 'Reality' is able to be approached via knowing or beholding and such beholding then characterizes the type of existence that human experience is presumed to have. A substantialist account of reality as a collection of entities raises the issue of the world independent and outside of human existence. The existence of human experience is portrayed as standing against and opposite the existence of the 'Real' objective or external world. That 'real' or 'objective' existence must then be represented internally in order for humans to interact with it in a meaningful way. In this way, human experience is presumed to exist in a way that has the character of witnessing, beholding or representing. By contrast, Heidegger's understanding of human existence was

one in which Being, or existence was directly manifest not merely witnessed. The understanding of Being that Heidegger located in pre-Socratic thinking and which he sought to re-imagine, lead to a view in which existence is not merely witnessed or internally represented by humans, but actually manifest within the structure of one's own experience.

For Heidegger, the object-oriented treatment of Being also lead to a further number of epistemological assumptions. The implicit ontological assumption that to exist is to be a substance relating to other substances, came to be reflected in a corresponding epistemological assumption that all knowledge of the natural world can be expressed in terms of logical relationships between independent atomic facts. That is, through this basic orientation towards Being, the trajectory of Western thought has been increasingly guided by a fascination with the insight that the plethora of natural phenomena can be explicitly understood in terms of an underlying formal structure. In this we can see a separation between theory and praxis that arises from the Platonic theory of Forms. From Kepler's theory of the tides to Newton's laws of motion, the description of these natural phenomena in terms of logical mathematical formalisms came to encapsulate what it meant to gain knowledge and to penetrate the mysteries of nature (Newton, 1972; Kelper, 1992).

With regards to this epistemic orientation, the broad project of Western Philosophy has been characterised as one of seeking to annihilate ambiguity (Dreyfus, 1991) and this has further impacted on the way in which we characterise human existence. Interpreting Being always in terms of discriminate entities or beings is part and parcel of a project of seeking to have the existence of nature present itself perfectly in a definitive way as the objects of natural science. Subscribing to such an ontology, we believe it is desirable and possible to develop a theoretical understanding of all domains. The *ego cogito* is the characterisation of human experience that satisfies this ideal of definitive theoretical clarity. Descartes sought to establish his *First Philosophy* through rejecting all in which he did not have an absolute certainty (Descartes, 1968). Such an approach resulted in a radical scepticism of all things save his own *ego cogito*. Thus, for Descartes as for modernity, human experience is characterised as 'consciousness'- a catalogue of positive phenomenal facts to which we have immediate and unquestionable epistemic access. In this way, Heidegger reads the emergence of the concept

of the *res cogito*, as the expression of an impulse in Platonic thought to find certainty and to secure absolute knowledge about reality through a separation of *essence* and *existence*. In other words, Cartesian dualism can be read as the legacy of a Platonic distinction between *essence* and *existence*.

In the 17th and 18th centuries, the new scientific understanding of nature progressively developed by Galileo, Copernicus and others increasingly drove a conceptual wedge between the domain of human experience and the domain of the material world. However, it was perhaps in the work of Descartes in the 17th century that the ramifications of this underlying ontological orientation for our understanding of human consciousness came to be articulated most clearly. Descartes not only cemented for Western thought a stark dichotomy between the mind or 'thinking substance' and physical 'extended substance', but also undertook seminal work in establishing a mechanistic account of nature. In continuing with an objectifying treatment of Being in terms of beings, entities or substances, Descartes was able to make significant advances in establishing a mechanical account of the natural world. In doing so he also contributed significantly to a concept of the physical world that was divorced from any inherent human meaning or significance.

In a break with his intellectual predecessors, Descartes sought to replace the main tenants of the prevailing Aristotelian thought with a universal and mechanistic account of nature. Aristotelian physics sought to explain the behavior of all bodies in terms of functions and qualities which inhered within matter and informed the way in which such material bodies existed and behaved. In this we can see a transformation of the Platonic notion of the Ideal as the underlying essence of the manifest Reality. For Aristotle, the qualities of heat and cold, wetness or dryness were conceived to inhere within matter in a manner similar to the way in which we experience these qualities tactually and sensually (Bostock, 2006). Whiteness for example, was an inherent property of objects that appear white to us. In contrast, Descartes divorced perceptual experience from the material processes of nature and described the universe as a single mechanistic system. All components of such a system were then explained through the mechanistic interaction of atomic components of matter possessing only the properties of shape, size, position and motion. In Descartes' *Treatise on Man* for example, the function of the brain or sensory organs such as the eye, were explained in terms

of purely mechanistic processes (Descartes, 1968). Descartes writes, "I suppose the body to be nothing but a statue or machine made of earth" (Lockhorst, 2017) and goes on to write-

> ….it is not necessary to conceive of this machine as having any vegetative or sensitive soul or other principle of movement and life, apart from its blood and its spirits, which are agitated by the heat of the fire burning continuously in its heart. (in Lokhorst, 2017).

The replacement of Aristotelian physics with Descartes' mechanical philosophy had direct implications for the way in which human mental processes are conceived to exist and fit within a broader theory of the world. It was in tandem, and as a result of Descartes' explanation of physical processes, that the central characteristic of human nature has seemed to be its internal mental subjectivity. Within Aristotelian thought the physical existence of material bodies was inherently associated with components and qualities of sensory experience. The quality of 'whiteness' for example was thought of as a real quality within objects which appear white, such as milk, and one which informed and shaped such matter in its very mode of existing. However, with Descartes, this theory of sensory qualities had to undergo significant change. For Descartes' mechanistic philosophy, the way of existing held by material nature did not rely on sensory reference for explanatory power. Rather, the qualities of sensory experience were arrived at as a result of mechanistic interaction of material components after the fact. For example, in anticipation of Newtonian physics, Descartes sought to explain colour in terms of the movement of light particles as they hit the retina (Wolf-Devine, 1993). Such a turn represents a far more powerful physical theory than that present since Aristotle. However, what is important here is the manner in which an underlying way of understanding physical processes is implicit in our way of characterizing the existence of experience or consciousness. For Descartes' natural philosophy there was no need for reference to actual sensual qualities as intrinsically existing within material bodies in order to inform and support their varied behaviors and existence. The manifest physical world became completely divorced from the domain of human meaning, in its way of existing. In this way, sensual phenomenal properties were divorced in principle from the physical existence of natural objects and the environment.

In particular, it was through Descartes rendering of the Aristotelian *hylomorphism*- the dichotomy between form and matter, that a modern understanding of the mind-body problem came to be especially keenly articulated. It was in Descartes' treatment of the soul (Greek psyche) that the human soul came to connote a mentalistic subjective type of existence along the lines suggested by the modern usage of the words 'mind' or 'consciousness'. The term *hylomorphism* refers to the Aristotelian understanding of being in terms of a 'substantial form' inhering in and informing the existence of a 'prime matter' (Granger, 1996). This itself reflects a Platonic distinction between the Ideal essence and manifest Real existence. The Aristotelian 'substantial form' can be thought of in terms of function, such that the 'substantial form' of a motor vehicle for example could be its respective shapes, or its characteristic activity of traveling on roads. Indeed, both of these can in the final analysis be seen to be the same thing. In the case of animate beings, the 'substantial form' corresponded to their psyche, which translates as 'soul' in English, or in more specific Aristotelian terminology, the 'sensitive soul'. This sensitive soul was further categorized in terms of vegetative soul, animal soul and in the case of humans, rational soul. But in all cases, the substantial form of an entity, animate or inanimate, was not a spiritual substance, but an organizing principle. This organizing principle informed the 'prime matter' of the entity concerned, in its particular way of existing and behaving. However, within the natural philosophy propounded by Descartes, the characteristic manner of existence pertaining to any physical body was divorced from the existence of the rational soul. For Descartes, the soul or mind did indeed direct the body and Descartes strived, without success, to describe a mechanistic means for the mind to do this (Lockhorst, 2017). However, in this case, what in Greek thought had been conceived of as an integrated organizing principle of a bodily form, was now conceived of as a separate and independent 'mental' substance. Indeed, it was in part this conceptual separation of mental and physical substances that allowed Descartes' mechanistic philosophy to be a far more powerful physical theory than that of Aristotle, and one, which anticipated the successes of Newtonian physics. However, it is precisely this manner of thinking about the psyche, now rendered as a conscious mind that has presented problems when we try to fit an understanding of consciousness into a theory of the world.

The miss-interpretation of Being that Heidegger saw endemic in Western thought has been discussed above in terms of an ontological and epistemological assumption that 'reality'

takes place as a collection of atomic independent substances relating together on the basis of a set of underlying rules. However, this ontological assumption can also be seen to lead eventually to a psychological assumption about the nature of the human mind. Increasingly throughout the late 19th and early 20th centuries, it came to be assumed that not only the processes in the natural world, but also human conceptual processes could be understood in terms of being the atomic components of symbolic logic relating together via a set of formal operations (Dreyfus, 1991). For example, Thomas Hobbes in the 17th century, and George Boole two centuries later came to conceive of human thought as a process of logical calculations.

It was in the philosophy of Logical Positivism in the early 20th century that this epistemological assumption and its psychological implications were articulated especially clearly (Stadler, 2015). Logical Positivism, comprised of a loose collection of philosophers and scientists, sought to articulate a firm basis for true knowledge, as against what they saw as a prevailing metaphysical and unscientific way of thinking in the early 20th Century. Members of the 'Vienna Circle', an active component of the movement, presented a manifesto in a paper titled the 'Scientific World Conception' (Neurath, 1973). It was such a conception that was broadly sought by Logical Positivists through the integration of mathematics and logic into a radical empirical verificationism. The epistemological issue at stake was to specify an exact structure for empirical confirmation relationships- using logic to provide a perfect account of scientific reasoning. In this way, logic became the point at which philosophy became part of the scientific and empirical enterprise and helped provide a sound foundation for what was presented as an accurate and scientific world view.

Ultimately logical positivism extended these ontological tendencies to include an understanding of human nature and its relationship with the world. The psychological assumption that arose assumed that knowledge and human meaning could be modelled as a logical structure of formal relationships between distinctly articulated atomic facts and entities. A dominant philosophical problem in post-Kantian thought up until the beginning of the 20th Century was that of relating the subject's realm of pure logic with the 'actual' objects of empirical knowledge. This problem broadly reflects the dilemma of the Cartesian

subject in its differentiation from the extended physical world, a mode of thinking which is still present in the 'Hard Problem' of consciousness (Chalmers, 1996). Rudolf Carnap, a prominent member of the Vienna Circle sought to resolve this issue through a thorough 'logicization' of human experience. Carnap (1947) portrayed empirical reality as constituted by definite ranks in a hierarchy of logical types. The empirical objects of knowledge, along with their representation for a subject and a subsequent construal of an inter-subjective shared cultural reality, was achieved by means of a sequence of formal structures as laid out in Bertrand Russel's *Principia Mathematica (*Whitehead & Russel, 1910). In the view of Carnap (1947), empirical reality simply *is* a particular logical structure, and this logical structure was able to include and unite what are conceived of as subjective and objective domains. Carnap (1947) affirmed the centrality of logic within ontological, epistemological and psychological domains.

It was in part through the spread of the orientation of logical positivism that the possibility of characterising the human mind in terms of atomic components and logical operations became increasingly entrenched in the imagination of philosophers and scientists throughout the 20th Century. Initially based in continental Europe, the Logical Positivists of the 'Vienna Circle' fell foul of the rising forces of Fascism in the lead up to the Second World War. As a consequence of this, members of the Vienna Circle fled to the USA, Britain and the Commonwealth (Gillies, 1993). In this way, the characterisation of mental processes as formal operations was brought to the centres of science in Britain and America. There it took root and influenced the dominant 'Anglo-American' perspective within Philosophy of Mind and Cognitivism throughout much of the 20th century (Gillies, 1993).

Cognitivism, as it unfolded in the USA, came to be the most explicit enactment of the psychological ramifications of what for Heidegger were mistaken ontological assumptions which had been present since Platonic thought. Cogntivism asserts that meaning generation and thought consisted of formal operations over symbolic representation (Varela & Thompson, 1993; Ramsey, 2007). The brain and the mind were understood as information processing devices whose analogy came to be seen in the digital computer. In this model, input was received from the external world and represented symbolically within mental

structures. Formal operations performed on those symbolic representations then lead to various appropriate motor outputs. For example, 'object identification', that process where by a human mind meaningfully understands elements of its environment, was described by David Marr (1976) as a process of identifying and combining atomic visual elements in a logical structure. The mind was presumed to progress through a series of stages in which discrete fundamental elements of an object were identified and successively combined to form an overall three-dimensional image. This image could then be cross referenced with a presumed mental catalogue where its 'meaning' could be established and an appropriate action undertaken. The same paradigm is still strongly precent in more recent cognitive science. One such model for example describes the processes of reading aloud as taking place on the basis of a logical regime of discrete mental operations or modules (Coltheart et al., 2001). These approaches strongly reflect ontological assumptions that Heidegger maintains found their origin in Platonic thought. Broadly by such a view the human experience of meaning is derived on the basis of explicitly relating together various logically independent atomic facts, on the basis of a set of explicit rules. That is, the core cognitivist characterisation of the human experience of meaning revolves around the idea of mental manipulation of symbolic representations.

However, it has been noted that elements of Continental and Heideggerian thought can be seen broadly reflected in growing trends in the cognitive sciences over recent decades (Gallagher, 2009; Wheeler, 2005; Clark, 1997). Heidegger characterized human existence (Dasein) as unable to be parsed separate from the broader environment, a notion broached by the term 'being-in-the-world' and criticized a mentalistic characterization of intelligible behavior. Within current cognitive science, the range of situated and environmentally extended characterizations of the mind for example, invokes this Dasein like sense of 'being-in-the-world' and a sublimation of mind-world distinction. Wheeler (2005), has also noted that a Heideggerian turn in the cognitive and brain sciences is evident in a move away from characterizing cognition as computation, and the increasing employment of non-linear dynamical analysis to explain mental processes.

## 1.3. Contemporary approaches to consciousness within the neurosciences

Contemporary approaches within the cognitive neuroscience and neurobiology of consciousness continue to uncritically import assumptions and biases that stem from Cartesian thought. This can be seen in the substantialist and reductive approaches taken, which contain the implicit conceptual separation of essence and existence as discussed above. Three dominant theoretical approaches to consciousness will be dealt with here: The Global Neuronal Workspace (GNWS) theory (Dehaene & Changeux 2011); The Integrated Information Theory (Tononi et al., 2016); and Naturalistic Dualism (Chalmers, 1996). Each theoretical approach will be outlined below. This is then followed in each case by an examination of the ways in which each theoretical approach contains a latent Cartesianism in its characterisation of human experience as a type of enclosed unit of subjectivity.

### 1.3.1. Global Neuronal Workspace theory

The GNWS theory (Dehaene & Changeux 2011) drew on the earlier work of Bernard Baars (Baars, 2005) and theorised consciousness as correlating with a globally distributed dynamic 'workspace' of neuronal activity. This global network is comprised of a range of separate specialised cortical modules that are dynamically and temporal interconnected via long range interconnector 'workspace' neurons. Various types of domain specific cortical modular activity may be seen for example in areas of the occipito-temporal cortex. Here for example V4 is isolated as a color processing region, MT/V5 encode movement processing, while low level facial processing for example occurs in the specialized activity of the fusiform face area (FFA). Cortical pyramidal cells with long-range excitatiory axons are then presented as possible examples of the 'workspace' neurons that connect these disparate modular regions. This Modular activity is then theorised to be linked at any given time via dynamic activity of the workspace neurons and the relevant thalamocortical loops, to become part of a globally distributed neuronal 'workspace'. The contents of subjective consciousness are then theorized to be represented by the sustained activity of a portion of these GNWS neurons.

According to this model, early functionally specified non-conscious processing in the sensory cortices and lower thalamic levels operate in a feed forward manner. In certain circumstances this advancing feed-forward wave of activity leads to an abrupt nonlinear and categorical transition to a late amplified globally distributed re-entrant loop of activity. Such a feedback loop is theorized to form a global self-sustaining state involving the sensory cortices, relevant thalamocortical loops and prefrontal, cingulate and parietal areas which are particularly dense in pyramidal neurons. It is the ignition of this globally distributed activity that may selectively include or exclude various cortical and subcortical modules, that is suggested to represent the Neural Correlates of Consciousness (NCC). Conversely, at any given time, many workspace neurons connecting to a range of other modular or functionally specific activity are also inhibited and fail to contribute to the ignition of a globally distributed pattern of activity. In these instances, such modular activity is not recruited into the GNWS and remains processed only up to a subconscious level.

The GNWS theory is currently one of the most functionally explicit accounts of the neurobiological underpinnings of subjective consciousness. For this reason, it has been a popular and useful model and has been supported by a number of empirical findings. In support of the broader model, conscious perception of a given stimulus has been shown to lead to globally distributed increases in the power of gamma band activity and its synchronization across regions (Dehaene, Sergent & Changuex, 2003). Similarly supportive is evidence shows that the processing of masked stimuli that are not consciously perceived occurs only in the relevant sensory cortices and does not lead to globally distributed patterns of activity (Dehaene & Naccache, 2001). Such findings support the view of the NCC as a global pattern of activity that can selectively and dynamically include lower level modular processes.

The GNWS model is also supported by the temporal profile of conscious and subconscious neural activity. Within the GNWS theory, the neural processing involving cerebral modules is suggested to be mediated through fast AMPA- feed forward connections. However the ignition to a globally distributed state is suggested to be mediated by slower NMDA receptors (Dehaene & Changeux 2005). This position is able to explain why subconscious processing may occur quickly and in a parallel manner, while conscious perception occurs in a serial manner and relatively late in the processing pipeline. Evidence

shows that conscious perception of a given stimulus correlates with late cortically distributed potentials occurring around 300 ms after stimulus presentation (Del Cul, Baillet & Dehaene, 2007). Conversely, the processing underlying a masked and invisible stimulus has been shown to take place more rapidly and occur up to and around 250 ms after stimulus presentation. In these instances, such activity occurs only in the relevant functionally specified regions and does not progress on to a globally distributed state. For example, in the case of a masked visual stimulus, processing may remain localized to the occipital cortex and associative regions but not progress onwards to activate a globally distributed state (Del Cul, Baillet, Dehaene, 2007).

The GNWS theory is one example of the many neurobiological approaches to consciousness that proceed to experimentation and neurobiological theory with only a very cursory treatment of the phenomenology. In this way, an essentially Cartesian characterisation of human experience is taken as self-evident. As is common throughout the literature, Dehaene and Naccache (Dehaene & Naccache 2001) deals with consciousness with one or two lines pointing to a phenomenon that is otherwise taken to need no further explanation. For example, Dehaene and Naccache (2001) simply state that what is meant by the word 'consciousness' is 'introspective phenomena' or the reportability of information. Once having made such brief clarifications, biological experimentation and theory is proceeded to almost immediately. 'Subjective experience' is characterized as being a supervisory system, operating in a serial processing manner and as constituting unified percepts that involve multiple sensory representations (Dehaene & Naccache 2001). Having established this brief outline, the bulk of the work of the GNWS theory is to provide neurobiological mechanisms for these functions. The approach taken by Deheane and Naccache (2001) is primarily to characterize what is implied by the words 'subjective experience' in biological terms. However very little attention is devoted to deconstructing the phenomenology and meanings packed into the words 'experience', 'introspection' or 'subjectivity'.

This seemingly self-apparent and self-explanatory nature of what we mean by the word 'subjective' or 'introspective phenomena' often masks a range of Cartesian assumptions that are erroneously carried through into the experimental paradigm. For example, the GNWS

theory (Dehaene & Naccache 2001) is typical of neurobiological approaches that begin with the a priori conceptual distinction between essence and existence that Heidegger discussed Heidegger, 1977a). That is, these approaches start with an intrinsic concept of consciousness that is already conceptually distinct from an extrinsic description of matter and material processes. For example, consciousness is dealt with as 'subjective experience' and neurobiological processes are dealt with in the extrinsic terms of glutamate receptors and thalamocortical loops (Dehaene & Changeux 2011). Dehaene and Naccahce express optimism that in pursuing the later, the former will ultimately be explained (Dehaene & Naccache 2001). However, an implicit but easily identified Cartesianism is built into this approach.

Following from this, the GNWS theory retains a covert Cartesianism in its fundamentally emergentist orientation. That is, any understanding of consciousness as 'emerging' from a range of neurobiological processes implicitly subscribes to a dualism between consciousness and its presumed non-conscious biological basis. As with many other approaches in the neurobiology of consciousness, the GNWS theory seeks to provide a binary characterization of the neurobiological basis of conscious and unconscious processes. That is, a neurobiological explanation of consciousness has been conceived of as an elucidation of the point in neural processes at which unconscious biological mechanisms are presumed to categorically transition into processes that correlate with consciousness. In the case of the GNWS theory, neurobiological processes are characterized dichotomously as early non-conscious processes, and late processes which correlate with consciousness (Dehaene & Changeux 2011). This body of work has undeniably furthered our understanding of some of the ways in which neural activity relates to phenomenal consciousness. However, such an approach recognizably embodies a Cartesian dichotomy between consciousness and non-conscious bodily processes. Therefore, it is questionable to what extent this body of research proceeds from and thus reinforces implicit Cartesian philosophical biases.

Dehaene and Naccahce (2001) do seek to distinguish the GNWS from essentialist approaches to consciousness. They write that "Many scientists and philosophers still adhere to an essentialist view of consciousness, according to which conscious states are ineffable experiences of a distinct nature that may never be amenable to a physical explanation" (Dehaene & Naccache 2001, p 4). They then go on to claim "Contrary to those extreme

statements, contributors to the present volume share the belief that the tools of cognitive psychology and neuroscience may suffice to analyze consciousness" (Dehaaene & Naccache 2001, pp 4). That is, Dehaene and Naccache (2001) appear to view the GNWS theory as a non-essentialist treatment of consciousness, simply because an optimism is expressed that through the GNWS theory, consciousness will be able to be explained in physical terms.

Nevertheless, the phenomenon of consciousness as outlined in the GNWS theory continues to bear many of the hallmarks of an essentialist treatment. Dehaene and Naccache (2001) freely admit that consciousness is intrinsic or 'internal' in nature and can be further described as an 'introspective phenomena'. However, no attention is directed to clarifying exactly how the language and metaphors of spatiality should apply to consciousness. A physical and therefore extrinsic explanation is sought for a phenomenon that remains intuitively grasped as intrinsic and essential. Throughout such an approach, a separation between what Heidegger (1977a) termed *essence* and *existence* remains unexamined but present.

## 1.3.2. Integrated Information Theory

The Integrated Information Theory (IIT) outlines some of the axiomatic phenomenal properties that Tononi and Edleman see qualitative experience as possessing (Tononi, Boly, Massimini & Koch, 2016). From these axioms IIT infers the type of characteristics that should be manifest by the physical substrate of consciousness (PSC). IIT begins with five basic axioms. These are that consciousness exists *intrinsically*, has *structure*, is *specific, unitary* and *definite*. The theory then goes on to postulate the sorts of properties that any physical substrate of consciousness must exhibit in order for phenomenal experience to exist in these axiomatic ways.

As with GNWS theory, the first axiom of IIT holds that experience exists *intrinsically*. As elaborated by Tononi and Boly et al., (2016), to say that experience has an *intrinsic* way of existing is to claim that experience is immediately and absolutely evident from a first-person perspective. Tononi and Boly et al., (2016) specifically draw on Descartes to substantiate this claim. The second axiom of *structure* or *composition* states that experience is structured. That is, experience is composed of qualitative components that are all internally distinct from each

other. Tononi and Boly et al., (2016) give the example of an experience in which a piano, a blue colour, a book, countless spatial locations etc. all may be distinguished. The third axiom of IIT claims experience is composed of *specific* information. That is, that any given experience is composed of a particular set of qualitative components (qualia), which differentiate it from any other given moment of experience. IIT's fourth axiom is that experience is *unitary*. That is, that despite being comprised of a range of different components, any given experience is formed of an integrated unitary whole that is not reducible to its individual components. This essentially corresponds to the notion of perceptual binding (Von der Malsburg, 1999; Ding et al., 2017) where consciousness may include awareness of a range of different sensory dimensions, but nevertheless exists as a singular unitary phenomenon. Broadly, this axiom holds that the content of an experience (information) is integrated into a singular phenomenal moment. The fifth and final axiom of *exclusion* holds that each experience is clearly defined in its content. That is, that any given experience includes a specific set of content, not more or less. For example, in the experience Tononi and Boly et al., (2016) give of seeing a piano and a blue book etc., this experience is differentiated from similar experiences that may be otherwise identical but possess less information (be in black and white) or possess more information (for example, have additional somatic or bodily sensations associated with it) (Tononi and Boly et al., 2016). Tononi and Boly et al., (2016) hold that consciousness can essentially be characterized through these five axioms: in the broadest terms IIT holds that consciousness is intrinsic information (qualia) that exists in a unified manner. That is, consciousness is integrated information.

From these axioms, IIT derives five corresponding postulates that define the principles that the PSC must satisfy. Tononi and Boly et al., (2016) state that to exist in the physical sense means to possess a cause and effect structure (Tononi & Boly et al. 2016). Therefore, the existence of the postulated mechanisms of the PSC are described as a series of cause and effect structures that are capable of giving rise to the axiomatic properties described. The descriptions of these postulates given in Tononi and Boly et al., (2016) are highly abstract and difficult to follow. Nevertheless, the first axiom of *intrinsic existence* provides perhaps the most intuitive and definitive characterization of consciousness and the corresponding postulate gives a relatively clear sense of the direction in which the theory is heading. The postulate

corresponding to the axiom of *intrinsic experience* is that the physical substrate of experience must have cause– effect power within and for itself. As the most minimal neural instantiation of this postulate Tononi and Boly et al., (2016) give the example of two interconnected neurons. Such a two-component system is capable of impacting on itself through its own internal reciprocal feedback.

The remaining postulates are perhaps less intuitively obvious. The corresponding postulate to the second axiom of *structure* or *composition* is that the individual components within the physical substrate of the experience must have internal cause–effect power. The third axiom of *specific information* gives rise to the postulate that the PSC must have a specific cause effect structure that differentiates it from the physical substrate of other possible experiences. The corresponding postulate to the fourth axiom of *integration* or *unitary existence* holds that the cause–effect structure of the PSC must not be reducible to the cause–effect structure of its various internal subcomponents. Lastly, the corresponding postulate to the axiom of *exclusion* is that the cause–effect structure of the PSC must contain a definite set of cause–effect structures. This postulate specifies a definite set of cause–effect structures over a defined set of elements, at a definite spatio-temporal grain (Tononi & Boly et al. 2016).

With these axioms and postulates in hand IIT is intended to be directed towards identifying the NCC. That is, in principle IIT holds that the NCC should correlate with the neurobiological processes that satisfy these postulated mechanisms. However currently, evaluation of consciousness as integrated information within the human nervous system remains unfeasible given the extraordinarily high number of observations across multiple levels of neural organization and within many different brain regions that this theory would require. Some testing of the predictions of IIT on human subjects has been undertaken using simplified proxies for integrated information such as the Perturbation Complexity Index (Casali & Gosseries et al. 2013). However as it stands the validity of IIT remains tested largely through computer simulation (Deco & Hagmann et al. 2014). Currently, IIT remains a theoretical tool that generates a number of predictions and promises a number of clinical applications, when and if IIT becomes validated at a neurobiological level.

IIT also contains many of the broad elements of a Cartesian and what Heidegger identified as a Platonic orientation in its presentation of human experience as a self-evident

enclosed unit of subjectivity. The axiom that experience is *intrinsic* places this theory directly within a Cartesian framework. Although the term 'intrinsic' is only given brief explanation, Tononi and Boly et al., (2016) link the term to notions of immediacy, self-evidence and subjectivity. The idea of *intrinsic existence* is linked here to a sense of interiority or internality of perspective that differs from the extrinsic objective existence of material processes. In short, the axiom of *intrinsic existence* subscribes directly to the Hard Problem of consciousness (Chalmers, 2010), seemingly without providing any means where by such a reciprocally connected network of neurons should be associated with the feeling of existence. The essentialist treatment of consciousness as having an internal and subjective ontology different from the extrinsic existence of physical processes clearly places this theory within an overarching framework of Cartesian dualism.

Alongside an intrinsic and essentialist treatment of consciousness, an aspect of Cartesianism is also demonstrated in both IIT and GNWS in their reductive approaches. As well as presenting a description of human existence as *res cogito* or thinking substance, Descartes was also one of the first proponents of a mechanistic philosophy that took a reductive approach to the phenomena of nature. Such an approach can be seen as an explicit embodiment of the traditional ontology that Heidegger saw originating with Plato. As discussed above, Heidegger characterized the traditional ontology originating with Plato as a conception of existence as a collection of context free atomic building blocks, relating together on the basis of an explicit set of formal laws (Heidegger 1962, p. 123). It was this ontological position that underlies the possibility of reductive approaches to natural phenomena. The reductivist and subjectivist strains of Cartesian thought are closely related in that the formation of the concept of the *res cogito* was implicit in allowing a reductive mechanistic approach towards nature. That is, in defining the *cogito* as ontologically distinct, the remaining portion of existence- the extended physical substance- remained as a medium perfectly suitable for reductive treatment. Descartes himself comments that separating the *cogito* from the *extensio* allowed him a more penetrating analysis. (Heidegger 1962, p. 127 note xvii). That is, bracketing the *cogito* aside was part of the processes that allowed a reductive analysis of nature to proceed in a way that it could not for Aristotelian thought. In this way, reductive approaches in the contemporary neurobiology of consciousness can also be read as a continuation of the Cartesian and Platonic ontology.

Heidegger presents a strong case for why reductive approaches are an inappropriate mechanism for explaining human experience. A reductive account of nature only proceeds on the basis of first having separated human meaning (and thus consciousness) away from the physical objects studied by science. This being the case, Heidegger argues that no amount of combining and recombining these decontextualized objects of science will reproduce or resurrect human meaning. By Heidegger's account, humans first encounter the world as a meaningful gestalt that is not separate from their own identity. This he terms *worldhood* and suggests that human meaning only ever arises on the basis of this *worldhood*- a pre-cognitive gestalt of significances, already having taken place (Heidegger 1962). Heidegger writes "'Nature'….can never make *worldhood* intelligible" (Heidegger, 1962, p. 94) and in his own marginalia writes "just the reverse" (Dreyfus, 1991, p. 121). By such a view, the decontextualized physical objects studied by science only come into view as such when this contextual gestalt of identity and world is broken down and human meaning is peeled away. The neurobiological approaches to consciousness seen in Tononi and Boly et al., (2016) and Dehaene and Changeux (2011) typify this effort. For example, these approaches suggest that we will be able to explicitly understand the advent of consciousness by examining varying combinations of non-conscious neural interaction. However, Heidegger treats *worldhood* as the basis of human meaning. He explicitly denies that human meaning can be built up to on the basis of any combination of decontextualized atomic components, such as the reductive approaches of in Tononi and Boly et al., (2016) and Dehaene and Changuex (2011) seek to do. When *worldhood* is withdrawn, such as is the assumed starting point of reductivism, what remains cannot then be used to reconstruct human meaning.

Heidegger does not deny the veracity of a physical or reductive description of nature. However, he suggests that this is an inappropriate approach towards understanding human meaning. Heidegger argues that materialism is not simply a belief that everything is physical but rather is a metaphysical position about what it means for something to exist (Heidegger, 1977b, p. 220). He makes the point that it is this same metaphysical orientation, who's seeds can be found in Platonic thought, that is covertly at play when we conceptualize human experience in terms of being a type of internal mental subject.

In a closely related way, the understanding of the world as an array of

decontextualized and meaningless components not only occurs through the methodology of scientific practice, but also in first conceptualizing our own existence as units of subjective consciousness. Not only did bracketing aside the *res cogito* allow a reductive or mechanistic philosophy to take place, but Heidegger maintains that the processes of understanding ourselves as Cartesian subjects was also part and parcel of a fragmentation of our view of the world into the collection of isolated independent components that seems to call for reductive explanation (Dreyfus, 1991). By Heidegger's account, a Pre-Socratic and perhaps ideal mode of human existence is one in which the world arises for us as a field of significance which is non-separate from our own identity. However, it is in conceptualizing ourselves as isolated units of subjective consciousness that the gestalt of human-worldly significances that Heidegger describes is shattered and a sharp subject-object distinction arises. In this way, an understanding of human experience as an isolated unit of subjectivity co-arises with the reductive view of reality as composed of a collection of independent atomic components.

### 1.3.3. Naturalistic dualism

As an alternative to the reductive approaches described above, Chalmers (2010) advocates treating consciousness as a fundamental property in a variant of naturalistic dualism. This approach aims for a more fundamental level of analysis than that allowed in contemporary neurobiological approaches. As such, the type of fundamental analysis and naturalistic dualism Chalmers advocates remains a primarily philosophical rather than empirical endeavor to date. Nevertheless this approach will be dealt with here because Chalmers is an oft sited voice within the broader science of consciousness and one that has articulated and clarified many of the definitive issues which the science of consciousness tries to grapple with (Chalmers, 1996; Dehaene & Changeux 2004; Koudier 2009).

Chalmers (2010) argues that reductive approaches to the problem of consciousness cannot succeed because reductive approaches are only able to explain abilities that are functionally defined. That is, reductive biological approaches are perfectly suited to providing an explanation for abilities that are entirely defined by the mechanisms for performing a given function. Chalmers gives the example of a gene, which by definition is a mechanism for transmitting information across generations (Chalmers, 2010). Once such a mechanism has

been explained, the gene has been explained. However, Chalmers argues that consciousness is not able to be functionally defined. Functional and mechanistic accounts may explain attention, reportability or perceptual binding. However, consciousness is not able to be exhaustively defined by the performance of these various functions. Chalmers maintains that consciousness is not functionally definable and is therefore resistant to reductive explanation.

Having argued that reductive approaches cannot succeed in explaining why and how consciousness arises from physical processes, Chalmers suggest that a non-reductive account of the problem of consciousness is the only alternative (Chalmers, 2010). What Chalmers advocates by this, is an account of consciousness as a fundamental property of the universe in the same way that mass, charge and space-time are fundamental properties. Rather than seeking a reductive account for how matter could combine to produce consciousness, what Chalmers seeks in such a theoretical orientation is an explanation of the basic principles that specify how experience depends on physical processes. The following three basic principles are presented as possible contenders for these; the principle of structural coherence, the principle of structural organizational invariance and the principle of double aspect (Chalmers, 2010).

With the principle of structural coherence Chalmers (2010) proposes an isomorphism between the structures of consciousness and the structures of awareness. Typically, awareness has been differentiated from consciousness (Block, 2005; Koudier, 2009). While Chalmers maintains this distinction he however notes that there is also a tight correspondence between consciousness and reportability. That is, one justifiable and often used measure of whether a given stimulus is consciously perceived, is whether a subject is aware of a given stimulus and thus capable of reporting on it (Seth & Dienes et al., 2008). This being the case, there should be a correspondence between the structure of neural mechanisms which allow awareness and reportability, and the structure of consciousness.

With the principle of organizational invariance, Chalmers (2010) suggests that what matters for subjective experience is not the specific material substrate the experience arises from but the abstract pattern of causal interactions embodied by the actions of a given substrate. For example, an identical conscious experience would be associated with a physical substrate, whether this substrate is one of an interaction of neurons or silicon chips, provided

the pattern of interaction remains the same. Chalmers writes "If the causal patterns of neural organization were duplicated in silicon, for example, with a silicon chip for every neuron and the same patterns of interaction, then the same experiences would arise." (Chalmers 2010, p. 23).

However, the most central and basic principle that Chalmers (2010) puts forward with this non-reductive and fundamental account of consciousness is the principle of double aspect. This principle treats information as a basic property of the universe, and treats phenomenal facts as the intrinsic aspect of such information, and physical facts as the extrinsic aspect of the same invariant information. Chalmers (2010) writes that –

> …we can note that the differences between phenomenal states have a structure that corresponds directly to the differences embedded in physical processes; in particular, to those differences that make a difference down certain causal pathways implicated in global availability and control. That is, we can find the *same* abstract information space embedded in physical processing and in conscious experience. This leads to a natural hypothesis: that information (or at least some information) has two basic aspects, a physical aspect and a phenomenal aspect. (Chalmers, 2010, p. 26).

Chalmers suggests that certain types of information have two basic aspects, a phenomenal aspect and a physical aspect and that therefore consciousness can be considered a fundamental property of the universe alongside mass, charge and space-time.

Clearly such an approach retains much of the ontological orientation that informed Descartes. Chalmers theory (Chalmers, 2010) embraces dualism and as with Descartes remains firmly within an essentialist treatment of consciousness. Further following Descartes, the way of existing that consciousness has is presumed to be as a passive instance of witnessing or beholding and this is fundamentally differentiated from the extrinsic way of existing that matter and material processes are presumed to have. That is, the structure of phenomenal human experience is not re-imagined such that a shared ontology between physical and phenomenal states could be described.

## 1.4. Is Heideggerian thought applicable to consciousness theory?

This chapter has drawn on Heideggerian thought to comment on the treatment of consciousness in Western science and philosophy. However, prominent elements in the secondary literature explicitly disavow that Heidegger addresses himself to the question of consciousness or qualitative experience. Elements of the secondary literature, in particular Dreyfus (Dreyfus, 1991) make a strong case that Heidegger describes human existence as one of absorbed involvement and not one of any sort of disembodied rational mind or consciousness. By such an account meaningful behaviour is not the enactment of a rational structure that unites a subject and its environment. Human's most fundamental relationship to the world is not cognitive in nature. Rather, Dreyfus makes the case that Heidegger describes a background network of cultural significances that implicitly inform meaningful behaviour in the absence of explicitly worked out mental representations. With this reading, Dreyfus strongly criticises use of Heidegger to inform any sort of theory of consciousness. For example Dreyfus writes-

> We are not to think of Dasien as a conscious subject. Many interpreters see Heidegger as …an edifying elaboration of Husserl. The most famous version of this mistake is Sartre's brilliant but misguided reformulation of *Being and Time* into a theory of consciousness in *Being and Nothingness*. (Dreyfus, 1991, p 13).

Instead, the type of approach Dreyfus advocates towards Heidegger can be read as a type of contextual behavioralism that undermines a strong subject-object distinction. Such an approach removes a mind like essence or self-consciousness from playing the definitive role in human's way of existing. By such a reading, Heideggerian thought has little to say about consciousness, as it simply brackets the issue of consciousness aside for a more pragmatic account of human meaning.

However, this interpretation of Heidegger in the secondary literature should be understood on a backdrop of a dichotomy that Heidegger saw as complicit in shaping the contours of Western thought. This was a dichotomy that fundamentally considered a things essential defining nature apart from its actual manifest existence. Joan Stambaugh (Heidegger, 1969. ed) for example writes that Heidegger viewed a traditional Western mode of thinking

as beginning "when Plato separates the realm of Being (the Forms or Ideas) and the realm of time (becoming, existence)" (Heidegger, 1969, p. ix). Similarly, Heidegger writes that the 'separation of essence and existence dominates Western thought" (Heidegger, 1977a, p. 208). Heidegger points out that this separation between essence and existence is thoroughly complicit in our concept of consciousness (Heidegger, 1977a). This can be seen in that Platonic theory of the Ideal and Real becomes a philosophical question on the relationship between the mind and the world (Guyer & Horstmann, 2015). Heidegger strongly rejected an essentialist treatment of human existence in terms of subjective consciousness. This rejection underlies the very concrete practical everyday treatment of human existence outlined in division one of *Being and Time*.

However, rather than a disavowal of a subjectivist characterisation of human existence in favour of a practical and pragmatic one as Dreyfus (1991) may suggest, Heidegger sought a description of human existence that undermined this dichotomy. He describes the being-structure of human existence without separating or even without simply combining, essence (internal, soul, mind, consciousness) and existence (external, everyday concrete manifest world). For him, a separation between essence and existence is thoroughly complicit in our concept of consciousness. Therefore, even though Heidegger does not consider the problem of consciousness in relation to its material basis, his reaching for alternatives to the dichotomy between essence and existence bears directly on the way in which we imagine human experience to exist as subjective consciousness. This in turn bears on key considerations in the science and philosophy of consciousness.

Indeed, much of Heidegger's work can be interpreted as strongly commenting on the existence of qualitative experience and this is the reading taken in this thesis. Heidegger terms human's way of being *'ek-sistance'* (Heidegger, 1977b, p. 204). The term can be read to connote *felt existence* as much as it does *manifest existence*. However, it does so while seeking to remove even the germ of distinction between these two senses of the word. While Division One of *Being and Time* (Heidegger, 1964) does read as a convincing account of meaningful behaviour in the absence of explicit mental representations, a broader reading of the range of Heidegger's writings suggests that this was in service of a subtler point. A broader reading

suggests that Heidegger sought to articulate an understanding of existence (Being) that undermines at its roots, any conceptual distinction between *manifest* human existence (factually existing entities in the world) and *felt* human existence (qualitative experience). This division between the actual existence of humans (i.e. as biological entities in the world) and what it feels like to exist (consciousness) is at the heart of the Hard Problem of consciousness. For this reason, Heidegger's discussion can be read as commenting meaningfully on qualitative experience and the very problems of consciousness that Chalmers (2010) addresses.

In constructing an analytic of Dasein and being-in-the-world Heidegger made it clear that he was addressing the question of subjectivity and consciousness, however re-defined. The phenomenon of the felt experience of an individual human being was under discussion. However, such a discussion took place whilst seeking to move away from any undertones of mental witness-hood that characterises a subject as against a separate world. For example, in discussing human existence as the 'lighting of Being' (Heidegger, 1977b, p. 211), Heidegger states that this phenomenon is concealed as 'subject' in traditional Western thought. That is, Heidegger suggests that the phenomenon that he discussed as the 'lighting of Being' is dealt with by Western thought, but dealt with defectively in its treatment as 'subjectivity'. Similarly, Heidegger specifically underscores that his discussion of *being-in-the-world*, is a modification of the traditional concept of consciousness and mind (Heidegger, 1984, p. 134). In his discussion of transcendence Heidegger also makes it clear he is seeking to analyse the underlying structure of subjectivity and selfhood, writing that 'Transcendence is … the primordial constitution of the *subjectivity* of a subject" (Heidegger, 1984, p. 165) or put more simply 'Transcendence constitutes selfhood' (Heidegger, 1976, p. 137). Throughout Heidegger's writings the phenomenon of the felt experience of a human being remains a locus of his attention. However, this phenomenon is re-cast and dealt with in a manner that seeks to remove any connotation of individual subjective mental witness-hood defined in opposition to the existence of the world or domains outside of the self.

The same point is underscored in that throughout much of Heidegger's discussion of human's way of being, his language unavoidably connotes felt experience and not simply the

issue of meaningful behaviour. Heidegger always seeks to avoid implying a conceptualist or cognitive connotation to human essence. Nevertheless, he does discuss a relation to Being as a contemplative activity. This can be seen in his latter writing where Heidegger moves away from the idea of philosophy as metaphysically oriented cognition and towards a type of non-conceptual relating to Being he terms 'thinking'. Heidegger discusses 'thinking', in its openness to Being as "a thinking more rigorous than the conceptual" clearly placing it as an experiential act. (Heidegger, 1977b, p. 235). Similarly, human's way of being which Heidegger terms *ek-sistance* is described in terms that make it clear that he is envisaging it as a state of experience. For example, Heidegger writes that the "essence of man lies in its ek-sistance" and that "what is required first is that we experience [this] essence of man more primordially" (Heidegger, 1977b, p. 224). In one passage while discussing *worldhood* and the relationship between world and human existence, Heidegger states that ""World" is in a certain sense, precisely "the beyond" within existence and for it" (Heidegger, 1977b, p. 229). Throughout Heidegger's writing there is a sense in which the language used implies the terrain of felt experience. Such language goes beyond the implication of any dissolution of subject-object dualism in an understanding of meaningful human behaviour, as commentaries such as Dreyfus imply (Dreyfus, 1991). While this remains a matter for scholarly debate, the interpretation of Heidegger taken in this thesis is that his many descriptions of human's way of existing include and subsume the significance of felt existence. As such, Heidegger's discussion of *ek-sistance*, *transcendence* or *being-by* presents as a useful framework to re-conceptualise the way of existing that qualitative experience could have, in contrast to a traditional characterisation as a unit of conscious subjectivity. These terms and their significance for understanding qualitative human experience will be discussed in more detail in Chapter Two.

## 1.5. Conclusion

This chapter has examined some of the ways in which the ontological orientation of Western thought has shaped the ways in which we conceive consciousness to exist and fit within a broader theory of the world. The purpose has been to open room to consider alternative characterizations of qualitative experience and this is taken up in the

following chapter. Plato's theory of the Forms was dealt with as underlying a construal of human experience as a self-contained subjectivity whose primary way of relating to 'reality' is by knowing it, that is, by representing it within consciousness. The Platonic distinction between the Ideal and the Real was then examined in terms of *hylomorphism*- the Aristotelian understanding of Being in terms of a 'substantial form' inhering in and informing the existence of a 'prime matter'. The inauguration of modernity proper was then dealt with in Descartes treatment of *hylomorphism* in terms of the concise distinction between thinking substance (subject) and extended material substance (object). The way in which, in Heidegger's view, Plato's understanding of Being has come to shape epistemological and psychological approaches was then discussed. This chapter further addressed some of the ways in which Cartesianism is present in the contemporary science of consciousness.

This chapter has sought to demonstrate that despite a commitment to the philosophy of physicalism, it is built into the structure of modern Western thought to conceive of human experience as an intrinsic subjective internal domain, ontologically at odds with an external domain of manifest reality. By highlighting some of the ways in which Heidegger saw this tendency of thought as exhibiting itself, the intention of this chapter has been to underscore that the characterization of human experience as 'subjective consciousness' arises from underlying philosophical biases. Once these biases are examined, it is possible to begin to consider other ways of characterizing and understanding the existence of qualitative human experience. The following chapter looks at Heidegger's characterization of human experience and uses this as a basis for alternative theoretical framework in the neuroscience of consciousness.

# Chapter 2

## A theoretical claim about the nature of qualitative experience supported by elements of Heideggerian thought

### 2.1. Introduction

This chapter presents a model of qualitative experience in terms of being a dynamic gestalt of conscious and non-conscious processes. This model is supported by drawing on elements of Heidegger's understanding of the specific way of existing that he saw humans as having. This is ultimately done in service of motivating alternative theoretical frameworks in the neuroscience of consciousness. The theoretical orientation outlined in the present chapter is used as a basis for empirical research in the following chapters.

The mechanisms of science have not been able to account for or explain the existence of lived qualitative human experience. Instead, the philosophical antecedents and very processes by which science is conducted have led to a view of nature in which qualitative experience simply has no place. This separation between what is conceived of as a human being's enclosed internal subjectivity on the one hand and a spatially extended material view of nature on the other, lies implicit in the ontological assumptions that Western thought has traditionally employed. Despite disavowing Cartesian dualism, the dominant trends in the psychologies, cognitive sciences and brain sciences throughout the twentieth century, have continued to entrench an implicit perception of a separation between subjective conscious experience and an objectivist conception of the natural world. However, the continental philosophical traditions have in their earliest inceptions, questioned and provided alternatives to this fundamental dichotomy. Over the last decade, there has been an increasing recognition of the indebtedness of the recent cognitive sciences to the characterization of human experience that is described by Heidegger, Merleau-Ponty and other philosophers within the Continental tradition (Wheeler, 2005; Gallagher, 2009; Clarke, 1997). This chapter draws on the works of Heidegger in particular, in order to examine and provide alternatives

to a traditional characterization of sentient human existence as a mental subject enclosed in the psychical domain of its own representations.

Heidegger's critique of the metaphysical assumptions present in traditional Western thought and the reinterpretation of Being that he offers, can be employed to re-inform the way in which we conceive qualitative human experience to exist and take place. Broadly, in much of the contemporary science and philosophy of consciousness the conception of human's way of existing continues to bare the stamp of Cartesian thought. It is difficult not to conceive of consciousness as something internal, subjective and mental in nature, and contrast this with an external and objective characterization of the natural world. In *Being and Time* Heidegger (1962) took direct issue with a Cartesian characterization of human existence. However, Heidegger critiqued not only the dualism present in Cartesian thinking, but more primarily, the underlying ontology or understanding of Being that implicitly informed Descartes' position in the first instance. In this way, Heidegger's elaboration of the question of the meaning of Being touches on and provides alternatives to a traditional characterization of human experience in terms of subjective consciousness. Heidegger was deeply critical of defining human existence in terms of the traditional idea of 'consciousness'. He sought to wrestle our conceptualization of human experience away from a characterization in terms of this sort of enclosed and internal subjectivity. In doing so, his writing deals directly with many issues central to the science and philosophy of consciousness as will be discussed below. Heidegger examines many of the prejudiced intuitions built into a seemingly self-evident characterization of human experience as an internal, subjective first-person domain that is ontologically at odds with an objective spatially extended view of nature. Heidegger's thinking can provide insight into alternatives to the jarring sense of mutual exclusivity between 'within' and 'without' that is central to an essentially modern characterization of human experience *as* subjective consciousness. This chapter uses Heidegger to motivate a theoretical approach to the question of qualitative experience and does this ultimately in service of empirical approaches.

In section 2.2, this chapter begins with a presentation of the central thesis as a claim about the nature of qualitative experience, which is motivated by elements of Heideggerian thought. The central thrust of this claim focuses on the relationship between consciousness

and non-conscious processes. It is suggested that any understanding of the way of existing that human experience has, must treat conscious and non-conscious processes not as separable and conceptually distinct, but rather as a singular phenomenon. Broadly such an approach takes the qualities of outwardness, externality and alterity that are typically associated with non-conscious biological processes and incorporates these within a characterization of qualitative human experience. It is through this that qualitative human experience is characterized in terms of groundlessness and an existential openness rather than as an enclosed unit of subjectivity. This central thesis in turn bears directly on the question of the relationship between consciousness and the spatially extended material processes of nature. In section 2.3 of this chapter, elements of Heideggerian thought are examined in order to justify and elaborate on this theoretical orientation. Heidegger's discussion of the question of the meaning of Being is addressed along with the way in which this allows for a non-substantialist and non-Cartesian understanding of qualitative experience. Heidegger's discussion of *transcendence* as well as *abgrund* (groundlessness) and his concept of *das nichts* (the nothing) and *offenheit* (openness) are also examined. These ideas are drawn on to highlight the way in which it is possible to move away from Cartesian based metaphors of interiority and exteriority in the way in which we conceive of qualitative human experience to exist. Consciousness research in the brain and cognitive sciences cannot help but begin with subjective first-person accounts of how consciousness appears to exist. This paper draws on Heideggerian phenomenology in order to inform models of empirical research into the relationship between neuronal dynamics and the phenomenon of human experience. It is suggested that such an approach contributes to a richer philosophical basis for research within the brain and cognitive sciences, and perhaps more importantly, broadens and enriches the scope within which we are able to conceive of our own existence.

## 2.2.1 Central thesis: Qualitative experience as a mutual instantiation of conscious and non-conscious processes

The central theoretical position in this chapter can be encapsulated as the claim that qualitative experience may be characterized as a dynamic gestalt of both conscious and non-conscious content and processes arising as a singular phenomenon. It is suggested that any given content of experience, or indeed qualitative experience as a whole, may not exist at one

point on a spectrum of liminality but rather, arise only as a gestalt consisting of supraliminal and subliminal elements. Peterson and Salvagio (Peterson & Salvagio, 2008) have demonstrated that the perception of bi-stable images are qualified in the context of other features of the visual environment. Such a finding suggests that the content of qualitative experience exists in a contextual manner and is constituted in terms of a range of other subliminal and supraliminal phenomenal elements. In particular, what is drawn out here is that this contextuality may extend across a spectrum of liminality. In this sense, the very subjective givenness of qualitative experience, such as the redness of red, may be considered to be constituted both of supraliminal and subliminal elements arising as a whole. Such a view contrasts with a traditional conceptualization of consciousness distinct from underlying unconscious mental and material processes.

This theoretical position should be distinguished from the well-established fact that unconscious processes impact on and feed into conscious human perceptions and behaviours. The role of unconscious processes in shaping human beliefs, perceptions and behaviours is a well-validated empirical fact (Breitmeyer & Kiefer et al., 2015; Bowser 2017; De Klerk, 2017; Eriksson. 2017; Schelonka & Graulty et al. 2017). It can be safely stated on the basis of a sizable body of research that human experience arises from a combination of both conscious and unconscious beliefs, desires and perceptions. Nevertheless, consciousness and non-conscious processes remain mutually distinct by definition within the framework of this research. For example, what research such as that of Kiefer et al., (2015) show is that there are both conscious and non-conscious components that go towards shaping human mental processes, behaviours and perceptions.

By contrast, the theoretical position outlined in this chapter is that we fall short of a complete characterization of what consciousness is, if we simply conceive of it as the collection of positive phenomenal facts that are by definition distinct from non-conscious biological or mental processes. In other words, processes that are both immediately perceptually present and completely hidden from perception are suggested to be part of the structure of the phenomenon that we refer to as 'consciousness'. In this sense, one could say that the phenomenon that we refer to as 'consciousness' cannot be fully represented 'in consciousness'. On the basis of such a position, it is suggested that we cannot behold what

consciousness is in its entirety, because it is not exclusively conscious in its way of existing. Rather, it is suggested that qualitative human experience viz 'consciousness' exists as a unified gestalt of both conscious and non-conscious processes arising as a singular phenomenon.

## 2.2.2. Qualitative experience as exhibiting absence and hiddenness

Phenomenologically the ideas discussed in 2.2.1 are approached in terms of describing qualitative human experience as exhibiting a hiddenness or absence in its characteristic manner of existing. Qualitative experience, as a gestalt of conscious and non-conscious processes, is suggested to exist in a way that is not only self-apparent and self-revealed but simultaneously also characteristically hidden and opaque to itself. Again, this can be clarified by comparison to a characterization of the concept of 'subjective consciousness'. Traditionally consciousness is understood as entirely self-transparent in that it is private and has immediacy of epistemic access to itself (Nagel, 1974; Van Gulick, 1985). This self-transparency subserves a sense in which consciousness is viewed as an enclosed unit of subjectivity. As self-transparent, it encloses itself and can be conceived of in a self-sufficient and atomic manner, as a unit of consciousness or a totality of positive phenomenal facts. Here however qualitative experience is described as being existentially open rather than existentially enclosed and this infers that consciousness cannot fully represent itself 'in consiousness'. The thesis of a shared ontology between conscious and non-conscious processes reflects in that qualitative experience is held to exhibit a hiddenness or absence in its way of existing.

A further implication here is that qualitative experience exists in a way that is cognitively evasive. A characterization of qualitative experience as unable to be explicitly disambiguated from a range of unconscious processes, suggests that its characteristic way of existing is not able to be fully explicated or made accessible to cognition or formal representation. In exhibiting this hiddenness or cognitive evasiveness, what is reached for is a non-mentalistic and non-representational way of characterizing the existence of qualitative experience.

## 2.2.3. Spanning Cartesian dualism: Seeking a shared ontology between consciousness and non-conscious biological processes

Challenging the traditionally perceived dualism between conscious and non-conscious processes in this way presents one possible avenue to draw new insight into the relationship between consciousness and matter. The thesis of a shared ontology between conscious and non-conscious processes subverts the strong distinction between the exteriority attributed to material processes and the interiority that subjective consciousness is always conceptualized as possessing. That is, this thesis subsumes the quality of exteriority within a characterisation of qualitative experience. The outwardness, exteriority and alterity associated with unconscious biological processes, are treated as qualities that are within and part and parcel of the being structure of qualitative experience. In this way qualitative experience viz 'consciousness' is characterised as exhibiting an alterity, a hiddenness and an outwardness in its way of existing, in the same instant as it also exhibits itself as a self-revealing interiority of self-feeling. Qualitative experience is viewed as an existential openness rather than as a unit of interiority distinct from its grounding basis in outward spatially extended material processes. This is part of what is implied in characterising qualitative experience as a gestalt of conscious and non-conscious processes. Such an approach begins to open an avenue to re-cast the relationship between a traditional concept of consciousness and the extended material processes of nature.

This approach relies on a conflation of the treatment of non-conscious mental and material processes. However, it is argued that such a conflation can be justified in this context. Unconscious processes have been traditionally interpreted either in terms of being unconscious *mental* processes (Kihlstrom, 1987) or unconscious *biological* processes (Dehaene & Changeux, 2004). However, such a distinction is relevant only to a third-person perspective. This distinction is lost in regard to the first-person perspective of qualitative experience. That is, from the perspective of the individual experiencing human being, there can be no distinction between their own unconscious *biological* processes and their own unconscious *mental* processes. These processes are simply non-conscious. Only from a perspective external to the experiencer can this theoretical distinction be made between unconscious processes understood either biologically or mentally. A central theoretical position presented in this

chapter is that phenomenal experience is described in terms of a co-existence of conscious and non-conscious elements. Accordingly, non-conscious processes variously defined as mental or biological in nature from a third-person perspective, simply represent a mentally un-representable alterity to a first-person perspective. The distinction between mental and biological is lost.

Such an approach provides an avenue to conceptualize qualitative experience as exhibiting it's formative grounding conditions (matter) in its way of existing. This theoretical orientation seeks to envisage how a characterization of the being structure of qualitative experience or consciousness would change if it was conceived to exist in a way that exhibits its primary conditions of existence (physical processes). This idea can be clarified by contrast to the traditional concept of subjective consciousness. Subjective consciousness can be conceptualized entirely independently from the existence of its fundamental basis in the spatially extended material processes of nature. Spin, charge or extensive properties of mass and volume play no part in the way we understand consciousness to exist as qualitative character, subjectivity or self-perspectival structure (Chalmers, 1996; Dharma-wardana, 2013; Husserl, 1929; Nagel, 1974). 'Subjective consciousness' is a concept that stands apart from the physical processes that we consider to be ontologically primary. That is, a conceptualization of 'consciousness' stands apart from the fundamental nature of 'reality' which we conceptualize in terms of being extended physical processes. In this sense, subjective consciousness is conceptualized as an enclosed mental interiority that is shut off ontologically from its formative ground in physical processes. In contrast to this, it is the proposition of this thesis that qualitative human experience should be thought of as existing in a way that is open to its grounding conditions. It's ground (physical processes) shows up *in* and *as* its characteristic way of existing, however shows up in terms of the absence and opacity which is theorised as a central part of the structure of qualitative experience. The ontological distinction between consciousness and non-conscious processes is treated here as directly paralleling the perceived ontological distinction between consciousness and matter. Following from this, the presentation of qualitative experience as a gestalt of conscious and non-conscious processes is one way of approaching, in the broadest terms, what it would look like for qualitative experience to encompass its formative grounding conditions in its way of exhibiting itself *as* experience. Only through such a characterization, it is here argued, is it

possible to begin to understand 'consciousness' as non-separate from 'reality'.

Seeking to link an understanding of consciousness and material processes in this way is not a claim for any sort of theory of extended consciousness such as described in Prinz (2009). For such a theoretical approach consciousness is thought to extend out into an environment external to the body. Rather, the approach outlined here interrogates the intuitions packaged into the concept of 'interiority' and 'exteriority' and seeks other alternatives for a description of the being structure of human experience.

Consciousness appears intrinsically to have internality as its essential characteristic and further comment is required if this assumption is to be challenged. Consciousness is understood as an interiority or in terms of a first-person perspective precisely because the specific phenomenal facts one person may be experiencing are private (Nagel, 1974; Chalmers, 1996; Van Gulick, 1985) and may not be directly conveyed to other people. However, it is argued here that this apparently self-evident interiority arises only because qualia have always been associated with a single nervous system. It is suggested that the fact that qualia have always been associated with a singular nervous system is dissociable from the question of whether interiority is an essential characteristic of the being-structure of consciousness. Given the advances in current brain computer interfacing (Umir, Ashfaq & Khan, 2017), connecting two nervous systems together becomes a technical rather than philosophical problem. In such a hypothetical case, the same sensation of coldness on the upper arm for example, may be simultaneously associated with two nervous systems. The nature of the quale (coldness) can be presumed not to change whether it is hypothetically associated with one or more nervous systems. What is highlighted with this example is the fact that qualia have always only been represented in a singular nervous system does not infer an essential interiority to the structure of qualitative experience itself. That is, the fact that the contents of consciousness are private and the question of whether consciousness exists as some sort of internal domain, are two separate and dissociable issues. This being the case, it is a reasonable conjecture that despite the fact that qualitative experience has always been private to an individual nervous system, it could still be better conceptualised in terms of existential openness rather than as existential interiority. Should consciousness be considered as somehow existentially internal in its way of existing? It is argued here that consciousness may

be better understood and described through the language and metaphors of 'openness' rather than 'interiority'.

The identity theory of the mind claims that the mind is identical with the brain (Stich, 2007). However, such approaches remain un-illuminating because they lack any conceptual link between the biological facts of the brain and the qualities with which qualitative experience is typically described. As long as qualitative human experience is understood exclusively in terms of 'consciousness', then there remains an unbridgeable gulf between our understanding of the mind and the physical processes of nature. If however, the being-structure of qualitative experience can be understood to span what we conceive of as conscious and non-conscious processes, then an avenue is presented in which to conceptualize a shared ontology between physical processes and the domain of perception.

## 2.3. Heideggerian thought and the structure of human existence.

The theoretical orientation described in the previous section is not presented as a direct interpretation of Heidegger. Rather, elements of Heideggerian thinking have been drawn on to provide an impetus for this theoretical approach. Addressing the relationship between consciousness and its underlying material basis was not Heidegger's concern and the reasons for this will be addressed below. Rather Heidegger examines assumptions around what we envisage human existence to be and the relationship between this type of existence and that of domains that are traditionally thought of as outside of human existence such as the 'world', 'reality' or the 'beyond'. Heidegger's ideas are of direct relevance to the science and philosophy of consciousness. This is because implicit in the concept of 'consciousness' are many of the relationships that Heidegger examines, such as that between self and world or between 'within' and 'without'. Heidegger's elaboration of his central concern, Being, bares directly on the way in which we conceptualize human experience to exist. Some of Heidegger's ideas will now be examined in order to justify and elaborate on the theoretical position outlined in the previous section 2.2.

## 2.3.1 Heidegger's discussion of Being

Heidegger was deeply critical of the traditional Western ontological orientation through which anything that can be said to exist does so as a discrete and logically independent fact or entity. Heidegger contended that the trajectory of Western thought subsequent to Plato had calcified around a particular mode of apprehending existence always in terms of being a collection of determinate entities, be they atomic facts, bits of information or pieces of matter. Such an approach was one in which any phenomenon was ultimately susceptible to reductive explanation. In this way, human's relationship to the world is able to be understood as primarily one of 'knowing', that is, as an explicit and internal mental representation. Nature, by such a view was able to be understood and explained in terms of being a collection of dissociable, positively circumscribed rule governed entities or atomic facts. For example, in *Euthyphro*, Plato lays the foundation of an understanding that orderly, non-arbitrary behavior comes about on the basis of the enactment of a rational structure (Plato, 2013). Platonic thought sought to understand nature by discovering its underlying components and governing principles. Such an approach was rooted, for Heidegger, in a denuded understanding of the possibility of existence, Being, always in object oriented terms as a collection of context free atomic elements bound together by explicit rules.

Heidegger maintained that when this ontological orientation was applied to human existence, the result was a characterisation of human existence as 'subjective consciousness'. That is, Heidegger saw 'subjective consciousness' as an ultimately mistaken characterisation that occurred when the existence of qualitative human experience is viewed through an object-oriented ontology. For Western thought, our grasp of what it means for something to exist cannot help but refer to an existent object. When this ontological orientation is turned on our own existence, we come to conceive of the existence of human experience also as an object, albeit as a mental object or self-contained unit of subjectivity viz 'subjective consciousness'.

However, in Being and Time (Heidegger, 1962) Heidegger distinguished human's characteristic way of existing from that exhibited by inanimate objects and tools. 'Dasein' was the term which Heidegger applied to human's way of existing. What set Dasein's way of

existing apart from that of objects and tools, was that human existence itself was constituted of what for Heidegger was a non-object oriented understanding of Being. That is, human existence *is* a direct revealing of Being, not a removed internal representation of beings or entities. In failing to grasp this mercurial and illusive understanding of Being, Heidegger maintained Western thinking also failed to grasp the full dynamic of what is unique about the existence of qualitative experience. Instead humans become inappropriately treated as units of subjective consciousness, isolated from their broader context or environment. For Heidegger, this failure to grasp an understanding of Being, which he felt was demonstrated in the broad trajectory of Western thought, amounted to a petrification of our ability to conceive of the scope of our own existence, and that of the world through which we exist. Ultimately Heidegger saw the failure to grasp the full import of Being in Western thought as closely related to a treatment of human existence as a subjectivity of consciousness.

In contrast to this, the underlying ontological orientation implicit in Heidegger's discussion of Being frames human existence in a radically different light. This becomes central to the current thesis. Initially here some of the significances contained in Heidegger's discussion of Being will be briefly summarised. What Heidegger sought to address in evoking the question of the meaning of Being was a way of apprehending existence and particularly human existence in a non-object-oriented or non-substantial manner. By Heidegger's account, an understanding of Being remains a-phenomenal and objectless and does not show up for us as any fact, bit of information or describable quality of our world. Heidegger writes that Being "cannot be conceived of as an entity…nor can it acquire such a character as to have the term 'entity' applied to it" (Heidegger, 1962, p. 23). In this way, Heidegger viewed an 'understanding of Being' as being impenetrable to cognition (Heidegger, 1962, p4).

Nevertheless, for Heidegger such an understanding of Being is implicit in a veiled way in an everyday understanding of entities and the world around us. Being refers to our pre-cognitive grasp of what it means for something to exist. In this way, an opaque understanding of Being is present for us simply in using the word 'is' when we ask 'what is a person?' or 'what is an object?'. Heidegger writes that Being is "…that on the basis of which entities are already understood" (Heidegger, 1962, p. 25). He goes on to write that "We do not know what

'Being' means. But even if we ask, 'What is Being"?', we keep within an understanding of the 'is' though we are unable to fix conceptually what that 'is' signifies." (Heidegger, 1962, p. 25). Broadly Being in this sense was a pre-cognitively grasped dynamic that lies hidden but active in our experience of entities, the environment and ourselves.

Being or existence should not be thought of as the sum totality of all 'things'. Rather, Being or *ek-sistance* (Heidegger, 1977a, p. 204) should also be more broadly understood as a hidden revelation pivotal to the way in which human experience exists and takes place. For humans, unlike inanimate objects or tools, our way of being is such that the existence of the world, as opposed to its non-existence, makes a difference to us. Experience exists in that a world is present for us rather than absent. Objects or tools of course do not exist in terms of this revelation. As such and in contrast to objects, the way in which human existence takes place is constitutive of an understanding or revealing of Being. Human experience takes place as a revelation of Being. For example, in *Being and Time*, Heidegger writes "Understanding Being is a definite characteristic of Dasein's Being" (Heidegger, 1962, p. 32). Heidegger writes in '*Letter on Humanism'*- "The 'Being' of the Da [Dasein] …has the fundamental characteristic of 'ek-sistance'" and goes on to define 'ek-sistance' as "standing out into the truth of Being" (Heidegger, 1977a, p. 204). In Heidegger's writings, the issue of Being should be understood as central to the way in which human experience exists. This was because an understanding of Being, albeit in a precognitive and veiled sense, is manifest *as* our particular way of existing. Unlike mere objects that take place as circumscribed entities, human experience *is* a revealing of Being.

A fuller grasp on the significances Heidegger associated with the term Being would be incomplete without briefly addressing the sense in which Being also served the function of being a generative source of significance and meaning at a cultural level. The loss in proximity and understanding of Being in the trajectory of Western thought was evidenced for Heidegger in a diminution of culture and a flattening of language. For example Heidegger refers to modernity as evincing a 'loss of the gods' (Heidegger, 1977d, p. 116) in which human experience is only able to be understood in terms of subjectivity. The modern experience, by Heidegger's account, is no longer a direct presenting of Being or direct contact with a reality

beyond oneself. Rather, all experience is framed as that present within one's own consciousness such that the question of god or gods becomes one of religious *experience* rather than a direct presencing of Being. Heidegger makes it clear that Being is not to be understood as god or cosmic ground. (Heidegger, 1977a, p. 210). Nevertheless, he suggests that what may be distinctive about modernity is a closure of the dimension of the holy in its failure to remain open to Being (Heidegger, 1977a, p. 230). Elsewhere Heidegger talks of the loss of understanding of Being leading to a decline and deformation of language. Heidegger writes that "Being for us is now just an empty word and an evanescent vapour……many words- indeed, the essential words- are in the same situation, that language in general is used up and abused" (Heidegger, 1959, p. 53). He goes on to write that "…the destroyed relation to Being as such is the real ground for our misrelation to language" (Heidegger, 1959, p. 54). For Heidegger, the significances associated with his discussion of Being had implications of broader culturally generative significance.

## 2.3.2 Heidegger's discussion of human existence or Dasein.

Heidegger used an exploration of human's way of existing (Dasein) in order to elaborate on the significances he associated with the term Being. His description of Dasein can serve to inform alternative ways of envisioning the existence of qualitative experience, shorn of many of the assumptions and conceptual orientations packed into the notion of 'consciousness'. For example, as discussed above Heidegger characterised Dasein's existence as being constituted of a revealing of Being. By Heidegger's account, human's way of existing is *as* the revealing of what is ontologically primary. What this idea signifies can be clarified by contrasting comparison to the concept of 'subjective consciousness'. We can conceive of what consciousness is wholly independently from any concept of the existence of the ontologically primary material processes of nature. Subjective consciousness is conceived of in such a way that it stands apart from the world and we require some conceptual mechanism to link these two distinct ontological domains. By contrast, what Heidegger suggests in describing Dasein as the revealing of Being is that human experience is itself the reaching over between domains which have traditionally been conceived as distinct. Heidegger described the way of existing that is characteristic of human experience as a straddling of boundaries that had traditionally

demarcated ipseity and self-feeling from a domain outside of the self. For example, Heidegger writes - "Dasein does not sort of exist and then occasionally achieve a crossing over outside of itself, but 'ek-sistance' [humans way of existing] originally means to cross over. Dasein is itself the passage across" (Heidegger, 1984, p. 165). For Heidegger, it was in particular this characteristic of existential openness or 'crossing over' that characterised human existence and allowed it to be the existence of experience. This idea will be discussed in more detail below in terms of Heidegger's use of the term *transcendence* (Heidegger, 1984, p. 159). What is emphasised here is the way in which Heidegger's description of the relationship between Dasein and Being presents the existential structure of qualitative experience in a way that is not located on one side of the dichotomy between within and without, self and world, or essential nature and actual manifest existence. Rather, Heidegger presented human experience as existing in a way that bridges this dichotomy.

This characterisation of Dasein in a way that undermines such a series of dichotomies is drawn on as a motivation for the thesis presented in section 2.2. This is the idea that is reached for in describing qualitative human experience in terms of a relationship between conscious and non-conscious processes. Heidegger did not equate Being with non-conscious processes. However, what is suggested here is that human experience should not be thought of as a unit of subjective consciousness, ontologically distinct from its ground in material processes. Rather this thesis suggests that qualitative human experience exists in a way that straddles the perceived dichotomies between 'within' and 'without', ipseity and alterity, self and world.

Heidegger's description of Being also serves to frame human experience as non-transparent to itself or partially hidden from itself. As discussed above Being held a significance that was evasive to object oriented cognition implicit in the broad trajectory of Western thought. Further Dasein exists *as* the revealing of Being, or a standing in the lighting of Being. Therefore, in describing Dasein's existence wholly as a relation to Being, a sense of absence, groundlessness and cognitive impenetrability is also implicit in human existence. Heidegger writes "the nothing is manifest in the ground of Dasein" (Heidegger, 1977c, p. 105). It is the inclusion of this absence and hiddenness that allows Dasein to take place as experience. Heidegger writes- "For human existence the nothing makes possible the openness

of beings as such. Only on the ground of the original revelation of the nothing can human existence approach and penetrate beings" (Heidegger, 1977, p. 106). The way in which hiddenness and absence underlie the dynamic that is human experience is dealt with in more detail in the section 3.4 below. What is outlined here is that Heidegger's discussion of Being in terms of cognitive impenetrability and hiddenness also affords a nothingness and hiddenness to his characterization of human experience.

The opacity in the midst of Dasein's way of existing and the way that it subserves Dasein's essential openness is also drawn on as a motivation for the theoretical position presented in section 2.2. This is what is reached for in a description of human experience as a relational gestalt of conscious and non-conscious processes. Qualitative experience is not merely self-transparent but also exists in a way that is cognitively impenetrable, hidden or opaque to itself. Moreover, this phenomenal absence which is suggested to take place at the heart of human experience undermines treatment of human experience as any sort of enclosed unit of subjectivity. Rather, such an approach internalises the alterity of 'the nothing' and domains that are traditionally viewed as outside the self, such that human experience is characterised as an existential openness.

### 2.3.3 Heidegger's discussion of Transcendence

The way in which Heidegger sought to undermine this dichotomy between self and world, 'within' and 'without' or Being and the Nothing is brought to light in his discussion of the term *transcendence*. It is through a discussion of this term in *Being and Time* and throughout his writings that Heidegger seeks a radical re-conceptualisation of human's way of existing. Through a discussion of *transcendence* Heidegger grapples with the question of what it would mean to understand the existence of human experience without appealing to any sense of an 'internality' of a subjective consciousness as against an 'external' and objective domain independent of consciousness.

Heidegger was critical of a traditional understanding of the term *transcendence* such as used by Plato andKant (Plato, 2013; Kant, 1855). He described the way in which this

traditional understanding of transcendence, both in its everyday usage and as a technical philosophical term, has been intimately tied to a concept of human existence as an enclosed unit of subjectivity. Heidegger discusses the way in which human experience is conceptualised as an instance of subjectivity, and is understood to exist in a box like and closed off manner (Heidegger, 1984, p. 161). This necessarily gives rise to the need for the traditional concept of transcendence as a mechanism to conceptually bridge such an internally existing subjective consciousness and a domain presumed to exist outside of or alien to this subjectivity. For example, epistemological transcendence as dealt with in Kant addresses the relationship between appearances within a subject and the objective existence of the thing in itself, considered to exist in a manner that is independent from consciousness (Kant, 1855). Similarly, Husserl's phenomenological transcendence draws from a conceptualisation of pure consciousness abstracted away from the factual existence of material objects (Husserl, 1999). Heidegger also raises the issue of theological transcendence in which the transcending relationship is understood to exist between conditioned beings in general and the unconditioned, traditionally understood as divinity (Heidegger, 1984, p. 162). This last usage is dealt with disparagingly. However, Heidegger raises these uses of the traditional idea of transcendence broadly in highlighting the way in which human experience has been traditionally understood as an ipseity of interior selfhood in contrast to world, alterity and exteriority. With such a characterisation, a concept of transcendence has traditionally become necessary in one form or another in relating this self-contained subjectivity to a domain which is considered to exist outside of and independent from consciousness.

As a point of departure, Heidegger did not locate the existence of human experience within the ipseity of subjective consciousness in such a way that it would then require some form of transcendence to relate it to a world outside of subjectivity. Rather, he sought a way of understanding human experience itself as a crossing over between ipseity and alterity. In this way for Heidegger, transcendence *is* human existence, understood as an openness or a 'crossing over' between traditionally distinct domains. Heidegger writes-

> Transcendence is rather the primordial constitution of the *subjectivity* of the subject……..This means that Dasein does not sort of exist and then occasionally achieve a crossing over outside of itself, but existence originally means to cross over. Dasein is itself the passage across. And this implies that transcendence is not just one possible comportment (among others) of Dasein towards other beings, but it is the basic constitution of its being. (Heidegger, 1984, p 165).

The existence of human experience is not located on one side of a wall and therefore requiring some conceptual bridge to relate it to a domain outside of and independent of consciousness. Rather, Heidegger sought to radically re-imagine the existence of human experience in a way that undermines this dichotomy. *Transcendence* or 'crossing over' is what human experience *is*. The ways in which Heidegger's approach to transcendence are used to provoke alternatives to a traditional understanding of qualitative human experience as subjective consciousness will be discussed below as follows.

How did Heidegger explain *transcendence* in practical terms and how did he elaborate on the sense of 'crossing over' or openness that this inferred upon human experience? Heidegger elaborated on *transcendence* by building up a description of *worldhood* and human worldly involvements with a sense of outwardness and practical engagement with tools and the environment. He then sought to characterise human existence in terms of this very outwardness and worldhood. Such an approach had the effect of supplanting internal subjectivity as human's essential and definitive way of existing. In Heidegger's use of the term *transcendence* he existentially inverts human experience into a groundless openness rather than being an enclosed subjective entity. For example, in *Being and Time*, Heidegger works out in detail a description of meaningful human activity in terms of a network of relational significances. This was a network of un-thought-out but nevertheless meaningful practical purposes and engagements with tools and the world that formed part of an overall structure of human concerns. This structure of concerns or 'care' (*sorge*), (Heidegger, 1962, p. 93) provided for meaningful behaviour in the absence of explicitly formed mental goals or representations. The unity of these concerns Heidegger termed 'world'. Here 'world' does not refer to a three dimensionally extended environment. Rather, Heidegger uses the term 'world' to signify a relational totality of significance, for example as the world of the carpenter, or the world of modernity. Heidegger then moves to broadly equate this sense of world with human

existence itself writing, "Dasein is its world existingly" (Heidegger, 1962, p. 416) and "Dasein 'has', in its essence, something like world" (Heidegger, 1984, p. 170). In one sense this applies for example, in that a depressed and unhappy person is a person for whom their world shows its moribund and gloomy aspects. In this sense elements of the secondary literature interpret *transcendence* as a way of understanding intelligibility and meaningful human behaviour in terms of practical engagement rather than as the product of an isolated intellectual agent (Dreyfus, 1991). Heidegger's use of the term *transcendence* can be understood as a way of characterising human existence through a type of contextual behavioralism in which the subject-object dichotomy between an intellectual agent and its world is dissolved.

Some of the ways we have seen these ideas ultimately play out in the sciences is a move away from Cognitivism and towards a more environmentally extended understanding of cognition. Increasingly over the later part of the twentieth century, approaches influenced indirectly by Heidegger have moved towards an understanding of cognition in which the distinction between intellectual agent and its environment are undermined. Heidegger characterized human existence as unable to be parsed separate from the broader environment, a notion broached by the term *being-in-the-world*. Dasein was not considered as an individuated entity contained inside and separate to an environment. It is in this sense that Dasein could be described as 'being-there', as existing outside of itself, rather than as having a primarily internal existence, shut off from the existence of the world. Dasein's primary way of existing, is one of meaningful involvement. It has been noted that these intuitions are seen broadly reflected in growing trends in the cognitive sciences over recent decades (Gallagher 2009; Wheeler 2005; Clark 1997). Such an approach for example is broadly reflected in the notion of 'extended mind' in which the body and world operate alongside the central nervous system, in forming the machinery underlying various mental states and contents (Clark and Chalmers, 1998; Clark, 2007). The range of situated and environmentally extended characterizations of the mind for example, invokes a Dasein like sense of 'being-there' and a sublimation of mind-world distinction (Smith & Semin 2007; Fischer, 2012). Wheeler (Wheeler, 2005) has also noted that a Heideggerian turn in the cognitive and brain sciences is evident in a move away from characterizing cognition as computation, and the increasing employment of non-linear dynamical analysis to explain mental processes. Non-linear

dynamical approaches have also been employed to allow non-representational accounts of intelligent behaviour (Beer, 1995) and descriptions of organism-environment coupling (Thompson & Varela 2001) evocative of Heidegger's use of the term of *being-in-the-world*.

However, what is at play in Heidegger's discussion of *transcendence* is also a sense in which he was commenting not only on cognition and meaningful behaviour but also on the being structure of qualitative human experience itself. In setting up a phenomenology of *worldhood* and then equating human existence itself with this openness and *worldhood*, Heidegger reads as strongly inferring that qualitative experience itself exists as an openness in which ipseity and alterity are both present. For example, Heidegger uses the term *ek-sistence* to refer to the way he saw human existence as an openness to Being and writes -

> …..man stands "in" the openness of Being. "World" is the lighting of Being into which man stands……Thought in terms of ek-sistence, *'world' is in a certain sense precisely "the beyond" within existence and for it.* Man is never first and foremost on the hither side of the world, as a subject…. Rather, before all this, man in his essence is ek-sistent into the openness of Being, into the open region that lights the "between" within which a "relation" of subject to object can "be". [Italics Mine]. (Heidegger, 1977 p 229)

In this passage, it is difficult not to read "the beyond within existence" as a commentary on the existence of *experience* rather than simply on the existence of meaningful behaviour. In discussing *transcendence* Heidegger can be read as striving to undermine basic categories of thinking that habitually and complicity frame qualitative experience as a thing that has internality and ipseity as an essential characteristic. Rather, qualitative experience viz consciousness, becomes understood in terms of an openness by virtue of its characterisation *as transcendence* or as a 'crossing over' between categories viewed in one way or another as ipseity and alterity. Here, the word 'alterity' is used in the sense of that which is outside of or beyond the ipseity implied in the traditional Cartesian subjective consciousness. When human experience is thought of in terms of *transcendence*, an alterity or a 'beyond' (traditionally associated with 'world' as opposed to 'self') becomes part and parcel of its characteristic way of existing.

What is important here is that what is ontologically primary for Heidegger, Being, is already manifest and essential in what human experience is. Being is manifest and revealed in the way of existing that human experience has. This idea can be clarified by contrast to a view of subjective consciousness, in which phenomenal facts are conceptualised distinct from their ground in material facts. Heidegger described a pre-ontological understanding of Being as constitutive of Dasein's basic make up, writing, "To Dasein's being, an understanding of being belongs". (Heidegger, 1962, p. 118). This way of existing Heidegger further describes as a 'standing in the lighting of Being' (Heidegger, 1977a, p 204). It is as a 'standing in the light of Being' that the world of beings and entities is able to become revealed to us. It is in proximity to Being that human existence is the existence of experience. In contrast to this, when approached through an object oriented way of thinking Heidegger writes that "'*Being*' acquires the meaning of '*reality*'" (Heidegger, 1962, p 245). That is, what is traditionally thought to be ontologically primary takes on the characteristic of 'reality' and consciousness stands ontologically apart from it, merely representing the 'real' within itself. This is the case whether the 'real' is understood as the intentional object, the thing in itself or a material substrate of consciousness. In all of these cases, subjective consciousness is conceptualised separate to and apart from what is ontologically primary. In his description of *transcendence* and Dasein, Heidegger reaches for a re-conceptualisation that avoids subscribing to this duality from the outset. The presence of what is ontologically primary, Being, is essential to the being structure of human experience and infers a sense of openness on human's way of existing. Although somewhat self-consciously elliptical, in considering the relationship between human ipseity and the alterity beyond this, Heidegger characterises human existence *as* the crossing over (Heidegger, 1984, p. 165). What is ontologically primary is part and parcel of qualitative human experience not separate to it. Such an approach offers a substantively different way of understanding the existence of human experience to that of a traditionally conceived 'subjective consciousness'. This is what is sought in describing qualitative experience as a gestalt of conscious and non-conscious processes.

In many regards, Heidegger's dealing with *transcendence* is incomplete and not entirely successful. In his writing on *transcendence* there is a sense in which Heidegger delivered a series of highly insightful provocations rather than a fully articulate conclusion. By

Heidegger's own account, his dealing with *being-in-the-world* as *transcendence* was not successful (Heidegger, 1977a, p. 208). Likewise, Heidegger moved away from use of the idea of *transcendence* in his later writings in recognition that such language is too deeply rooted in Platonism (Moran, 2014).

However, what is important and useful in Heidegger's discussion of *transcendence* is the way in which it presents alternatives to the sense of human existence as an internal unit of subjectivity. He draws out how the intuition of human experience as an internal subjective entity is complicit in the philosophical roots of Western thought. In contrast to a dichotomy with subjective consciousness on one side and the ontological ground as 'reality' on the other, Heidegger presents human experience *as* the crossing over or transcending of this divide. In this we can begin to conceptualise a way of existing that is neither internal nor external, and so could encompass an understanding of human experience as a gestalt of conscious and non-conscious material processes. Heidegger presents a workable consideration of human experience *as* the revealing of what is ontologically primary, rather than standing apart from it. Furthermore, in dealing with these issues, he makes it clear that he is seeking a radical transformation of our understanding of mind and subjectivity. For example, in discussing the way in which *transcendence* underlies the issue of intentionality, Heidegger writes that "Underneath the entire problem of the 'relation' of 'subject' to 'object' is the undisclosed problem of *transcendence"* and that "this concept …. brings a modification of the traditional concept of consciousness and of mind" (Heidegger, 1984, p. 135). These ideas are drawn on directly for support of the thesis of a shared ontology between consciousness and non-conscious processes presented in section 2.2.

### 2.3.4 Heidegger's treatment of *abgrund* (absence) and *das nichts* (the nothing) in relation to human experience

A discussion of *das nichts* (the nothing) appears throughout Heidegger's earlier and later writings (Heidegger, 1962; 1984). The use of this term along with others such as *lethia* (concealment), *abgrund* (absence or groundlessness), underscore a cognitive evasiveness and hiddenness that were central to Heidegger's characterisation of human existence and his

treatment of Being. Below the way Heidegger uses absence in his characterisation of human existence is examined as well as some of the ways in which this can allow us to re-envisage the being-structure of qualitative experience.

Absence and 'the nothing' are central to the way in which Heidegger defines human experience as encompassing the broad categories of ipseity and alterity. As discussed above, Heidegger's way of capturing what is unique about human experience is in describing such a mode of existing as straddling boundaries that had traditionally demarcated selfhood from alterity - the domain outside of the self. It is through this 'crossing over' (Heidegger, 1984, p. 165) that he characterises what experience *is*, as an openness rather than as a closed unit of subjectivity. For example, as discussed above, *worldhood* is described as part of Dasein's way of existing. Heidegger writes that "Dasein "has" in its essence, something like world and does not obtain a world by the fact that it exists" (Heidegger, 1984, p. 170). However, in broadly taking this approach, the outwardness and otherness traditionally attributed to world as opposed to self, is maintained even when *worldhood* becomes characteristic and definitive of what human experience is. In this way, human existence now contains an otherness and alterity and is inverted and characterised as existentially open and standing outside of itself in its way of existing. Heidegger writes "'world' is in a certain sense precisely 'the beyond' within existence and for it" (Heidegger, 1977a, p. 229). Similarly, Dasein translates as "being there' and this carries a sense in which human existence is a 'there', open and outside of itself, rather than simply the 'here' of ipseity. Similarly, 'the nothing', in one sense an extreme alterity, takes place within and essential to the dynamic of human existence. In Heidegger's treatment, 'the nothing' is a central structural element of human experience. Heidegger writes "the nothing is manifest in the ground of Dasein" and that "Only on the ground of the original revelation of the nothing can human existence approach and penetrate beings" (Heidegger, 1977c, p. 106). Elsewhere Heidegger writes ""If in the grounds of its essence Dasein were not transcending, which now means, if it were not in advance, holding itself out into the nothing, then it could never be related to beings nor even to itself" (Heidegger, 1977c, p. 106). Whether it is in discussing worldhood, the nothing or Being, Heidegger characterizes human existence as straddling the domain of selfhood and domains traditionally held to be beyond the self. In doing so, he characterizes human existence as internalizing the sense of exteriority associated

with these domains. Heidegger therefore characterizes human existence as exhibiting an absence and openness. Heidegger uses 'the nothing' to invert the concept of human existence such that it is not thought of as an enclosed unit of subjectivity but rather as an existential openness.

This is in part the position that this thesis sought to lay out in section 2.2 above. It is suggested that the exceptional quality that distinguishes the existence of qualitative experience from the existence of an inanimate object is located in the dynamic gestalt between conscious and non-conscious processes. In this, qualitative experience is no longer exclusively characterised as internal and self-transparent. Rather, a level of absence and alterity or openness becomes part and parcel of the being-structure of qualitative experience.

The use of absence and nothingness also helps to make phenomenological sense of the way in which Heidegger viewed that which is ontologically primary as manifest in Dasein, in a way that it is not for subjective consciousness. Being represents the condition for the possibility of human experience. However, Being is also characterised as obscure and only pre-cognitively grasped by Dasein. We can then begin to envisage the way in which Dasein exists as a relational openness to its ontologically primary conditions (Being), by seeing Dasein as also having an evasiveness and hiddenness in its own being structure. Heidegger discusses Being and 'the nothing' in close and near synonymous proximity writing - "'Being' in contrast to all 'beings' is no 'being' and, in this sense, is a 'nothing'" (Tsujimura, 208). Further he writes that "the nothing is manifest in the ground of Dasein" and that "Only on the ground of the original revelation of the nothing can human existence approach and penetrate beings" (Heidegger, 1977c, p. 105). In characterising qualitative human experience as possessing an essential hiddenness and evasiveness it becomes possible to envisage human experience and its underlying ontological basis, together and in a non-dichotomous fashion.

Such is not the case with a characterisation of human experience as subjective consciousness. Consciousness, as immediately and entirely self-transparent, is conceptualised in a way that stands apart from its ontologically primary grounding conditions. That is, when human experience is conceptualised as a totality of positive phenomenal facts (viz

consciousness) it must be viewed entirely independently from its grounding conditions, which for modernity are the underlying material processes of nature. When approached through an object oriented metaphysics Heidegger writes pejoratively that " '*Being*' acquires the meaning of '*reality*' " (Heidegger, 1962, p 245) and goes on to write that "it has long been held that the way to grasp the Real is by that kind of knowing which is characterised by beholding. Such knowing 'is' as a way in which the soul-or consciousness- behaves" (Heidegger, 1962, p. 246). That is, what is traditionally thought to be ontologically primary takes on the characteristic of 'reality' and in this case consciousness can only be understood as standing ontologically apart from this, merely representing the 'real' within itself. Implicit in the concept of a self-transparent consciousness is a fundamental ontological division between subjective consciousness and its grounding basis in a domain outside of consciousness and selfhood.

This is relevant to the theoretical position presented in section 2.2 because it begins to open an avenue into conceptualising a relationship between the being-structure of qualitative experience and that of material objects and processes of nature. As discussed above Heidegger's approach to the existence of human experience undermines the differentiation between a 'within' and a 'without'. Although Heidegger did not do so, such an approach can be applied to re-conceptualising the relationship between what we think of as consciousness, and the extended material processes of nature. The thesis of a gestalt of conscious and non-conscious processes undermines the dichotomy that arises when we characterise qualitative experience as a unit of interiority as against a grounding basis of 'reality' conceived of in terms of outward spatially extended processes. Such an approach can begin to provide alternative avenues into the relationship between what we conceive of as consciousness and matter.

Absence and hiddenness is also used by Heidegger in averting treatment of human existence as an entity or object. When human experience itself is characterised as a dynamic that exhibits an essential hiddenness or nothingness it cannot be rightly treated as a self-enclosed entity or atomic 'thing'. It is rather treated as a 'no thing', that is, in a non-substantialist manner. Heidegger maintained that human existence was not any sort of object or thing writing "Dasein does not have the kind of Being which belongs to something merely

'present-at-hand' (*vorhandenheit*) within the world" Heidegger, 1962, p. 68) and defining present-at-hand broadly as any entity that can be referred to as a 'what', or *res* (thing) Heidegger, 1962, p. 71). This was precisely the mistake he felt traditional Western thought had made in treating human existence as 'subjective consciousness'. Heidegger explicitly frames subjectivity in terms of reification and thus as a present-at-hand 'thing'- "Every idea of a 'subject'…..still posits the subjectum along with it, no matter how vigorous one's ontical protestations against 'soul substance' or the 'reification of consciousness" Heidegger, 1962, p. 72). Heidegger claims that Dasein cannot be treated as an object nor solely as an independent subject writing that "In the Who? Or the What? We are already on the lookout for something like a person or an object. But the personal no less than the objective misses and misconstrues the essential unfolding of 'ek-sistance'" (Heidegger, 1977a, p. 207). Instead, Dasein's way of existing is differentiated from that of present-at-hand objects in part through proximity to absence. Here, Heidegger writes - "the nothing is manifest in the ground of Dasein" (Hediegger, 1962, p 105) and elsewhere "Without he original revelation of the nothing, no selfhood and no freedom" (Heidegger, 1962, p. 106). Absence and nothingness avert a substantialist treatment of human existence (Dasein) as any sort of object or 'experiencing thing'.

The reason this is important in Heidegger's approach is that a treatment of human experience as a 'thing' or object obliterates the very dynamic that infers on human existence it uniqueness and differentiates its existence from that of an inanimate object or tool. What Heidegger saw as unique in human existence is the way in which human existence is itself a relating beyond itself and is not simply a self-enclosed subjectivity which must be related to world or alterity after the fact. Heidegger writes- "Dasein is as it is, in standing outside its being as such, and within the truth of Being" (Heidegger, 1977a, p. 206) and "Such a standing in the lighting of Being I call the 'ek-sistance' of man" (Heidegger, 1077a, p. 204). This mode of being that he termed 'ek-sistance' or 'standing in the lighting of Being' (Heidegger, 1077a, p 204) is also "that condition which makes it possible for entities within-the-world to be discovered at all" (Heidegger, 1962, p 121). That is, Dasein's condition of 'standing outside of itself' is the mechanism that underlies sentience, that is, underlies the possibility of qualitative experience. By contrast subjective consciousness is self-contained and is therefore enclosed and 'thing like'. In this case the characterisation of subjective

consciousness omits just that quality which Heidegger sees as essential to human's way of being, that is- the openness to Being captured through the terms ek-*stance*, *transcendence* or *being-in-the-world*. For this reason, Heidegger claims that what is unique to the existence of human experience cannot be captured in any object like, self-contained characterisation of existence. Dasein evades treatment as an object through the way in which absence and 'no-thingness' acts as a fulcrum of it's *openness* and *ek-sistance*.

Again, this is relevant to the theoretical position presented in section 2.2 in that what is unique and distinctive about qualitative experience is lost when it is treated as a self-enclosed object of any sort for example, as a unit of subjectivity. For Heidegger, what is unique about human experience is its openness, that is, it's way of existing as a dynamic that takes place in part beyond itself. Such a dynamic is not exhibited in the idea of consciousness existing as a self-enclosed unit of subjectivity. Again, what Heidegger suggests is not that selfhood first of all exists in a worldless way and then relates to a domain outside of itself after the fact. What is suggested is that human experience is *itself* a crossing over or a relating to a domain that is somehow outside of itself. Such a dynamic disqualifies qualitative human experience from being treated as a self-enclosed entity, which then relates to a domain outside of itself after the fact. This is in part what is suggested in a theory of qualitative experience existing as a gestalt of conscious and non-conscious processes.

Consequently, non-conscious processes are not merely thought of as a wall behind which consciousness has no access. Non-conscious processes are also conceptualized as part of the dynamic that allows qualitative human experience to be conceived of as an existential openness rather than as an enclosed unit of subjective consciousness. While providing a formative basis of qualitative experience, non-conscious processes are also presented as providing an absence and groundlessness that acts as a fulcrum for the sort of existential openness that is described. While only approached in the broadest of theoretical terms, the dynamic by which human existence is able to be the existence of experience is located in this existential groundlessness and openness. Such a dynamic would be lost if qualitative experience is simply treated as a unit of subjectivity or a totality of positive phenomenal facts.

## 2. 4. Problematic elements in the current thesis

The thesis as outlined in this chapter is not without a number of problematic issues. Heidegger never dealt with the relationship between consciousness and its material basis. One reason Heidegger did not address the problem of consciousness in this way is that he saw the understanding of nature and physical processes in the natural sciences as already exhibiting an interpretation and misunderstanding of Being. Building up to an explanation of consciousness on the basis of a reductive view of physical processes is the antithesis of Heidegger's project. Heidegger would claim that theoretical abstraction such as this only ever arises on the basis of meaningful human involvement already having taken place. At least from a human perspective, experience comes first and only on that basis does theoretical abstraction take place. From this perspective, the idea that we could create a theoretical structure that explains consciousness in terms of underlying atomic components is about faced. For this reason, Heideggerian thought is not likely to bear fruit if turned to an explication of the 'hard problem of consciousness' as currently understood (Charmers, 1996).

Qualitative experience has also been maintained as a focus in interpreting Heidegger, even while this is an approach that is explicitly denounced in prominent elements of the secondary literature (Dreyfus, 1991). Dreyfus explicitly claims that Heideggerian thought cannot work as any sort of theory of consciousness and even cites the example of Sartre's as a sophisticated example of just this mistake (Dreyfus, 1991, p 13). Nevertheless, this thesis has sought to provide sufficient evidence that in discussing human's way of existing (Dasein), Heidegger has sought to explore the being-structure of qualitative human experience, rather than simply the being structure of intelligible behaviour.

Further to this, the idea of non-conscious processes have been conflated in the theory presented above with Heidegger's treatment of Being, worldhood, 'the nothing' and 'being-beyond'. Such an approach cannot be substantiated if it is intended as a direct interpretation of Heideggerian thought. The approach taken here is to treat Heidegger's discussion of worldhood and Being as signifying in a broad sense, a domain that is essential to the structure of human experience, but nevertheless one which stands conceptually outside of self-feeling

and self-agency. In this case it is contended that a meaningful comparison can be made between the alterity of worldhood, 'the nothing' and Being, and the alterity represented by non-conscious processes.

Moreover, an additional problem arises in that the experimental approach taken to this philosophical orientation can be viewed as overly neuro-centric and thus failing to engage with core Heideggerian insights. That is, one of Heidegger's enduring impacts within the cognitive sciences is an appreciation of the impossibility of parsing a living being separate from its environment (Wheeler, 2005). However, the approach taken in this thesis of addressing themes in Heidegger's philosophy entirely in terms of the dynamics of the nervous system, could be criticised as failing to adequately grasp this key Heideggerian insight. This issue will be discussed in more detail in Chapter 3 below.

Clearly the approach outlined in this thesis is not capable of establishing a link between phenomenology and a theoretical understanding of material processes. That is, consciousness has not been explained in terms of matter, nor the converse. However, this has not been the focus. Rather, Heideggerian thought has been used to re-examine our assumptions and alternative possibilities for the phenomenology and being-structure of human experience. Such an approach may help us to better understand how neural processes relate to the mercurial phenomenon of human experience if as Heidegger believed, the current concept of 'subjective consciousness', for all its self-evidence, is misguided.

## 2. 5. Conclusion

This chapter has used Heideggerian thought to motivate a novel theoretical approach to consciousness or qualitative experience. Ultimately this has been done as a basis for empirical investigation which will be dealt with in the remaining chapters. The central theoretical position as outlined here was that qualitative experience may be best characterized as a dynamic gestalt of both conscious and non-conscious content and processes arising as a singular phenomenon. What is suggested by this claim is that qualitative experience itself can be characterized as referencing and making salient phenomenally inaccessible processes, in

its way of exhibiting itself *as* experience. It is in this sense that qualitative experience is characterized as 'standing outside of itself' in its characteristic manner of existing. With such a characterization, the being-structure of qualitative experience is better thought of in terms of openness rather than solely as an enclosed unit of subjectivity. This openness is suggested in treating qualitative experience as containing and exhibiting a phenomenal absence- vis non-conscious processes. What is also sought in a characterisation in terms of openness is that qualitative experience is envisaged to exist in a way that references and is open to its underlying grounding conditional processes. This is contrasted with the type of existence attributed to a traditional view of consciousness, which can be imagined independently from any concept of underlying material processes. In envisaging qualitative experience as a gestalt of conscious and non-conscious processes, the latter are not thought of as an a-phenomenal blankness or a wall behind which consciousness has no access. Rather, non-conscious processes are also presented as providing an absence and groundlessness that acts as a fulcrum for the sort of existential openness that is described. This openness is suggested to be a central and defining quality of qualitative experience. Broadly this approach is suggested as representing a novel means to begin conceptualizing qualitative experience and non-conscious biological processes from within a singular perspective. That is, this thesis explores the possibility of a shared ontology between conscious and non-conscious processes.

The theoretical orientation described in section 2.2 is not presented as a direct interpretation of Heidegger. Rather, elements of Heideggerian thinking have been drawn on to provide an impetus for this theoretical approach. Section 2.3 outlined elements of Heideggerian thought to justify and motivate the preceding theoretical position. Heidegger's discussion of Being was addressed along with the way in which this discussion provides alternatives to a view of human existence as 'subjective consciousness'. Heidegger's discussion of *transcednence* was also examined as well as *abgrund* (groundlessness) and his concept of *das nichts* (the nothing) and *offenheit* (openness). What is drawn on in this chapter is the way in which Heidegger provides alternatives to the characterisation of human existence as an enclosed unit of subjectivity standing apart from the world. This chapter has examined Heidegger's description of human's way of being (Dasein) as straddling boundaries that have traditionally demarcated selfhood from a domain beyond the self. This conceptual

orientation has been used as a novel basis for consciousness theory. A way of thinking about consciousness has been outlined that has sought to reflect the outwardness, alterity and sense of nothingness within Heidegger's description of human existence, and the way in which this becomes for Heidegger, a key part of the dynamic through which humans encounter and experience the world.

# Chapter 3

## Proceeding towards empirical investigation

This chapter outlines an avenue to proceed towards empirical investigation on the basis of the theoretical and philosophical considerations presented in the previous chapters. Chapter Four then goes on to detail two experiments while Chapter Five and Six deal with one experiment each.

The theoretical orientation dealt with in the previous chapter can be summarised in the following way: Qualitative experience is suggested to exist in a manner that does not have full epistemic access to itself. In this sense, qualitative experience or consciousness is characterised as being partially hidden from itself rather than being the type of immediately accessible positive phenomenal facts of a traditionally conceived 'subjective consciousness'. It is in this regards that qualitative experience is described here as a dynamic gestalt of conscious and nonconscious processes, arising as a singular phenomenon. There is some circularity associated with this idea and this reflects conceptual circularity also present in Heidegger's writing. For example, Heidegger treats human existence or Dasein as a 'being-beyond' or as in a certain sense standing outside of itself (Heidegger, 1984, p. 165). Similarly, as discussed above in section 2.3.3, Heidegger characterises human existence as itself the dynamic that crosses over between the ipseity of self-hood and the alterity of domains traditionally viewed as beyond the self, such as 'world', the 'thing in itself' (ding an sich) (Kant, 1885) or the Nothingness. This inherent circularity here in regarding qualitative experience as a dynamic that incorporates both conscious and nonconscious processes is not viewed as evidence of a theoretical flaw. Rather, the elliptical nature of this idea arises due to the fact that this thesis draws on Heidegger to question and challenge the traditional characterisation of consciousness an internalised subjectivity that stands apart from the world.

Broadly, this approach is also suggested here as one avenue to conceptualise the existence of qualitative experience in a manner that subsumes both the material processes outside of subjectivity, and the mental processes within subjectivity. That is, the hidden, non-representational or non-conscious aspect that is suggested here to be part of the structure of qualitative experience is envisaged as being the presence of material processes, from within a phenomenal or experiential perspective. It follows from such a characterisation that qualitative experience should not be grasped as some sort of mental thing that has internality as an essential characteristic. Non-conscious material processes are traditionally conceptualised as outwardly existing 'things'. Consciousness is traditionally characterised as an inwardly existing 'thing'. However, implicit in a characterisation of qualitative experience as a gestalt of conscious and non-conscious processes is that it should not be envisaged as essentially internal in its way of existing, but rather as an openness that subsumes this internal-external dichotomy. Concomitant with this description is a non-substantialist treatment of qualitative experience as an absence rather than as any sort of 'thing' or representable object.

In order to approach this broad theoretical position empirically, it is simplified to a question of whether qualitative experience can be understood as arising from an interaction between supraliminal and subliminal processes. This idea is explored by drawing on the mathematics of nonlinear dynamics and circular causality (Haken, 2006). That is, the circular causality described in the theories of nonlinear dynamics is suggested to represent a mathematical analogy to the idea that consciousness could arise as a mutual interaction between higher order and lower order neurological processes. Higher and lower order processes are here taken crudely to represent conscious and non-conscious processes respectively. Incorporating physiologically plausible assumptions that the brain operates as a dissipative system operating far from thermal equilibrium, emergent patterns of cortical activity are able to be modelled using the mathematics of nonlinear dynamical systems (Haken, 2006). Of particular relevance here is the capacity of such systems for self-organising pattern formation and circular causality. Circular causality describes the manner in which emergent patterns can arise from the nonlinear interaction of a collection of weakly connected components, but then in turn constrain the behaviour of those components. A reciprocally

causal relationship exists between emergent patterns at a macroscopic scale and the underlying behaviour of components at a microscopic scale. An assumption in the approach taken here is that activity at such a microscopic scale could represent non-conscious processes, while that at a macroscopic scale would represent or correlate with consciousness. In experiment 1 and 2, macroscopic neuronal pattern formation is approached as a correlate of foreground elements of phenomenal experience. Similarly, the underlying synaptic dynamics from which these patterns emerged may be understood as a correlate of non-conscious processes. If these assumptions prove to be plausible then a circularly causal relation between these states may represent an empirically verifiable consequence of the hypothesis laid out in Chapter two.

Because this theoretical orientation was not carried through into experiment 3 and 4, and in fact appears to contradict elements of these later two studies, some further justification and explanation is required. The approach taken with experiment 1 and 2 is simply that the mathematical description of circular causality appears to represent a good analogy to what is being proposed in this thesis in terms of the relationship between conscious and non-conscious processes. Circular causality describes the manner in which simple lower order processes in some specific cases, do not merely generate and cause higher order processes but are also causally impacted on by these higher order processes. The causal relationship takes place in both directions. In the case of circular causality, higher and lower order processes of pattern formation are not distinct processes, but form one holistic phenomenon. It is not unreasonable given the apparent strength of the analogy, to ask if this broad concept could also apply to the relation between lower order non-conscious neurobiological processes, and the higher order processes underlying consciousness. This is suggested to be an interesting approach because immediately it suggests one avenue to break down the hard distinction between consciousness and non-conscious processes that underlies the 'hard problem' of consciousness (Chalmers 1996).

In this case the question arises as to which biological mechanisms should be taken to represent lower order and non-conscious processes and which should represent the higher order neural correlates of consciousness? In this regard, the theory underlying experiment 1

and 2 makes a conjecture and then proceeds on a path that is ultimately aimed at testing that conjecture. Because the non-linear mean field model of Liley, Cadusch and Dafilis (2003) suggests that the alpha rhythm may be a predicate state for higher order percepts, and because some of these macroscopic patterns (such as the alpha rhythm) take place at an approximately behavioural time scale, it is conjectured that the alpha rhythm may act as a marker of higher order conscious perception. This was specifically the conjecture that is tested in experiment 1 and 2. Conversely, because many non-conscious neurological processes are much faster than those underlying consciousness (Kihlstrom, 2003), and because consciousness is often thought to emerge globally from a complex combination of synaptic and other lower level neural activity, it is conjectured that small sub-populations of excitatiory or inhibitory neurons could represent the lower order level non-conscious processes. The mean field model of Liley et al., (2003) describes how the patterns of activity seen in these small neural sub-populations give rise to the macroscopic patterns of activity such as the alpha rhythm. Thus, this model is well suited to the question at hand. Experiment 1 and 2 sought to test whether non-linear alpha activity could act as a marker of higher order conscious perception. This was envisaged as an initial step in this broader experimental inquiry. After testing this question, the second stage in this inquiry was envisaged to be a closer exploration of whether the relationship between neural subpopulations on the one hand, and the alpha rhythm on the other, could be described as one of circular causality. If this was found to be the case, then this would provide some evidence in support of a view of qualitative experience as a gestalt of phenomenally foreground (conscious) and phenomenally background (unconscious) processes.

Importantly, the term 'microscopic' was not exclusively equated to non-conscious activity, nor was the term 'macroscopic' exclusively equated to neural patterns underlying consciousness. It is only suggested on the basis of the mean field models of Liley, Cadusch and Dafilis (2003), that this was one avenue to approach the theoretical description of qualitative experience laid out in Chapter Two. It is entirely possible that consciousness may be represented in lower level cellular processes. For example, Sheets-Johnson (1998), and Thompson (2007) both suggest that consciousness does find its initial instantiation at this biological level. Similarly, macroscopic patterns of activity such as early P200 ERP peaks in the EEG can and do represent non-conscious processes (Dehaene et al., 2001). It is specifically

the later case that is taken up as part of the theoretical frame work underlying experiment 3 and 4. This does not however contradict the suggestion that in some instances, microscopic neuronal activity may be equated with unconscious activity while some macroscopic processes, for example the alpha rhythm, may be associated with consciousness. That is, the theoretical proposition here was not that microscopic activity can only ever represent non-conscious processes or that macroscopic patterns of activity must only ever represent conscious perception. This was simply conjectured specifically in regard to the alpha rhythm and its underlying causal substrate of excitatiory and inhibitory neural sub-populations. This was presented as one theoretical framework that was used to translate the theory outlined in Chapter One and Two into an empirically testable proposition. The theory underlying experiment 1 and 2 does not contradict that underlying 3 and 4, but simply represents a different avenue to test the same broad philosophical question.

It should be noted at this stage that the experimentation presented here did not go on to specifically test for the presence of circular causality, and as such remains a significantly incomplete project. As will be discussed in the conclusion and discussion sections below in more detail, experiment 3 and 4 discarded the theories of non-linear dynamics for an alternative experimental approach to the primary philosophical questions outlined in Chapter One and Two. Briefly, this was due to a paucity of findings in initial analysis of the data recorded in the initial two studies. The results of experiment 1 and 2 were being analysed as experiment 3 and 4 were being designed. Because initial findings were not positive, the application of circular causality to the question of consciousness was discarded in favour of an analysis of event related fields. This event related field analysis in experiment 3 and 4 thus represented a completely alternative and experimentally unrelated route to the question of consciousness, as it had been approached in experiment 1 and 2. Upon final analysis, the results of experiment 1 and 2 *were* able to reject the null hypothesis and provide some, albeit weak, evidence that the alpha rhythm does act as a marker of higher order conscious perception. Thus, the more relevant question to this thesis of whether there is a circular causality involved in the microscopic and macroscopic components of the EEG, and whether this also relates to the emergence of consciousness remains an as yet untested question for future research.

While standard extra-cranial EEG is not capable of directly observing microscopic neuronal activity, an understanding of microscopic synaptic activity has been able to be produced through application of the mathematics of non-linear dynamical systems to the raw EEG. Mean inhibitory and excitatory neurotransmission for example have been able to be modelled using differential equations that are capable of describing EEG like oscillatory patterns of behaviour. Various mean field and non-linear models of the EEG have in this way been created (Freeman, 2005; Liley, Cadusch, & Dafilis, 2003; Nunez, 1981; Wilson, 1973), and validated to the extent that such models are capable of predicting the effects of a range of pharmacological agents in experimental data (Liley, Cadusch & Dafilis, 2003) and describe the main features of the EEG. Thus, even while a microscopic level of brain activity cannot be examined directly using EEG, an informed theory of microscopic neuronal activity is nonetheless capable of being derived from an application of the mathematics of non-linear dynamics, in conjunction with extra-cranial EEG. It was such a theory (Liley, Cadusch, & Dafilis, 2003) on which the predictions in experiment 1 and 2 were based. Clearly, the electrocorticogram can directly record microscopic neuronal activity with greater anatomical specificity even to the level of single cell analysis (Quiroga, Mukamel, Isham, Malach, & Fried, 2008). However, this was beyond the resources and technical scope available for experimentation in studies 1 through to 4.

A necessary though not sufficient empirical test of such a hypothesis involves determining the degree of non-linearity in the evoked EEG associated with a conscious percept. In experiment 1 and 2 (Chapter Four), EEG time-locked to the emergence of a conscious percept is examined for the presence of non-linearity. On the basis of a positive finding, further modelling of conscious perception in terms of circular causality between macroscopic and microscopic neural processes becomes possible. Experiment 1 uses stimuli presented at a perceptual threshold to separate perceived and non-perceived events. The presence of non-linearity in the EEG associated with the perceived stimuli is then investigated using the proxy of Alpha-Beta EEG synchrony. The use of this proxy is justified on the basis of a hypothesis that nonlinear alpha oscillations are predicted to generate harmonics in the higher frequency bands, while linear noise driven alpha activity is not. This implies that beta

activity may be a first harmonic of a periodic process originating in an alpha base frequency (Nikulin & Brismar 2006). Therefore, a cross frequency phase synchrony in the EEG can be taken as an indicator of non-linearity. Experiment 2 separates perceived and non-perceived events using an auto-stereogram stimulus. Again, the presence of non-linearity in the EEG associated with the perceived stimuli is investigated using the proxy of Alpha-Beta EEG synchrony.

In experiments 3 and 4 (Chapters Five and Six), the relationship between supraliminal and subliminal processes is investigated within a temporal window of neural processes associated with conscious perception. Conscious perception has been associated with neural processes occurring 300 milliseconds after the presentation of a given stimulus (Dehaene & Changeux 2005; 2011). Experiments 3 and 4 examine the contribution of non-conscious activity occurring during this 300 to 500 millisecond window, to the overall phenomenology of the conscious percept. In particular, experiment 3 examines whether the reaction time and error rates associated with the perception of a given stimulus can be impacted by the simultaneous processing of a separate non-consciously perceived stimulus. Experiment 4 extends this idea by examining the interaction between the processing of consciously perceived and non-consciously perceived stimuli during the same temporal window, using the N400 event related field (ERF) in the MEG at both source and sensor space. N400 ERFs are used here as a marker of semantic processing, which is examined occurring at both supraliminal and subliminal levels.

The philosophical orientation presented in Chapter One and Two is a broad one, and could be examined through a number of different specific theoretical frameworks within the neurosciences. The approaches taken in experiments 1 to 4 represent just one extrapolation of this broader philosophical stance to theoretical and empirical neuroscience. Across all experiments, results showing an interaction of conscious and non-conscious processes in the neural activity that correlates with qualitative experience is taken as a necessary condition in support of the theoretical perspective described in Chapter Two.

Despite a strong implicit commitment to physicalism, a great deal of the scientific study of consciousness continues to subscribe to Cartesian intuitions in its broad conception and execution. For example, dominant empirical approaches in the neurosciences have sought to provide a binary characterization of the neurobiological basis of conscious and unconscious processes (Del Cul, Baillet & Dehaene, 2007, Dehaene & Changeux 2011). Essentially and for the most part, the science continues to be shaped by a seemingly unshakable sense that subjective internal consciousness just seems to exist in a categorically different manner from the objective physical processes 'out there' in the natural world.

These Cartesian intuitions can be seen to be paralleled and reflected in the sciences in the stark conceptual distinction between consciousness and unconscious processes. Whilst substance dualism is almost universally rejected within the sciences, this conceptual dichotomy is implicitly retained when science examines non-conscious biological processes for a point of categorical transition into process that correlate with consciousness. For example, as discussed in Chapter One, one dominant theoretical framework- the GNWS model (Dehaene & Changeux, 2004; 2011), describes an abrupt nonlinear and categorical transition between early feed forward non-conscious processes, and a late amplified re-entrant loop of cortical processes that correlate with consciousness. In this model, consciousness is seen as arising when early feed forward information from the sensory cortices is amplified and included in a global neuronal network of activity through long-range connectivity and the active participation of frontal and parietal cortical regions. Theories such as those of Dehaene and Changeux (2004; 2011) have undeniably helped develop an understanding of some of the ways in which neural activity relates to conscious perception. However, such an approach covertly adopts a way of thinking about qualitative experience that was already at play in Descartes. A set of common ontological assumptions which has informed both Descartes and the contemporary science of consciousness is discussed in Chapter One.

The question of whether consciousness is starkly disambiguated from unconscious processes or whether there is a gradual transition between the two has been debated in the literature and received some experimental investigation. As discussed above Deheane and Changuex (2004; 2011), have argued and provided convincing data for an abrupt

transition and disambiguation between consciousness and non-conscious neural processes that take place earlier in the processing stream. Conversely Overgaard et al., (Overgaard et al., 2006) has argued that a tendency for previous studies to show conscious perception of stimuli arising in an all or nothing fashion resulted from methodological artefacts. In their study, participants were asked to assess the presence of masked stimuli using a subjective four-point Perceptual Awareness Scale. Both subjective and objective ratings of perception suggest a graded and linear relationship between masking strength and both correctness and perceptual clarity. Such results were taken to indicate that conscious percepts arise in a graded and continuous manner rather than as an abrupt and distinction from earlier non-conscious processing.

Nevertheless, the question of whether a stimulus becomes conscious by degrees, or 'all or none' as it were, does not in fact address the relationship between consciousness and non-conscious processes as an ontological question. This ontological question concerns what consciousness actually is and the structure of its manner of existing. For example, one can ask whether the actual existence of qualitative experience stands in stark contrast to that of non-conscious processes. Alternatively, it can be considered whether the being structure of qualitative experience crosses or subsumes the division between what we habitually and historically conceptualise as conscious and non-conscious processes in the first place. The question of such a relationship is more than simply a question of perceptual thresholds such as discussed in Deheane and Changuex (2004) or Overgaard et al., (2006). Rather, such a question also raises the ontological issues concerning the characteristic manner of existing that qualitative experience has.

In this thesis the ontology of qualitative experience is examined in terms of the relationship between consciousness and non-conscious processes. The experimental determination of this relationship is important because it raises a host of unexamined assumptions that implicitly guide out thinking about what consciousness is and the way we go about it's scientific examination. For example, the characterisation of qualitative experience as in internal domain of psychical representations, imports assumptions about the relationship between consciousness and non-conscious mental and material processes. That

is, only through preconceiving an ontological separation between consciousness and unconscious processes are we able to arrive at the modern characterisation of consciousness as some sort of circumscribed unit of self-representing subjectivity. A conceptual separation between consciousness and unconscious processes is covertly present when we approach consciousness as a *thing*, albeit a mental thing, that is able to be cognitively represented in its entirety. For experimental approaches based in this assumption, a process of reification takes place through a determination of conscious and unconscious processes as having distinct and independent ontologies. In sum, qualitative experience is reified and prescribed an objectlike sort of existence when it is characterised as 'consciousness'. An ontological separation between consciousness and unconscious processes is an implicit part of such a characterisation.

However, it must be noted that a problem for this thesis arises in what may be judged to be the neuro-centric approach taken in these experiments towards key Heideggerian ideas. An important aspect of Heidegger's philosophy is the notion of *worldhood* and *being-beyond* in which human existence and agency arise as a contextual embodiment of a world of shared social meanings and practices (Dreyfus, 1991). By such an approach, the human being doesn't first exist and then encounter a world. Rather, the existential horizon that defines the living being is manifest in its encounter with a world. In this sense, the 'world' becomes a type of 'beyond-within' and comes to define rather than lie outside of human existence (Heidegger, 1977a). The impact of this line of thinking can be observed in embodied and extended theories of mind where the living being's environment is incorporated into the mechanisms underlying it's own agency and cognition (Gallagher, 2009, Wheeler, 2005, Clark, 1997). Such an understanding subverts a traditional approach in which human existence is viewed as that of an isolated Cartesian subject, defined in contrast to its objective environment.

However, where the 'being-beyond' is equated with unconscious processes as it is in this thesis, and these in turn are examined entirely in terms of the dynamics of the nervous system, such an approach can be criticised as succumbing to just the sort of isolated Cartesian subjectivism that Heidegger argued against. This thesis criticises the Cartesian foundation present in many traditional approaches within the cognitive and brain sciences (Tononi et al.,

2016, Dehaene & Changeux, 2011, Chalmers, 2010). Yet the argument laid forth here can also be viewed as one of framing human consciousness in terms of processes taking place within the skin and skull of an independent isolated human entity. The neuro-centric approach taken in the present studies arguably undermines the critique of latent Cartesianism in the broader science of consciousness.

To an extent, this must be acknowledged as a limitation present in the current work. This thesis is not intended as a direct interpretation of Heidegger nor technically a 'Heideggerian Neuroscience'. Rather, elements of Heideggerian phenomenology are drawn on in as much as they may suggest an alternative theoretical and philosophical basis for the neuroscience of consciousness and this necessarily focuses on the brain. This thesis is primarily a work of philosophy and neuroscience. Any research that sought to do justice to the fuller import of Heideggerian philosophy would necessarily be a work not only of neuroscience and philosophy, but also biology, sociology, linguistics and psychology. This is beyond the scope of the current work. In examining how elements of Heideggerian phenomenology can comment on and guide experimental examination of perception and consciousness, this work has declined to engage with other significant components of Heideggerian thought regarding the nature and existence of the living being.

Nevertheless, in defence of the approach taken in this thesis, *being-beyond* was approached as a statement about the impossibility of parsing consciousness separate from its material basis. This concept runs parallel to, though differs from the more widely embraced interpretation of Heidegger's notion of *being-beyond* as a statement about the relationship between a living being and its environment. Heidegger inverts the polarities of a sense of a 'beyond' and a 'within' such that that which is traditionally viewed as beyond or outside of the human subject, now takes place within the living being and so, defines it. For example, Heidegger talks of *worldhood* as a 'beyond-within' (Heidegger, 1977a, p 229), such that the living being is no longer an enclosed subject witnessing its world, but rather, the living being in essence *is* the practical real engagement with a world. It is from this that the phenomenology of openness proceeds and this approach can be seen reflected in contemporary theories of environmentally extended cognition (Clark & Chalmers, 1998,

Wheeler, 2005, Clark, 2007). However further to this, a similar inversion of this polarity between a 'within' and a 'beyond' can also be applied in terms of the relationship between consciousness and matter, and this is the approach taken in the current work. Material processes are traditionally viewed as taking place in a way that is outside of or ontologically distinct from consciousness. However, by the analysis presented in this thesis, material processes may be viewed as an alterity that manifests at the heart of the way of existing that consciousness has, and this also strongly evokes a phenomenology of openness in its own way. Phenomenologically, matter is first and foremost approached in this thesis in terms of a dynamic of unfathomable alterity in relation to which, and only in relation to which, one's own sentience shows itself and becomes manifest. Much like Heidegger's discussion of Being, the fundamental grounds of existence are in this sense salient though hidden in every aspect of what human experience reveals itself to be. It is this beyond-ness, opaque and hidden within what consciousness is, that is suggested to give rise to a sense of openness and this is presented as the definitive characteristic way of existing that consciousness has. Such an approach conceptually opens consciousness up from being grasped as an enclosed 'nugget' of subjectivity, passively witnessing its world, to being a type of existence that is already intrinsically part of its world.

Such an approach cannot be substantiated as a direct interpretation of Heidegger's text. Heidegger did not equate openness or being-beyond with non-conscious processes. Nevertheless, such a theoretical stance captures elements of Heideggerian thought perhaps more effectively than approaches that have defined the living being in terms of a broader biological or environmental context. Proponents of extended, embodied and enactive theories of mind all call into question the relevance of inner-outer, subject-object categories in a manner that subverts the neural/extra-neural distinction (Prinz, 2009, Clark, 2009). However, this becomes a debate about the location of the material substrate of cognition and consciousness, not the constitution of consciousness itself. Such a debate treats the question of internality and externality in terms of whether the substrate of cognition and consciousness is contained within the skin and skull, or extends out into the physical environment. This approach does not question or provide alternatives to the sense in which consciousness appears to exist in an internal way, always viewed as though from within and as ontologically distinct from the

external and objective material processes of nature. In this, extended and embodied mind theorists do not undermine or provide an alternative to the distinction between essence and existence as Heidegger strove to do. However, when being-beyond is thought in terms of the alterity of material processes exhibiting themselves within the structure of consciousness, this does conceptually reposition consciousness in a way that it can no longer be viewed as essentially internal or circumscribed in nature. In this way, the approach taken towards being-beyond in this thesis perhaps captures some aspects of Heidegger's thinking more effectively than embodied, enactive or extended mind theories (Hurley, 1998, Noe, 2004, Block, 2005, Clark, 2009).

In final analysis though, the theoretical position described in this thesis may have been more convincingly and effectively carried through if 'being-beyond' were analysed at a lower biological level than the approaches taken in experiment 1 through to 4. A number of authors have sought to characterize a rudimentary level of sentience in terms of phylogenetically primitive corporeal life (Sheets-Johnson 1998, Deacon 2012, Margulis 2001, Thompson 2007). Such approaches would suggest that consciousness is not an emergent property of the brain. Rather, such approaches argue that the basic constituent of consciousness is present in any animate living form. Thompson for example has argued for a 'mind-like' interiority at the level of rudimentary animate biological life. Taking recourse to the concept of autopoiesis (Varela, Thompson & Rosch, 1993, Maturana 1987) Thompson describes sentient interiority in terms of a self-emergent cellular autonomy. Thompson characterizes this rudimentary interiority in terms of the concept of 'sentience', defining this as "the feeling of being alive and exercising effort in movement" (Thompson, 2007, pp. 161). However, in discussing interiority at a rudimentary cellular level, Thompson distinguishes this from first-person subjective consciousness, arguing that without some form of elaboration via the nervous system, it is unlikely that such minimal interiority would entail full phenomenal subjectivity. Thus, rudimentary autopoiesis of this sort in fact could represent a type of sentient interiority that is simultaneously within and outside of full subjective consciousness. This cellular level of analysis perhaps then serves as a better avenue to examine the *being-beyond* or openness, than markers of subconscious neuronal processing such as early ERP peaks or certain features of the EEG or MEG oscillatory spectrum. This is because such markers of neuronal processing represent an analysis of consciousness that is essentially discontinuous with more

rudimentary biological processes and the broader physical environment. However as discussed above, such an approach was beyond the scope and expertise of the current work. The *being-beyond*, thought of as non-conscious processes taking place within the structure of phenomenal consciousness, have instead been examined in terms of a range of conventional markers of subconscious neural processing.

To summarise, the philosophy and research presented here seeks to explore ontological questions regarding the being-structure of qualitative experience. This is done through examining the relationship between consciousness and non-conscious processes. Broadly, the possibility of a shared ontology between conscious and non-conscious processes is examined. In the remaining chapters, this approach is specifically examined through an investigation of the interaction of the neural correlates of liminal and subliminal processes. Findings in support of a more complex and reciprocally causal relationship between conscious and non-conscious processes would go some way to undermining a prevailing conception of consciousness as a self-sufficient unit of subjectivity. In such a case, elements of Heideggerian thought provide some avenues for considering an alternative understanding of qualitative experience.

# Chapter 4

## Experiment 1 & 2. Modelling a gestalt of conscious and non-conscious processes as a circular causality between macroscopic and microscopic neuronal activity

### 4.1. Background

For the sake of enabling empirical an approach, the model of consciousness discussed in Chapter Two is here interpreted in terms of a gestalt of conscious and non-conscious processes. The two experiments detailed in this chapter take a step towards examining this broad theoretical position, through investigating the use of non-linear dynamics as a tool to understand brain function associated with conscious perception. Broadly, circular causality (Haken, 2006) is discussed below as a possible mathematical analogy to the type of reciprocally causal gestalt between conscious and non-conscious processes discussed in Chapter Two. The first step in exploring this hypothesis is in determining the presence of nonlinearity in the EEG associated with perception. In this regard, alpha-beta synchrony in the EEG is taken as an initial proxy for non-linearity. The initial experimental question examined in the following two studies then, is whether EEG time locked to the emergence of a perceptual event shows an increase in the power of 1:2 alpha-beta phase synchrony compared to EEG arising in the absence of the given perceptual event. 1:2 alpha-beta phase synchrony refers to a condition of phase coupling between the neuronal oscillations in alpha and beta frequency bands (Nikulin & Brismar 2006). In such a condition, a $2\pi$ advance in the phase of the alpha oscillation will be accompanied by a $4\pi$ increase in the phase of the beta oscillation. This is discussed in more detail below. If alpha-beta synchrony is found to be stronger in the 'perceived' compared to 'not perceived' conditions, this will be taken as a positive finding. In such a case, further exploration of the use of non-linear dynamics and circular causality to model qualitative experience will be justified.

As a basis for this approach the work of Liley et al., (2010) is drawn on. Liley et al., models synaptic activity in subpopulations of neurons on a macro-column scale as a set of coupled non-linear partial differential equations (Fig. 4.1). Using this model, the emergent patterns of cortical activity recorded in the EEG are able to be modelled using the mathematics of nonlinear dynamical systems (Haken, 2006). Of particular relevance here is the capacity of such systems for self-organising pattern formation and circular causality. Circular causality describes the manner in which emergent patterns can arise from the nonlinear interaction of a collection of weakly connected components, but then in turn constrain the behaviour of those components. A reciprocally causal relationship exists between emergent patterns at a macroscopic scale and the underlying behaviour of components at a microscopic scale. The implicit assumption in the following two experiments is that macroscopic pattern formation at the level of the cortical EEG may represent phenomenologically foreground contents of consciousness. Activity at the microscopic level, such as the underlying synaptic dynamics may represent non-conscious processes or phenomenologically background content and processes. If a circular causality can be shown to exist between these two levels of activity, this would represent a mathematical analogy of the type of relationship proposed in Chapter Two to exist between consciousness and non-conscious processes. That is, if such a circular causality can be shown to exist, this would support a view in which qualitative human experience may arise as a unified gestalt of both conscious and nonconscious processes. Elsewhere, circular causality has similarly been used to provide a metaphor for the relationship between consciousness and the physical processes of which the brain is comprised (Haken, 2006).

The approach outlined here can be seen to contrast with other Cartesian influenced methodologies that seek to characterise the NCC by specifically distinguishing such activity from the neural correlates of non-conscious processes. When qualitative human experience is characterised as an entirely self-transparent subjective consciousness, experimental methods that seek to examine such a phenomenon frequently do so by subtracting away neuronal processes that are shown to underlie only non-conscious processes. For example, Dehaene and Changeux (2011) exclude from the NCC, those functionally localised processes in the

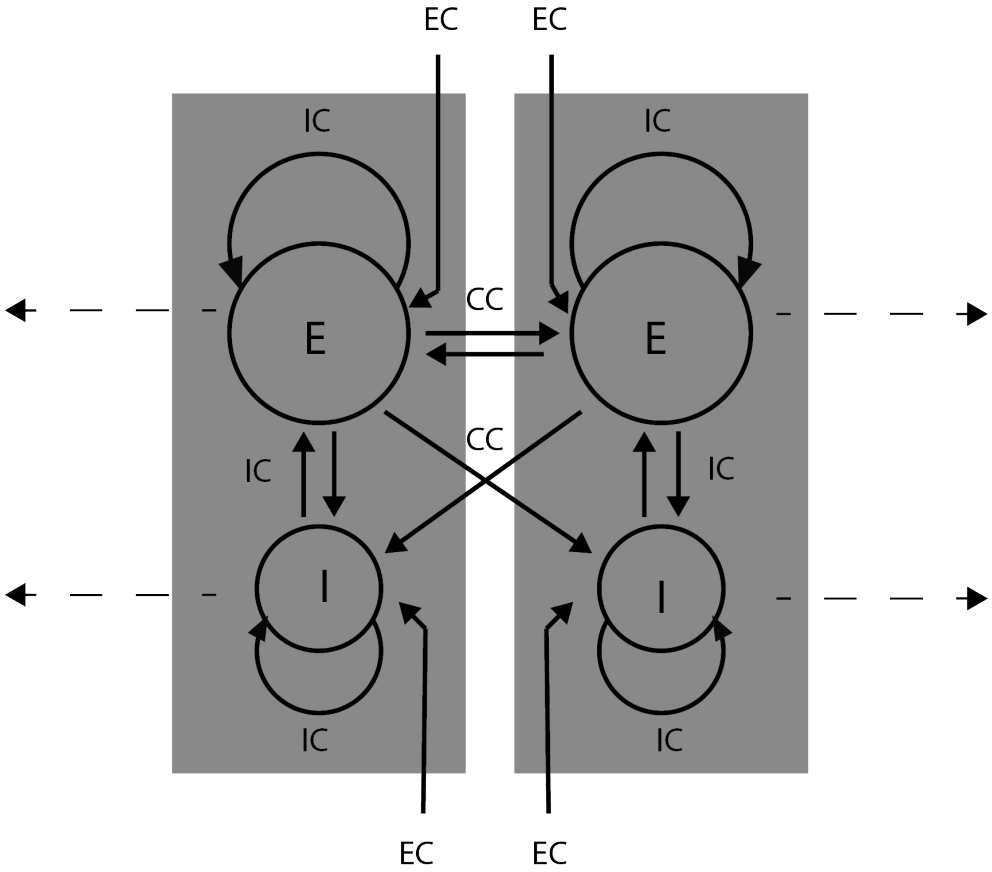



Figure 4-1. Schematic diagram of the cortical macro-column (grey rectangle) described in Liley & Bojak (2005). The macro-column is comprised of excitatory (E) and inhibitory (I) neural subpopulations connected via short range intra-cortical (IC) and long range cortical-cortical (CC) connections along with extra cortical input (EC). Arrows represent direction of excitatory or inhibitory influence. Synaptic activity in subpopulations of neurons on a macro-column scale are modelled in Liley & Bojak (2005) as a set of coupled non-linear partial differential equations. This 'mean field model' is capable of producing the main characteristics of spontaneous human EEG and also describes the transition from a linear noise driven alpha oscillation to a non-linear limit cycle alpha wave. In the human neo-cortex a cortical macro-column can be envisaged as a cylindrical region of approximately 0.5 - 3 mm in diameter penetrating the entire thickness of cortex and is estimated to contain approximately 100,000 - 300,000 neurons (Nunez, 1981).

sensory cortices that remain isolated from broader global patterns of activation, as may occur in the case of visual masking. This exclusion is a dynamic one. That is, functionally specialised activity in the sensory cortices may or may not be recruited into the GNWS depending on a range of factors such as attention, context, masking paradigms etc. Nevertheless, the NCC embodied in the GNWS at any given time, is defined in contrast to that neural activity underlying only non-conscious or subliminal processes. A Cartesian approach implies a stark disambiguation between consciousness and non-conscious processes and this is embodied in many of the approaches taken in the contemporary neuroscience of consciousness (Crick &

Koch 2003; Dehaene & Changeux 2004; Baars, 2005; Block, 2005; Del Cul, Baillet and Dehaene, 2007; Seth, et al., 2008).

The mathematics of nonlinear dynamics offers a tool that may be able to formalise the complex patterns of electrocortical activity that arise in the presence of both normal and disordered brain function (Stam, 2005). Once the computational power and algorithms capable of dealing with nonlinear dynamics became available, numerous studies applied nonlinear analysis to EEG time series data. Early application of nonlinear theory to brain function sought to characterise neural activity in terms of nonlinear mathematical chaos (Basar, 1990; Duke, 1991). Whilst initial findings were positive, limitations in the algorithms used in the analysis became evident. Subsequent studies using a more robust statistical analysis of nonlinearities, including the use of surrogate data testing, lead to a rejection of the notion that the brains activity can be broadly characterized by an appeal to deterministic chaos (Stam, 2005). However, more recently developed statistical measures have revealed small but significant nonlinearities do exist in the dynamics associated with a range of normal and abnormal brain function. For example, nonlinear analysis has been successfully applied to the neural activity underlying the mechanisms of IQ (Anokhin et al., 1999), working memory (Stam, 2000), emotion and affect (Aftanas et al., 1994), as well as a range of abnormal brain function (Ehlers et al., 1998; Kotini & Anninos 2002; Kim et al., 2003).

Nonlinear analysis of electrocortical activity may also offer a tool to assess levels of consciousness. Numerous studies have shown a strong link between sleep stages and nonlinear measures of cortical activity (Achermann et al., 1994; Fell et al., 1996). The success of these findings provided impetus to investigate whether nonlinear measures can also profile other states of reduced consciousness, such as in the case of anaesthesia. Widman et al., (2000) found that estimated levels of anaesthesia based on levels of servoflurane in the blood showed negative correlation with the nonlinear correlation index (Widman, Schreiber et al. 2000). Further, Myles et al. (2004) has shown that the electrocorticaly derived nonlinear bispectral index (BIS) is also effective in providing real time analysis of depth of anaesthesia (Myles, Leslie et al. 2004). However, replication of use of BIS in clinical setting has produced contrary evidence. Frenzel et al., (2002) showed only moderate correlation between BIS measures and

depths of anaesthesia (Frenzel, Greim et al., 2002). The findings in this study suggested that at deeper sedation levels, inter-individual difference may interfere with the capacity of the BIS index to measure depth of anaesthesia with the clinically required precision.

The two experiments in this chapter represent an initial step in a broader experimental enquiry into the use of nonlinear dynamics to model the type of relationship between consciousness and non-conscious processes discussed above. This initial step, embodied in the current two studies, is to determine whether nonlinearity in the EEG can be meaningfully associated with the emergence of a perceptual event. Further exploration of the broader theoretical position laid out in Chapter Two is predicated on a positive finding in this regards. The work of Liley et al., (2010) was drawn on to provide a mathematical description of the emergence of a non-linear alpha rhythm in the EEG (Liley, Bojak et al., 2010) (Fig. 4.1). The Liley model describes the manner in which linear noise driven alpha activity is able to transition to a nonlinear limit cycle alpha wave. Such 8-13 Hz non-linear alpha activity is capable of producing harmonics of this base frequency in the beta (18-25 Hz) and low gamma (32-50 Hz) oscillatory frequency ranges. In this way, the nonlinear alpha activity can be understood as a self-organizing state of marginal stability from which the cortex can be perturbed towards emergent harmonic nonlinear activity in the higher frequency bands.

This bifurcation from linear noise driven alpha to a nonlinear alpha and a subsequent emergence of higher frequency activity in the beta and gamma ranges is here hypothesized to occur in the case of a cognitive or perceptual event. In support of such a hypothesis, the dynamics of both alpha and beta activity has been shown to be associated with a range of cognitive and perceptual processes (Klimesch, 1996; Basar et al., 1997; Pfurtscheller & Lopes da Silva, 1999; Jensen et al., 2002; Mima et al., 2001; Schürmann & Basar, 2001; Linkenkaer-Hansen et al., 2004). Thus non-linear marginally stable alpha activity can be conceived of as a 'readiness rhythm' and as a predicate and marker of higher order perceptual events. The aim of the current two studies is to determine whether non-linear activity is comparatively greater in the EEG time-locked to the emergence of a perceptual event compared to EEG recorded in the absence of a given perceptual event. If non-linear activity is comparatively greater in the EEG time-locked to the emergence of a perceptual event, such a finding would motivate and

justify further application of non-linear dynamics to model a circular causality between non-linear alpha activity and the underlying synaptic dynamics within the cortical macro-column. In this manner, the two studies contained in this chapter represent only an initial step in this broader experimental project.

As an initial explorative step, alpha-beta synchrony in the EEG was used as an easily accessible proxy of non-linearity. Nonlinear alpha activity is expected to produce harmonics in the higher frequency ranges such as beta and gamma, while linear noise driven alpha is not. Therefore, evidence of non-linear alpha activity may be detected in the presence a phase synchrony between alpha and beta or alpha and gamma oscillations. In the case of linear alpha activity, randomly induced oscillatory 'noise' impacts on the base alpha frequency. This is observed in the frequency domain as a smooth gaussian fall-off in power on both sides of the base frequency. However, in the case of non-linear systems, as the damping tends towards zero the resonance becomes sharper until an autonomous non-linear oscillation emerges. This emergent activity is a limit cycle oscillation at the base natural frequency, in this case around 10 Hz. The limit cycle alpha activity is described as a weakly non-linear function of a sinusoid, i.e. not as a perfect sinusoidal wave and will produce harmonics of the natural frequency, in this case, at around 20 Hz and 40 Hz (Liley & Bojak 2005). Such harmonics have been shown to be able to be detected as an increase in1:2 phase synchrony between alpha and beta waves, or as an increase in 1:4 phase synchrony between alpha and high gamma waves respectively (Nikulin & Brismar 2006).

Therefore, the presence of 1:2 alpha-beta phase synchrony in the EEG, is used in the following two experiments as an initial proxy for non-linearity. The detection of 1:2 alpha-beta phase synchrony would therefore represent an initial step towards using the mathematical concept of circular causality to describe the type of gestalt of conscious and non-conscious processes discussed in Chapter Two.

The idea of neural synchronization can represent three distinct processes. The first of these relates to the number of single neurons firing in synchrony. In this case, amplitude increases or decreases in the EEG are related to changes in the number of active neurons firing in synchrony (Elul, 1971; Pfurtscheller & Lopes da Silva, 1999). Secondly, neural synchrony

can also refer to the process whereby oscillations of a similar frequency can be seen in spatially separate regions of the brain. This type of neural synchrony has been detected and interpreted for example in the processes underlying feature binding in perceptual tasks (Rodriguez 1999; Singer 1999). Synchronisation in gamma frequencies in globally distributed patterns across the cortex has also been associated with conscious perception (Dehaene & Changeux 2011). However neural synchronisation can also refer to cross frequency synchronisation in which phase coupling is seen between different oscillatory frequencies. For example, a $2\pi$ increase in phase of the alpha oscillation is accompanied by a $4\pi$ increase in the phase of the beta oscillation in the case of 1:2 alpha-beta phase synchrony. It is this cross-frequency phase synchronisation between alpha and beta oscillations that is studied in experiment 1 and 2 contained in this chapter. The principles of alpha-beta phase synchrony are illustrated in figure 4.2. Similarly, a $2\pi$ increase in alpha oscillation is accompanied by an $8\pi$ increase in gamma oscillation in the case of 1:4 alpha-gamma phase synchrony. A more detailed exposition of this measure of phase locking is presented in equations 1 to 4 in section 4.2.3 below.

Cross frequency coupling has been understood to form one possible mechanism for integrating spectrally distributed processing again across distributed cortical regions (Varela, Lachaux et al. 2001; Palva, Palva et al. 2005; Jensen & Colgin 2007; Canolty & Knight 2010). Palva and Palva (2011) have shown evidence of phase coupling between different frequency band brain activity. In this instance, cross frequency synchronization between theta oscillations and those in alpha and low gamma bands were observed. The strength of this cross-frequency synchronization was shown to correlate with visual working memory loads. Cross frequency synchronization coupling of this sort has been suggested to provide a mechanism to pass information from neural activity operating at slower behavioural timescales to the faster activity underlying synaptic modification and computation (Canolty & Knight 2010; Palva & Palva 2011). Phase synchronization specifically between alpha and beta band activity has also been shown to underlie visual and working memory function (Palva & Palva 2005; 2011) as well as being present during resting state (Nikulin & Brismar 2004; 2006; Gruber, Klimesch et al. 2005). Cross frequency synchronization between alpha and beta oscillations was also correlated with visual working memory load within visual, and dorsal attentional systems. These effects were shown to be most salient over the right parietal

regions (Palva, Palva et al. 2005; Palva & Palva 2007; 2011). Nikulin and Brismar (2006) suggest that this cross frequency synchronisation points to a common origin of both oscillations in a unitary periodic process. Drawing on Liley et al., (2010) such a common periodic process is suggested to be a non-linear alpha wave capable of producing harmonic activity that would be observed in a phase coupled beta wave.

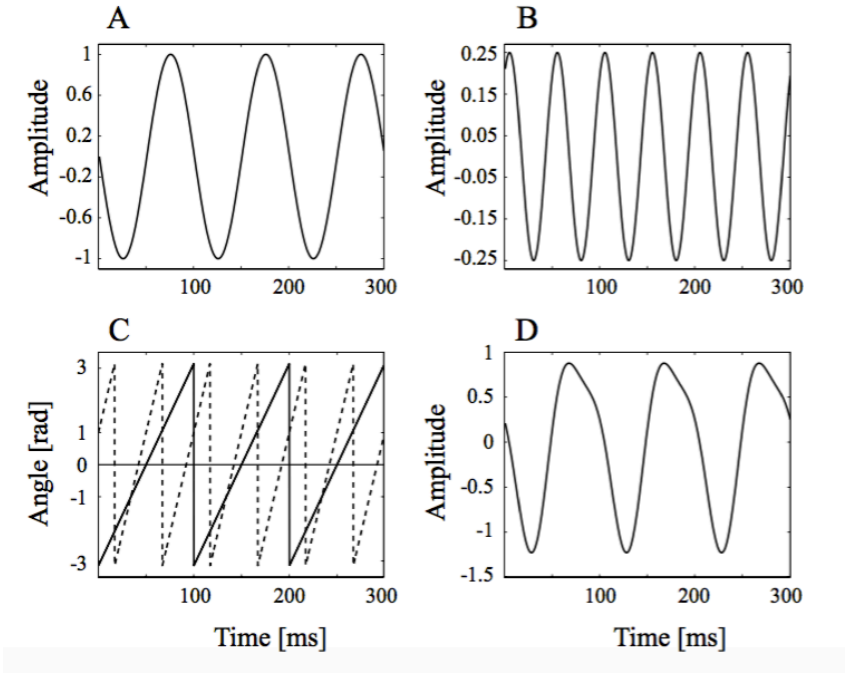



Figure 4-2. Example of phase synchrony between alpha (10Hz) and beta (20 Hz) oscillations. Sinusoids represented are artificial generated. A) A 10 Hz sine wave. B) A 20 Hz sine wave, shifted by 1 radian with respect to $2\varphi\alpha(t)$, and with four times smaller amplitude than the 10 Hz oscillations. C) Phase relationship between sine waves shown in (A) and (B). The phase of the signal changes from $-\pi$ to $\pi$. Dashed and solid lines represent 20 and 10 Hz oscillations respectively. The difference in phase between the two sine waves $\varphi\alpha$-$\beta(t)$ is -1 radian in the example shown here. D) Sum of sine waves shown in (A) and (B). This summation between alpha and beta waves produces the appearance of comb-like shaped oscillations which is frequently seen in the EEG. Figure adapted from Nikulin and Brismar (2006, p. 649).

The primary experimental question in the following two studies is whether the strength of 1:2 alpha-beta phase synchrony will increase in the presence versus absence of time locked higher order perceptual events. Significantly stronger alpha-beta phase synchrony in the 'consciously perceived' compared to 'not perceived' conditions would open the possibility for future studies to model perceptual events more thoroughly in terms of non-linear dynamics and a circular causality between emergent patterns in the EEG and underlying synaptic dynamics within the cortical macro-column. Such a model could be

empirically explored and would provide some support for the description of consciousness drawn out in Chapter Two.

Both experiments 1 and 2 described below examine whether EEG time-locked to the emergence of a perceptual event shows stronger alpha-beta synchrony than EEG recorded in the absence of the given perceptual event. Therefore, the methods of determining the strength of alpha-beta synchrony and the statistical analysis remain identical for both experiments. The difference between experiments 1 and 2 described in this chapter is primarily in the visual stimulus used in each study. Experiment 1 uses a stimulus containing visual differences at the participant's visual threshold, while experiment 2 uses an autosterogram stimulus. In each case, these stimuli are used to create 'perceived' and 'not perceived' conditions. This is discussed in more detail in sections 4.2.2 (experiment 1) and 4.4.2 (experiment 2) below. It is the strength of alpha-beta synchrony in the EEG recorded in these conditions that is then compared.

# Experiment 1

## 4.2. Method

### 4.2.1. Subjects

Ten healthy participants with normal or corrected to normal vision participated in this study (male/female: 2/8, age range 22-36 years). All participants were provided with a written and verbal explanation of the tasks they would be performing and signed a written consent form prior to taking part. This experiment received ethics approval from the Swinburne University of Technology Human Research Ethics Committee (HREC) and was conducted in accordance with the HREC guidelines.

### 4.2.2 Stimuli & Procedure

Participants were seated at a distance of 1 meter from a CRT monitor in a darkened electrically shielded room. A fixation cross was presented on the monitor screen for

between 250 ms and 350 ms, followed by a presentation of the target stimuli. The target stimuli used in this study were a replication of those used in Van Dijk et al., (2008) and are described in figure 4.3 below. After the target stimulus was present on screen for 16 ms, it was replaced by a checker board masking stimulus which was present on the screen for 0.7 s. Participants were asked to respond as quickly as possible with a button push as soon as they detected a tonal difference between the inner and outer target disks. Following the participant response, the following trial would begin automatically, after an inter-trial interval of between 2.5 and 3.5 seconds.

The target stimuli in this study consisted of two concentric tonal disks, together occupying a visual angle of 2.1° presented for 16 ms, (Fig 4.3). These disks could be presented in a 'clear visual difference' condition, a 'threshold difference' condition and a 'No visual difference' condition. The adaptive staircase procedure for determining each participant's perceptual threshold is described below. Stimuli in the 'clear visual difference' condition were presented in 30 out of 120 trials, (Fig 4.3 a). In this condition, a tonal contrast between an inner and outer concentrically positioned disk was set to be well above perceptual threshold, based on a prior staircase procedure. Stimuli in the 'threshold condition' (Fig. 4.3b) were presented in 84 out of 120 trials. In this condition, the difference in tonal contrast between inner and outer disk was set at a perceptual threshold based on a prior staircase procedure. Finally, 'no visual difference' stimuli were presented in 6 out of 120 trials. The stimuli in this condition consisted of only one disk, ie, with no difference in tone between 'inner' and 'outer' disk (Fig 4.3c).

The perceptual thresholds for each participant was determined using an adaptive staircase procedure run prior to each participant undertaking the primary experimental task. This staircase procedure followed a 3-step adaptive staircase method such as is described in Leek (2001). As used in this study, this method initially required participants to determine whether a difference existed in the tone of the inner and outer disk, when such a difference was in fact clearly evident. The adaptive staircase procedure then marginally increases the difference in visual tones with each incorrect response and decreases the tonal difference after three successive correct responses. This procedure was run for approximately 20 minutes for

each participant and was able to determine each participant's perceptual threshold. This threshold, determined individually for each participant, was the difference in tonal contrast between disks that would result in a correct detection of such differences in approximately 50% of the trials.

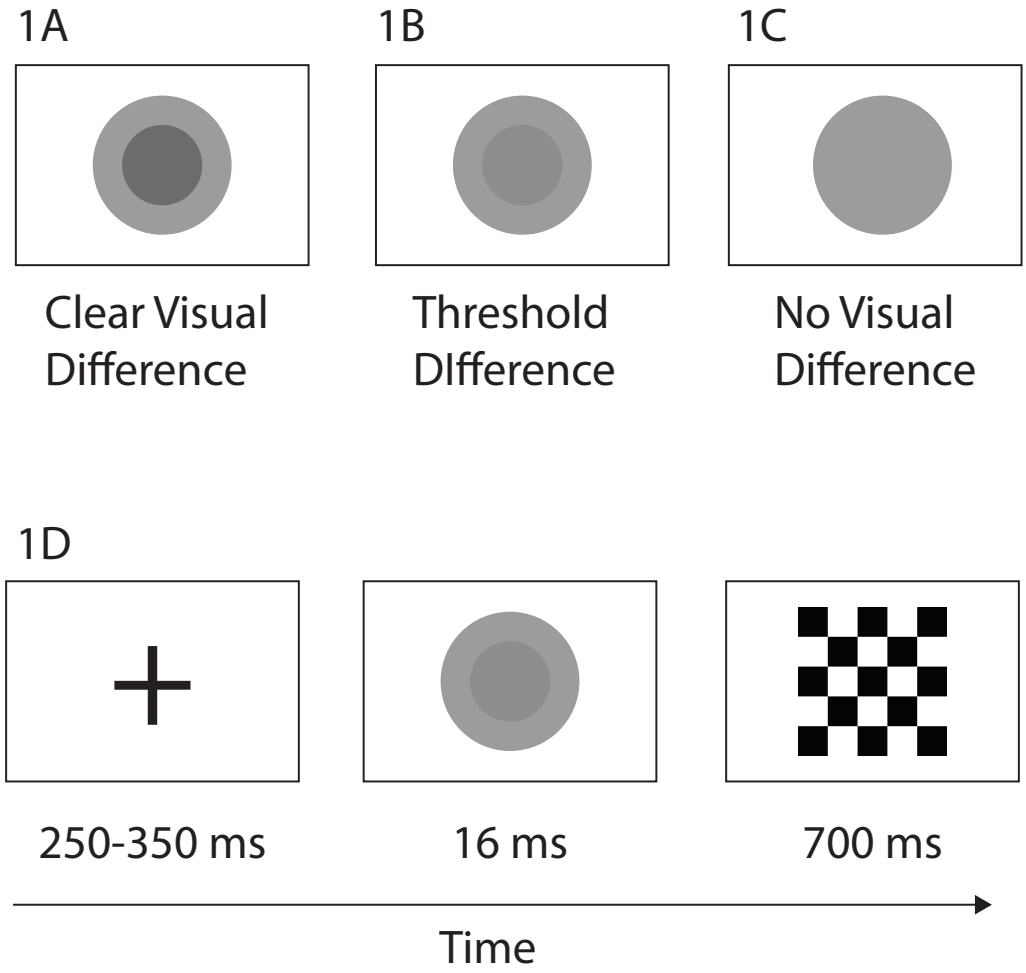



Figure 4-3. Experimental Stimuli and protocol. 1A) Stimulus used in 'Clear Visual Difference' condition accounting for 4% of trials. Difference in tone between inner and outer disks is easily detectable based on prior staircase procedure. 1B) Stimulus used in 'Threshold Difference' condition accounting for 70% of trials. Perceptual threshold for differences in tone between inner and outer disks was based on prior staircase procedures. 1C) Stimulus used in 'No Visual Difference' condition accounting for 26% of trials. Only one disk is presented in this condition, i.e. there is no difference in tone between 'inner' and 'outer 'disks. 1D) Experimental protocol. Participants were presented with a fixation cross for between 250 ms and 350 ms. This was followed by the presentation of a concentric disk stimuli from one of the three conditions shown above. The disk stimuli were then replaced by an obscuring checkerboard mask which was present for 700 ms.

## 4.2.3. Data collection and analysis

EEG was recorded with a 64 channel ASA Lab ANT system using an extended 10-20 montage and a sampling rate of 256 Hz. This system used a common referencing system rather than a specific reference channel and used the AFz as the ground. Pre-processing and analysis was conducted using the Matlab package (MathWorks, Natick, MA) with EEG LAB open source toolbox (Delorme & Makeig 2004). Key presses were detected using a regular PC keyboard, which fed triggers to the ANT system via the PC serial port. Subsequently, EEG lab was used to band pass filter each participant's data between 0.5 and 45 Hz. The data was then epoched into 1-second segments consisting of the 256 time samples recorded immediately after each button press. The EEG selected for analysis in this way is indicated in figure 4.4 below. The data was then divided further into responses for each of the three conditions. Trials pertaining to the Clear Visual Difference and No Visual Difference were removed from further analysis. The following analysis was then conducted only on trials pertaining to the Threshold Difference condition. EEG lab was used to further divide the data into a 'Perceived' and 'Not Perceived' data set. The 'Perceived' data set contained trials from conditions in which a visual difference was detected. The 'Not Perceived' data set contained trials from conditions in which the visual difference was not detected. Data containing motion artifacts were then visually detected and removed from further analysis. This lead to data from channels O2, AF8, and CP4 for all participants being completely removed from the analysis.

The following procedure for calculating the strength of alpha-beta phase locking replicated that used in Nikulin and Brismar (2006) and was carried out on the 'Perceived' and 'Not Perceived' data sets separately. Using Matlab, the 1/f linear trend in the data was removed from the spectrum in order to more reliably visually estimate the peak alpha and beta frequencies. This was achieved by performing a logarithmic transform for both the frequency and power values using Welch's method of estimating power spectral density (Welch, 1967). A least squares line was fitted on the basis of the data in the 2-5Hz and 30-40 Hz frequency ranges. The linear trend was then removed in order to more easily visually detect both alpha and beta peaks in the spectrogram. A peak in the traditional 8-13 Hz

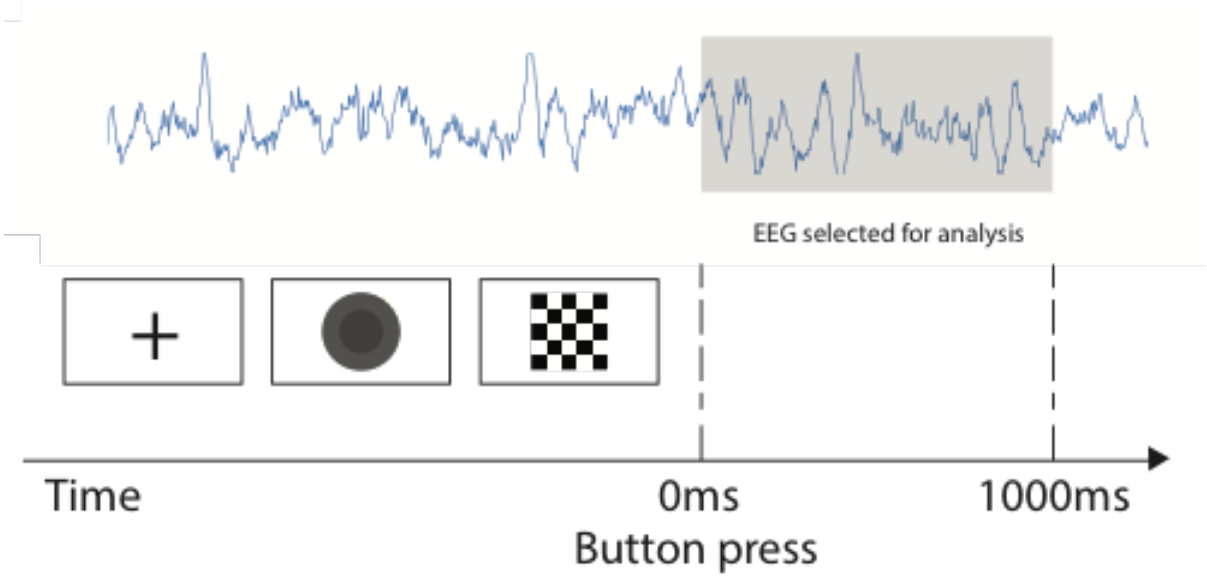



Figure 4-4. Selection of EEG data for analysis. Participants indicated with a button press immediately when they detected a visual different in the stimulus. Data selected for analysis was the 256 time samples or 1 second of data recorded immediately after the button press.

frequency range was then visually determined for each participant at each electrode. This value is referred to hereafter as 'peak alpha'. The epoched data was then filtered at the peak alpha value, +/-1.5 Hz and at 2 x peak alpha +/- 1.5 Hz, thus resulting in an 'alpha' and a 'beta' data set for both Perceived and Not Perceived conditions. The instantaneous phase value $\varphi$ for each of the 256 data points in each epoch for both alpha and beta data set was then extracted using the Hilbert transform method (Le Van Quyen, Foucher et al., 2001; Rosenblum, 2001).

Following Nikulin and Brismar (2006) the instantaneous phase at each time point in the alpha and beta data sets was then used to calculate the phase difference (relative phase) for each time point, between these two data sets:

$$\varphi_{\alpha-\beta}(t) = 2\varphi_{\alpha}(t) - \varphi_{\beta}(t) \qquad (1)$$

From these values, a cyclic relative phase value at each time sample across each epoch of data was calculated, determined as:

$$\varphi_{\alpha-\beta}(t) = \varphi_{\alpha-\beta}(t) mod 2\pi \qquad (2)$$

Where phase synchronisation between two separate oscillations does not exist, the cyclic relative phase taken at various time points will be random as there is by definition no relationship between the phases of each oscillation. If these values are plotted in a histogram, the distribution will be roughly uniform. Such a situation is indicated in figure 4.5a. However, where a level of phase synchronization *does* exist, samples of the cyclic relative phase will cluster around a particular value. This will be represented in a peaked distribution of cyclic relative phase values, with the peak representing the specific cyclic relative phase which these two oscillations tend towards (Rosenblum et al., 2001; Tass et al., 2003). Such a situation is indicated in figure 4.5b. The strength of synchrony value calculated in equation 3 below represents the extent to which such a distribution will be peaked, that is the extent to which the cyclic relative phase at each time sample tends towards a particular value. If the phases of the alpha and beta oscillation maintain a strict 1:2 phase synchronisation, all cyclic relative phase values drawn from over time will be identical. However, where phase synchrony occurs in a natural system such as the brain, the relative phase between oscillations will not be rigid or strictly uniform but will tend towards a certain value. It is in this case that a peaked distribution of cyclic relative phase will occur.

Drawing on the cyclic relative phase at each of the 256 time samples in any given epoch, the strength of alpha-beta phase synchronization is calculated for each epoch at each electrode, individually across all participants for both Perceived and Not Perceived data sets using equation 3. Here, alpha-beta phase locking is aggregated across each time sample in the epoch to create a single strength of synchrony value (s) for each epoch. This value varies between 0 and 1. Higher values represent stronger phase locking compared to lower values. Stronger phase locking (phase synchronization) for any given epoch refers to the extent to which the cyclic relative phase at each time point in the epoch tends towards to a single value. This would be represented for example in a sharper peak in the distributions of cyclic relative phase across the epoch.

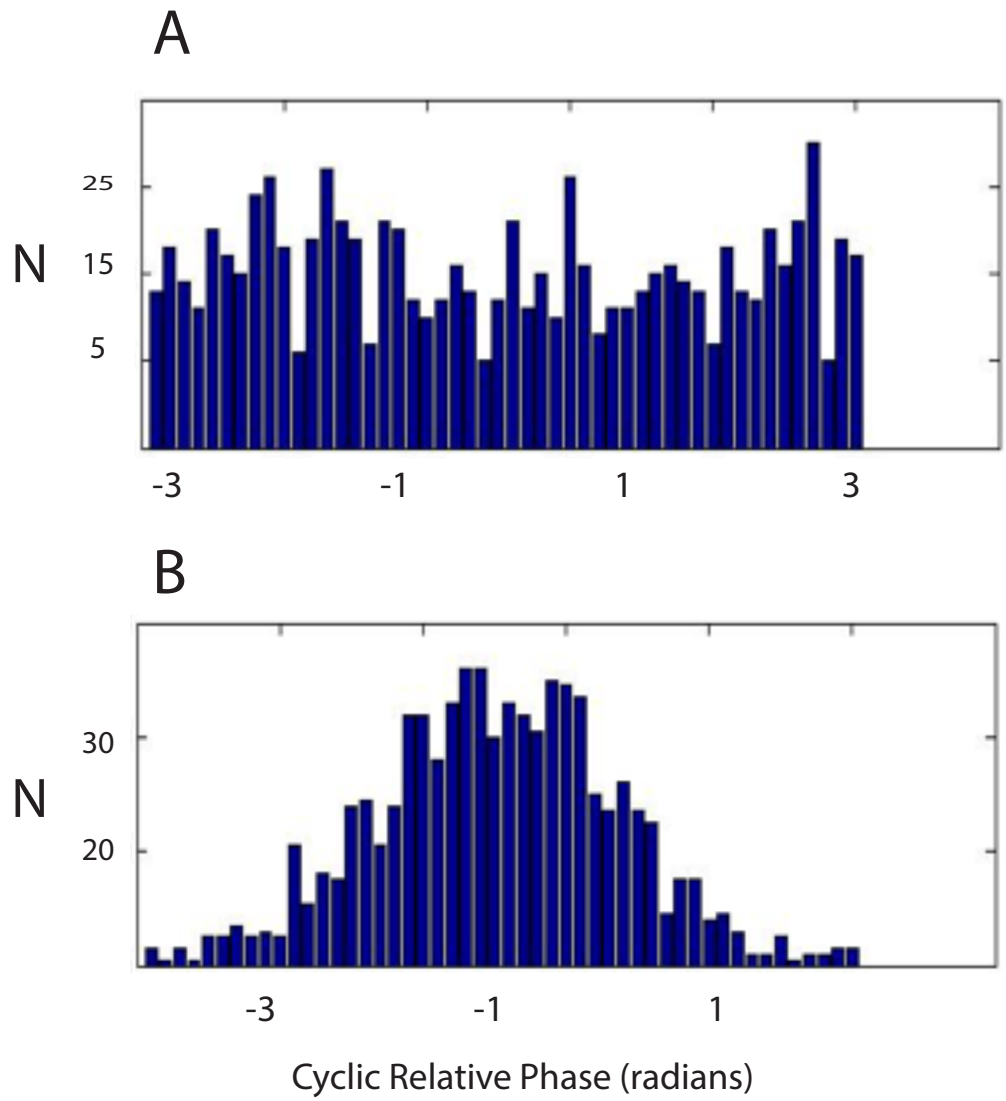



Figure 4-5 Simulated Histogram of Cyclic Relative Phase. A) Histogram of cyclic relative phase values is uniformly distributed indicating a random phase relationship, eg no phase synchrony between alpha and beta oscillations. B) Histogram of cyclic relative phase values is peaked indicating a level of phase synchrony. The peak around -1 radians indicated the presence of phase locking between alpha and beta oscillations.

The strength of phase synchronization at each epoch was calculated as:

$$s = \left| \frac{1}{N} \sum_{t-1}^{N} \exp\left(j\varphi_{\alpha-\beta}(t)\right) \right| \qquad (3)$$

Here, N refers to the number of samples in each 1 second epoch of data, which in this case was 256. The imaginary unit of the cyclic relative phase is used in this equation and is

represented here by j. The strength of alpha beta synchrony as determined in equation 3 was then averaged across trials, resulting in a single 'synchrony value' for each electrode of each participant, for both the Perceived and Not Perceived conditions. It is expected that the Perceived condition will exhibit more alpha-beta phase synchronization than the Not Perceived condition. This will be indicated by higher strength of synchrony 's' values. This is because, as predicted on the basis of the Liley Model (Liley, Cadusch & Dafilis 2003) and as discussed in Chapter three above, the Perceived condition was expected to correspond to the emergence of a non-linear alpha rhythm. This non-linear rhythm will produce harmonics in the higher frequency bands (and therefore more phase synchronization between the fundamental alpha frequency and its harmonics in beta and gama) while linear noise driven alpha will not.

The choice of a 1 second integration window for this calculation was made in accordance with the methods described in Nikulin and Brismar (2006). The phenomenon of alpha-beta phase synchronization in these experiments is understood as a property of the neurological activity associated with the continuous conscious perception of the stimulus. Therefore, it was expected that this would be a continuous phenomenon throughout the period in which the stimulus was consciously attended to. The choice of 1 second epochs represented a duration corresponding to that used in the analysis outlined in Nikulin and Brismar (2006) and which was behaviorally meaningful, corresponding roughly to the period of time over which participants were able to consciously perceive the target stimulus. Potential problems associated with this choice of a time window for the analysis are discussed in section 4.6 below.

The strength of alpha beta phase synchrony was then compared at a group level, between the Perceived and Not Perceived conditions using the statistical methods described below. Following on the methods of Nikulin and Brismar (2006) comparisons of the strength of alpha beta phase synchrony were also made across topographical locations on the scalp, again at a group level. For the analysis of differences in synchrony values across these regions, electrodes were selected and grouped in the following manner: pre-frontal (AF7, FP1, AF3, FP2, AF4, AF8), midline (F, FCz, CPz, Cz, Pz, POz), posterior (PO7, O1, Oz, O2, PO8), left

frontal (F1, F3, F5, FC1, FC3, FC5), right frontal (F2, F4, F6, FC2, FC4, FC6), left center (C1, C3, C5, CP1, CP3, CP5), right center (C2,C4,C6,Cp2,CP4,CP6), left parietal (P1, P3, P5, PO3, PO5, PO7), right parietal (P2,P4,P6, PO4, PO6, PO8). The selection of these particular electrodes for comparison across topographical locations was drawn from Kielar and Joanisse (2010).

### 4.2.4. Statistics

The following statistical analysis was performed at a group level. That is, data from all 10 participants were combined into the Perceived and Not Perceived data set divided further into topographical regions as described above. The comparative strength of alpha-beta phase synchronization across both Perceived versus Not Perceived conditions as well as across topographical locations for all participants was then statistically tested using a Friedman's test (Wayne, 1990) using 'Perceived/Not Perceived' and 'electrode position' as factors. The non-parametric Friedman's test was used over a parametric two-way ANOVA because the data did not meet the statistical assumptions required of the ANOVA (Lindman, 1974). As described in Lindman (1974), under certain conditions ANOVA may be robust to violations of the assumptions of normality. However, it is noted that in some cases, such as with smaller data sets, Kurtosis may still lead to smaller *F*-values, therefore increasing the difficulty of rejecting the null hypothesis (Lindman, 1974). In such a case, the ANOVA is not robust to the violation of normality. A Kolmogorov–Smirnov test of goodness of fit to a normal curve showed that the data gathered in experiment 1 did not satisfy the condition that variances from the mean be normally distributed, $D=0.8080$, $p<0.05$ (Perceived) $D= 0.8080$, $p<0.05$ (Not Perceived). An analysis of statistical residuals showed a kurtosis of 6.6799 (Perceived) and 6.8980 (Not Perceived) indicating that residuals were far from normally distributed. For this reason, the non-parametric Friedman's test was chosen over a two-way ANOVA. Separately to this, Perceived and Not Perceived rates across all participants was also calculated and compared using a repeated measure t-test.

## 4.3. Results

As discussed above, the analysis of the results was conducted only on data from the 'threshold condition' shown in figure 4.3, 1b. This was because it was this condition

in which differentiation between perceived and not perceived visual differences in the stimulus were driven by factors endogenous to the brain rather than external physical components in the stimulus. Data from the threshold condition was further divided into a 'Perceived' and 'Not Perceived' data sets based on participant responses. It was differences between these two data sets that were statistically compared in the following analysis.

A non-parametric Friedman's test showed significantly stronger Alpha-Beta phase synchrony in Perceived compared to Not Perceived conditions, $\chi^2(1) = 5.99$, $p = 0.01$, N=62. As a primary finding of this study, the strength of alpha-beta synchrony was shown to be greater in the Perceived compared to the Not Perceived condition (Mean Perceived=0.369 ± 0.61 sd, Mean Not Perceived=0.365, ± 0.060 sd). The Friedman Test was able to show a main effect of Perceived compared to Not Perceived conditions on alpha-beta phase synchrony, while adjusting for topographical differences. This adjustment was part of the statistical process of the Friedman test and was not a manipulation of raw EEG data. The Friedman test adjusts for differences between levels in a statistical test, but is not designed to be able to statistcally compare these differences across levels (e.g. topographical regions) within the overall main effect, as an ANOVA can (Daniel, 1990). For this reason, statistically significant comparisons of Perceived and Not Perceived conditions within specific topographical regions are not shown in the figures below. However, relative differences in mean strength of synchrony values across different topographical regions can be seen in figure 4.6, figure 4.7 and figure 4.8. The relative strengths of alpha-beta phase synchrony in Perceived compared to Not Perceived conditions, across topographical regions and averaged over all participants is shown in figure 4.6. These same data are shown at the individual participant level in figure 4.7. Figure 4.8 shows topographic plots of strength of synchrony values as calculated in equation 3, for both the Perceived and Not Perceived conditions, averaged across all participants. Overall, the results of the study were able to determine the presence of significant differences in alpha-beta phase synchrony for conditions in which a given stimulus was Perceived compared to those in which it was Not Perceived.

There was no significant difference in behavioural error rates between Perceived and Not Perceived conditions, across all participants, t(18)=0, p=1.0. This later result was to be

expected using stimuli at individual participants' perceptual threshold. That is, it was part of the design of this study that participants would fail to correctly identify roughly half of visual stimuli presented at individual participant's perceptual threshold.

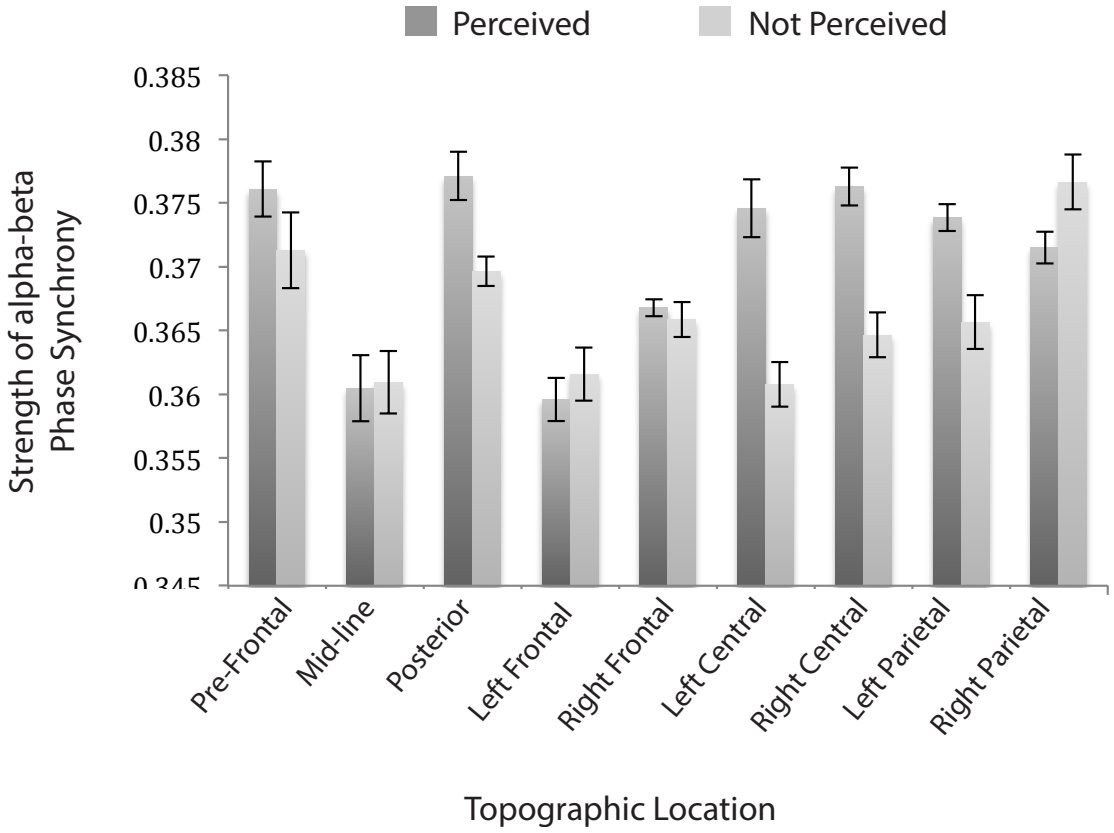



Figure 4-6. The relative strength of alpha-beta phase locking in both Perceived and Not Perceived conditions averaged within topographic locations and across all participants. Electrodes were selected and grouped in the following manner: pre-frontal (AF7, FP1, AF3, FP2, AF4, AF8), midline (F, FCz, CPz, Cz, Pz, POz), posterior (PO7, O1, Oz, O2, PO8), left frontal (F1, F3, F5, FC1, FC3, FC5), right frontal (F2, F4, F6, FC2, FC4, FC6), left center (C1, C3, C5, CP1, CP3, CP5), right center (C2,C4,C6,Cp2,CP4,CP6), left parietal (P1, P3, P5, PO3, PO5, PO7), right parietal (P2,P4,P6, PO4, PO6, PO8). Error bars show standard error. The selection of these particular electrodes for comparison across topographical locations was drawn from Kielar and Joanisse (2010).

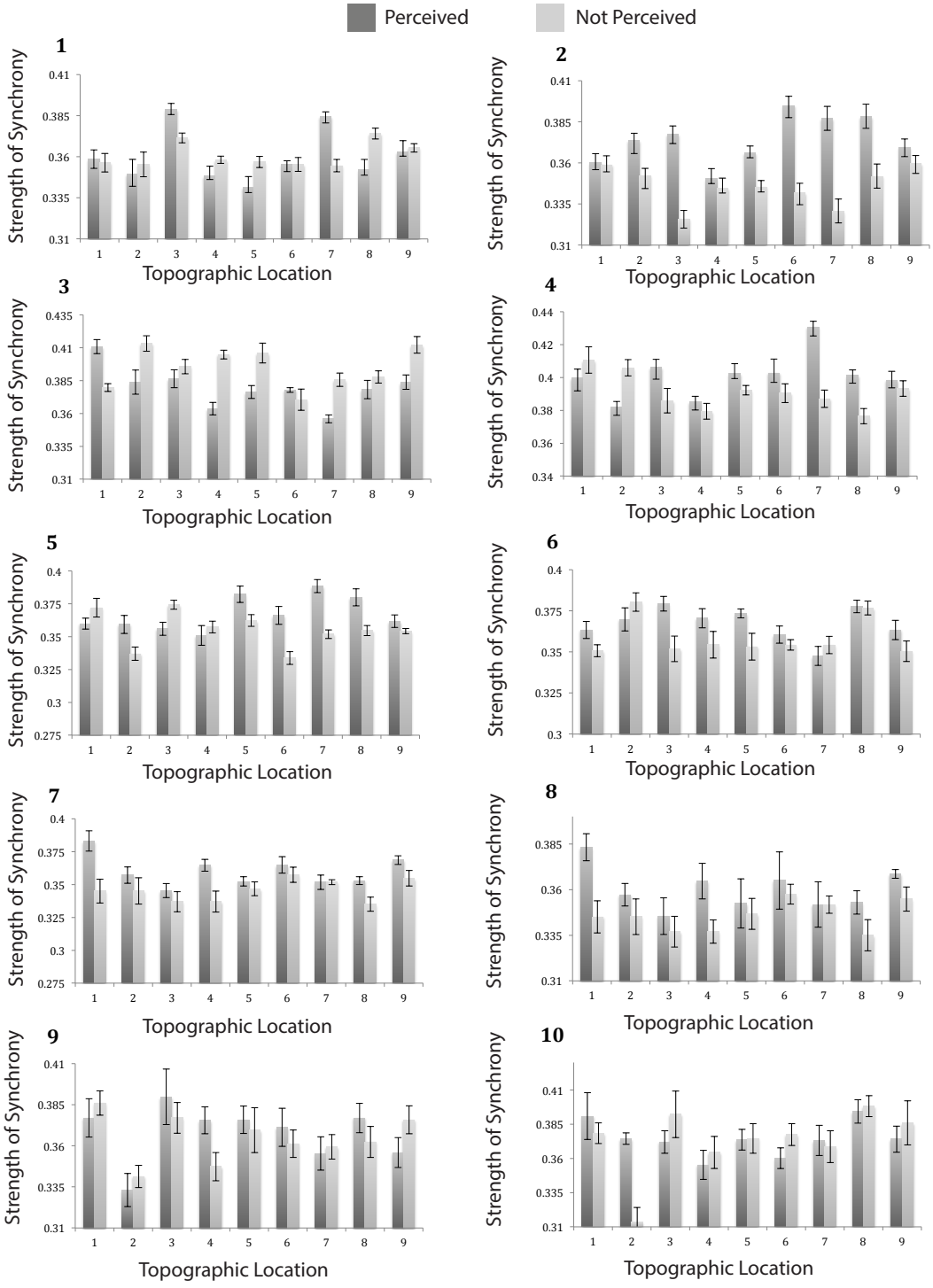



Figure 4-7. The relative strength of alpha-beta phase locking in both Perceived and Not Perceived conditions averaged within topographic locations for each participant individually. Data from each participant is numbered from 1 to 10. The nine topographic locations on the horizontal axis refer to 1) pre-frontal (AF7, FP1, AF3, FP2, AF4, AF8), 2) midline (F, FCz, CPz, Cz, Pz, POz), 3) posterior (PO7, O1, Oz, O2, PO8), 4) left frontal (F1, F3, F5, FC1, FC3, FC5), 5) right frontal (F2, F4, F6, FC2, FC4, FC6), 6) left center (C1, C3, C5, CP1, CP3, CP5), 7) right center (C2,C4,C6,Cp2,CP4,CP6), 8) left parietal (P1, P3, P5, PO3, PO5, PO7), 9) right parietal (P2,P4,P6, PO4, PO6, PO8). Error bars show standard error. The selection of these particular electrodes for comparison across topographic locations was drawn from Kielar and Joanisse (2010).

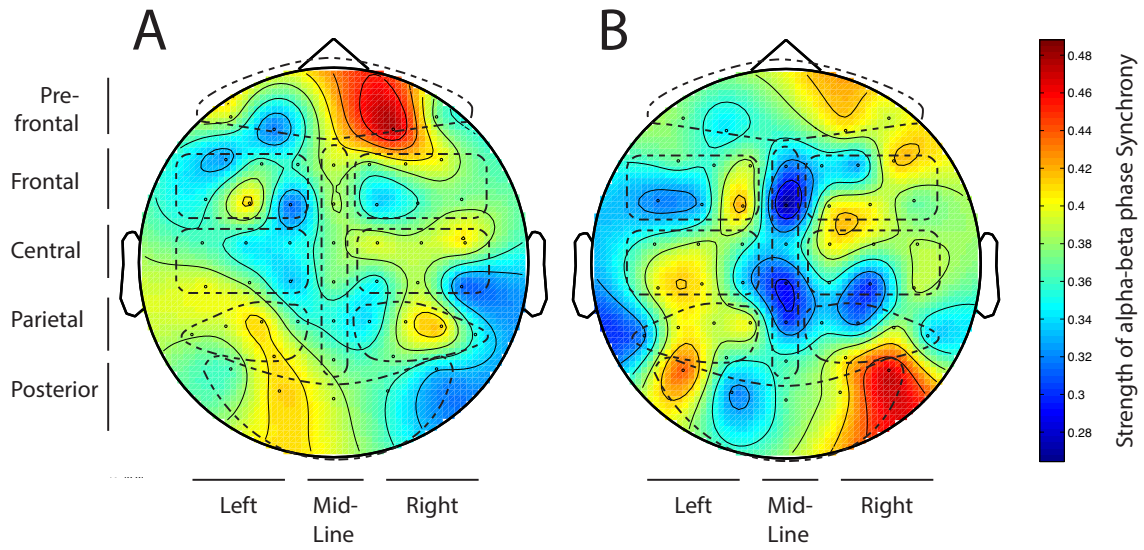



Figure 4-8. Topographic plots of strength of synchrony values for both the A) Perceived and B) Not Perceived conditions, averaged across all participants. Strength of synchrony is calculated as $s = \left|\frac{1}{N}\sum_{t-1}^{N} \exp\left(j\varphi_{\alpha-\beta}(t)\right)\right|$, as shown in equation (3) above. 'Warmer' or red areas indicate regions in which the strength of alpha-beta synchrony was relatively stronger. 'Cooler' or blue areas indicate regions in which the strength of alpha-beta synchrony was relatively weaker. Dotted lines show topographic regions into which electrodes were grouped for the purposes of statistical analysis. Electrodes included in these grouping Pre-frontal (AF7, FP1, AF3, FP2, AF4, AF8), midline (F, FCz, CPz, Cz, Pz, POz), posterior (PO7, O1, Oz, O2, PO8), left frontal (F1, F3, F5, FC1, FC3, FC5), right frontal (F2, F4, F6, FC2, FC4, FC6), left center (C1, C3, C5, CP1, CP3, CP5), right center (C2,C4,C6,Cp2,CP4,CP6), left parietal (P1, P3, P5, PO3, PO5, PO7), right parietal (P2,P4,P6, PO4, PO6, PO8). The selection of these particular electrodes for comparison across topographical locations was drawn from Kielar and Joanisse (2010).

# Experiment 2

## 4.4. Method

### 4.4.1. Subjects

Eleven healthy participants with normal or corrected to normal vision participated in this study (male/female: 5/6, age range 25-36 years). Participants in experiment 2 were newly selected and different from those who participated in experiment 1. All participants were provided with a written and verbal explanation of the tasks they would be performing and signed a written consent form prior to taking part. Of those who volunteered to take part in this study, participants were selected who showed an ability to visually fuse the autostereogram stimulus and perceive the 'hidden' image at will. This experiment received

ethics approval from the Swinburne University of Technology Human Research Ethics Committee (HREC) and was conducted in accordance with the HREC guidelines.

## 4.4.2. Stimuli and procedure

As with Experiment 1, Experiment 2 also sought to compare strength of alpha-beta phase synchrony in Perceived compared to Not Perceived conditions. The primary difference in experiment 2 is that an autosterogram image was used as an experimental stimulus. Autostereogram stimuli such as those shown in figure 4.10 are able to provoke vivid perceptual changes in participants without any change in the physical stimuli. While viewing an autostereogram, binocular disparity is able to spontaneously provide visual depth cues (Julesz & Spivack 1967; Tyler & Clarke 1990; Burgess, Rehman et al., 2003). When these visual cues are perceived, a 2-dimensional background noise pattern is able to resolve itself into a vivid but previously hidden three-dimensional percept. This perceptual transition takes place without any physical alteration in the stimulus. Changes in the EEG associated with these perceptual changes evoked by the autostereogram can therefore be attributed solely to alterations in perception and visual consciousness rather than any underlying physical difference in stimuli used across experimental conditions. For this reason, autostereograms have been particularly useful as an experimental stimulus in a range of studies investigating visual consciousness (Portas, Strange et al., 2000; Burgess, Rehman et al., 2003; Hsieh & Colas 2012).

Participants in experiment 2 were seated at a distance of 1 meter from a CRT monitor in a darkened electrically shielded room. The following experimental protocol was drawn from Burges and Rehman et al., (2003). Participants were presented with an autostereogram image (Fig. 4.10) and instructed to initially passively view the image without attempting to fuse the image into a clear perceptual impression. Participants were instructed then to indicate with a button press when they began attempting to fuse or perceive the 'hidden' image, then to indicate again with a button press when they had perceived the image. Participants were instructed to hold the image for 'several seconds', and to indicate again with a button press, when they had allowed the perceived image to resolve back into the background noise element of the autostereogram stimuli. Participant responses were not speeded, and

instruction simply indicated voluntary movement through the stages of searching for the image, holding the image 'for several seconds' and then releasing perception of the image. After this third button press indicating that the participant had ceased to perceive the hidden 3D image, the autostereogram image remained on screen for 3 seconds. After this 3 second period, the autostereogram stimulus disappeared from the screen and after a further 2 second inter-stimulus interval, was replaced by another autostereogram image. Again, following the methods described in Burges and Rehman et all., (2003) for 1 second preceding the button press, participants were assumed to be in a transitional state between their prior subjective state and the state indicated by their response. This led to six different states based on button press responses (Fig. 4.9): Resting state to Searching, Full Searching, Searching to Perceived, Full Perceived, Perceived to Rest, and the final full Resting state. Data for the following analysis was drawn solely from two of these states, the 'Full Perceived' and the 'Full Resting' state. These correspond to conditions in which the 3D image was either perceived or not perceived respectively. Each autostereogram comprised of a rectangular image filling 12 x 12 visual angle and created using SIRDS 2.2 software for Mac OS X (http://www.katsurashareware.com/pgs/sirds.html). On passive viewing, the image consisted of a colored noise pattern. The hidden image which was perceived when the autostereogram image was visually fused was one of the four single numerals (3, 5, 7, 9) in Times New Roman font, placed centrally on the screen, with a height of 9 degrees visual angle. The noise backgrounds in which the images were placed was one of four monochromatic colors (red, green, blue, and mauve). This procedure allowed for 64 trials, comprising of stimulus of one of the four different colors over four repetitions of each of the four numerals.

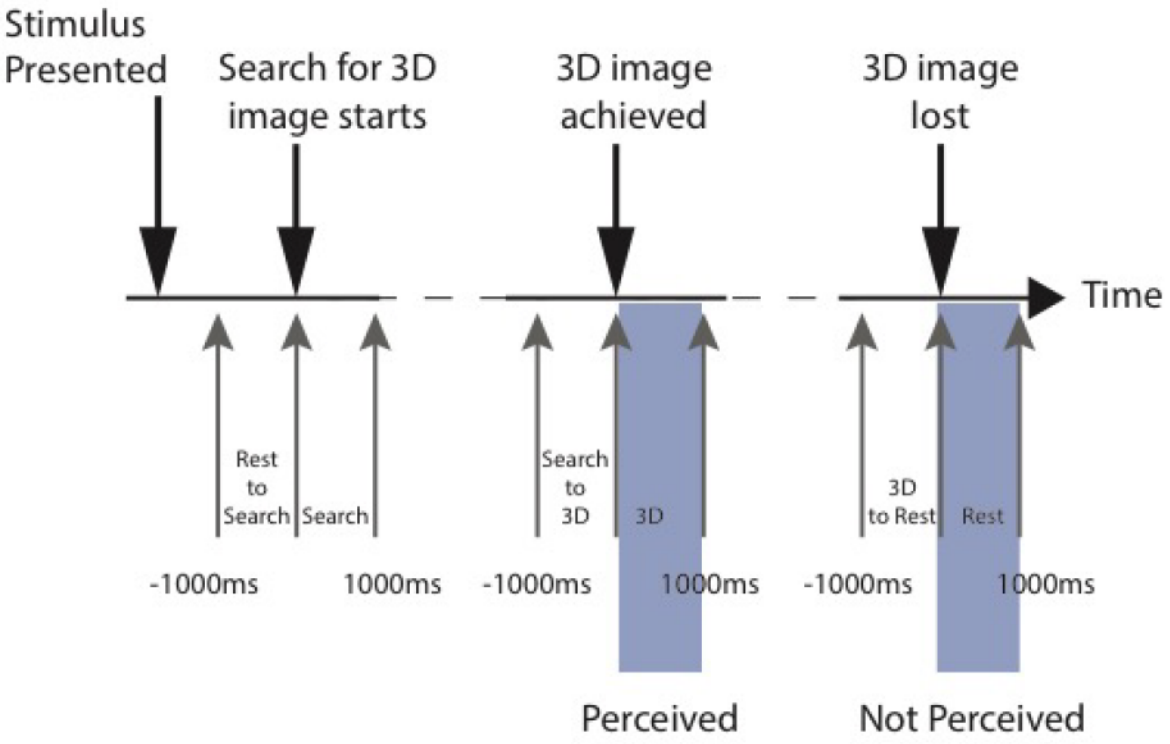



Figure 4-9 Time course of an individual trial. Grey boxes below the timeline show the time periods and corresponding perceptual states investigated in this study. Larger arrows above the timeline indicate when participants made motor responses. Smaller grey arrows below the timeline indicate the boundaries of perceptual states indicated in Burges and Rehman et al., (2003) (+/- 1000ms either side of motor responses).

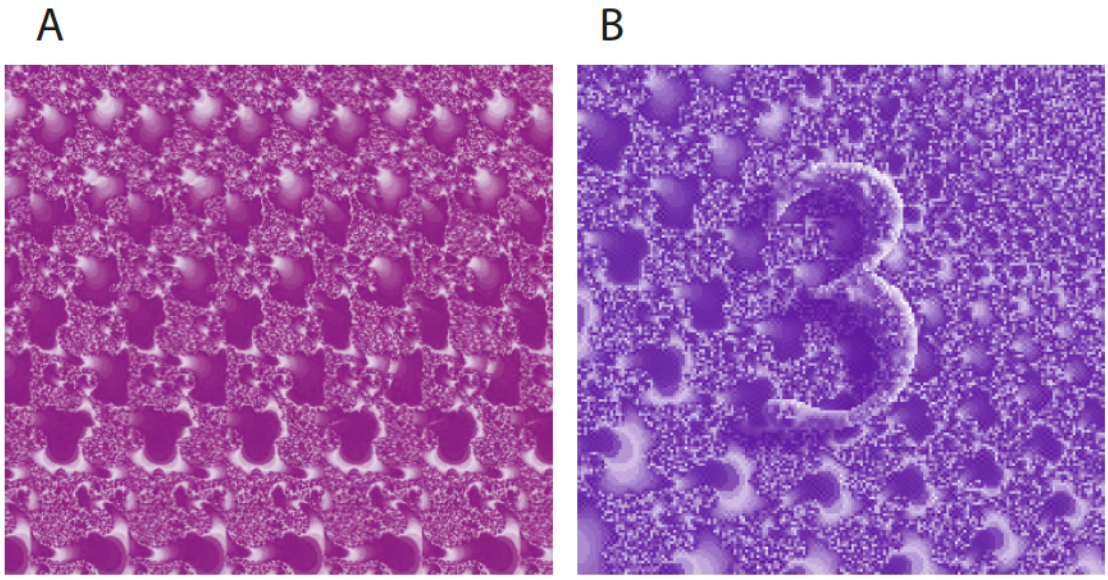



Figure 4-10. An example of the autostereogram stimuli. A) Actual autostereogram image. The stimulus appears to be a haphazard 'snowstorm' or noise pattern without any depth or 3D spatial structure. However, by diverging the eyes such that images originating in the two eyes come into correspondence the vivid stereoscopic illusion can be seen. In this case, the stimulus depicts the numeral '3'. B) Simulation of what participants perceive when the stereoscopic image resolves itself from the background noise pattern.

## 4.4.3. Data collection and analysis

EEG was recorded with a 64 channel ASA Lab ANT system using an extended 10-20 montage and a sampling rate of 256 Hz. This system used a common referencing system rather than a specific reference channel and used the AFz as the ground. Pre-processing and analysis was conducted using the Matlab package (MathWorks, Natick, MA) with open source Fieldtrip software (Oostenveld, Fries et al., 2011). Key presses were detected using a regular PC keyboard, which fed triggers to the ANT system via the PC serial port. Subsequently, EEG lab was used to band pass filter each participant's data between 0.5 and 45 Hz. EEG data was segmented into one second epochs beginning immediately from each button press indicating having fused or perceived the image, or alternatively, having released or ceased perceiving the 3D image as shown in figure 4-11. This lead to one second EEG epochs representing the two conditions, 'Perceived' and 'Not Perceived', that were being compared. An identical procedure to that described in 4.2.3 was then carried out to determine strength of alpha-beta synchrony in all Perceived and Not Perceived EEG epochs, across all participants and EEG channels. That is, the 1/f linear trend in the data was removed from the spectrum in order to easily visually estimate alpha and beta peaks at each channel. Data was filtered +/- 1.5 Hz around both alpha and beta peak frequencies, resulting in an alpha and beta data set, for both Perceived and Not Perceived conditions. Instantaneous phase for each of the 256 data points in each 1 second epoch of data was determined using the Hilbert transform method (Le Van Quyen, Foucher et al., 2001; Rosenblum 2001). Phase locking between alpha and beta data sets, for both Perceived and Not Perceived conditions were then calculated using equations (1), (2) and (3) described in section 4.2.3. This resulted in two new data sets showing strength of alpha-beta phase synchrony for each 1-second epoch of data, in both Perceived and Not-Perceived conditions. Data containing motion artifacts were then visually detected and removed from further analysis. 27 Epochs were removed from the data due to artefact and poor-quality recording. These included those in which eye-blinks were clearly visible after ICA or which contained clear motion artefacts. 16 Epochs across all participants including those from incorrect trials and epochs in which response time exceeded twice the participant's mean reaction time were also removed from further analysis.

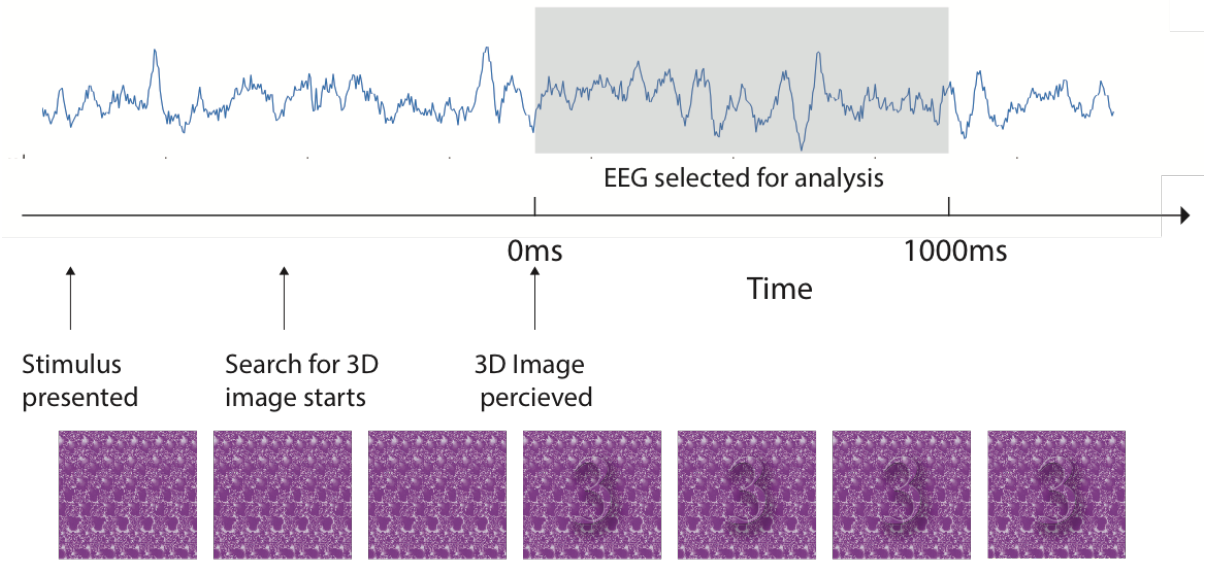



Figure 4-11. Selection of EEG data for analysis. Participants indicated with a button press immediately when they perceived the 3D stimulus. Data selected for analysis is indicated in the grey box and comprised of the 256 time samples or 1 second of data recorded immediately after the button press.

## 4.4.5. Statistical analysis

The differences in strength of alpha-beta phase synchronization in Perceived compared to Not Perceived conditions was then statistically tested using a cluster based permutation analysis (Bullmore 1996; Maris & Oostenveld, 2007) using Matlab (MathWorks, Natick, MA) with open source Fieldtrip software (Oostenveld, Fries et al., 2011). This non-parametric statistical test was able to utilize and provide more information than the Friedman's test used in experiment 1. The Friedman's test used in the previous study treated EEG channels within selected topographical regions homogenously and was not able to provide specific statistical comparisons of these different regions within the overall main Perceived/Not perceived condition effects. By comparison, the cluster based permutation analysis used in the present study was able to utilize information pertaining to spatial relationships between all EEG channels in its statistical analysis of differences between experimental conditions. The cluster based permutation analysis was also able to solve the multiple comparisons problem in a way that was sensitive to type II errors. The multiple comparison problem arises in that statistical comparisons of EEG and MEG data are typically

evaluated at many channel-time pairs. Due to the large number of statistical evaluations, standard statistical corrections for multiple comparisons can lead to a failure to reject the null hypothesis, when the null hypothesis is in fact incorrect. The cluster based permutation analysis implemented within Fieldtrip software is presented by Maris and Oostenveld (2007) as one method of controlling the family wise error rate without blunting the sensitivity of the statistical test.

## 4.5. Results

Significant differences were seen in the strength of alpha-beta phase synchronization in 'Perceived' compared to 'Not-Perceived' conditions when data for each channel was averaged across all participants. Comparing strength of alpha-beta phase synchronization over a latency of 1000 ms during both the perception and absence of perception of the 'hidden' stereoscopic image, a cluster based permutation analysis found three significant positive clusters ($p = 0.039$, $p=0.039$, $p=0.049$). These significant differences in the strength of alpha-beta synchrony were observed at right prefrontal and parieto-temporal regions along with left central regions over this time period (Fig 4.12).

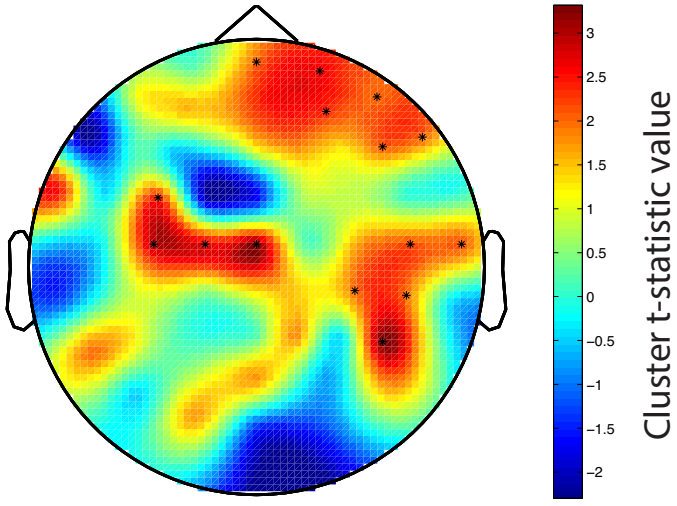



Figure 4-12. Topographic plot of cluster t-values from a statistical comparison of the strength of EEG alpha-beta synchrony in Perceived versus Not Perceived conditions averaged across all participants. Cluster t-values were determined by a cluster based permutation analysis and statistically significant clusters are highlighted by asterisks with an $\alpha$ level of 0.05. Significant differences in the strength of

alpha-beta synchrony in Perceived compared to Not Perceived conditions were observed at right prefrontal and parieto-temporal regions along with left central regions.

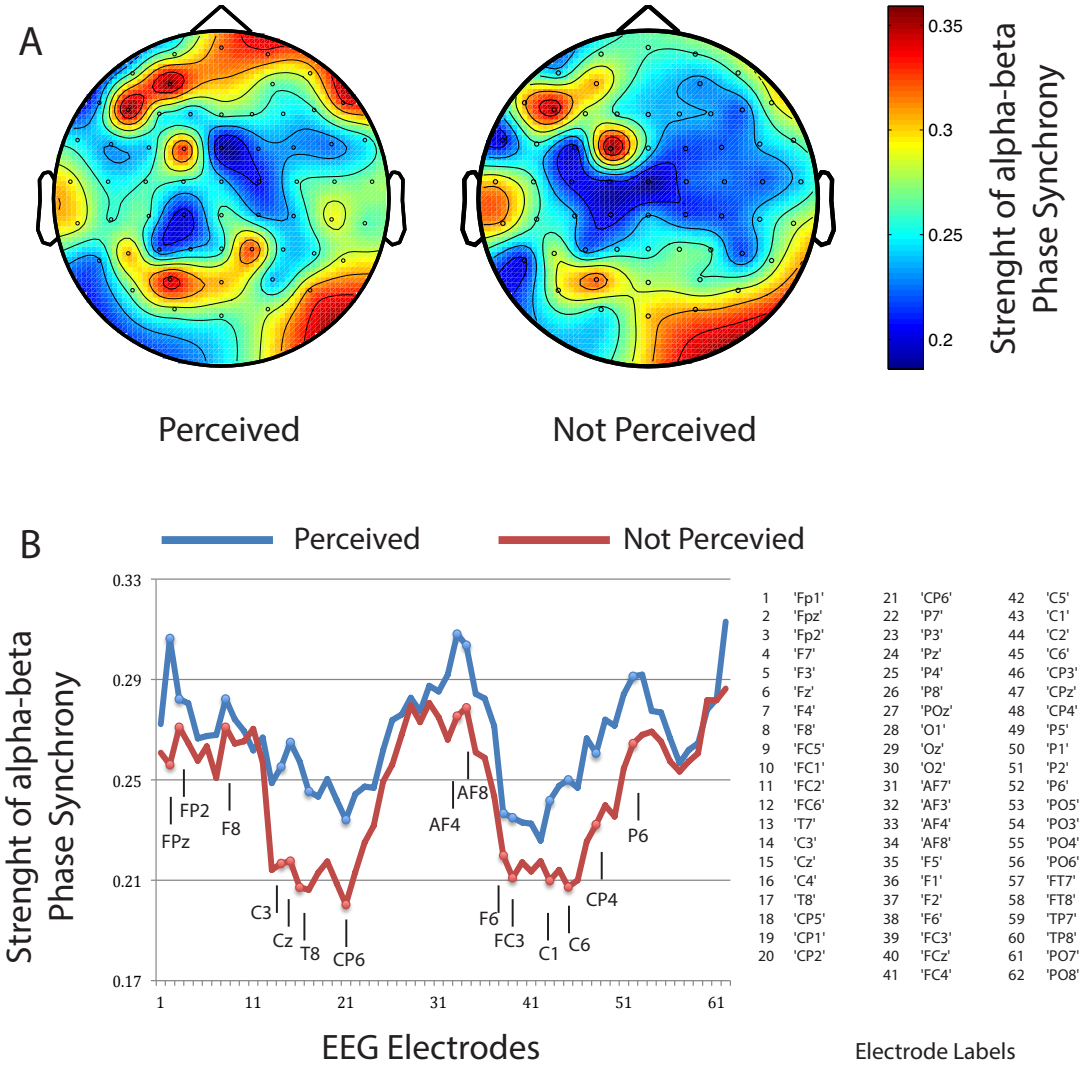



Figure 4-13. Strength of alpha-beta phase synchrony in the EEG recorded during Perceived and Not Perceived conditions. Strength of synchrony is calculated as $s = \left|\frac{1}{N}\sum_{t-1}^{N} \exp\left(j\varphi_{\alpha-\beta}(t)\right)\right|$, as shown in equation (3) in section 4.2.3 above. A) Topographic plots of strength of synchrony values for both the Perceived and Not Perceived conditions, averaged across all participants. B) Strength of EEG alpha-beta phase synchrony at each electrode in an ANT 64 electrode montage for both Perceived and Not Perceived conditions averaged across all participants. Mastoid electrodes (M1 & M2) have been removed and data is smoothed using a 5-point moving average. Electrodes from significant clusters have been highlighted.

## 4.6. Discussion

The experimental investigation of alpha-beta phase synchrony in the EEG undertaken in this chapter was envisaged as an initial step towards examining the broader theory outlined in Chapter Two. In Chapter Two, it was suggested that qualitative human experience be understood as a gestalt of consciousness and non-conscious processes. This was contrasted with the prevailing view that consciousness and non-conscious processes are separate by definition and have mutually distinct ontologies. In Chapter three the idea of circular causality described in the mathematics of nonlinear dynamical systems was employed to provide an outline for this type of reciprocally causal relationship between consciousness and non-conscious processes. Circular causality describes the way in which macroscopic patterns may emerge in a nonlinear system and then in turn constrain the individual low-level components of the system from which they arose, in a circularly causal manner. In this way, circular causality as a concept is capable of linking different ontological levels of description. Such levels of description may for example be those of synaptic dynamics and cortical EEG patterns or correspondingly, those of non-conscious processes and consciousness. Circular causality described in the mathematics of nonlinear dynamics provides a mathematical analogy for the type of reciprocally causal gestalt of consciousness and non-conscious processes described in Chapter Two. A prerequisite for using circular causality in this way was to determine the presence of non-linearity in the EEG. In the two experiments contained in this chapter, alpha-beta phase synchrony was treated as a possible indicator of the presence of non-linearity in the EEG associated with conscious perception. Therefore, the two studies in this chapter represent only an initial step in the exploration of this broader theoretical position. As an initial step in exploring the application of non-linear dynamics and circular causality to this broader theoretical orientation, the strength of alpha-beta phase synchrony in EEG was examined as a possible proxy for non-linearity.

Identifying non-linear alpha wave activity in the EEG represented a necessary but not sufficient proviso for the theoretical position described above. The work of Liley and Bojak et al., (2010) was used to provide a mathematical description of the emergence of a non-linear alpha rhythm, time locked to the emergence of a perceptual event. Non-linear alpha activity is predicted to produce harmonics in the beta range while linear noise driven alpha activity is

not. The emergence of such harmonic activity is predicted to give rise to an increase in alpha-beta phase synchrony. Therefore alpha-beta synchrony in the EEG has been taken as an initial proxy for the presence of non-linearity. As an initial step in this theoretical and experimental approach, EEG time locked to the emergence of a perceptual event was examined for an increase in the power of 1:2 alpha-beta phase synchrony, compared to EEG recorded in the absence of such a perceptual event. Further exploration of the use of non-linear dynamical systems theory including circular causality was predicated on a positive finding in this regard.

The results from both experiments provide tentative support for the initial experimental question regarding whether alpha-beta phase synchrony in the EEG could serve as a marker of higher order perceptual events. There was a significant difference in the strength of alpha-beta phase synchrony in the Perceived compared to Not Perceived conditions across both experiments. Experiment 1 used a two-disk stimulus where the visual tonal difference between disks was presented at the participant's perceptual threshold. A data set of EEG epochs time locked to the successful detection of this subtle difference between visual tones of the stimulus was compared to a data set of EEG epochs for which the visual difference in the stimulus was not detected. This was presumed to offer a comparison of EEG recorded in the presence versus absence of the perceptual event evoked by the two-disk stimulus. This comparison showed significantly higher levels of alpha-beta phase synchrony in Perceived compared to Not Perceived conditions. In experiment 2, an autostereogram stimulus was used to evoke conditions in which participants were either able, or unable to perceive the underlying 'hidden' image. Similar to the results in experiment 1, alpha-beta phase synchrony in EEG time-locked to the perception of the hidden image was significantly greater than alpha-beta synchrony in EEG time-locked to the absence of this autostereogram induced percept. The results of both experiments indicate that a synchrony in the alpha and beta oscillatory activity in the EEG may be associated with processes involved in conscious visual perception.

However, both experiments had some methodological weaknesses and this should be born in mind when assessing the strength of the results. The difference in strength of alpha-beta synchrony between perceived and not perceived conditions in both experiments, whilst

statistically significant, is minor. Given that the sample size is also relatively small (experiment 1, N=10, experiment 2, N=11) the statistical analysis may be judged to be underpowered. A larger sample size in both experiment 1 and 2 would provide a more convincing and reliable analysis in the case of either a rejection or acceptance of the null hypothesis, as the case may be.

The choice of a 1 second duration over which the strength of synchrony was calculated was somewhat arbitrary and may have impacted negatively on the results. As discussed above, the choice of a 1 second integration window in which to calculate strength of synchrony between alpha and beta oscillations was based on the methods described in Nikulin & Brismar (2006). However, Nikulin & Brismar (2006) examined resting state data, while the data here is recorded in an event related task. The assumption here was that the alpha-beta synchrony was expected to be a continuous phenomenon associated with the continuous conscious perception of the stimulus. However, this was an untested assumption. If the non-linear alpha rhythm is thought to be a predicate state for the emergence of a conscious perception, then in fact phase synchrony would be expected to be associated with the emergence of the percept, rather than a continuous process throughout the maintenance of the percept in visual working memory. In this case, briefer time periods closer to the onset of the stimulus should have been used for the analysis.

Nevertheless, the mechanisms underlying the phase synchrony here were not those understood to arise from the process of event related desynchronization. This process typically does not persist over a 1000 ms duration (Benedek, Bergner, Koenen, Fink, & Neubauer, 2011). Had the alpha-beta synchronization examined here been understood to arise from the sort of event related desynchronization described in Benedek et al., (2011), then the choice of 1 second epochs in the analysis presented here would have been inappropriately long. As discussed above though, this was not the case. Nevertheless, the choice to perform phase synchrony analysis on 1 second epochs was somewhat arbitrary and should have been tested, for example, in comparing this analysis with a similar analysis over a range of briefer time periods in closer proximity to the stimulus onset.

Methodological problems also arise in the issue of whether or not the autostereogram stimulus used in experiment 2 in fact discriminates between conscious and non-conscious conditions. That is, given that the percept induced by the stimulus is one of either a visual noise pattern or a 3D image, the stimulus may be judged to provide a contrast in the content of consciousness, but not a contrast between consciousness and genuinely non-conscious processes. Moreover, the different perceptual states induced by the autostereogram may arise from a change in the vergence of the eyes rather than from the underling difference in neuronal processes. In this case, the percept of the 3D image may arise simply through a change in the ocular system, and be judged to reveal little about the neural processes relating to consciousness. Similarly, the ocular motor processes for both conditions are likely to be different and this has been poorly controlled for. It is likely that when the 3D percept arises, the participant engages in saccadic exploratory eye movements. By contrast, the percept of the visual noise pattern may only induce more passive visual processes and this could confound the analysis of difference between conditions.

Whilst at face value, these issues may undermine the strength and logic of these experiments, on further consideration these problems may be more superficial than they first appear. Whilst it is true that the difference in perception between conditions in experiment 2 is not one of a difference between consciousness and genuinely non-conscious processes, this is the case in the vast majority of neuroscientific studies of consciousness. Indeed, most such studies into consciousness openly acknowledge that the phenomenon studied is the content of consciousness, not the wholesale presence or absence or conscious awareness (Aru & Bachmann, 2015; Stanislas Dehaene & Changeux, 2011; Del Cul, Baillet, & Dehaene, 2007). For example, experiments using stimuli that induce binocular rivalry, a common protocol in consciousness studies, specifically examine shifts in consciousness between awareness of, for example, a face or a house (Lumer, Friston, & Rees, 1998). The difference between conditions in these studies is not between consciousness and its complete absence, but between differences in the content of consciousness. The participant may be aware of a face, and not conscious of perceiving a house or vica versa. Similarly, most visual masking studies make inference about the conscious and non-conscious processes underlying visible and masked stimuli respectively (Dehaene et al., 2001). Yet participants in these studies remain conscious

throughout the experiment and are only subject to changes in the content of their visual processes. In these cases, peer review judges it reasonable to infer that the data represents the conditions of the presence versus absence of consciousness. Moreover, the purpose of experiment 1 and 2 was only to judge whether alpha-beta synchrony can be used as a marker of consciousness or higher order perception. Experiments that were planned to subsequently take place were then intended to examine the way in which such synchrony could relate to an interaction between microscopic non-conscious processes and macroscopic patterns in the EEG which were suggested to correlate with consciousness. However, these later experiments were not conducted and the reason for this is discussed below.

The criticism of each condition inducing and relying on different ocular motor processes may also not be as damning as first suspected. It is likely that vergence difference do contribute to the emergence of the 3D percept (Julesz & Spivack 1967). This may interfere with the purity of the data and the strength of deductions regarding brain activity. However, EOG artifacts were removed from the data. Motion artifacts due to eye movements are not uncommon in vision studies, and removing these from the data is a typical stage in any EEG or MEG analysis. Regardless of whether the vergence in the eyes helps to produce the awareness of the 3D percept, nevertheless vivid changes in perception do occur in ways that are not due to physical changes in the stimulus and these must correlate with difference in neural activity. Furthermore, the autostereogram stimulus has been previously used in studies that contrast consciousness with non-conscious processes (Burgess, Rehman, & Williams, 2003) and peer review has not judged ocular motion differences across conditions to cloud the conclusions of such studies.

The results in experiment 1 and 2 not only provide some initial support for the broader theoretical considerations described above, but are also novel findings in themselves. The association of alpha-beta phase synchrony in experiment 1 and 2, with processes underlying visual perception complements and extends previous findings regarding the functional role of neural synchronization (Varela, Lachaux et al., 2001; Palva, Palva et al., 2005, Canolty & Knight 2010; Siebenhuhner, Wang et al., 2016). Cross frequency phase synchronization between alpha and beta activity has been previously associated with visual

working memory, perception and consciousness (Palva & Palva 2005; 2007). Extending beyond this, the results in experiment 1 and 2 in this chapter demonstrate a role for alpha-beta phase synchrony in visual perception, and more broadly provide additional evidence to that of Palva and Palva (2005) for a role of alpha activity in neural processes underlying consciousness. Previous findings also have suggested that cross frequency phase synchronization of this sort may provide a level of integration between neural activity operating at slower behavioural timescales and the faster activity underlying synaptic modification and computation (Canolty & Knight 2010; Palva & Palva 2011). This cross-frequency phase coupling between faster and slower timescale brain activity along with the mathematical ideas of circular causality (Haken, 2006) are thus well suited as concepts to provide a common level of description for both behavioural and synaptic levels of activity. This is suggested in the context of experiment 1 and 2 as a possible means of providing a shared ontological level of description between conscious and non-conscious processes. Such an approach relies on equating non-conscious processes with activity at the level of synaptic computation and conscious perception with the macroscopic activity at the level of the EEG. Currently, such an approach remains speculative, and can only be evaluated on the basis of future research.

## 4.7. Conclusion

Both experiments 1 & 2 complimented and built on a previous literature regarding the functional role of cross phase synchrony in the EGG. Whilst these results were tentative and were partially undermined by methodological problems as discussed above, they nevertheless were able to link alpha-beta synchrony in the EEG with processes underlying visual perception and suggest that alpha-beta phase synchrony may play a role in processes underlying consciousness. These results provide a positive initial contribution to the broader theoretical orientation outlined in Chapter One and Two. This was on two accounts. Firstly, the detection of alpha-beta phase synchrony associated with perception provides support for treating the neural activity underlying the EEG as a non-linear system. Subsequent more robust tests of non-linearity, for example using surrogate data testing (Schreiber & Schmitz, 1997; Stam, 2005), could provide a stronger basis for this approach. Positive findings in this regard could then justify exploration of the EEG for a circular causality between microscopic

(synaptic) and macroscopic (scalp EEG) levels of activity. In Chapter three, circular causality was presented as a mathematical analogy to a model of qualitative experience arising as a unified gestalt of conscious and non-conscious processes. In regard to the experiments presented in the current chapter, the positive finding of alpha-beta synchrony associated with visual perception represents an initial step in this broader research project because it supports a view of cortical EEG as a non-linear system. Secondly, the phase synchrony demonstrated in experiment 1 and 2 may represent an ideal mechanism within which to examine this use of circular causality. Phase synchrony between faster and slower frequency band oscillations has been suggested to represent an integration between neural activity operating at slower behavioural timescales and the faster activity underlying synaptic modification and computation (Canolty & Knight 2010; Palva & Palva 2011). Thus, the cross frequency phase synchronization demonstrated in the results of experiment 1 and 2 already represents a mechanism that could provide an integrated and circularly causal understanding of both macro and micro levels of description. This approach would rely on the equating of non-conscious processes with activity at the level of synaptic computation and conscious perception with macroscopic activity at level of the EEG.

The failure to include further investigation in this thesis into circular causality between higher and lower order components of the EEG represents a failure of experimental planning. Preliminary analysis on early data while conducting experiment 1 and 2 appeared to fail to reject the null hypothesis. Timely completion of the thesis required concomitant design of subsequent experiments while experiment 1 and 2 were being conducted. Because the results of these early experiments did not look promising, it was decided that experiment 3 and 4 would be based around previously established masking paradigms instead of continuing an analysis on circular causality and alpha-beta synchrony. While the results in experiment 1 and 2 were not strong, the eventual positive finding of alpha-beta phase synchrony associated with visual perception did come to justify further experimentation, although this proved to be beyond what was able to be included in this thesis.

# Chapter 5

## Experiment 3. Examining the interaction of simultaneously occurring subliminal and supraliminal neural processes on Reaction Time and Error Rate.

## 5.1. Introduction

As with the experiments discussed in the previous chapter, experiment 3 in this current chapter continues to explore the model of qualitative experience discussed in Chapter Two, that is, as a gestalt of conscious and non-conscious processes. However, experiment 3 in this chapter explores the relationship between conscious and non-conscious processes by experimentally manipulating the timeframe within which stimuli are presented. That is, the experimental manipulation in this study primarily concerns the temporality of consciousness. Through manipulating the time frame in which stimuli are presented, this study seeks to examine the theoretical assumptions of previous masked priming studies that appear to rely on a spatiotemporal and categorical distinction between the neural pmechanisms underlying conscious and non-conscious processes (Kiefer & Brendel, 2006; Ortells, Frings, & Plaza-Ayllón, 2006; 2012; Van den Bussche & Reynvoet, 2007). Typically, such previous experimental paradigms treat qualitative human experience as a 'consciousness' that is categorically distinct from non-conscious processes. By way of contrast, this study explores the temporality of consciousness in order to examine a hypothesis in which qualitative experience arises as a gestalt of foreground supraliminal phenomenal content and background subliminal phenomenal content.

The following experiment examines whether reaction times (RT) and error rates (ER) in response to a consciously perceived target word can be impacted by *simultaneously occurring* neural processing of an invisible masked prime word. The prime-target word pairs are presented in either semantically congruent or incongruent pairings. The experimental protocol contains a range of stimuli onset a-synchrony (SOA) durations between the masked prime word and the visible target word. However, the condition of primary experimental

interest is one in which the invisible masked prime word is presented between 50 ms and 100 ms after the presentation of the visible target word (Fig. 5.2. Ciii & Civ). In such a case, the neural processing of the invisible masked prime and the visible target stimulus are predicted to occur simultaneously, that is, are temporally superimposed. This differs from traditional masked priming protocols discussed below, in which the prime is presented prior to the target, and for which neural processing of the prime is typically resolved just prior to the neural processing of the visible target. The current study examines the interaction between the *simultaneously occurring* neural processing of liminal and subliminal stimuli. This interaction is indexed through RT and ER benefits for semantically congruent compared to incongruent prime-target word pairs. Where RT and ER benefits do occur, this positive finding would undermine a temporal and spatial distinction between consciousness and non-conscious processes. That is, an RT benefit in the neural processing of conditions where the prime and target words occur simultaneously would provide an additional level of support for the hypothesis of qualitative experience arising as a gestalt of conscious and non-conscious processes.

While this experiment presents a novel stimuli time course, with the masked prime word being presented *after* the visible target word, in many other regards the design of this experiment conforms to that of other studies in the literature. Lowered reaction times and error rates in response to visible target stimulus presented after a related invisible prime stimulus is a well validated effect (Forster, Mohan, & Hector, 2003; Ortells, Daza, & Fox, 2003; Ortells, Frings, & Plaza-Ayllón, 2012; 2006; Van den Bussche, & Reynvoet, 2007). This priming effect has been shown to take place up to and including a semantic level of subliminal processing (Kiefer & Brendel, 2006). For example, where the masked and invisible word 'cat' is presented immediately prior to the target word 'dog', a semantically congruent relationship exists. In such cases lower reaction times and error rates are observed compared to an incongruent prime-target word pairing such as 'cat'-'boat'. For example, comparing semantically congruent with incongruent prime-target pairs, in both masked and non-masked conditions, Kiefer (2002) demonstrated a semantic priming effect in masked ($F(1,23) = 71.441$, $MSe = 531.3$, $P$ , 0.0001) and un-masked ($F(1,23) = 12.958$, $MSe = 292.0$, $P$ , 0.01) conditions. Reaction times to semantically congruent word pairs were faster than to incongruent pairs

(Fig. 5.1). In such cases, the subliminal processing of the prime word occurs prior to the processing of the visible target word. RT benefits and ER effects are understood to reflect this pre-activation of the neural semantic representation by the masked prime allowing faster subsequent processing of a semantically related visible target stimulus.

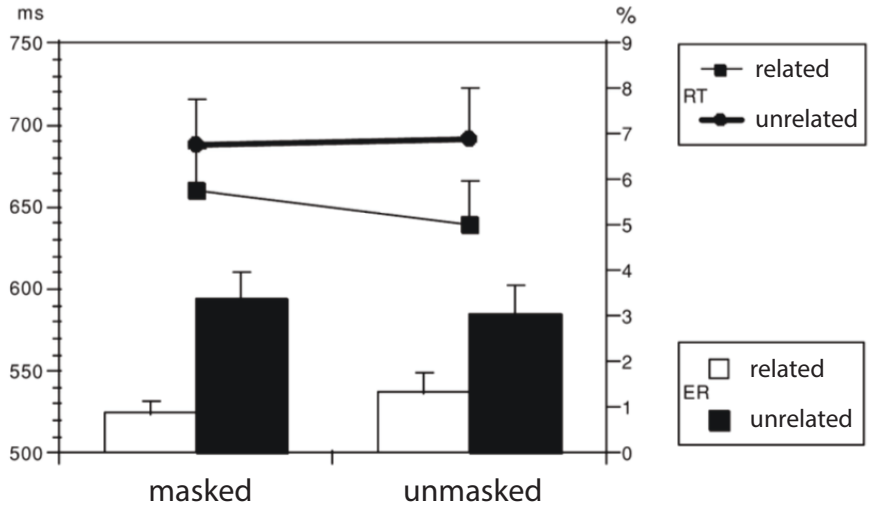



Figure 5-1. Reaction times (lines, left y-axes) and error rates (bars, right y-axes) as a function of semantic relatedness and masking in Kiefer (2002). The vertical lines depict the standard error of means of each condition. Figure adapted from Kiefer (2002).

These traditional masked priming studies implicitly treat the neural representation of conscious and non-conscious processes as temporally and spatially distinct. That is, the processing of the non-conscious stimulus is understood to take place 'early' in the processing pipeline and feed forward in time to impact on the 'later' occurring processing of the visible stimulus. A late temporal window of neural activity (>250ms after a given stimuli) has previously been associated with conscious perception. The Global Neuronal Work Space model (GNWS) (Dehaene & Changeux 2011) correlates consciousness of a stimulus with a profile of a late globally distributed event related potential (ERP) beginning around 250 ms which are associated with an all or nothing ignition of prefrontal-parietal networks along with an amplification of related sensory cortices. This is represented in figure 5.2. Aii. Here an ERP profile for the visible stimulus is depicted. The P300 peak shown is correlated with conscious perception of a given stimulus while the earlier P200 peak correlates with unconscious processing of the same stimulus Dehaene & Changeux, 2011). 'Early' ERP peaks occurring at and prior to 200 ms and limited to contralateral occipital and temporal pathways have been

shown to correlate with subliminal processing of a visual stimulus (Del Cul, Bailey, & Dehaene,2007).

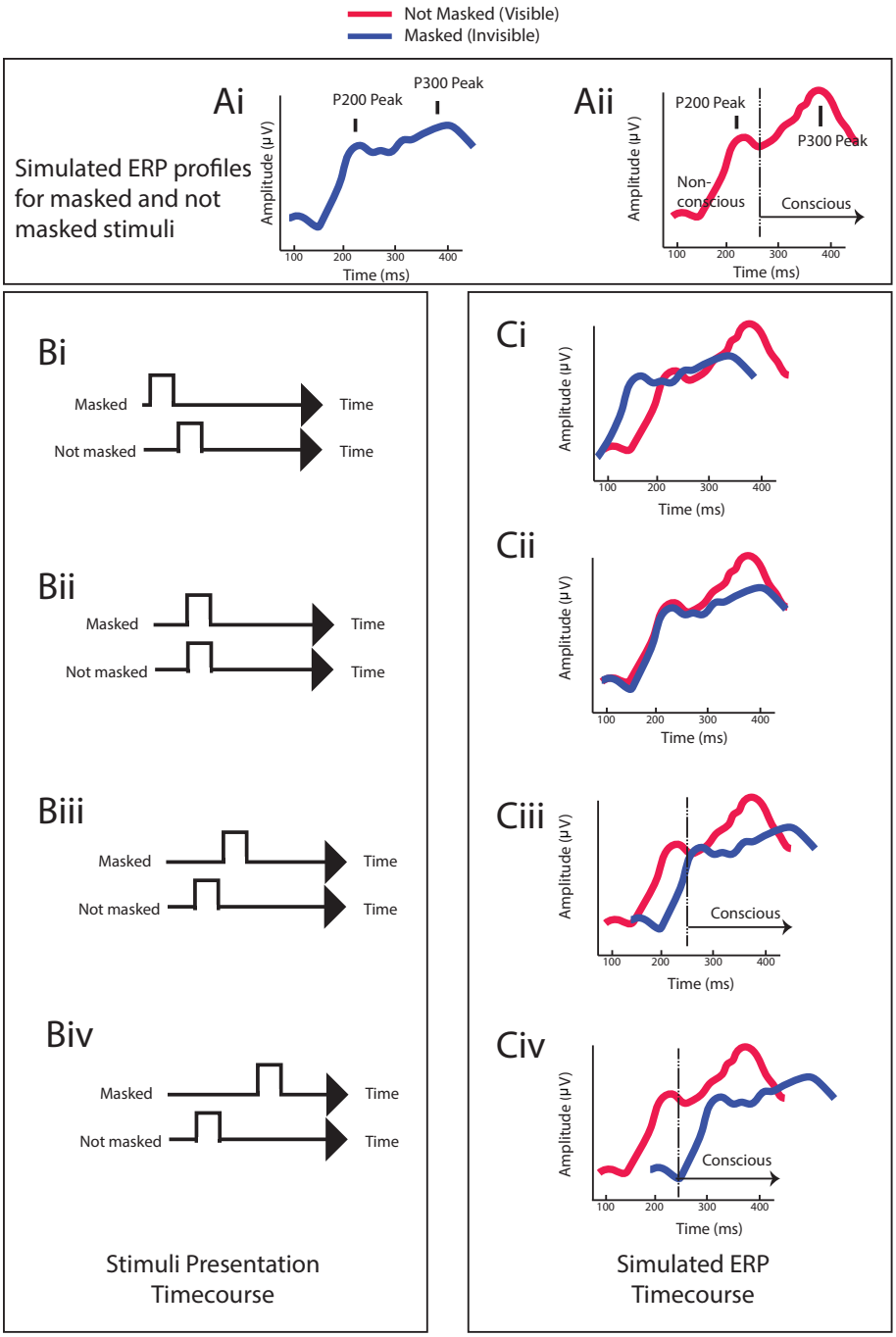



Figure 5-2. Time-course for stimuli presentation and simulated event related potential (ERP) peaks for unmasked (visible) compared to masked (invisible) stimuli. Ai) Simulated ERP profile for masked (invisible) stimulus. The p300 peak is muted and fails to ignite to higher amplitude. Aii) Simulated ERP profile for unmasked (visible) stimulus. The p300 peak ignites and is clearly detectable. B) Stimulus presentation timecourse showing presentation time for masked prime stimulus in relation to unmasked visible target stimulus. Bi) Masked prime presented prior to visible target stimulus. Bii) Masked prime presented simultaneous to visible target stimulus. Biii) Masked prime presented 50 ms after target stimulus. Biv) Masked prime presented 100 ms after target stimulus. C) Simulated ERP profile for

masked (invisible) and unmasked (visible) stimuli. Ci) Masked prime presented prior to visible target stimulus. Prime P200 ERP peaks take place prior to and leads into Target P300 ERP peaks. Cii) Masked prime presented simultaneous to visible target stimulus. Here Prime ERP peaks take place simultaneous to Target ERP peaks. **Ciii) Condition of primary experimental interest. -50ms SOA condition:** Masked prime presented 50 ms after target stimulus. In this case the masked Prime P200 peaks (blue) are occurring just as the target P300 ERP peak (red) begins to take place. Biv) **Condition of primary experimental interest. -100ms SOA condition:** Masked prime presented 100 ms after target stimulus. In this case the masked Prime P200 ERP peaks (blue) are taking place well within the duration of the target P300 ERP peak (red).

In the case of an adequately masked (invisible) stimulus, this neural processing resolves quickly, within 250 ms. This early and short-lived activation fails to ignite to the globally distributed patterns of activity that correlate with consciousness and occur from 250 ms onwards after stimulus presentation. This is represented in figure 5.2.Ai. This figure represents the ERP profile for a masked (invisible) stimulus. The early P200 peak remains similar to that of an unmasked stimulus, see 5.2.Aii. However the later P300 peak fails to ignite to a higher amplitude level or globally distributed patter across the cortex. In the case of a masked stimulus, a participant will not consciously perceive the stimulus. Nevertheless, if a semantically related visible target word is presented immediately after a masked prime, the processing of the target word is able to develop on the basis of the short lived but pre-existing activation of the prime, leading to faster reaction times in response to the target. The model of Dehaene and Changeux (2011) thus can be observed to represent a dichotomy in which non-conscious and conscious processes are temporally separate. Subliminal processing is understood to occur early in the processing pipeline (<250 ms) while neural processing correlating with consciousness of a given stimulus is understood to occur later, from 250 ms after stimulus presentation.

What differentiates experiment 3 in this chapter from previous masked priming studies in the field, is that the stimulus is designed such that the neural processing of the masked prime word occurs *simultaneous* to rather than prior to the processing of the visible target stimulus. While the experiment includes a range of prime-target SOA conditions, the conditions of primary experimental interest are those in which the prime word occurs 50ms and 100ms after the target word presentation. In these cases, 'early' (<250 ms) activation in the temporal and occipital cortices associated with subliminal visual processing of the prime

word, is able to occur simultaneously with the 'late' (>250 ms) globally distributed cortical processing of the visible target word. This is depicted in figure 5.2. Ciii & Civ. In both figures, the 'early' P200 ERP peaks of the masked prime (blue) occur just as the Target (red) P300 ERP peaks are beginning to take place. That is, the subliminal processing of the masked prime word takes place approximately within the temporal window associated with the P300 ERP peak, which is thought to correspond to the conscious perception of the visible target word (Dehaene & Changeux 2004). In these cases, an interaction between neural activity underlying the processing of supraliminal and subliminal stimuli, as indexed through RT and ER benefits, will call into question the temporal distinction between conscious and non-conscious processes that implicitly exists in the prior literature. This is because both neural processes occur simultaneously. A high level of interaction for processes which are both conscious and non-conscious, indexed by a high RT benefit, would be in support of a model in which the qualitative experience is considered to contain both liminal and subliminal structural elements. In this case it may be suggested that consciousness, as a phenomenal object correlating with the GNWS (Dehaene & Changeux 2011), be thought of more as a dynamic relationship between subliminal and supraliminal processes, rather than as purely conscious processes in contradistinction to subliminal processes. Conversely, a low level of interaction, indexed by the absence of an RT benefit and non-different error rates would fail to provide evidence for a model of qualitative experience as arising as a gestalt of liminal and subliminal content and processes.

To the best of our knowledge, masked priming where the masked stimulus is presented *after* the visible target stimulus has not been previously attempted. Orthodoxy simply places the prime stimulus before the target stimulus, because priming is viewed as a process that feeds forward in time (Kiefer & Pulvermuller 2012; Ulrich, Hoenig et al. 2013). While it can only be conjectured, this may stem in part from the endemic Cartesian conceptual separation between consciousness and non-conscious mental and material processes that was discussed in Chapter One. This conceptual distinction between conscious and non-conscious processes can also be seen reflected in the temporal profiles attributed to these processes. For example, as discussed above, Del Cul, Bailey and Dehaene (2007) along with Dehaene and

Changeux (2011) present a model in which the neural correlates of subliminal and supraliminal perception are spatially and temporally distinct.

Subliminal processes in discrete cortical regions are viewed as taking place early in the processing pipeline and are related to P200 ERP peaks. These are viewed as distinct from, but resulting in later more globally distributed neural processes that correlate with consciousness and relate to P300 ERP peaks (Fig. 5.2 Aii) (Del Cul, Bailey, & Dehaene, 2007; Dehaene & Changeux, 2011). From this perspective, it would make no sense to think of placing a prime stimulus after a target stimulus. These views can also be seen to parallel a broad understanding that non-conscious material processes somehow combine to result in or cause consciousness. In both cases, consciousness and non-conscious processes are presumed to have distinct ontologies, and are explained and understood to exist in a distinct and mutually exclusive manner. By manipulating the SOA and placing the masked prime word 50 ms and 100 ms *after* the visible target word, this study explores the possibility that subliminal processes don't simply exist prior to or underneath consciousness, but may actually be part of what consciousness *is*.

Quite apart from these theoretical and philosophical considerations, placing a masked stimulus after a visible target stimulus may not have previously been attempted because this presents a number of methodological challenges. Given the brief timeframes within which both non-conscious and conscious stimuli are processed (<250 and 300 to 500 ms respectively (Dehaene & Changeux, 2011)), the masked prime word would need to be presented very rapidly after the target word. In this case, the prime itself may act at a mask and hinder further processing of the target stimulus. To account for this possible confound, prime and target words were spatially offset so that they could be presented at the same time without obscuring each other. However, this in itself may have introduced further methodological issues. Additionally, confounds may arise in that the mask and prime may be thought to simply exchange roles. That is, the initially presented word may simply play the role of prime for the subsequently presented word, regardless of how these stimuli are designated by the experimenter prior testing. However, this was considered not to be a problem for the current study. The reason for this was that if an interaction between subliminal and supraliminal

stimuli processing comes about, this was reasoned to be on the basis of a temporal overlap between the neural processes taking place. Technically, whether one is considered the prime, and the other the target is irrelevant. What was important is simply that the neural processing of the masked prime and the visible target both take place within the same temporal window, which was reasoned to happen in the 50 ms and 100 ms SOA conditions. This is depicted in figure 5.2 Ciii & Civ where the prime p200 peak (blue) overlaps in time with the target p300 peak (red).

This study used a range of Stimuli Onset Asynchronies (SOA) between prime and target words allowing an examination of the temporal dynamic that exists between non-conscious and conscious processing. Conditions were used in which the masked prime word was temporally offset with regards to the target word such that the prime occurs 500ms, 200ms, 100ms and 50 ms prior to the target word. Additionally, SOA conditions were designed such that prime and target words occurred simultaneously, as well as the prime word occurring at -50ms and -100ms, that is, *after* the target presentation. The primary conditions of experimental interest were those in which the invisible prime was presented after the target word, e.g. the -50ms and -100ms SOA conditions. In these cases, both supraliminal and subliminal processes were reasoned to take place within the same temporal window of activity (Fig. 5.2. Biii, Biv, Ciii & Civ). For these conditions, an RT and ER benefit, arising from the interaction from processes that are both reportable (conscious) and non-reportable (non-conscious) would be in support a model in which qualitative experience is considered to contain both liminal and subliminal structural elements. Conversely, the absence of an RT benefit and non-different error rates between congruent and non-congruent word pairs in these conditions would fail to support such a hypothesis. We predict that the -50ms and -100 ms SOA conditions will lead to a small but significant RT and ER benefit. However, this effect may be expected to be smaller than that seen with traditional masked priming studies (Kiefer & Pulvermuller 2012; Ulrich, Hoenig et al., 2013) because placing the prime after the target word may also degrade the processing of the target word. This could be the case for example due to the presentation of the prime and target words being spatially offset, or if the prime word acts in any way as a mas  to obscure subsequent processing of the visible target word.

## 5.2. Method

### 5.2.1. Subjects

Twenty-three healthy participants with normal or corrected to normal vision participated in this study (male/female: 15/8, range 21-35 years). All participants were provided with a written and verbal explanation of the tasks they would be performing and signed a written consent form prior to taking part. This experiment received ethics approval from the Swinburne University of Technology Human Research Ethics Committee (HREC) and was conducted in accordance with the HREC guidelines.

### 5.2.2. Stimuli

The stimuli used were words based on the Kučera & Francis word data set (Kucera & Francis, 1967). These were 90 prime words and 90 target words matched for word length and SUBTLEX frequency of use per million words (Brysbaert & New 2009). Also selected were 90 prime pseudo words and 90 target pseudo words. Pseudo words consisted of pronounceable permutations of real words. These were created by re-arranging 1 or 2 letters from words also drawn the Kučera and Francis et al., word data set. The real and pseudo words used in this study are shown in Appendix 1. All stimuli were presented on a white screen. All prime word sequences were presented in black text and had an average length of 5 letters (range 3-10). The presentation screen had a viewing distance of 100 cm from participants. Prime and Target words subtended a visual angle of about 5.04 degrees width by 3.20 degrees height.

The masked prime words and target words were presented in the following sequence: Participants were presented with a visual fixation cross on a computer screen for a randomly varied duration of between 0.5 and 1 second. A forward mask consisting of a random letter sequence then replaced the fixation cross, counterbalanced to either 10mm above or 10mm below the point of fixation. The forward mask was presented for 35ms. Immediately following the forward mask, the prime word was presented again for 35 ms. The prime word was then replaced by a backwards mask, again consisting of a random letter sequence and presented for 35 ms. The use of a 35 ms mask and prime duration was based on the methodology and

results used in Kiefer (2002) Kiefer and Spitzer (2000) and Kiefer and Brendel (2006). A target consisting of either a word or a pseudo word was then presented at a point in time relative to the masked prime according to six SOA conditions. That is, target words were presented 500ms, 200ms, 100ms and 50 ms after the masked prime. Additionally, a 0ms SOA condition existed in which the target and prime were presented simultaneously. Two further SOA conditions also existed in which the target was presented 50ms and 100ms prior to the masked prime word. The target words appeared immediately above or below the fixation cross, but opposite to the side of the prime word. This allowed for the conditions in which the target and prime words were on the screen simultaneously. The target words were presented for 200 ms. Whether the prime occurred above the fixation cross and the target below or vice versa was counterbalanced across stimulus presentations to account for the disparity in attentional resources drawn by upper and lower hemifields respectively (Michael & Ojéda, 2005).

Within the seven SOA conditions, prime-target word pairs were also ordered into Congruent and Incongruent conditions. That is, the prime and target formed either a semantically congruent pairing (eg Cat-Dog) or semantically incongruent pairing (eg Cat-Iron). In addition to this, half of the prime-target word pairs in fact used pseudo words each of equal letter length. Pseudo word conditions were discarded from experimental analysis and were only included to obscure from the participants the underlying focus of the experiment on the impact of semantic congruency on priming and reaction times. This will be discussed in section 5.2.3 below. Leaving aside the pseudo word conditions, there were 15 congruent word pairs and 15 incongruent word pairs in each of six SOA conditions. Thus, there were 90 congruent word pairs, and 90 Incongruent word pairs included in the experimental analysis.

## 5.2.3. Procedure

The experiment was run in a semi-darkened room. Participants were not told about the presence of the prime words and were not aware of the semantic dimension of the experiment. They were instructed only that random letter strings and targets consisting either of a real word or pronounceable pseudo word would be presented on a CRT screen. Participants were instructed to respond with a button press as quickly as possible, to indicate whether the target was a real word or a pseudo word. Pairing of responses to participant

handedness was randomly assigned for each participant such that half of the participants responded to the real words with their dominant hand and half with their non-dominant hand. However, unbeknownst to participants, where target words were real words (i.e. not pseudo words) they formed a semantically congruent or semantically incongruent relationship with the prime word. Participants were not aware of this dimension of the experiment. The experiment was designed in this way such that semantic priming could occur subconsciously and not be aided by conscious direction of attention and cognition. Pseudo word conditions were removed from the analysis. Reaction times and error rates were collected across all real congruent/incongruent word pair condition comparisons as well as across all SOA conditions.

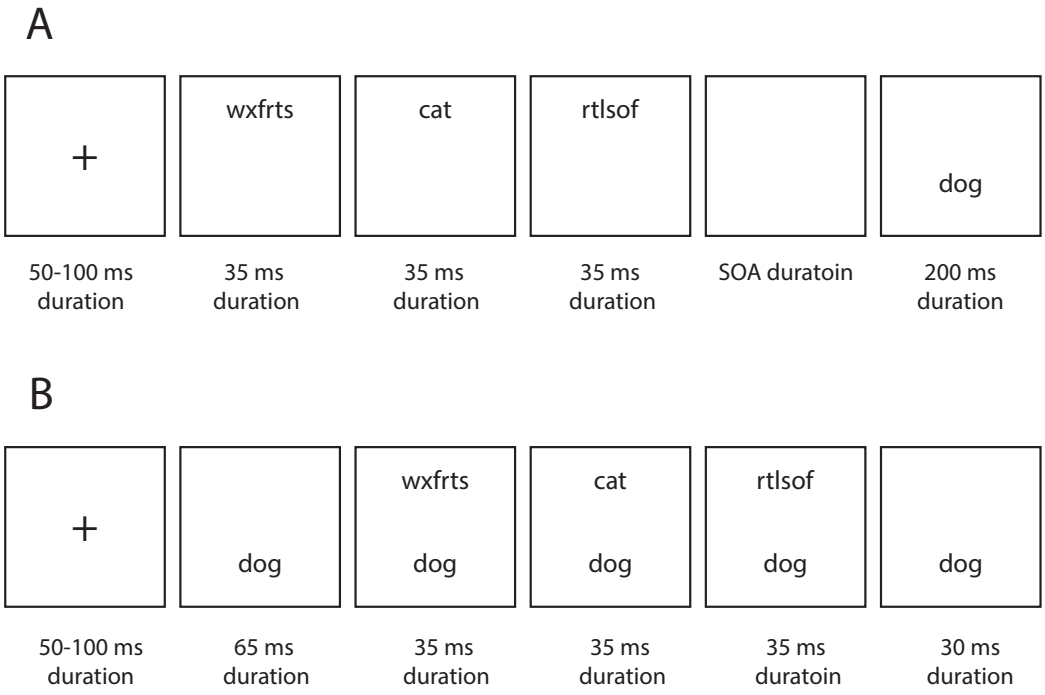



Figure 5-3. Experiment 3 stimulus design. A) Typical masked prime design in which a masked prime sequence is presented prior to a target word. Here, the SOA duration corresponds to the SOA condition, allowing target presentation to occur 500ms, 200ms, 100ms and 50ms after the presentation of the prime word. B) Represents the a-typical SOA conditions in which the target word is presented prior to or simultaneous with the prime word. In the case shown here, the target word 'dog' is presented 100 ms prior to the masked prime word 'cat'. Because the target word is presented for a 200 ms, duration this necessitates the target and the masked prime word sequence to be on the screen simultaneously.

### 5.2.4 Statistical analysis

The RT and ER benefits were separately assessed with analysis of variance (ANOVA) using 'congruency' and 'SOA' as factors. The factor 'congruency' was represented with two levels, corresponding to congruent and incongruent prime-target word pairings. The factor of SOA was represented with 7 levels corresponding to the seven different prime-target stimuli onset asynchrony conditions. These were SOA between prime and target words of 500ms, 200ms, 100ms, 50ms, 0ms, -50ms, and -100ms. In this way, two separate 2 x 7 repeated measures ANOVA were calculated for both reaction times and error rates ($\alpha$-level of 0.05). The data most likely was not normally distributed. A Kolmogorov–Smirnov test of goodness of fit to a normal curve showed that the RT and ER data gathered in experiment 3 did not satisfy the condition that variances from the mean be normally distributed, D=0.5, p <0.05 (Congruent) D= 0.5, p<0.05 (Incongruent). However, F-values in ANOVA have been described as robust to violations of the assumption of normality (Lindman, 1974). In this case it was reasoned that the size of the data set may have protected against this violation of normality. Moreover, a parametric equivalent to the ANOVA, a Friedman's test was used to assess differences in RT and ER across congruency levels and revealed substantively identical statistical results to the ANOVA, discussed below in section 5.3.

## 5.3. Results

### 5.3.1. Reaction times

There was a significant main effect of SOA on reaction time F(6,286)=10.84, p=<0.05. However there was no significant main effect of congruency on the reaction times, F(1,286)=0.44, p=0.51. There was also no significant interaction between congruency and SOA on reaction time, F(6,286)=0.44, p=0.99. In sum, reaction times were significantly higher when the prime was presented after the target word compared to conditions in which the prime was presented prior to the target. This can be seen in Figure 5.4 where mean reaction times for the -100ms, -50ms and 0 ms conditions are visibly and categorically higher than those in the 50ms, 100ms, 200ms and 500 ms conditions. However, overall there was no significant difference in reaction time between congruent and incongruent word pairings across SOA conditions. Nor

was there any significant difference in reaction times between congruent and incongruent word pairings at any specific SOA condition.

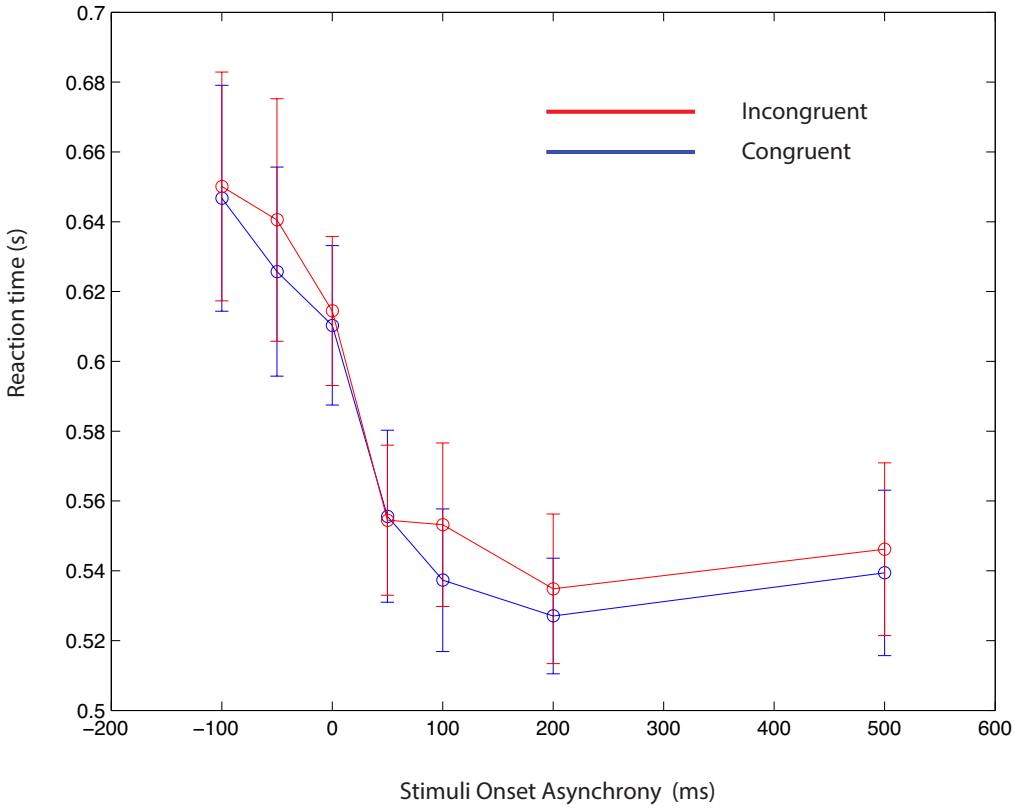



Figure 5-4. Grand averaged mean reaction times from Congruent (Blue) and Incongruent (red) word pairings across Stimuli Onset Asynchrony (SOA) Conditions. X axis (SOA) shows duration in milliseconds at which the prime word *preceded* target word for a given SOA condition. In two conditions, the Target word preceded the Prime word and in these cases the SOA is represented here by a negative value. Error bars show standard error in each condition.

## 5.3.2. Error rates

There was a significant main effect of SOA on error rates $F(6,252)=34.1$, $p=<0.05$. However there was no significant main effect of congruency on the error rates, $F(1,252)=2.54$, $p=0.11$. There was also no significant interaction between congruency and SOA on error rates, $F(6,252)=1.58$, $p=0.15$. In sum, error rates were significantly higher when the prime was presented after the target word compared to conditions in which the prime was presented prior to the target. However, overall there was no significant difference in error rates between congruent and incongruent word pairings across SOA conditions. Nor was there any

significant difference in error rates between congruent and incongruent word pairings at any specific SOA condition.

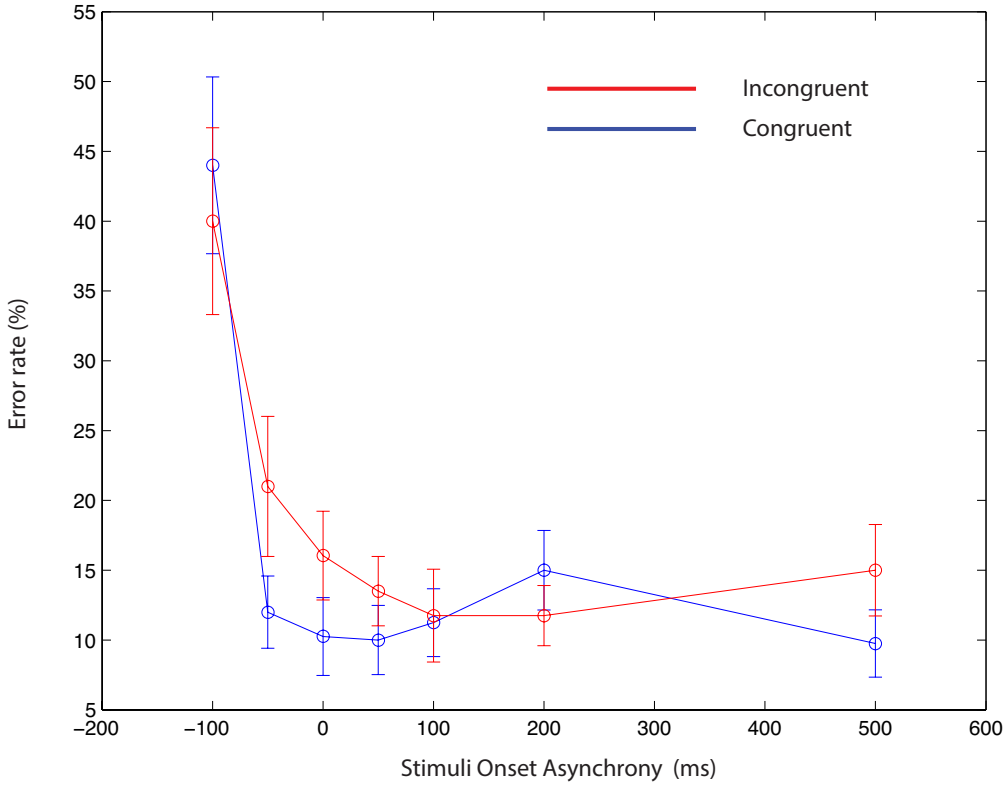



Figure 5-5. Error Rates from Congruent (Blue) and Incongruent (Red) word pairings across Stimuli Onset Asynchrony (SOA) Conditions. X axis (SOA) shows duration in milliseconds at which the prime word *preceded* target word for a given SOA condition. In two conditions, the Target word preceded the Prime word and in these cases the SOA is represented here by a negative value. Error bars show standard error in each condition.

## 5.4. Discussion

The primary hypothesis was not supported by the results of the current study. There was neither a statistically significant decrease in reaction time or error rate in congruous compared to incongruous conditions. The -100ms and -50ms SOA conditions in which the masked prime word was presented just after the target word represented the conditions in which the subliminal processing of the prime was reasoned to take place simultaneous to the processing correlating with conscious perception of the target word. These were the conditions of primary interest. However, the lack of significant difference in RTs and ER

across congruency conditions did not provide any evidence of interaction of liminal and subliminal processes within the gestalt of the perceptual phenomenal object.

Further to this, statistical analysis of the results of this study did not show any evidence of an interaction between congruency and SOA. Neither reaction time benefits nor reduced error rates were seen in congruent condition compared to incongruent across all SOA conditions. This result in itself is surprising given the well-validated nature of masked priming on RT and ER rates. However, it should be noted that despite a lack of statistical significance in the analysis, figure 5.4 and 5.5 both show a tendency towards reduced reaction time and error rates in congruent compared to incongruent conditions for the -50ms condition in line with the primary hypothesis of this study. This is particularly evident in error rates as plotted in figure 5.5. Furthermore, congruent word pairs also showed a non-significant tendency towards greater error rates compared to incongruent word pairs at the 200 ms SOA condition. This effect is the inverse of what has been previously shown to be the case. (Forster, Mohan, & Hector, 2003; Ortells, Frings, & Plaza-Ayllón, 2012).

It is likely that a number of methodological problems contributed to this null finding. For example, spatially offsetting prime and target words may have played a part in ameliorating what is otherwise a robust finding of reaction time benefit in the case of semantically congruent prime-target pairing (Kiefer 2002; Kiefer & Brendel 2006). In experiment 3 the prime and target words were presented on opposite sides of the fixation cross, and at a distance of 10 mm from the cross. The stimuli were designed in this way to allow prime and target words to be presented at the same time, which was required in the -100ms, -50ms and 0ms SOA conditions. However, the role of attention in visual perception is well documented (Cohen, Alvarez et al., 2011). It may be the case that removing the prime and target words from the immediate zone of visual attention, and presenting them on alternate sides of the fixation cross, inhibited what is otherwise a strong and well validated priming effect.

Additionally, where the prime word was presented immediately after the target word, the prime may in fact have acted as a backward mask, inhibiting further visual processing of

the target word. This possibility was addressed in the design of the study and discussed above. It was reasoned that as the prime and target words were spatially offset, the prime would be unlikely to obscure or act as a backward mask for the previously presented target word. However, given the null findings, this assumption should be called into question and could be investigated in future studies.

Thirdly, the very brief prime duration (35 ms) may have negatively impacted on the semantic priming effect that was anticipated. Across the masked priming literature, a range of durations of both mask and priming stimuli have been explored (Mattler 2003; Ansorge, Kiss et al., 2009; Eddy & Holcomb 2010; Ansorge, Fuchs et al., 2011; Kunde, Reuss et al., 2012). Where a prime stimulus is presented for too long a duration, it becomes inadequately masked. This is an issue in that any priming effects that may arise cannot necessarily be attributed to unconscious processing. Where a prime stimulus is inadequately masked, any experimental effects that arise may be in part due to processes that are partially conscious (Song & Yao 2016). However, a 35 ms mask and prime duration has numerously been shown to allow both adequate stimulus masking, as well as sufficient unconscious processing to allow for a subliminal semantic priming effect (Kiefer & Spitzer 2000; Kiefer 2002; Kiefer & Brendel 2006). It is unclear whether this very brief prime duration represents a confound in the current study. However, the failure to reject the null hypothesis (i.e that semantically congruent conditions will not lead to shorter reaction times compared to semantically incongruent conditions) may provide reason to reassess the literature regarding prime and mask duration.

A significant difference between error rates and reaction times was observed between SOA conditions. However, this effect was not of experimental interest. Statistical analysis revealed both a significant main effect of SOA on reaction time $F(6,286)=10.84$, $p=<0.05$ and on error rates $F(6,252)=34.1$, $p=<0.05$). This can be easily observed in both figures 5.4 and 5.5. In figure 5.4 reaction times for the -100ms, -50ms and 0ms SOA conditions was categorically higher than those of the 100ms, 200ms and 500ms SOA conditions. However, this result simply shows that placing the prime after the target stimulus fails to evoke a reaction time benefit effect, and thus broadly argues against the design of the study. Similarly, in figure 5.5, error rates for the -100ms SOA condition were clearly and categorically higher than those of

the remaining SOA conditions. Again, this result argues against placing the prime after the target and has no significance regarding the effect of semantic congruency/incongruency on priming effects.

## 5.5. Conclusion

This study was not able to provide evidence of an interaction of liminal and subliminal processes within the temporal window of neural processing associated with conscious perception of a given stimuli. The results supported the null hypothesis that conscious and non-conscious processes have separate ontologies. This null finding was likely to be in part due to the methodological errors discussed above.

# Chapter 6

## Experiment 4. A MEG study examining the interaction of simultaneously occurring subliminal and supraliminal processes on N400 event related fields

## 6.1. Introduction

Experiment 4 in this chapter continued to explore the theoretical orientation discussed in Chapter One and Two. Drawing on Heideggerian thought, qualitative experience, viz consciousness, was suggested to exist in a manner that is both revealed and hidden from itself. That is, part of the structure of what consciousness *is*, was suggested to be non-conscious. This lead to a view in which the being structure of consciousness was understood to contain an absence or groundlessness rather than exist as a collection of positive reportable phenomenal facts. This was further suggested as one possible means to begin to construct a shared ontology between consciousness and non-conscious mental and material processes. This theoretical position was summarised as a description of qualitative experience arising as a gestalt of conscious and non-conscious processes. Similar to experiment 3 in the previous chapter, the hypothesis of such a gestalt has been empirically scrutinised here through examining the level of interaction between liminal and subliminal processes within a temporal window of neural activity associated with conscious perception. In the current experiment, such a window of neural activity is indexed by MEG derived Event Related Fields (ERF). The following experiment examines whether the neural processing of subliminal semantic content impacts on the simultaneously occurring processing of supraliminal semantic content associated with conscious perception. A positive finding will be taken to support a view in which qualitative experience be considered a gestalt of foreground supraliminal phenomenal content and background subliminal phenomenal content, rather than as 'consciousness' distinct from non-conscious processes per se.

The experimental question addressed in the current study is whether an N400 ERF effect can be evoked through an interaction of subliminal and supraliminal perceptual

processes, when such neural processes occur simultaneously within the same temporal window associated with conscious perception. The N400 effect is discussed in more detail below and is broadly understood to reflect semantic integration (Kutas & Hillyard 1980; Kutas & Federmeier 2011). The relationship between consciousness and unconscious processes is examined here, as in the previous chapter, using traditional masked priming techniques. In the primary experimental condition, the timing of traditional masked priming experimental designs is inverted such that masked subliminal stimuli are presented 50 ms *after* the presentation of a consciously perceived target stimuli. In this case, ERF peaks in neural activity taking place around 200ms after the presentation of a subliminal prime are superimposed with peaks in neural activity taking place around 250 ms after the presentation of a supraliminal target stimulus (Fig. 6.1). Both processes take place within the same temporal window associated with conscious perception. That is, GNWS theory posits that consciousness correlates with a temporal window of neuronal activity arising from around 250 ms after a given stimulus (Dehaene & Changeux 2011)-see Chapter Five section 5.1. In the current experimental design both liminal and subliminal processes take place in this same temporal window correlating with consciousness of the supraliminal target. The interaction of subliminal and supraliminal perceptual processes associated with this temporal window are then examined using behavioural and MEG derived N400 ERF profiles. MEG was used rather than EEG in this experiment because MEG was judged to be able to provide more accurate source space data. This arises from the fact that brain derived magnetic fields are not degraded when passing through the cranium and scalp as are the electrical fields recorded in the EEG. An observable interaction between conscious and non-conscious processes within this temporal window, as indexed by a later ocurring N400 effect, will be taken as some evidence for a less dichotomous view of conscious and non-conscious processes within the overall gestalt of qualitative experience. That is, an N400 effect shown in the primary experiential condition will be taken as some initial support for the theoretical orientation outlined in Chapters One and Two.

Visual masking represents an effective paradigm to evoke and examine neural processes associated with unconscious perception. In such a paradigm, a visual stimulus is briefly presented and is either preceded or followed by an obscuring unrelated image or

'mask'. Such a procedure has been shown to render the stimulus invisible whilst still facilitating visuomotor and semantic processing associated with the stimulus (Kouider & Dehaene, 2007). Typically, such a masked stimulus is used to prime or pre-activate processing for a subsequently presented target stimuli. In this way, masked priming has been numerously shown to lead to faster reaction times and the detection of sematic incongruence between target and masked prime, even while the prime remains undetected, viz unconscious or invisible (Kouider & Dehaene 2007).

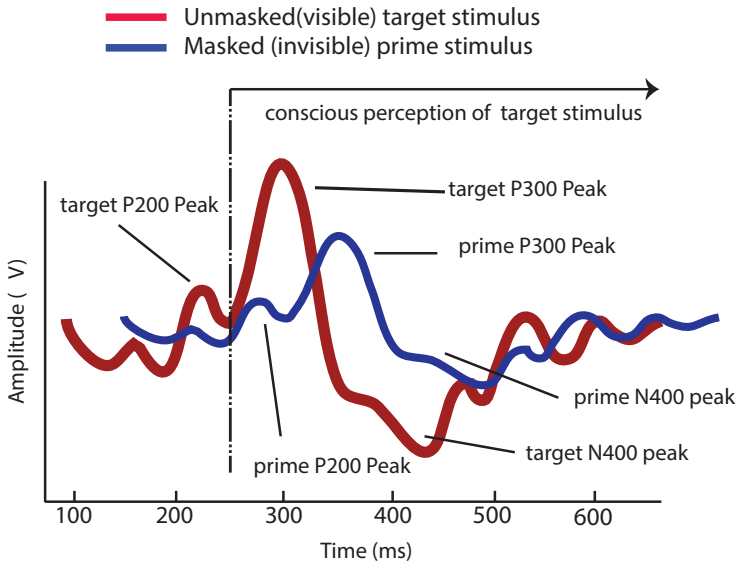



Figure 6-1. Simulated ERP profile for primary experimental condition in which a masked prime stimulus is presented 50 ms after the visible target stimulus. In this case, the 'early' P200 peaks associated with processing of the masked prime stimulus occurs just as the P300 peak associated with conscious perception of the target stimulus is beginning to take place. In this case, the temporal window of neural activity which has been associated with conscious perception of a given stimulus (from 250 ms after stimulus onset) (Dehaene & Changeux, 2011) includes not only processing of the visible target stimulus, but also the processing of the unconsciously perceived prime stimulus. Note that while the effect of experimental manipulation is examined in terms of the n400 peak the logic of this experiment, as with experiment 3 in Chapter 4, concerns the overlap in time between the prime n200 peak and the target p300 peak, and this is primarily what is illustrated in this figure.

Dehaene and Changeux (2011) have presented a model in which masked stimuli remain unperceived because of the way in which the mask interrupts processing in the visual pathways. In their approach, neural processes associated with consciousness are characterised as occurring when a feedback loop of top down activity leads to an amplification of a global

network of activity linking prefrontal, cingulate, and parietal regions alongside thalamocortical loops. A mask, presented up to 50 milliseconds prior to a given stimulus reduces the duration and the intensity of the stimuli evoked processes, such that a bifurcation to a globally amplified state (correlating with consciousness of the stimuli) is unable to occur. While an ignition to a global state characteristic of conscious perception is unable to occur, elements of the masked stimuli remain able to be locally processed for a range of properties.

The extent to which the masked stimuli are processed has received some debate and experimental investigation. It is broadly established that motor and low level sensory processes are able to take place in response to unconsciously perceived stimuli (Neumann & Klotz 1994; Vorberg, Mattler et al., 2004). However, some debate has persisted in the literature as to whether unconscious stimuli are able to be processed to the level of their semantic properties (Abrams & Greenwald 2000; Damian, 2001). For example, Abrams and Greenworld (2000) found that subliminal word analysis is able to take place only up to the level of the words orthographic constituents but not at higher semantic levels for novel words. However more recent and methodologically improved studies have given stronger evidence for unconscious processing of semantic level information. For example, using an N400 ERF paradigm, which indexes sematic integration of information, N400 components have been shown to be modulated by well masked invisible primes (Carr & Dagenbach, 1990; Kiefer & Spitzer, 2000; Kiefer, 2002). Considerable evidence now exists for semantic processing of unconsciously perceived stimuli, and use of the N400 paradigm has been instrumental in this finding (Kouider & Dehaene 2007).

In the following study, we have also used an N400 paradigm to investigate the relationship between conscious and unconscious components of perception. The N400 is an amplified ERP or ERF deflection with a left dominant centro-parietal scalp distribution, peaking around 400 milliseconds and reflecting semantic processing (Maess, Herrmann et al., 2006; Van Petten & Luka, 2006; Kutas & Federmeier , 2011). Original EEG studies detected this effect as a large *negative* Event Related Potential (ERP) deflection in EEG amplitudes (Kutas & Hillyard, 1980). However, because MEG sensors detect magnetic fields running transverse to the cortical surface, an N400 effect is observed as an amplification of both negative and

positive field amplitudes. Typically, this effect is shown to be greater when participants are presented with semantically incongruent stimuli sets compared to congruent. For example, sentences ending in an incongruent word such as *'a sparrow is a vehicle'* produces a significantly higher amplitude N400 ERF component compared to a sentence such as *'a sparrow is a bird'*. N400 evoked ERF amplitudes correlate strongly with measures of the expectancy of the sentence's concluding word. That is, greater N400 effects arise in response to sentences ending with words that have a low cloze probability (Kutas & Federmeier, 2011). Here, the cloze probability of a given word is defined as the percentage of individuals who would continue a sentence fragment with that word (Taylor 1953; Staub, Grant et al., 2015). This effect has been shown to take place across input modalities, with N400 effects seen in response to sentences, word pairs, spoken words or pictures (Kutas & Federmeier, 2011). The N400 is not a marker of conscious perception, but rather a marker of processes broadly relating to semantic integration. Importantly, in regards to this study the N400 effect can take place in response to non-conscious processing and does not rely on a conscious recognition of semantic incongruity. For example, Kiefer (2002) elicited N400 effects in the case of semantic incongruity between masked prime words and supraliminal target words.

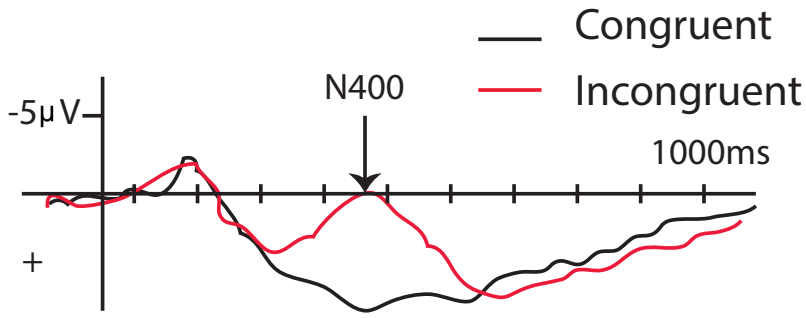



Figure 6-2 A standard N400 ERP. Depicts event-related potentials taken from a midline central electrode in the case of sentences with congruent (black) and incongruent (red) sentence endings. Arrow indicates the N400 component. Figure adapted from (Lau, Phillips et al. 2008)

Supraliminal and subliminal perceptual processes have been described as being temporally distinct (Kouider & Dehaene 2007; Del Cul, Baillet & Dehaene, 2007). Unconscious processes associated with visual perception are thought to occur early in the processing stream, with peaks in processing occurring up to 200 milliseconds after a given stimuli. For example, 'early' ERP peaks at 200 ms in contralateral occipital and temporal pathways have

been shown to be correlated with subliminal processing of a visual stimuli (Kouider & Dehaene, 2007; Del Cul, Baillet & Dehaene, 2007). Del Cul et al., have also shown conscious perception of a stimulus to correlate with a profile of a late globally distributed event related potentials (P300) beginning around 250 ms which are associated with an all or nothing ignition of prefrontal-parietal networks along with an amplification of related sensory cortices. Typically, a masked prime stimulus is presented prior to a visible target stimulus (Kiefer, 2002). In this way, the activity associated with the processing of a subliminal prime is thought to spread over a brief period of time and thus pre-activate and impact on later processing associated with unmasked consciously perceived target stimuli. Such a model represents a dichotomy in which non-conscious and conscious processes are temporally separated.

In contrast, in this study the stimuli onset asynchrony (SOA) between prime and target is structured such that the subliminal prime and supraliminal target are processed in the same temporal window. That is, in the main experimental condition, masked prime word onset occurred 50 milliseconds *after* the onset of an unmasked target picture. In this case, processing underlying P200 peaks evoked by the invisible stimulus are superimposed with processes underlying the P300 peaks evoked by the visible target stimulus (Fig. 6.1). In this case, 'late' processing of the target picture, occurring from 250 milliseconds after stimulus onset, overlaps with 'early' processing of the masked prime word. Such an experiential design then allows an investigation into the interaction between simultaneously occurring subliminal and supraliminal processes and the contribution of both, to the overall gestalt of qualitative experience.

A 50 ms SOA was chosen between visible target and invisible prime, based on the well known morphology of ERP peaks and on the results of experiment 3 dealt with in the previous chapter. As discussed above, ERP peaks occurring around 200ms are thought to represent local subliminal processing of a given stimulus within the sensory cortices (Del Cul, Baillet & Dehaene, 2007). ERP peaks occurring around 300 ms are thought to correlate with conscious perception and a bifurcation into global distributed activity involving prefrontal-parietal networks along with an amplification of related sensory cortical activity (Kouider & Dehaene, 2007; Del Cul, Baillet & Dehaene, 2007). It was reasoned that by offsetting the presentation of

the subliminal prime 50 ms after that of the target stimulus, P200 peaks for the invisible prime would be occurring just as P300 activity associated with conscious perception of the target is beginning to take place (Fig. 6. 1). In this case, any later N400 effects occurring in response to the target stimulus can be reasoned to have arisen from neural processing within the temporal window associated with conscious perception of the visible target picture, which in this experimental design, also includes processing of the masked prime word stimulus.

In addition to this reasoning, results from experiment 3, whilst not statistically significant, did show some tendency towards interaction between visible and invisible stimulus when the masked prime was presented 50 ms after the target stimulus. Figures 5.4 and especially figure 5.5 both show some tendency for RT and ER benefit for congruent compared to incongruent conditions when the masked prime was presented 50 ms after the visible target stimulus, although this effect did not reach statistical significance. This suggests that a genuine RT and ER benefit may have been present but partially obscured due to the various methodological problems inherent in experiment 3, discussed in the previous chapter. In experiment 4 dealt with in the present chapter, confounds due to spatially offsetting prime and mask stimulus, and due to backward masking effects in experiment 3 were addressed in the choice of stimulus, discussed in section 6.2 below. Taken together, a condition in which the invisible stimulus was presented 50 ms after the visible target stimulus was judged to best represent a condition in which supraliminal and subliminal processes are temporally and spatially superimposed.

The experimental hypothesis for this experiment then is that greater deflections in N400 amplitudes will be observed in incongruent compared to congruent prime-target pairings, and that this will be the case in the primary experimental condition in which the prime is presented 50 ms after the target stimulus. Correspondingly, the null hypothesis is that N400 amplitudes will not be significantly different in congruent compared to incongruent prime-target pairs. In the experimental design used here, if N400 amplitudes are greater in the case of semantically incongruent visible-invisible stimulus pairs compared to semantically congruent, this would represent some evidence in support of a dynamic interaction between unconscious and conscious processes within the global neuronal workspace commonly

associated with consciousness alone. The N400 effect evoked from the perception of the target stimulus will have arisen from the temporal window of activity occurring from 250 ms to 500 ms after target stimulus presentation and which has previously been associated with conscious perception of the given stimulus (Dehaene & Changeux, 2011). However, in this case, because the prime stimulus is presented 50 ms after the target stimulus, this window of temporal activity will also include the neural processes associated with the early unconscious perception of the masked stimulus (Fig. 6.1). An N400 effect arising from an interaction between these subliminal and supraliminal processes both taking place within the same temporal window of activity that has been previously associated with conscious perception of the target, would provide some support for the theoretical orientation towards qualitative experience outlined in Chapters One and Two.

The model outlined in Chapter Two was not merely that consciousness and unconscious processes interact or form two components in the overall gestalt of qualitative experience. Rather, a stronger claim was put forward. It was suggested that a significant element in the structure of consciousness is itself not conscious and that consciousness should not therefore be thought of as having a mutually distinct ontology from non-conscious processes. Empirically, these two hypotheses should be distinguishable. The traditional view in most current consciousness studies is that consciousness and non-conscious processes do interact yet remain categorically distinct. By such a view, human experience does involve both consciousness and un-conscious processes, however these two remain conceptually distinct from each other. For example, is it a well validated finding that non-conscious processes feedforward in time to impact on later occurring conscious processes and this is the logic of most masked priming studies (Ansorge, Kiss, & Eimer, 2009; Eddy & Holcomb, 2010; Kouider & Dehaene, 2007; Martens, Ansorge, & Kiefer, 2011). Similarly, in psychological research, unconscious perception has been shown to impact on later occurring beliefs and behaviours (Merikle, 1998). Yet even while accommodating this level of interaction between conscious and non-conscious processes, these two categories are viewed as distinct. For example, consciousness continues to be defined in terms of positive reportable phenomenal facts (Aru, Bachmann, Singer, & Melloni, 2012; Chalmers, 1996; de Graaf, Hsieh, & Sack, 2012) and these are clearly disambiguated from non-conscious perceptions and processes which are not able

to be explicitly reported on. In this case, the relationship requires causal processes to occur prior in time to resultant processes. This is reflected in the fact that to the best of our knowledge, no previous masked priming studies have examined conditions in which the masked prime is presented simultaneous to or after a visible target. If non-conscious processes merely interact with consciousness without forming an essential element in the structure of consciousness, then conditions in which the masked prime is processed simultaneous to the processing of the visible stimulus (such as in the SOA2 condition) should not show an interaction as measured by an N400 incongruence effect.

However, rather than suggest that unconscious processes merely impact on consciousness, the claim presented here is that an essential element in the structure of consciousness is itself not conscious. In this sense, it is suggested that the gestalt of qualitative experience is formed of both phenomenally foreground processes (traditionally viewed as consciousness) and phenomenally background processes (those which are traditionally viewed as non-conscious). In such a case, both processes are predicted to simultaneously contribute to the gestalt of qualitative human experience. This is the hypothesis examined in experiment 4 within the SOA2 condition where the neural processing of invisible and visible stimuli should be occurring simultaneously. An N400 Incongruence effect in the SOA2 condition will provide some support for this hypothesis.

However, it must be acknowledged that simultaneity of neuronal processing is an assumption in the SOA2 condition, and this experiment cannot completely rule out a temporally distinct causal relationship between unconscious and conscious processes. This experiment examines neuronal processing over windows of hundreds of milliseconds. This is based on well validated findings regarding the correlation of conscious perception to neural processes occurring over a 300ms to 500ms post stimulus window, and not to processes occurring prior to this (Dehaene et al., 2001). However, it remains possible that even within these time windows, non-conscious processes could be occurring prior to conscious processes and impact on these while remaining temporally distinct. In this case the ERP methodology used here may be too course grained in its analysis. Nevertheless, the design of experiment 3 and 4 has been based on well-established masked priming protocols (Dehaene et al., 2001),

recent criticism not withstanding (Aru, Bachmann, Singer, & Melloni, 2012; de Graaf, Hsieh, & Sack, 2012). A positive finding in this primary experimental condition, as evidenced in an N400 incongruency effect would provide some initial evidence in support for this theoretical orientation, which has been elaborated on in Chapter Two.

## 6.2. Methods

### 6.2.1. Subjects

Twenty healthy participants with normal or corrected to normal vision participated in this study (male/female: 12/8, range 18-40 years). These participants were newly selected and represent a separate cohort to those who took part in the previous experiments 1, 2 and 3. The data from five of these participants were excluded from the analysis based on prime detection exclusion criteria. This resulted in a final cohort of 15 participants being included in the final analysis (male/female: 10/5). All participants were provided with a written and verbal explanation of the tasks they would be performing and signed a written consent form prior to taking part. This experiment received ethics approval from the Swinburne University of Technology Human Research Ethics Committee (HREC) and was conducted in accordance with the HREC guidelines.

### 6.2.2. Stimuli

The target stimuli used were coloured line drawn pictures taken from the image set of the ''Snodgrass and Vanderwart-like'' objects (Rossion and Pourtois 2004). These were 92 pictures representing 46 human made and 46 naturally occurring objects. The masked prime stimuli were words drawn from a selection of words depicting the target picture stimuli from the ''Snodgrass and Vanderwart-like'' objects. The prime words were presented in black text on a white screen and had an average length of 5 letters (range 3-10). The presentation screen had a viewing distance of 100 cm from participants and in the case of prime words, subtended a visual angle of about 5.04 degrees width by 3.20 degrees height. Target pictures had a visual angle of about 8.3 degrees width by 6.2 degrees height. The collected set of prime words can

be seen in Appendix 2. Target pictures were not able to be reproduced due to copyright restrictions.

### 6.2.3. Procedure

The following procedure was run according to two experimental conditions as discussed below (referred to as SOA1 and SOA2 conditions) and also included an initial training procedure and a concluding prime identification task (Fig. 6.3). The training procedure was identical to the main experimental conditions, except run over 10 trials, and having correct/incorrect feedback after each trial. A prime identification task was also run following the main experimental conditions. This will be described after the procedure for the main experimental conditions, below.

Participants were seated at a distance of 1 meter from the presentation screen in a semi darkened magnetically shielded room. They were presented with a fixation cross for 50 ms. The fixation cross was replaced with a masked prime word sequence. This sequence consisted of a forward masking random letter string for 100 ms, followed by the prime word for 34 ms, and concluded by a backwards masking random letter string presented for 34 ms. A target picture was also presented in the same location as the fixation cross, and remained present for 2 seconds or until the participant made a response. As discussed in more detail below, participants were instructed to respond with a button press as quickly as possible to indicate whether the picture represented a naturally occurring or human made object. The stimuli onset asynchrony (SOA) between prime word and target picture was varied over two separate experimental conditions. In Stimuli Onset Asynchrony condition 1 (SOA1) the target picture was presented immediately following the masked prime word sequence. In this instance, there was a stimuli onset asynchrony of 68 ms (34 ms prime duration plus 34 ms mask duration). That is, the masked prime was presented 68 ms prior to the presentation of the visible target (Fig. 6.5a). This SOA1 design was used to replicate and validate previous experimental masked prime N400 findings (Kiefer 2002; Martens, Ansorge et al., 2011). For Stimuli Onset Asynchrony condition 2 (SOA2) the target

picture was presented 50 ms after the masked prime word sequence had begun to be presented (Fig. 6.5b). In this case there was a stimuli onset asynchrony of -50 ms. In this condition, the masked prime was presented 50 ms *after* the presentation of the visible target. The SOA2 condition represented the condition of primary experimental interest. Both prime word and target picture stimuli were presented in the same spatial location to which participant's attention was drawn by the prior presentation of the fixation cross. In the case of the SOA2 condition, this necessitated that prime word and target pictures would be superimposed for a brief (110ms) period of time. There were 92 trials with a break after 46 trials and using 92 prime words and picture targets. Prime words could either refer to 46 human made or 46 naturally occurring objects. 46 prime-target pairs were run in a 'Congruent Condition'. That is, 23 of the pictures depicted human made objects, and 23 depicted naturally occurring objects (46 in total) occurred in congruent picture-word pairs. For example in a congruent prime-target set, the word 'dog' could be paired with a picture of a dog. The remaining 46 prime word-target picture sets were presented in the 'Incongruent Condition'. The incongruent prime-target pairs consisted of words that depicted an object other than the target picture, and which contrasted with the picture in regards to being either naturally occurring or human made. For example, the word 'cat' paired with the picture of an iron.

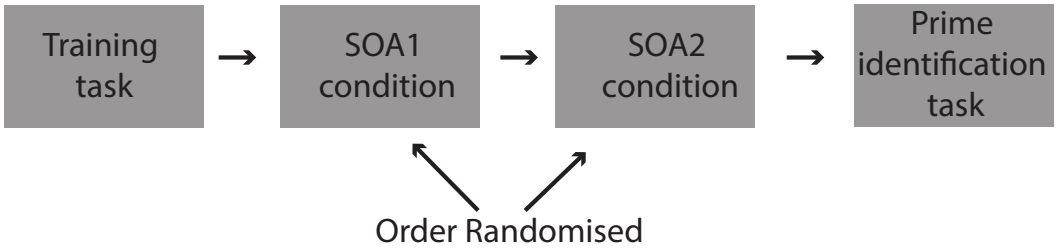



Figure 6-3. Order of tasks in experiment 4. Participants began with a training task. The training task was identical to the conditions SOA1 and SOA2 conditions, except run over 10 trials, and having correct/incorrect feedback after each trial. Novel stimuli were used. Stimuli were not repeated across the experimental conditions. Subsequently participants took part in the experimental conditions, SOA1 and SOA2. The order of these tasks was randomised across participants. Finally, participants undertook a prime identification task in order to assess the status of primes as adequately masked invisible stimuli.

Participants were not told about the presence of the prime words. They were instructed only that random letter strings would be presented prior to pictures and that these pictures would depict either naturally occurring or human made objects. As discussed above, participants were instructed to respond with a button press as quickly as possible, to indicate whether the picture represented a naturally occurring or human made object. In this way, participants were neither cognisant of the presence of the masked prime or the semantic congruency dimension of the experiment. Pairing of responses to participant handedness was randomly assigned for each participant such that half of the participants responded to naturally occurring objects with their dominant hand and half with their non-dominant hand. Furthermore, the order in which participants took part in each experimental condition was automatically and randomly assigned. This was done such that ten participants undertook the standard SOA1 condition first while the remaining 10 participants undertook the alternate SOA2 condition first. The order of tasks is depicted in figure 6.3.

The prime identification task was not of primary experimental interest but was included after the main tasks, in order to assess the prime word's status as genuinely invisible to participants. After the main experimental tasks (SOA1 and SOA2 conditions), participants were informed of the presence of the masked primes and asked if they were aware of these prime words. For both SOA1 and SOA2 experimental conditions, 15 participants indicated that they were unaware of the presence of any of the masked prime words. Data from the 5 participants who indicated an awareness of the prime words were excluded from further analysis. In addition to simply indicating whether they had had subjective awareness of the prime words in the main experimental task, participants also undertook a separate prime identification task to ascertain an objective measure of prime word visibility. The prime detection task consisted of exactly the same protocol as described above, except run across only 46 sets. Further to this, half (23) of the prime words were real words and half were pseudo words, consisting of real words that had 1 or 2 letters re-arranged. Pseudo word primes and real word primes were randomly ordered throughout the 46 trials. The only difference in this task was that participants were instructed to respond to prime words rather than target pictures. Participants were instructed to indicate with a button press whether the prime was a real word, or a pseudo word. A t-test was then conducted comparing Hit rates to False

Alarm rates. That is, the rate at which participants were able to correctly identify a masked prime word was compared to the rate at which they falsely identified the pseudo words as real words. A lack of significant difference between Hit rates and False Alarm rates would demonstrate an inability on the part of the participants to distinguish the real prime word from the pseudo word at higher than chance levels. Such a result would indicate that the prime word was fully masked and remained invisible to the participant. Conversely, a significant difference between Hit and False Alarm rates would indicate a higher than chance level of detection of real words. This in turn would indicate that the prime words were not adequately masked. Data from participants who indicated an awareness of the prime words was excluded from the analysis.

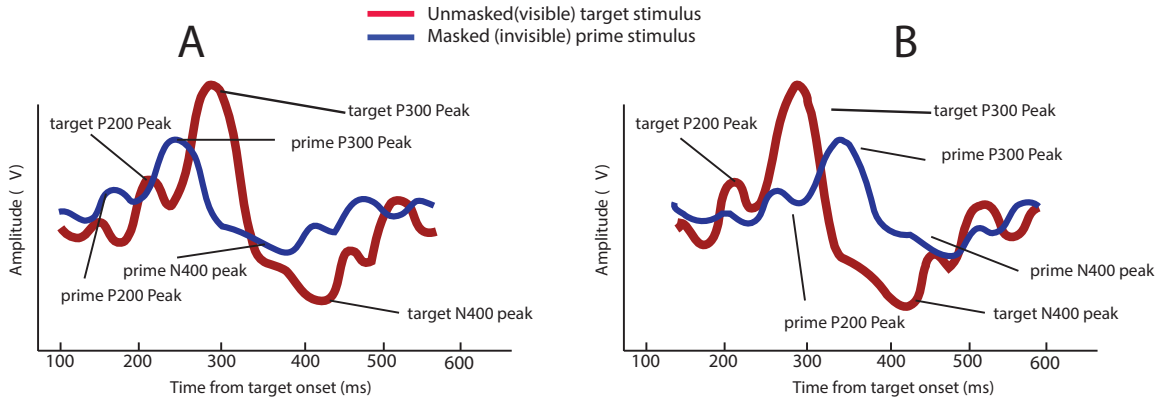



Figure 6-4. Simulated Event Related Potential peaks for visible compared to invisible (masked) stimuli. A) Predicted ERP profiles in the SOA1 condition: Stimuli Onset for the masked invisible stimulus occurs 68 ms prior to onset of visible stimulus. A 200 ms positive peak is observable in both visible and invisible stimuli. However only the visible stimuli produces the later P300 peak correlating with conscious perception. B) Predicted ERP profiles in the SOA2 condition: Stimuli Onset for the masked invisible stimulus occurs 50 ms after onset of visible stimulus. In this case, the p200 ERP peak evoked by the invisible prime stimulus (blue) occurs just as the P300 peak for the visible stimulus (red) is beginning to take place. Note that while the experimental effect is examined in terms of the n400 peak the logic of this experiment, as with experiment 3 in Chapter 4, concerns the overlap in time between the prime n200 peak and the target p300 peak, and this is primarily what is illustrated in this figure.

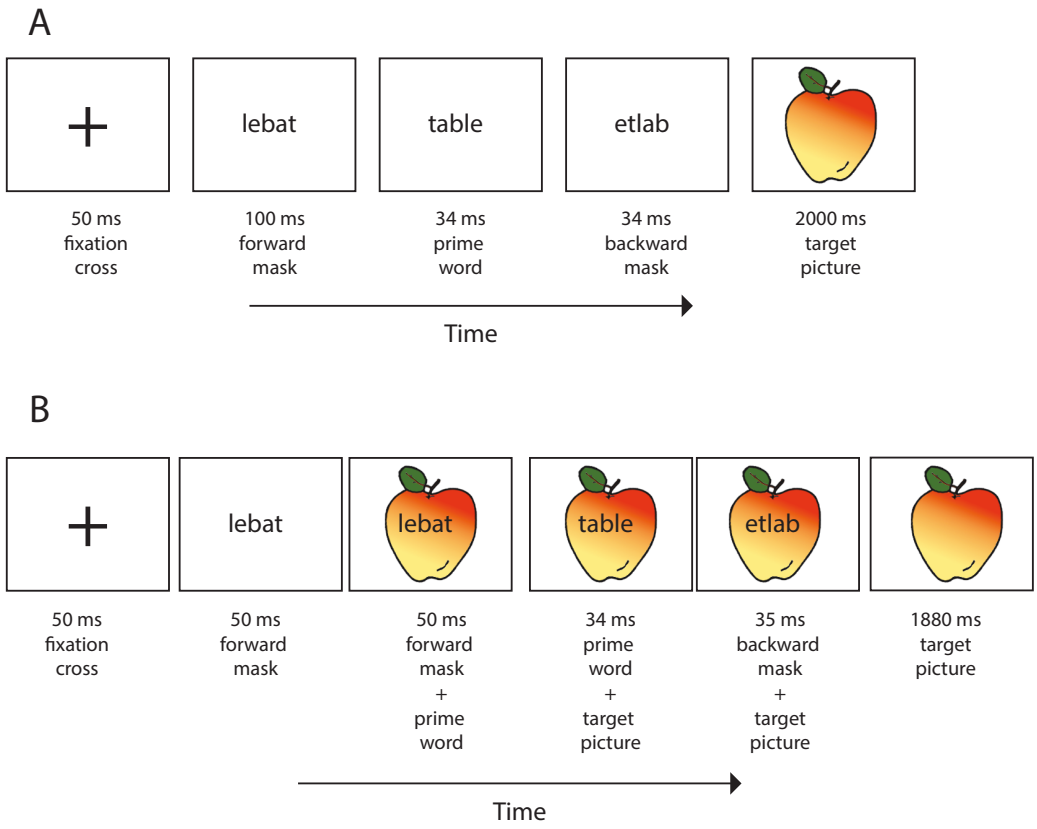



Figure 6-5. Stimuli Onset Asynchrony for SOA1 and SOA2 conditions. A) SOA1: Standard masking paradigm (Kiefer, 2002). A forward and backward masked prime is presented 68 ms prior to the target stimulus. Target stimulus remains for 2 seconds or until a response is made. B) SOA2: Alternate masked priming design. This SOA design was the condition of primary experimental interest. The masked prime word sequence as well as target picture are presented for the same duration of time as in SOA1. However in this case, target onset (picture of an apple) is brought forward in time such that the target picture is already present for 50 ms at the time of prime word onset. For the sake of the clarity of figure 6.5, it should be noted that the duration of the final window for the SOA2 condition (1880 ms) is the total duration of target presentation (2 seconds) minus the duration for the previous frames in which the target picture is also present. Participants are required to respond with a button press to indicate whether the target picture is a human made or naturally occurring object. In the case depicted, the target picture (an apple) is indeed a naturally occurring object. However, the salient experimental fact is that the masked prime word 'table' is semantically incongruent with the target picture of an apple. Both conditions depicted here are predicted to produce larger N400 amplitude deflections compared to a semantically congruent condition, for example if the prime word was also 'apple'.

## 6.2.4. MEG recording and signal extraction

Data from SOA1 and SOA2 conditions was recorded using a MEG Elekta TRIUX system with a sample rate of 1000 Hz. This MEG system consists of 102 triaxial sensors configured in such a way that each triaxial sensor comprises a magnetometer and two planar gradiometers. Head position coils were attached and their position relative to naison and

fiducial points were recorded using a Polhemus 3SPACE FASTRAK system in order to track head position within the MEG dewar. Bio-leads were attached for the measurement of electro-oculogram (EOG) and electro-cardiogram (ECG) artefacts. Following recording of MEG data, structural MRI scans were conducted for all participants to use in subsequent source space modelling. MRI scans were conducted using a Siemens Tim Trio 3T MRI system.

## 6.2.5. Data Pre-processing

Pre-processing along with sensor and source space analysis was conducted using open source Fieldtrip software (Oostenveld et al., 2011). A signal-space separation filter was implemented on recorded data using MaxFilter Neuromag software (Elekta NEUROMAG, Elekta AB, Stockholm, Sweden) in order to remove magnetic fields from sources outside of the brain. Signal-space separation filtering using MaxFilter Neuromag software was also applied to the data, using information from the Polheumus 3SPACE FASTRAK system in order to remove motion artefacts from the data. Data was band pass filtered between 0.5 and 45 Hz and segmented into 1 second epochs beginning from 200 ms prior to target onset, to 800ms after target onset. An independent component analysis was then run, and components corresponding to eye blinks and electrocardiograph artefacts detected in the bio-leads were removed. Visual inspection was then carried out for eye blink and movement artefacts. 27 Epochs were removed from the data due to artefacts and poor-quality recording. These included those in which eye-blinks were clearly visible after ICA or which contained clear motion artefacts. 16 Epochs across all participants including those from incorrect trials and epochs in which response time exceeded twice the participant's mean reaction time were also removed from further analysis. Further to this, three participant's data were removed from further analysis due to strong and persistent motion artefacts.

## 6.2.6. Sensor space analysis

Sensor space analysis refers to an analysis of the data recorded at each MEG sensor and effectively is an analysis of brain derived magnetic fields at the scalp. Following pre-processing and artefact removal, data were then divided into congruent and incongruent condition sets. Time-locked Event related fields (ERF)

were calculated for each participant at each MEG channel. Subsequent to this, combined participant grand averaged ERFs were calculated for each condition. Based on Kiefer (2002) analysis of the N400 effect focused on a condition dependant time window of 150 ms which centred around mean N400 peak latencies. In the case of the SOA1 condition, ERF amplitudes at a latency of 400 to 550 ms post target onset were selected to test for statistical analysis of N400 effects. For the SOA2 condition, ERF amplitudes at a latency of 500 to 650 ms post target onset were selected to test for statistical analysis of N400 effects.

## 6.2.7. Source space analysis

Source space analysis refers to an analysis of reconstructed magnetic fields as they would occur within the brain volume. This level of analysis examines magnetic fields at their source, that is, within various anatomical regions of the brain. As with sensor space analysis, temporal windows centred around mean N400 peak latencies were selected for further source space analysis. For the SOA1 condition these were from 400 ms to 550 ms post target presentation and for the SOA2 condition, these were from 500 ms to 650 ms post target presentation. Event Related Fields at source level were constructed using an adaptive linear constraint minimal variance (LCMV) beamformer localization technique (van Veen et al., 1997). Structural MRI scans from each participant were realigned to MEG data using head position data from the Polhemus 3SPACE FASTRAK system and marked fiducial and naison points. Individual volume conduction models were constructed for each participant from realigned structural MRI data. A three dimensional grid was then constructed using SPM8 (Friston 2007), representing a regular 10 x 10 x 10 mm grid of voxels located throughout a template brain (International Consortium for Brain Mapping; Montreal Neurological Institute (MNI), Montreal, Canada). Individual grids were then constructed for each participant and warped to fit this template MRI and the template's grid, such that grid points across individual subjects are aligned in MNI space. This process allowed inter-participant comparisons without normalising MRI. Leadfields were calculated based on individual participants warped grid points and volume

conduction models. Individual beamforming was then carried out using condition combined (congruent/incongruent) spatial filters and the covariance matrix of all combinations of sensors at the latency of interest (Nolte, 2003). This LCMV beamformer produced a time series representing the magnetic fields at each of the 10 x 10 x 10 mm voxels within the individual participant brain while attenuating the influence of activity across the rest of the brain.

### 6.2.8. Statistical analysis at sensor and source space

Statistical comparison between congruent and incongruent conditions were carried out using a cluster-based permutation test with moving time window (P-level of 0.05), (Bullmore 1996; Maris and Oostenveld, 2007) using Matlab (MathWorks, Natick, MA) with open source Fieldtrip software (Oostenveld, Fries et al. 2011). Statistically significant results, where discussed below, refer to results of the cluster analysis with a p-threshold lower than p=0.05. As discussed in Chapter Four the cluster based permutation analysis implemented within Fieldtrip software is presented by Maris and Oostenveld (2007) as one method of controlling the family wise error rate without blunting the sensitivity of the statistical test. That is, using a cluster based permutation analysis, multiple comparisons are able to be made, such as typically happens when comparing conditions over many channel-time pairs in EEG or MEG data, without artificially inflating the likelihood of type II errors.

## 6.3. Results

A brief summary of the overall results is discussed here, with a more detailed reporting below. At sensor space level, an N400 effect was observed in both the SOA1 and SOA2 conditions, with greater ERF amplitude deflections observed in the case of incongruent compared to congruent prime-target pairings. For both SOA1 and SOA2 conditions, this effect was maximal in left frontal, temporal and parietal regions. At the level of source space analysis, an N400 effect

was only observed in the SOA1 condition and not in the SOA2 condition. In the case of the SOA1 condition, this effect was again maximal in left fontal, temporal and parietal regions.

For the prime identification task component of the SOA1 condition, the level at which participants correctly identified the prime words was not significantly different to the level at which they miss-identified prime words. This result indicates that the masked prime words in the SOA1 condition were adequately masked and invisible to participants. However, for the prime identification task component of the SOA2 condition, the level at which participants correctly identified the prime words was significantly higher than the level at which they miss-identified prime words. This result calls into question the status of the masked prime word as genuinely invisible to participants and undermines the ability of the over-all results to comment on the interaction of conscious and genuinely unconscious visual processes.

## 6.3.1. Behavioural results

### 6.3.1.1. Behavioural results. Prime identification task

The prime identification task results are dealt with first. Having dealt with issues of whether the masked prime words were genuinely invisible, reaction times and error rates for the SOA1 and SOA2 conditions are then presented. Broadly, the masked prime words were shown to be genuinely invisible for the SOA1 condition. The prime words status as genuinely masked and invisible for the SOA2 conditions is seen to be problematic. Five participants indicated that they were able to detect masked primes, when asked after conducting this test. Data from these participants were removed from further analysis. Having also previously removed the data sets of three participants due to strong and persistent motion artefacts, this resulted in a set of 12 participants who reported being unable to detect the presence of masked prime words. Using this behavioural data, statistical testing for masked prime visibility was carried out using repeated measure t-tests comparing Hit rate against False Alarm rate in the Prime Identification task. That is, t-tests compared the number of correctly identified masked

primes against the number of pseudo words falsely identified as real words. In the SOA1 standard experimental design, the Hit rate (M=9.7 ±1.21 sd) was not significantly different from False Alarm rate (M=8.3 ± 1.04 sd), indicating that masked prime words remained invisible in this condition (p = 0.7023, t=0.3923). However, in the SOA2 design, the Hit rate (M=16.8 ± 2.18 sd) was significantly higher than the False Alarm rate (M=10.4 ±1.45 sd) indicating that primes were detected at significantly higher rate than chance level (p =0.0036, t=3.6799). As a subsidiary enquiry, prime identification was also examined based on whether the prime word was congruent with, or incongruent from the visible target picture. In the SOA2 design, congruent primes were more identifiable compared to incongruent primes (p = 0.0020, t=4.0392) although not in the SOA1 design (p=0.1802, t=1.4312). That is, for the SOA2 design, masked real words were more successfully discriminated from pseudo words when the visible target picture was congruent with the prime but not when incongruent, despite identical masking parameters. The ramifications of this result for the overall experimental inquiry is addressed in more detail in the discussion section below.

**Table 6-1. t-test results comparing Hit and False Alarm rates in a prime word detection task in both the SOA1 and SOA2 conditions.**

| SOA1 Condition | Mean | SD | p-value | t-statistic |
|---|---|---|---|---|
| Hit Rate | 9.7 | 1.21 | 0.70 | 0.40 |
| False Alarm Rate | 8.3 | 1.04 | | |
| | | | | |
| **SOA2 Condition** | | | | |
| Hit Rate | 16.8 | 2.18 | <0.05* | 3.68 |
| False Alarm Rate | 10.4 | 1.45 | | |

Note. In a masked prime word detection task, statistically significant differences were observed between Hit Rates and False Alarm Rates in the SOA2 condition, but not the SOA1 condition. This result indicates that the masked prime words were detected at higher than chance level in the SOA2 condition, and may therefore have been inadequately masked. Asterisks indicate significance with $\alpha$=0.05.

## 6.3.1.2 Behavioural results. Main masked priming task: SOA1 & SOA2

Repeated measures t-tests were carried out on RT to the target pictures and on ER across both semantically congruent and incongruent conditions in the main masked priming tasks (SOA1 and SOA2). No significant differences were found in RT and ER when comparing Congruent and Incongruent conditions, in both the SOA1 and SOA2 experimental designs. t-tests for the SOA1 condition comparing RT for the Congruent condition (mean=0.64 ± 0.08 sd) compared to the Incongruent condition (mean=0.65 ± 0.09 sd) showed no significant differences (p>0.05, t =-1.78). Similarly, t-tests for the SOA2 condition comparing RT for the Congruent condition (mean=0.70 ± 0.10 sd) with those from the Incongruent condition (mean=0.69 ± 0.08 sd) also showed no significant difference in reaction time (p>0.05, t=0.62). Likewise, ER in both SOA1 and SOA2 designs showed no significant difference between Congruent and Incongruent conditions. For SOA1, ER for the Congruent condition (mean=1.7 ±0.80 sd) was not significantly different from the ER in the Incongruent condition (mean=1.8 ±0.73 sd) (p>0.05, t=-0.67). For SOA2, ER for the Congruent condition (mean=2.2 ±0.80 sd)

was also not significantly different from the error rates in the Incongruent condition (M=1.8 ± 0.74) (p>0.05, t=1.0).

**Table 6-2. t-test results comparing RT and ER for congruent versus incongruent prime-target pairs in both the SOA1 and SOA2 conditions.**

| | SOA1 Condition | Mean | SD | p-value | t-statistic |
|---|---|---|---|---|---|
| **Reaction Time** | Congruent | 0.64 | 0.08 | >0.05 | -1.78 |
| | Incongruent | 0.65 | 0.09 | | |
| **Error Rates** | Congruent | 1.7 | 0.80 | >0.05 | 1.0 |
| | Incongruent | 1.8 | 0.73 | | |
| | **SOA2 Condition** | **Mean** | **SD** | **p-value** | **t-statistic** |
| **Reaction Time** | Congruent | 0.70 | 0.10 | >0.05 | 0.62 |
| | Incongruent | 0.69 | 0.08 | | |
| **Error Rates** | Congruent | 2.2 | 0.80 | >0.05 | 1.0 |
| | Incongruent | 1.8 | 0.74 | | |

Note. No statistically significant differences in RT or ER were observed for congruent compared to incongruent prime-target pairs in either SOA1 or SOA2 conditions.

## 6.3.2. MEG derived source and sensor results

### 6.3.2.1. MEG derived source and sensor results for SOA1 condition

In the SOA1 experimental design, significant differences were seen in Congruent compared to Incongruent conditions. For sensor space analysis, conducted over the selected latency of 400 to 550 ms after target presentation, (see Methods section 6.25 & 6.2.6), a cluster based permutation analysis found one significant positive cluster (p = 0.01, table 6.3), which was maximal over the left frontal and superior temporal regions. Over this time period, this significant cluster appeared first in pre-fontal regions and progressed backward to encompass much of the left temporal region (Fig. 6.6). A source space cluster analysis conducted on event related fields within a grid of 10 x 10 x 10 mm source space voxels within the brain volume

found one significant negative cluster (p=0.019, table 6.3). This cluster was maximal within frontal as well as left superior temporal and parietal regions (Fig 6.7).

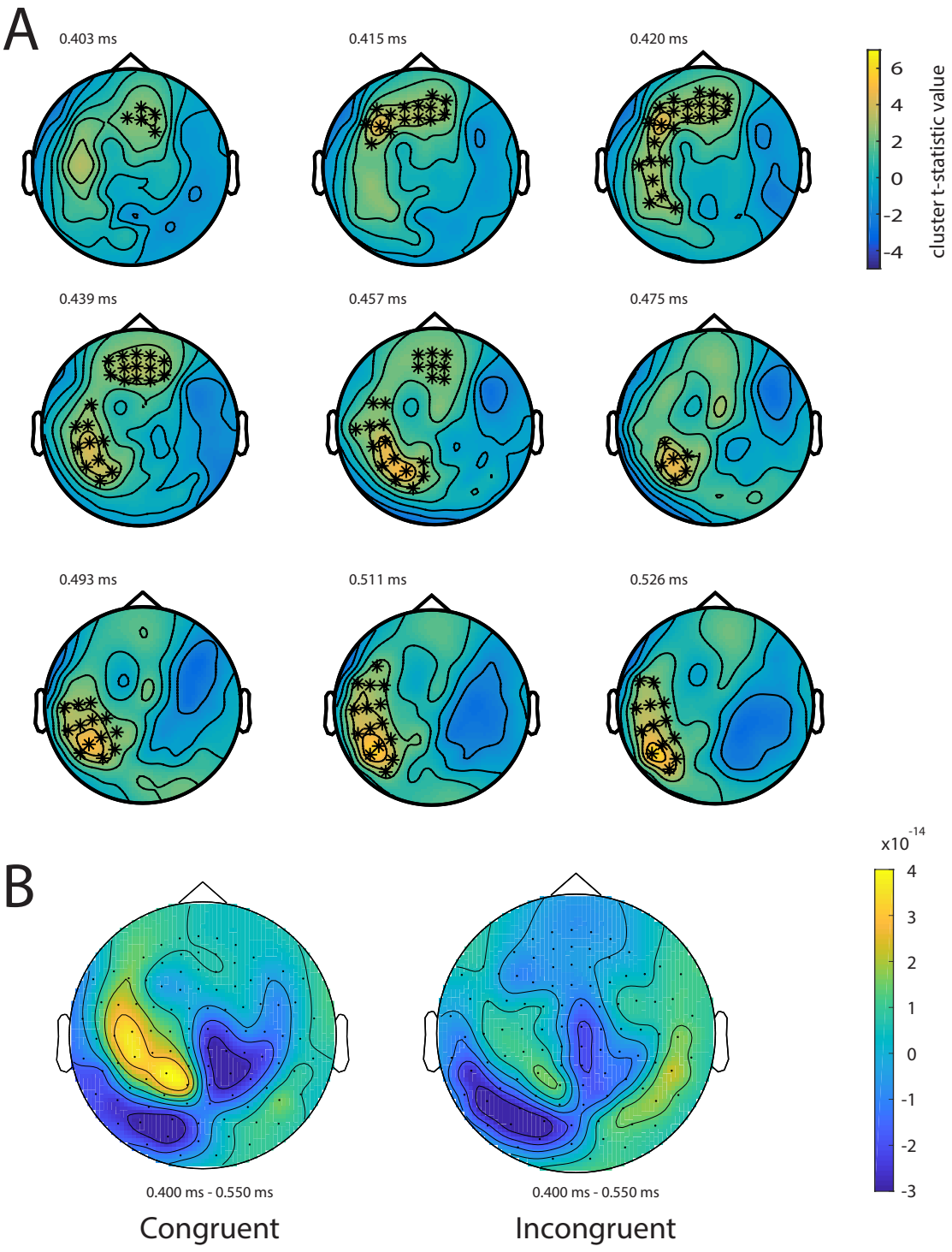



Figure 6-6. Topographic plots for SOA1 condition. A) Topographic plots of cluster t-statistic values derived from a cluster based permutation analysis comparing Congruent to Incongruent data averaged across all participants and calculated over a timeframe of 400 ms to 550 ms from target onset. Asterisks indicate channels that were part of the significant cluster of differences between Congruent and Incongruent conditions, calculated over this time period (p<0.05). B) Topographic plots of data from

Congruent and Incongruent conditions for SOA1 over a period of 400 ms to 550 ms after target onset, averaged across all participants.

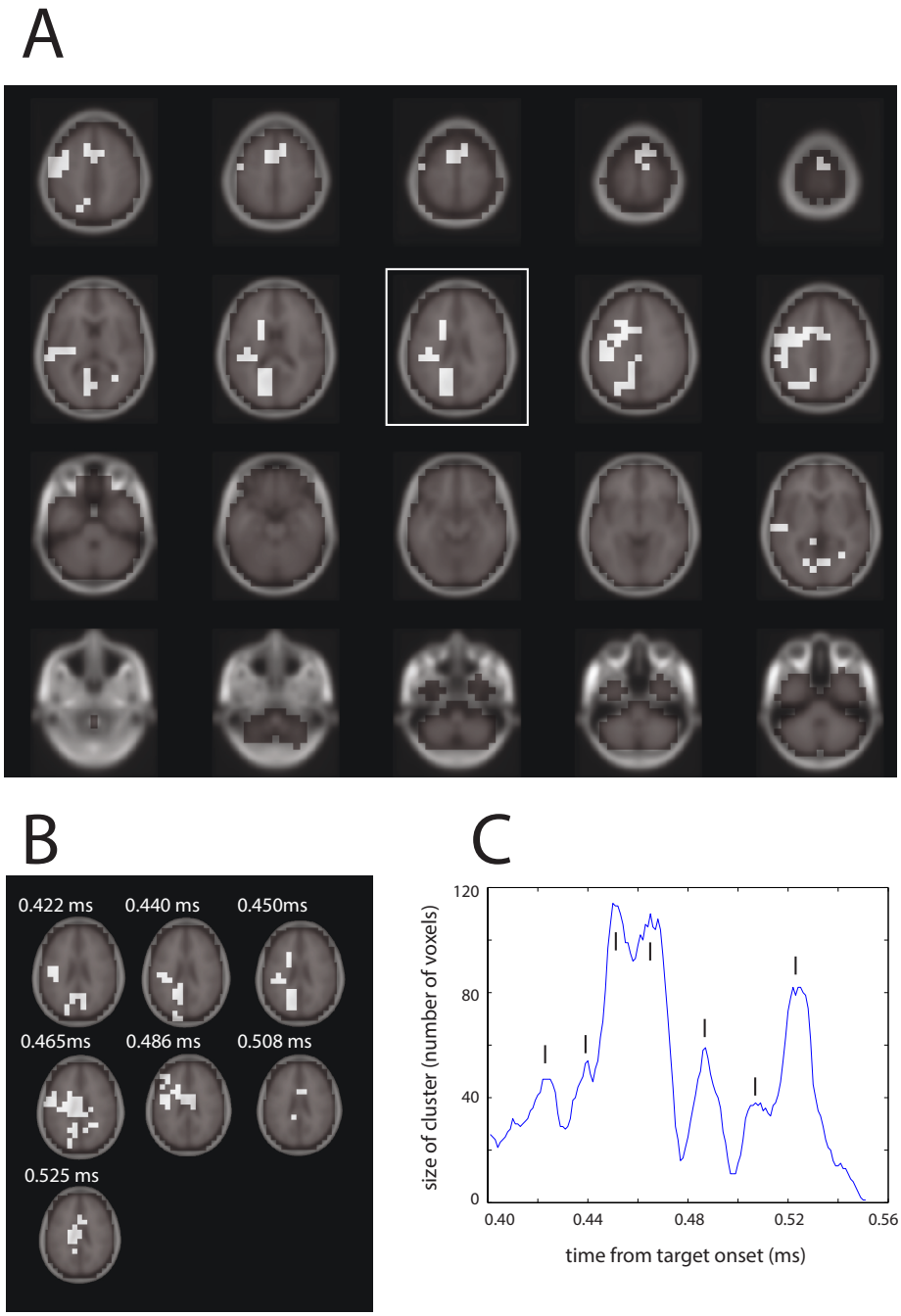



Figure 6-7. Source regions incorporated within a significant cluster of differences between Congruent and Incongruent conditions for all participants, derived from a cluster based permutation analysis calculated over a timeframe of 400 ms to 550 ms from target onset. A) Horizontal slices of a template brain of showing areas of the significant clusters of differences across all participants at a point in time 0.450 ms from target onset. The white box highlights the mid horizontal slice which is replicated at various different time points in figure 6.6b. B) Areas of the significant cluster of differences between

conditions at the same horizontal brain slice indicated in the white box in figure 6.6a, across time points of peak cluster size. C) Cluster size over time, showing the number of points in the 10x10x10mm grid within the brain volume that were part of the significant cluster of differences between Congruent and Incongruent conditions across all participants, from 400 ms to 550 ms post target onset. The marked peaks represent the time points represented in 6.6b.

### 6.3.2.2. MEG derived source and sensor results for SOA2 condition

Significant differences in N400 amplitudes were also seen when comparing Congruent to Incongruent conditions in the SOA2 design. However, these significant differences were seen only at sensor level data. No significant differences in N400 amplitudes were observed between Congruent and Incongruent conditions for source space data in the SOA2 condition. Possible reasons for this are discussed below. Over a latency of 500 to 650 ms after target presentation, a cluster based permutation analysis conducted on sensor level data found one significant negative cluster (p=0.04, table 6.3.). This cluster again appeared maximally at left frontal and superior temporal regions (Fig. 6.8). As in SOA1, this cluster also appeared first in pre-fontal regions and progressed backward over time to encompass broader left temporal region of activity. No significant cluster was found at a source-based level of analysis for the SOA2 condition.

**Table 6-3. Statistical values derived from cluster based permutation analysis for both SOA1 and SOA2 conditions, comparing N400 ERF amplitudes in Congruent and Incongruent conditions.**

| | p-value | cluster statistic |
|---|---|---|
| **SOA1 Sensor space cluster** | 0.01* | 1.02e+03 |
| **SOA1 Source space cluster** | 0.02* | =1.96e+04 |
| | | |
| **SOA1 Sensor space cluster** | 0.04* | -750.55 |
| **SOA1 Source space cluster** | 0.57 | 4e+03 |

Note. Asterisks indicate significance with $\alpha$=0.05. These results indicate a significant N400 ERF effect in the data at both sensor space and source space in the SOA1 condition, but only in the analysis of sensor space data for the SOA2 condition.

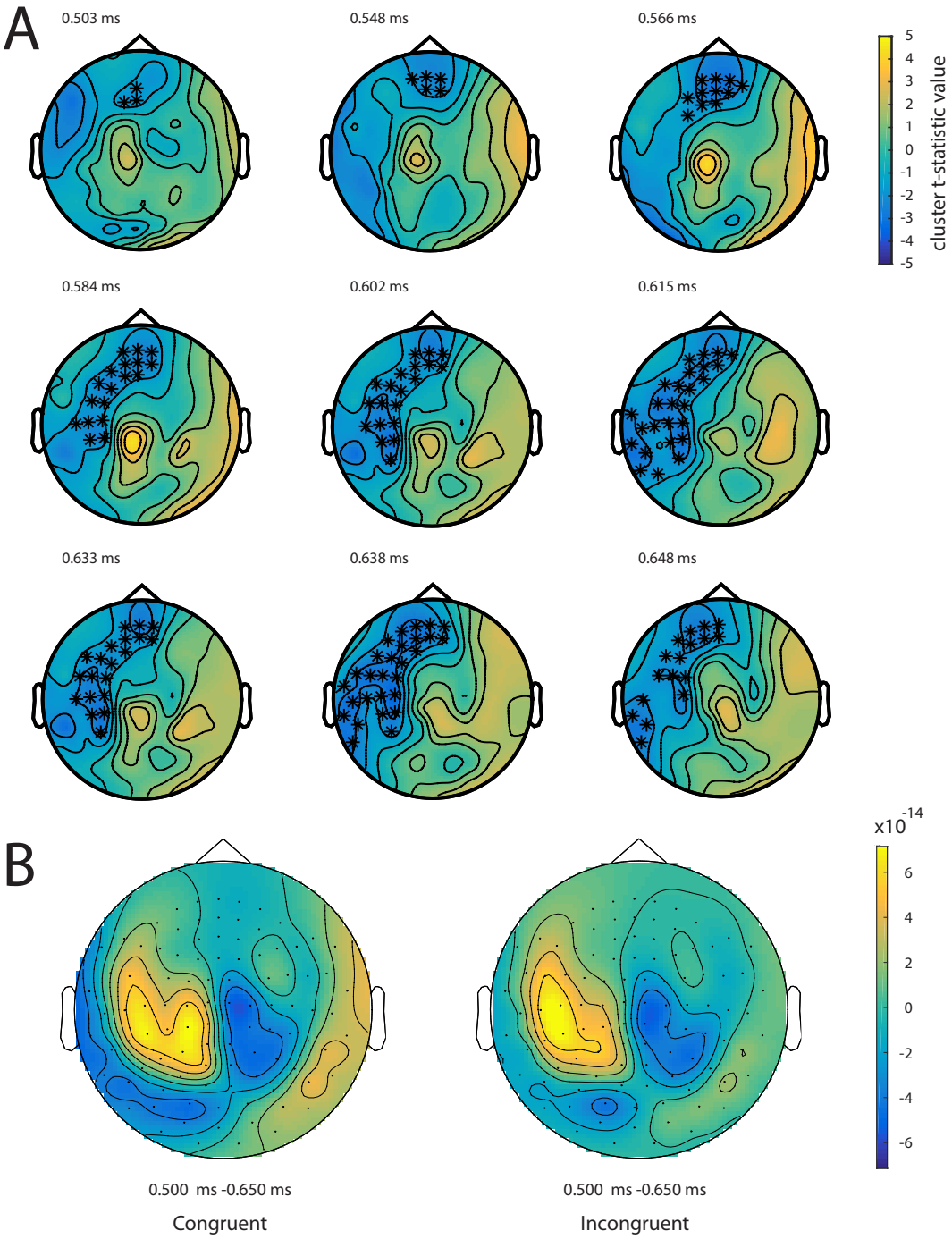



Figure 6-8. Topographic plots for SOA2 condition. A) Topographic plots of cluster t-statistic values derived from a cluster based permutation analysis comparing Congruent to Incongruent data averaged across all participants and calculated over a timeframe of 500 ms to 650 ms from target onset. Asterisks indicate channels that were part of the significant cluster of differences between Congruent and Incongruent conditions, calculated over this time period ($p<0.05$). B) Topographic plots of data from Congruent and Incongruent conditions for SOA2 over a period of 500 ms to 650 ms after target onset, averaged across all participants.

## 6.4. Discussion

Both subjective reports along with the objective results from the masked prime identification task indicate that in the SOA1 design, the masked primes were not visible to participants. Therefore, the following discussion of the SOA1 design results below can be undertaken with the assumption that these masked primes were genuinely invisible to participants. For the SOA2 design however, the masked prime words were not shown to be genuinely invisible. Participants indicated that they had been subjectively unaware of the presence of the prime words during the task. However, objective measurements of prime visibility in the prime identification task indicate that masked primes may have been partially visible to participants during the identification task. In this case, correct identification of masked prime words occurred at a significantly higher rate than miss identified pseudo words during the prime identification task. These results may have arisen due to the prime word and target picture being both spatially and temporally superimposed. That is, the prime word and target picture occurred on the presentation screen both at the same time and the same location. It is likely that this may have focused participant's attentional resources on the prime word, despite it being heavily masked. Overall, the results of the prime identification task in the SOA2 condition indicate an above chance level of prime word identification. Given these results, whether the SOA2 experiment represents genuinely unconscious priming may be called into question. This undermines the strength of the results of the experiment to comment on the relationship between conscious and non-conscious processes within the overall gestalt of qualitative experience.

Nevertheless, the contradictory results from subjective and objective measures of prime word detectability in the SOA2 experiment indicate the limitations inherent in tasks that assess masked prime visibility. Several previous reviews have raised the issue that an above chance performance at masked prime identification can arise simply due to non-conscious influences. (Cheesman & Merikle, 1986; Kouider & Dehaene, 2007). This has the effect of making objective thresholds an extremely conservative index of masked prime visibility. While the SOA2 prime identification task indicated that primes may have been partially visible, in both designs a majority of participants indicated that they were not at all

aware of the presence of the masked prime words, when asked following task performance. Only data from participants who indicated that they had not consciously seen the masked prime was included in the remaining analysis.

Further to this, a difference in the allocation of attention between the prime identification task and the main task could also account for these discrepancies. In the main task, attention was directed towards the target picture while participants effectively ignored the mask-prime sequence. However, in the prime identification task, participant's attention was directed at the prime word sequence, effectively lowering the likely threshold for conscious access. Broadly, these considerations suggest that the objective prime identification task may have been an overly conservative index of conscious access of masked prime words.

The results from the SOA1 experiment serve to confirm and replicate results from previous studies demonstrating unconscious priming mechanisms influencing processes assumed to be relevant to a semantic level of processing (Deacon, Hewitt et al. 2000; Kiefer 2002). Invisible prime words were able to be processed to a semantic level. This activity interacted with neural processing of incongruent target pictures, resulting in an N400 effect at both sensor and source level's. In line with previous literature, activity associated with this effect were localised to left temporal regions (Maess, Herrmann et al., 2006; Van Petten & Luka 2006; Kutas & Federmeier, 2011). Both congruent and incongruent conditions showed a dipole source of activity located in the posterior temporal region at around 400 ms post target onset. While this dipole is weaker in the congruent Condition and persists only for 100ms, the dipole focus of activity in the Incongruent condition continues for around 200ms and progresses forward to anterior temporal regions over this time (Fig. 6.6b). Clusters of significant differences in activity between Congruent compared to Incongruent conditions show the pattern of differences appearing first in prefrontal regions and progressing posterior, to connect with and involve activity in left anterior temporal and parietal regions (Fig. 6.6a.) This pattern of activity broadly conforms to previous studies investigating N400 effects and likely represents post lexical

sematic integration and the processing of language related semantic violations (Kiefer & Spitzer, 2000; Hunt et. Al., 2013).

While the SOA1 experimental condition served primarily to test design parameters and replicate previous N400 results, the SOA2 design represented the condition of primary interest. An N400 effect (significantly greater N400 ERF amplitudes for semantically Incongruent to Congruent conditions) was observed in the SOA2 condition for sensor level data but not for source level data. As a significant experimental finding, the neural processing of subliminally detected semantic incongruence was able to be observed in an N400 ERF effect within sensor level data, even when the subliminal and supraliminal components of this processing were temporally superimposed, e.g. in the SOA2 condition. The sensor level results from the SOA2 design suggest that temporal and spatial regions of activity that previous models have correlated with consciousness (Dehaene & Changeux, 2011), here include an interaction between both conscious and unconscious activity.

However, this result was not able to be replicated with a source space analysis in the current study. This failure to detect an N400 effect in source space data in the SOA2 condition, alongside the significant detection of an N400 ERF effect at sensor space in the SOA2 condition, suggests that this null finding may have arisen due to failures in the analysis pipeline. For example, it may have been that motion artefacts were not able to be effectively removed and this may have undermined accurate source space reconstruction of the magnetic fields. Additionally, the status of the masked prime words as genuinely invisible to participants remains problematic for the results of the SAO2 condition. Participants reported that subjectively they were unaware of the presence of the masked prime words, indicating that the prime words were processed subliminally. However objective results from the prime identification task indicated that the masked prime words were partially being processed at a supraliminal level and hence that the primes were partially visible. This may have been due to the word-picture overlap as discussed above. The strength of claims that this data shows an interaction between supraliminal and subliminal processes during the same temporal window is undermined because the processing of the prime words cannot be unequivocally classified as subliminal.

A methodological criticism of experiment 4 arises in that for the N400 congruency effect, prime and target stimuli both interact and this calls into question which stimulus should be judged to be the prime and which the target. This is an issue where analysis is performed on p300 peaks of the stimulus judged to be the target. That is, it could be reasoned that the post target 50 ms prime presentation in the SOA2 condition is in fact simply a regular 50 ms separation between an inverted prime/target pair.

However, this should not prove problematic for this study because the designation of which stimulus is the prime and which is the target is not important to the logic of the experiment. What is important is that neural processes occurring 250 ms after an invisible stimulus should be occurring at the same time as processes occurring 300 ms after a visible stimulus. In this case, non-conscious processing of a masked stimulus is temporally superimposed with the processing of the visible stimuli. The N400 congruency effect can be used to judge whether these processes interact, regardless of which stimulus is deemed the prime and which the target.

Additional methodological issues arise in light of recent discussions of the conflation of multiple different neural processes within what has traditionally been viewed purely as the neural correlates of consciousness (Aru, Bachmann, Singer, & Melloni, 2012; de Graaf, Hsieh, & Sack, 2012). Aru et al., (2012) and de Graff, Hsieh & Sacks (2012) have recently criticised traditional contrastive studies into conscious perception for including within the NCC, neural processes which may necessarily precede perception or those that follow as a consequence of perception but which in fact do not represent the neural substrate of consciousness itself. For example, contrastive studies where a perceived condition is distinct from a non-perceived condition have traditionally been used to determine some signature or correlate of conscious perception (Del Cul, Baillet, & Dehaene, 2007a; Martens, Ansorge, & Kiefer, 2011). This approach is also used in the current thesis. However, Aru et al., (2012) has suggested that processes previously understood to represent the NCC varied in response to altering cognitive processes that precede perception, such as attention or expectation. In this case Aru et al., (2012) suggest that what had been taken to be the NCC, in fact included both the NCC

proper, and the neural correlates of processes that are merely the prerequisite to consciousness, referred to there as 'NCC-pre'. Similarly, Medial Temporal Lobe (MTL) processes have been shown to follow as a consequence of conscious perception and be distinct from the NCC proper (Postle, 2009). However, MTL processes can take place within 300ms of a given stimulus (Quiroga, Mukamel, Isham, Malach, & Fried, 2008) and this places these processes within the window of activity previously associated with p300 ERP peaks and conscious perception (Del Cul, Baillet, & Dehaene, 2007b). In this way, again it is suggested that the NCC described by Del Cul, Baillet & Dehaene (2007) in fact include processes that are merely consequential to consciousness ('NCC-co') but not in fact part of the underlying physical substrate of consciousness itself. This distinction between NCC-pre, NCC-co and NCC proper suggested by Aru et al., (2012) is a relatively new theoretical position and was only entering the literature at the time that the experiments in this thesis had largely been conceived and designed. For this reason, this distinction has not been taken into account in the design of the studies included in this thesis and this potentially undermines the results of experiments in Chapters 4 to 6.

Of particular importance to the experiment 3 and 4 in the current thesis, a recent study (Melloni, Schwiedrzik, Muller, Rodriguez, & Singer, 2011) presented evidence that working memory processes altered the time frame of neural processes underlying consciousness. Melloni et al., (2011) suggested that late waves of EEG activity occurring around 300ms after a given stimulus may in fact represent the NCC-co, not the NCC itself. Because experiment 3 and 4 drew explicitly on the theory of Dehaene & Chaangeux (2011) and Del Cul, Baillet & Dehaene (2007) and relied heavily on the idea that p300 peaks represent the window of neural activity associated with conscious perception, these newer findings in Melloni et al., (2011) are particularly problematic for the current thesis. Melloni et al., (2011) found that when a stimulus was already represented in working memory, in this case p300 ERP peaks were not greater in perceived compared to not perceived conditions. Rather, it was waves of activity in the EEG occurring around 200ms in these conditions that distinguished perceived from not perceived stimuli. This challenges the previously accepted theories of Dehaene & Chaangeux (2011) which framed the NCC temporally as those processes occurring from around 300ms after a given stimulus. Rather, these new findings in fact suggests that these late waves may

represent the NCC-co. If the reasoning suggested in Melloni et al., (2011) holds, this would undermine the basic logic of experiment 3 and 4 because these studies explicitly relied on a distinction between post 300 ms and pre 300 ms waves of activity representing conscious and non-conscious processes respectively.

More recent experimental approaches in the wake of the distinction in Aru et al., (2012) between NCC-pre, NCC-co and the NCC, have sought to tease apart potential underling conflation of processes. Some of the approaches taken up in Melloni et al., (2011) and suggested in Aru et al., (2012) could have been employed in strengthening the experimental methodology used in experiments 1 to 4 and in this way, make more robust any claims that this thesis has been able to make regarding the structure of consciousness. One approach Aru et al., (2011) puts forward to distinguish between the NCC and the NCC-pre, is to examine neural processes taking place while varying the sensory modality, for example from visual to auditory stimulus presentation. Because de Graff, Hsieh & Sacks (2012) and Aru et al., (2012) define consciousness in terms of phenomenal content, any neural process that remains unvarying, while sensory modality is altered, must represent the prerequisites for consciousness, not the NCC itself. This is the case for example in activity in the PFC which is suggested to play a causal role in conscious perception (Dehaene and Changeux, 2011). Aru et al., (2012) also suggest including experimental conditions that manipulate pre-sensory behaviour in the participant. If this alters neural activity previously associated with the NCC, then such activity may be thought to be a better candidate for the NCC-pre, than the NCC proper. This is exactly the approach taken in Melloni et al., (2011). Here, within a contrast between 'perceived' and 'not perceived' conditions, the effects of attention versus expectation were also examined. Short-latency event related potentials were examined within a perceived/not-perceived and expectation/attention matrix of conditions. Neural signatures differed across 'expectation' and 'attention' conditions, and Melloni et al., (2011) took this to suggest that this neural activity, previously associated with conscious perception (Pins & Ffytche, 2003), should more likely be considered to represent pre-requisite processes leading into the NCC proper.

The theoretical distinction between NCC-pre, NCC-co and the NCC has been a useful addition to approaches within the neuroscience of consciousness and has been taken up widely in the literature (Aru et al., 2012; Melloni et al., 2011; Ruhnau, Hauswald, & Weisz, 2014; Sandberg, Andersen, & Overgaard, 2014). It is likely that including the newer methodological approaches suggested in Aru et al., (2012) would have strengthened the results of the experiments undertaken in this current thesis.

However, it should also be pointed out that this approach relies on explicitly defining consciousness in terms of qualitative content (de Graaf et al., 2012, p 192, Aru et al., 2012, p 738) and this is a position that is philosophically argued against in chapters 1 and 2 in this thesis. That is, the implicit a priori position of de Graaf et al., (2012) and Aru et al., (2012) is that consciousness is a collection of positive phenomenal facts and is distinct from any non-representational processes which may underlie these phenomena. Thus, a Cartesian distinction is established between consciousness and non-conscious processes, the latter of which in the case of Aru et al., (2012) are now defined as pre or post conscious and these are sought to be disambiguated from the NCC. The position laid out in Chapters 1 and 2 in this thesis is that consciousness should not be thought of as explicit representational content but as a dynamic that necessarily includes a background of non-representational and cognitively impenetrable content and processes. From this perspective, it is not clear to what extent the theoretical distinctions in Aru et al., (2012) provide clarity to the experimental community or continue philosophical biases and assumptions that already mark the literature. This highlights the way in which philosophical problems remain implicit within empirical approaches towards the science of consciousness and are often extremely hard to disentangle from these.

Regarding the results of experiment 4 in this thesis, the subjective reports taken alongside the statistically significant interaction between supraliminal and subliminal semantic information in the suggests a more nuanced and less dichotomous characterisation of the relationship between conscious and non-conscious processing. The GNWS model (Dehaene & Changeux 2011) correlates consciousness with a profile of a late global P300 event related potentials associated with an all or none ignition of prefrontal-parietal networks along

with an amplification of related sensory cortices. An implication of this model is that early sensory driven activity prior to global ignition around 300ms, represent purely nonconscious processing. In the SOA2 design, the presentation of the invisible prime is negatively offset with respect to the visible target, such that the processing of the prime word occurring < 250 ms overlaps with p300 window associated with the processing of the visible target picture. This activity encompasses prefrontal and parietal networks along with left occipito-temporal regions associated with visual word form processing and can therefore be approximately included in the GNWS. Clearly, in the stream of perceptual processing associated with ongoing interaction with an environment, early non-conscious bottom up sensory activity at any point in time will be occurring concomitantly with other processes correlating with consciousness. However, the results from the SOA2 design task at a sensor space level of analysis, show a dynamic interaction between both conscious and non-conscious processes (indexed by an N400 effect) occurring within the same temporal and spatial window of activity associated with the GNWS. These processes occurring at the same time and in similar gross anatomical regions give rise to an interaction effect indexed in the N400 effect. This N400 activity continues to be associated with the same prefrontal-parietal network along with left temporal regions.

This is a novel finding despite the methodological problems regarding prime invisibility. Such results require more investigation and raise the question of a more nuanced picture of the representation of conscious perception at a neuronal level. These findings lend tentative support for a model in which the structure of phenomenal experience, typically referred to as 'consciousness', subsumes the boundary and distinction between consciousness and unconscious processes. Broadly the GNWS model (Dehaene & Changeux, 2011) represents a categorical neuronal differentiation between consciousness and non-conscious processes. Neural activity which has either not exceeded a threshold required for global ignition, or activity which is not able to be part of a globally distributed network is considered to be non-conscious. As categorically distinct from this are neural processes that have become part of a globally distributed network of activity correlating with conscious perception. Such a model supports a categorical and essentially dualistic or tripartite differentiation between consciousness and non-conscious/pre-conscious neural processes. The results presented in

this chapter suggest a consideration of qualitative human experience as a dynamic that subsumes the boundary and distinction between conscious and non-conscious processes. Such findings provide some support for the hypothesis examined in this thesis that a significant element of the structure of consciousness is not itself conscious.

The hypothesis of a gestalt of conscious and non-conscious processes arising as a singular phenomenon also allows other results in the literature to be re-examined in a new light. Zeki (Zeki, 2008; Zeki et al., 1991) for example presents a case for consciousness arising in the brain as a multitude of spatially and temporally disjointed units of micro-consciousness. Such an atomic approach to consciousness, piecing the overall phenomenon together from a collection of clearly demarcated perceptual units would certainly appear to fly in the face of a Heideggerian analysis. Evidence for the micro-consciousness theory in Zeki (2008), arose initially from lesion studies where for example lesions in areas V4 and V5 of the visual cortex lead selectively to achromatopsia and akinetopsia respectively. Similarly, the manner in which the visual motion centre V5 received direct visual inputs that bypass the primary visual cortex is also presented by Zeki, (2008) as undermining the idea that consciousness is a unified phenomenon that must be subserved by a unifying biological mechanism of perceptual binding. Zeki, (1991, 2008), also presents a range of other animal and non-invasive human studies supporting this notion of consciousness as a disparate collection of micro-perceptual units. However, such a reductive view of consciousness and human meaning presents in almost a direct opposition to the position laid out by Heidegger in Being and Time and throughout his writings (Heidegger, 1962). The case made by Heidegger is that unlike other objects in nature which may be grasped reductively, human experience exists as an understanding of Being and not as an object of any sort. This implies that human experience arises only on the basis of a non-explicit grasp of background significances that cannot be explicitly represented. Whether these non-representable background significances are understood in terms of implicit social contexts or as a salient absence within the structure of consciousness, the point here is that this precludes human experience from being understood as made up of explicit demarcated components fitting together in a mechanistic way. Heideggerian phenomenology would appear to conflict with the theory of consciousness laid out in Zeki (Zeki, 2008, 2015a, 2015b). Whether this is due to a failure of philosophy to map

onto the biological facts, or a failure of scientific theory to adequately consider phenomenology is a moot point.

An exception to the above could be if the idea of micro-consciousness in Zeki (2008) were viewed as a type of 'unconscious-consciousness'. In this case, the notion of micro-consciousness may to an extent also break down the Cartesian dichotomy between conscious and non-conscious processes that is present in much of the literature. Zeki (2008) describes consciousness in terms of a hierarchy of multiple levels of combined micro-conscious components. For example, single attributes such as colour are referred to as units of micro-consciousness. Sitting above these in the hierarchy are posited to be macro-consciousness-conglomerate attributes such as bound percepts of colour and form. Atop all of these is situated 'unitary consciousness' – described as the self-representing subject at the apex of the hierarchy. This 'unitary consciousness' is compared to Kant's synthetic transcendental ego (Kant, 1885). In as much as Zeki (2008) suggests that the multiple distributed components of micro-consciousness ontogenetically precede the sense of oneself as the perceiving subject, one may consider to what extent they represent a type of 'unconscious consciousness'. By such a view, consciousness would not categorically emerge and disambiguate itself from non-conscious processes, but rather consist of a type of non-conscious consciousness or sentience. That is, in the process of the development of the organism, micro-consciousness in the absence of the sense of the self as the perceiving subject may represent a level of awareness comparable to a background understanding of Being in the absence of explicit cognition. Such a view would be in alignment with elements of the position laid out by Heidegger, because in this sense there could be said to be a cognitively impenetrable evasiveness at the heart of the phenomenon of a conscious self. However, this position was not explicitly suggested by Zeki (Zeki, 2008, 2015a, 2015b)

A similar case may be made for other suggestions of a type of 'unconscious consciousness' in the literature. Elsewhere in the literature, some theorists have posited a level of sentience that whilst exhibiting mind-like interiority (thus being able to be viewed as a type of consciousness) that at the same time does not manifest as full self-referencing subjectivity (thus also being viewed as non-conscious) (Deacon, 2012; Oizumi, Albantakis, & Tononi, 2014)

Thompson, 2007). Thought of in terms of the ideas laid out in this thesis, the notion of 'unconscious consciousness' becomes more clearly elucidated in terms of the structural need for hiddenness or opacity at the heart of the phenomenon of consciousness. For example, in the Integrated Information Theory (Oizumi et al., 2014) consciousness simply manifests across a spectrum of degrees of integrated information. Even a photodiode may possess a low level of consciousness in that it integrates information and is responsive to its environment. Oizumi et al., (2014) posit a level of minimal-consciousness to take into account this idea of budding components of sentience that have yet to bloom into a recognisable subjective consciousness. However, the essentially *non-conscious* aspect of this minimal-consciousness does not play any important role in the final phenomenon. This is so in that according to this theory full consciousness does not structurally rely on the presence of a level of hiddenness or cognitive opacity in its make-up. This theory shares with others a view of the possible existence of a type of 'non-conscious consciousness' as merely a partial and incomplete development towards full subjective consciousness (Deacon, 2012; Oizumi, Albantakis, & Tononi, 2014) Thompson, 2007). However as presented in this thesis, the cognitive impenetrability and inability to fully self-represent may be understood as a necessary and characteristic aspect of the way of existing that consciousness has. In this sense, 'unconscious-consciousness' plays a necessary rather than incidental role in the phenomenon of full qualitative human experience.

Dehaene & Changeux's GNWS (2011) theory has been invoked numerously in this thesis as an example of a model which derives philosophically in part from Descartes. Yet the data in support of GNWS is strong (Del Cul, Baillet & Dehaene, 2007; Kouider & Dehaene, 2007; Dehaene & Changeux 2011). Amongst the range of theories of consciousness, the GNWS remains one of the most empirically useful models because of the specific and highly testable biological frameworks it employs. Does this then argue against the current thesis? The predictions of GNWS do indeed conflict with the results of experiment 4. Data presented within the framework of the GNWS theory numerously show a clear bifurcation in states from non-conscious to conscious and presents a workable tripartite theory to account for this. Relatively demarcated states exist in non-conscious, sub-conscious and conscious content and processes. According to this well validated theory, the conscious state does emerge in a

disambiguated way from previous non-conscious processes and convincing data has been presented to support this dualistic or tripartite framework.

However, to compete effectively with the GNWS model requires stronger data than has been produced in experiment 3 and 4. As noted, source space data in particular was weak due to motion artefact and this undermined the conclusions in experiment 4. Similarly, the small sample size used in both experiment 3 and 4 may have undermined the analysis from detecting a genuine effect, if a genuine effect did in fact exist. At best the results presented in experiment 3 and 4 were equivocal and require substantial methodological improvement to be able to genuinely challenge prevailing theories of consciousness in the literature.

Alternatively, if the hypothesis of a gestalt of conscious and non-conscious processes arising as a singular phenomenon is valid, does the strength of the results supporting the GNWS suggest that that model does not cleave to Cartesianism as strongly as has been suggested here? The authors of the GNWS theory may in fact accept that whichever part of the brain correlates with consciousness, it may do so only due to its relationship with the background physiology of the brain and body. In this sense, even within the GNWS theory consciousness may be viewed as only ever arising as a shared ontology and relationship between conscious and non-conscious processes. In this case, the characterisation in this thesis of the GNWS as relying on a dichotomous and Cartesian split between consciousness and non-conscious processes may be overstated.

However as has been noted above, the GNWS theory does explicitly frame itself as a dualistic or tripartite theory (Dehaene & Changeux, 2011; Dehaene & Changeux, 2004; Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006). That is, initially the framework was one of neural processes categorically emerging from dissociated non-conscious modules of activity, into globally connected patterns of activity that correlate with consciousness (Dehaene & Naccache, 2001). This dualistic position was later re-framed as a tripartite model, to account for a distinction between pre-conscious and non-conscious processes. Non-conscious processes were those for example taking place in the cerebellum which were structurally unable to ever become part of the global workspace underling consciousness. Pre-

conscious processes by contrast where those processes which structurally could be included in the global workspace, but which due to attentional allotment, remained outside of a given moment of conscious awareness. An example of these could be processes taking place in the auditory cortex due to sounds in the environment, but which due to a focus of attention on vision may remain dis-connected to the currently active global workspace of activity, and hence remain temporally outside of conscious awareness. Regardless of whether the model is examined in its dualistic or tripartite version, the theory explicitly relies on the notion of a bifurcation and thus clear disambiguation between what consciousness is, and the existence of non-conscious or pre-conscious content and processes. Clearly, at a biological level there cannot be a categorical split here between consciousness and non-consciousness, otherwise the organism would literally be split in two. Nevertheless, the model presented in the GNWS theory does rely on a biological representation of consciousness as a collection of reportable positive phenomenal facts that are qualitatively and ontologically distinct from other non-conscious processes in the brain. In this sense, the model does commit to a philosophical stance informed by Descartes even if the biological facts of an organism necessarily implies a constant interaction between conscious and non-conscious processes.

Clearly the results in experiment 4 in the current chapter are far from unequivocal. While sensor space analysis show an interaction between conscious and non-conscious processes in both SOA designs, motion artefacts undermine a clear result in source space analysis. Moreover, the status of the masked prime words as genuinely invisible remains problematic for this study. More extensive piloting of the experimental protocol may have been able to eliminate this significant methodological confound. As discussed above, this failure to conclusively mask the primes may have been due to the temporal and spatial overlap between prime and target presentation as well as due to the use of an overly conservative measure of conscious access. However, the possibility also remains that the threshold of conscious access for the masked prime words is lowered precisely because the activity is taking place broadly within the temporal and spatial window of neural activity associated with the Global Neuronal Workspace. Were this the case, this would in fact reinforce a model in which the GNWS represents the neural correlates of consciousness in an all or nothing fashion.

Spatially and temporally superimposing the prime word and target picture was an inherent methodological challenge for this study. The primary experimental question concerned the interaction of subliminal and supraliminal processes that were occurring within the same time window. Given the very brief presentation time for the prime word, this necessitated that the prime word and target picture occur on the screen at the same time. As discussed above, this methodology may have lowered the level of processing required for conscious access making it easier to consciously detect a masked prime. This methodological flaw could have been counteracted by masking the prime more heavily during this time. Stronger masking parameters could for example be achieved through use of a more distracting masking stimulus than the random letter strings used in this study. Alternatively, the prime word could have been more heavily masked by presenting it for a shorter period of time. However, this in itself runs up against experimental hardware constraints given that the prime was already only presented for 35 ms.

Reconstructing magnetic fields recorded at the MEG sensors to fields as they would occur within the brain using signal-space filtering is in itself a complex process. Confounds or undetected errors in the analysis pipeline may have been responsible for the null finding at source space in the SOA2 experimental condition. As discussed above, this null finding besides the positive experimental finding for the same data at a sensor level of analysis may also have been due to imperfect removal of motion artefacts from the data. This possible confound underscores the value of methods such as those explored in Meyer et al., (2017) where by flexible head casts may be employed within the spacious MEG dewar in order to absolutely minimise head movements during MEG recording.

However, despite these unresolved issues with the current study, the primary intention and value of this experiment is in raising the issue of ontology as relevant and important in the study of consciousness. Many of the current approaches to consciousness maintain unexamined assumptions about the nature and structure of consciousness that have been active since at least the time of Descartes. Such approaches start with an unexamined preconception about what consciousness is, and proceed to examine neural activity on the

basis of this assumed ontology. Heidegger raises the question of ontology specifically in regards to understanding the existence of human experience. Yet the body of his work remains largely unexamined within the science of consciousness. The primary intention of the current study then has been to raise this issue theoretically, and make an initial effort to draw a link between theory and possible empirical approaches.

## 6.5. Conclusion

Elements of Heideggerian thought have been used to inform an enquiry into the issue of the ontology of consciousness. Heidegger's thinking surrounding *abgrund* (groundlessness), *offenheit*, (openness) and *lichtung* (clearing) dealt with in Chapter Two, have been interpreted here in terms of the notion of a shared ontology between conscious and non-conscious states. Broadly, such a theoretical orientation argues against consciousness and unconscious processes existing as dichotomous and mutually distinct ontologies. This theoretical orientation was investigated here through examining the relationship between conscious and unconscious processes. Masked prime words were offset with regards to visible target pictures such that the unconscious processing of the primes was temporally superimposed over the processing of the visible target stimuli. That is, the experimental protocol was designed such that the unconscious and conscious neural processes relating to these specific stimuli take place within the same temporal and spatial window. The level of interaction of conscious and non-conscious processes taking place within the same temporal and spatial window of activity associated with the GNWS (Dehaene & Changeux, 2011) is indexed through an N400 effect. A high level of interaction, indexed by a strong N400 effect, for processes which are both reportable (conscious) and non-reportable (non-conscious) would be in support of such a model, or at least encourage further study. Conversely, a low level of interaction, indexed by the absence of an N400 effect, again from both conscious and non-conscious processes occurring in the same temporal and spatial window, would provide evidence against a model of shared ontology. The results from this study did show an N400 effect, arising between conscious and nonconscious processes taking place within the temporal and spatial window of activity associated with the GNWS. However, due to a number of methodological issues, the status of the masked prime words as genuinely invisible

remains problematic for this study. The results of this study can be taken to provide some preliminary evidence against dichotomous mutually distinct ontologies for both conscious and nonconscious processes. Rather, these results are in line with a view in which qualitative experience, in its existential structure, could be thought to cross or subsume the division between what we conceptualise as conscious and unconscious processes in the first instance. In human terms, such an approach would suggest that consciousness is not entirely transparent to itself and therefore would not exist as a self-contained unit of subjectivity. The prevailing view in which consciousness is conceived to exist as a reified and self-contained unit of subjectivity represents an implicit starting point for much of the research in the field of consciousness studies. Such a view of consciousness is questioned by the current study. Despite methodological issues in this study, the primary intention has been to raise the question of ontology as relevant and important in the scientific study of consciousness.

# Chapter 7
# Conclusion

Heidegger's critique of the traditional Western ontological tradition has been examined. Some of the ways in which this tradition has characterised the existence of human experience has been explored and an alternative characterisation of the existence of experience, based in elements of Heideggerian thought, has been put forward. This broad theoretical orientation was simplified to a hypothesis that qualitative experience arises as a mutually instantiating gestalt of conscious and non-conscious mental and material processes. This hypothesis was tested by selecting a characterization of the neural correlates of qualitative experience, for example the GNWS (Dehaene & Changeux, 2011) and then examining the extent to which this neural activity arises as a relationship between conscious and non-conscious processes. Experiments 1 and 2 revealed an increase in alpha-beta synchrony in the EEG associated with the conscious perception of a given stimulus. Alpha-beta synchrony was approached as a proxy for non-linearity in the EEG. Therefore, such a finding provided some initial support for the use of the mathematics of non-linear dynamical systems and circular causality to model qualitative experience as a dynamic gestalt of conscious and non-conscious processes. Experiment 1 and 2 represent only the initial steps in testing such a hypothesis. A more extensive test of this hypothesis is warranted by the results of these studies, but remains the purview of future research. In experiment 4, an interaction of simultaneously occurring conscious and non-conscious semantic content and processes was observed within the overall gestalt of the 'conscious' percept. Such a finding also provided some support for a theoretical approach towards consciousness laid out in the initial two chapters.

Some methodological flaws were present in the four experiments outlined in chapters four through to six. As such, the results of these experiments contained some inherent

weaknesses. As has been discussed above, all of the experiments may have been statistically underpowered due to low sample sizes. This was true in particular of experiment 1, 2 and 3. In the first experiment, findings were only just above the threshold of statistical significance. This positive finding may have disappeared with a larger sample size and correspondingly stronger statistical analysis. Alternatively, a positive finding in experiment 1 with an analysis run on a larger sample of data would have provided more robust and convincing results. Likewise, although experiment 4 began with a sample of 20 participants, once data had been removed due to a range of methodological issues, the final sample size only amounted to N=13. It may have been that positive tendencies in the data (for example the positive finding in the SOA1 condition) would have crossed the threshold to genuinely statistically significant findings in the SOA2 condition, had the experiment been run with a larger sample size.

Motion artifact also contributed to the weakness of the results. This was because motion artifact was one of the issues that required some of the data sets to be removed from the analysis in experiment 4. This in part arose due to the long duration in which participants were required to sit still in the MEG. That is, combining the training session along with the main experimental condition and the subsequent prime identification task required participants to maintain focussed attention and a still posture for an unrealistic amount of time, even taking into account resting periods. This often couldn't happen, which eroded the quality of the data and subsequent statistical analysis. These methodological problems could have been ameliorated to some extent by splitting the session up and running the training session on a day previous to the actual recording session. Removing the requirement for button press responses may have also lessened the problem with motion artifact. N400 effects have been shown to occur even without the requirement of a physical response (Kutas & Federmeier, 2011). In this case, the button press may have been a superfluous addition to the study design which only degraded the quality of the data and the strength of the final results.

The inability of the results in experiment 4 to confirm that the primes were processed unconsciously and not in part due to conscious awareness, was also a fundamental weakness in one of the main experiments to be included in this thesis. As discussed above, the prime identification task and the main experimental task, while similar, were in fact not the same.

Far more attentional resources were directed towards the masked prime sequence in the prime identification task, and this likely contributed to a higher than chance detection rate. This in turn undermined the whole logic of the experiment that sought to investigate genuinely unconscious processes. If the prime identification task had been combined with the main experimental task, prime word detection could have been measured in a condition in which participant's attentional resources would have been primarily directed towards the target stimuli. In this case, not only would an awareness of the masked primes have been measured in the actual experimental condition and not in a separate task, but it is likely that prime detection would have fallen to chance levels because the primes were not directly attended to. In this case, masked prime words could have been judged to have been processed purely unconsciously and the results would have more convincingly commented on the relationship between consciousness and genuinely non-conscious processes.

A separate issue which may have undermined the logic of experiment 3 and 4 is that an analysis on MEG event related fields may have been too course grained to effectively reveal the dynamic of neurological processes underlying consciousness. That is, despite the high temporal resolution of both EEG and MEG, the process of averaging multiple trials effectively loses a considerable amount of information that would have been contained in the raw data. Time series analysis such as that conducted in the first two experiments, especially when combined with the mathematics of non-linear systems, captures a great deal more information than standard ERP or ERF approaches. It may have aided in the consistency of the thesis and the sophistication of the results to continue with time series analysis after experiment 2, rather than switching to ERF analysis- a completely different experimental approach for the final two studies.

This change of experimental approach midway through the thesis presented some theoretical inconsistencies and undermined the possibility of further exploration of the positive findings in experiment 1 and 2. For example, the theory underling experiment 1 and 2 crudely equated non-conscious processes with microscopic patterns of EEG activity, and equated conscious processes with macroscopic activity. However, experiment 3 and 4 then discarded with this distinction and to some extent contradicted it, by equating P200 ERP

peaks, themselves macroscopic EEG patterns, with non-conscious processes. On final analysis though, this theoretical inconsistency is cosmetic rather than fundamentally problematic for the thesis. The microscopic-macroscopic distinction was simply not relevant to the logic of experiment 3 and 4. The claim was not that non-conscious processes cannot be represented in macroscopic patterns, such as early ERP peaks. Rather, circular causality (Haken, 2006) between lower order and higher order processes was suggested to represent a good analogy to the idea that qualitative human experience could arise as a mutually instantiating gestalt of conscious and non-conscious processes. One avenue to explore this idea was through non-linear time series analysis of microscopic and macroscopic patterns of activity in the EEG or MEG. This distinction was only relevant to experiment 1 and 2 and not to the ERP analysis conducted in experiment 3 and 4.

However, the change of track in experiment 3 and 4 from the approaches of the earlier two studies did cut short experimental exploration before it was able to provide convincing support, or the lack thereof, for the core philosophy in the initial two chapters of the thesis. Despite the positive (although admittedly weak) findings in experiment 1 and 2, further exploration of this approach, for example directly testing the idea of circular causality in MEG data, was not undertaken. It would only have been a positive finding of some form of circular causality in the data that would have genuinely supported the basic philosophical and theoretical position laid out in Chapter One and Two of the thesis. Upon final analysis, the results in experiment 1 and 2 provided positive but weak support for the interesting phenomenon of alpha-beta phase synchrony, without being able to relate this directly back to the primary philosophical question regarding the structure of consciousness.

As has been discussed above, this change of experimental approach after experiment 2 was due to a failure in broader methodological and planning issues. Experiment 3 and 4 were being designed as the data from experiment 1 and 2 was being analysed. What were perceived to be poor initial results motivated a different experimental approach for the final studies. This was despite the fact that final analysis of the data in experiment 1 and 2 in fact was able to reject the null hypothesis.

The final two studies included in this thesis could also be taken further or refined in future research. The aim, and to some extent the conclusion of experiment 3 and 4, was to show that approaching conscious and non-conscious processes as mutually and ontologically distinct is theoretically and empirically incorrect. The results of these two experiments suggest that the mutual distinction in previous findings (Dehaene & Changeux, 2004) between 'late' processes (>300ms) underlying conscious and early (<300 ms) non-conscious processes may have been an inaccurate picture. Tentatively it was suggested that a more mutually instantiating relationship between conscious and non-conscious processes may exist in the overall gestalt of qualitative human experience. Having called into question this temporal distinction between consciousness and non-conscious processes on which many consciousness studies are based (Dehaene & Changeux, 2004; Dehaene & Naccache, 2001; Dehaene, Sergent, & Changeux, 2003; Del Cul, Baillet, & Dehaene, 2007), future research could look at refining the protocol used in these studies. To a large extent current studies have already begun doing this (Aru, Bachmann, Singer, & Melloni, 2012; de Graaf, Hsieh, & Sack, 2012). Aru et al., (2012) for example has already presented convincing data which suggests that the neurological processes that Dehaene & Changeux (2004) correlated with consciousness may sweep in and include many processes that simply proceed or follow consciousness, but which are not in themselves constitutive of consciousness. Aru et al., (2012) and de Graaf et al., (2012) have both begun suggesting methodological improvements that could potentially tease out this issue. These for example could include examining neural processes taking place while varying the sensory modality, for example from visual to auditory stimulus presentation. Invariant neural processes in response to such a manipulation would not represent consciousness and could therefore be subtracted from any potential characterisation of the NCC. These and other methodological refinements have been discussed in section 4.6 above. Other refinements could for example include determining whether changes in conscious perception correspond with experimental manipulation of unconscious stimuli. To a certain extent this is what experiment 3 and 4 sought to do. However, these studies did not seek to observe the experimental effect in alterations of conscious perception of the target itself. Rather, this interaction and combination of phenomenally foreground and background processes was extrapolated from the observation of later occurring N400 effects.

As a refinement upon this approach, unconsciously perceived stimuli could be manipulated in order to observe the effect on conscious perception itself. For example, target stimuli could be ambiguous images that could represent two different objects such as a drawing that could equally depict a house with a pointed roof or a rocket. Masked stimuli could then prime one of other of these interpretations. A masked semantic priming in this case would perhaps more directly support a view of what we refer to as 'consciousness' as arising from a combination of phenomenally foreground and phenomenally background (unconscious) content and processes.

One issue that arises with some of the methodological refinements that have recently been suggested for consciousness research (Aru, Bachmann, Singer, & Melloni, 2012) is that these alterations in experimental protocol further instantiate a Cartesian duality which may undermine genuine progress in the science. That is, the underlying assumption in these recent studies is that consciousness will be more explicitly understood by extracting out any non-conscious processes that may have been erroneously included in previous characterisations of the NCC. This clearly flies in the face of the approach suggested in this thesis. Drawing parallels to Heidegger's discussion of human experience as Dasein, it has been suggested that what we think of as 'consciousness' may only ever exist in relation to something outside of or beyond consciousness. Drawing out this idea further, instead of trying to define the NCC by increasingly identifying and removing non-conscious processes from what is thought of as the neural correlates of consciousness, future research could more closely investigate the dynamic relationship between these two states. Indeed, the NCC may be more accurately thought of as the dynamic that mediates between foreground and background content, rather than as any particular state that is arrived at by subtracting out certain background or unconscious processes. In this sense, rather than trying to disambiguate what Aru et al., (2012) refers to as NCC-pre from the NCC proper, the actual neural correlates of consciousness may be the dynamic condition that mediates between these two processes. This could be a focus for future research.

However, the strength of this thesis is suggested to lie in its examination of the philosophical biases implicitly packed into much of the contemporary science of consciousness as well as in presenting some alternatives to these biases. Heidegger provides an in-depth and unique analysis of elements in the structure of Western thought which undoubtedly underlie the way we think about consciousness. In presenting an understanding of human existence that reconciled essence and existence, or Being and temporality, Heidegger's writings speak directly to the modern problem of conceptually reconciling the existence of consciousness with that of physical or material processes. The experiments undertaken in Chapters Four, Five and Six of this thesis represent one way amongst many, of practically taking the theoretical orientation outlined in Chapter Two, into empirical approaches within the laboratory.

The theoretical orientation dealt with in Chapter Two is directed towards both the 'Easy Problem' and the 'Hard Problem' of consciousness (Chalmers, 1996). The 'Easy Problem' refers to the question of what sort of neural processes underlie the various aspects of conscious experience. Such approaches unavoidably begin with phenomenology, and then seek to find a way such phenomenology could be represented by the brain. For example, consciousness is understood to represent information, and disparate informational components are believed to come unified together within the singular gestalt of an individual's experience (Wolfe & Cave, 1999). For example, we may perceive red triangles and in such a case, redness and the triangle shape are integrated and not able to be reduced to two separate components of experience. Based on such axiomatic phenomenology, Tononi (2004) presents a theory in which the brain represents consciousness as integrated information. Such an approach seeks to provide answers to the manifestly difficult 'easy problem' of consciousness.

In the current study, an interpretation of Heideggerian phenomenology is also used as a starting point for an approach to the 'easy problem' of consciousness (Chalmers, 1996). Chapters One and Two drew on Heidegger's writings to describe qualitative human experience as possessing the qualities of groundlessness, absence and alterity rather than solely being conceived of as a collection of positive reportable phenomenal facts. In this, it was suggested that a significant part of the structure of what consciousness *is*, is not able to

be made fully conscious at all. Thus, qualitative experience was suggested to exist in a way that is partially revealed but also partially hidden from itself. Following from this approach, the current thesis has sought a way to represent such a phenomenon in terms of an interaction of neural activity underlying supraliminal and subliminal processes. It has been suggested that the idea of 'subjective consciousness' is an inappropriate characterisation of qualitative experience. Rather, this thesis could be thought of as characterising and exploring the possible neural correlates of a Heideggerian *ligthctung* or *offenheit* rather than the neural correlates of a decidedly Cartesian 'consciousness'.

Less directly however, this thesis is also directed at the 'hard problem' of consciousness (Chalmers, 1996). For traditional Western metaphysics, of the type which Heidegger saw underlying the scientific enterprise, a broad dichotomy exists between ipseity and alterity. 'Consciousness', 'self-hood' or 'mind' are all understood as categorically distinct from the domains of 'world', 'matter' or the environment. This has been an enduring philosophical problem dealt with throughout the history of Western thought for example in Plato, Descartes, Kant, Searle, Whitehead and others (Descartes, 1972; Searle, 1984; Brooks, 1994; Griffin, 2001). Drawing on Heidegger, the being structure of human experience is described in this thesis in a way that straddles this dichotomy. When qualitative experience is understood as a Cartesian consciousness, 'nonconscious' simply refers by definition to that which consciousness is not. However, drawing on Heidegger's discussion of human existence as an openness and groundlessness that is in part obscure and hidden from itself, both ipsiety and alterity become part of the structure of what qualitative human experience is. The qualities of outwardness, otherness and alterity are described in this thesis as being part of the qualities that consciousness possesses and exhibits. Further, this sense of alterity or un-representable otherness which arise in Heidegger's discussion of *abgrund*, *das nitsch* and human existence, is discussed in this thesis as one way of approaching the existence of physical material processes from a phenomenological perspective. Where this un-representable alterity is viewed as the presence of material processes from a phenomenological perspective, an avenue is opened to understand the presence of material processes within the overall phenomenology of human experience. This theoretical orientation has not been able to be presented in the current thesis as an explicit disprovable

theory. However, it has been presented as a step towards articulating such a testable theory, and one that would be directly relevant to the 'hard problem' of consciousness.

Heidegger's work represents one of the most significant challenges and alternatives to the ontological orientation that guided Descartes and continues to inform much of the science of consciousness. Some of Heidegger's thinking can serve to highlight unexamined assumptions still present in this work. In this thesis, Heideggerian thought is suggested as relevant to a reconsideration of human experience and as capable of informing approaches and theory in the neurosciences. In the final section of Being and Time, Heidegger writes

> It has long been known that ancient ontology works with 'Thing Concepts' and that there is a danger of 'reifying consciousness'. But what does this "reifying" signify? Where does it arise……Why does this reifying always keep coming back to exercise its dominion? What positive structure does the being of 'consciousness' have, if reification remains inappropriate to it?……And can we even seek an answer as long as the question of the meaning of Being remains unformulated and unclarified? (Heidegger 1962 p. 414).

Here, Heidegger raises the question of the meaning of Being and ontological enquiry, as central to understanding the existence of consciousness and developing an understanding of its positive structure without resorting to habitual reification. Elaborating on this position, this thesis has drawn on a range of elements of Heideggerian thought, such as *abgrund* (groundlessness) *offenheit* (openness) and *das nichts* (the nothing) in seeking to re-examine our ideas about the structure and existence of consciousness. These ideas have then been drawn on as a novel phenomenological starting point for empirical research into the neurophysiological correlates of consciousness.

To a great extent, nature has proven to be explicable through science, in terms of formal processes. Consciousness is certainly a natural phenomenon. So it is logical that we should have sought to also characterize the mind and human consciousness as an objectifiable formal process. This endeavor has not been successfully completed. However, it has taken root in our imagination, perhaps falsely informing our sense of what it is to be human. The

imagined objectification of qualitative experience has cast the mind, consciousness and human experience as entirely knowable and bounded by mental conceptual categories. However, it may be that physical processes exist as an unknown and as an otherness, within and essential to the very dynamic of sentience which we relate to most intimately as our 'self'. Human experience then, may exist between the concrete and the void, never fully attaining to either, but always consisting essentially of both.

# References


Abrams, R., & Greenwald, G. (2000). Parts outweigh the whole (word) in unconscious analysis of meanin. *Psychological Science, 11*(2), 118-124.

Achermann, P. (1994). Correlation dimension of the human sleep electroencephalogram - cyclic changes in the course of the night. *European Journal of Neuroscience*, *6*(3), 497-500.

Aftanas, L. (1994). Dimensional Analysis of Human EEG During Experimental Affective Experience. *International Journal of Psychophysiology, 18*(1), 67-70.

Alter, T. (2015). *Consciousness in the Physical World: Perspectives on Russellian Monism*. New York: Oxford University Press.

Anokhin, A. (1999). Spatiotemporal organization of brain dynamics and intelligence: an EEG study in adolescents. *International Journal of Psychophysiology, 33*(3), 259-273.

Aristotle, (1995). *Complete Works of Aristotle-The Revised Oxford translation* Vol. 2, (ed.) Jonathan Barnes, Princeton: Princeton University Press.

Aru, J., Bachmann, T., Singer, W., & Melloni, L. (2012). Distilling the neural correlates of consciousness. *Neuroscience and Biobehavioral Reviews, 36*(2), 737-746.

Baars, B. (2005). Global workspace theory of consciousness: toward a cognitive neuroscience of human experience? *Progress in Brain Research, 150*, 45-54.

Basar, E. (1990), *Chaos in Brain Function*. Berlin: Springer.

Basar, E., Schürmann, M., Basar, C. &, Karakas S. (1997). Alpha oscillations in brain functioning: an integrative theory. *International Journal of Psychophysiology, 26*, 5– 29.

Beer, R. (1995). A dynamical-systems perspective on agent environment interaction. *Artificial Intelligence, 72*(1-2), 173-215.

Beer, R. (2000). Dynamical approaches to cognitive science. *Trends in Cognitive Sciences, 4,* 91-99.

Beer, R. (2003). The dynamics of active categorical perception in an evolved model agent. *Adaptive Behavior,* 11**,** 209-243.

Benedek, M., Bergner, S., Koenen, T., Fink, A., & Neubauer, A. C. (2011). EEG alpha synchronization is related to top-down processing in convergent and divergent thinking. *Neuropsychologia, 49(*12), 3505-3511.

Block, N. (2005). Two neural correlates of consciousness. *Trends in Cognitive Sciences, 9*(2), 46-52.

Bostock, D. (2006). *Space, time, matter, and form: essays on Aristotle's physics.* Oxford: Clarendon Press

Bowser, B. (2017). Racism: Origin and Theory. *Journal of Black Studies 48*(6), 572-590.

Braun, J., Machlitt, D. & Schack, T. (2015). Masked priming of complex movements: perceptual and motor processes in unconscious action perception. *Psychological Research-Psychologische Forschung, 79*(5), 801-812.

Breitmeyer, B., Kiefer, M. & Niedeggen, M. (2015). Exploring the visual (un)conscious. *Consciousness and Cognition 35,* 178-184.

Bridgeman, B., & Tseng, P. (2011). Embodied cognition and the perception-action link. *Physics of Life Reviews,* 8**,** 73-85.

Brook, A. (1994). *Kant and the Mind*. Cambridge: Cambridge University Press.

Brysbaert, M. & New, B. (2009). Moving beyond Kucera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavior Research Methods 41*(4), 977-990.

Bullmore, E., Brammer, M., Williams, S., Rabe-Hesketh, S,. Janot, N. & David, A. (1996). Statistical methods of estimation and inference for functional MR image analysis. *Magn Reson Med, 35*, 261-277.

Burgess, A., Rehman J. & Williams, J. (2003). Changes in neural complexity during the perception of 3D images using random dot stereograms. *International Journal of Psychophysiology 48*(1), 35-42.

Canolty, R. & Knight, T. (2010). The functional role of cross-frequency coupling. *Trends in Cognitive Sciences 14*(11), 506-515.

Carnap, R. (1947). *Meaning and Necessity: A Study in Semantics and Modal Logic.* Chicago: University of Chicago Press.

Casali, A., Gosseries, O., Rosanova, M., Boly, M., Sarasso, S., Casali, K…. Massimini, M. (2013). A Theoretically Based Index of Consciousness Independent of Sensory Processing and Behavior. *Science Translational Medicine, 5*(198).

Carr, D. (1999). *The Paradox of Subjectivity: The Self in the Transcendental Tradition*, Oxford: Oxford University Press

Carr, T. & Dagenbach, D. (1990). Semantic Priming And Repetition Priming From Masked Words - Evidence For A Center-Surround Attentional Mechanism In Perceptual Recognition, *Journal of Experimental Psychology, Learning Memory and Cognition* 16(2), 341-350.

Cerbone, D. (2002) Heidegger and Dasein's 'Bodily Nature': What is the Hidden Problematic? *International Journal of Philosophical Studies*, 8(2).

Chalmers, D. J. (1996). *The conscious mind: in search of a fundamental theory*. New York, Oxford University Press.

Chalmers, D. J. (2010). *The Character of Consciousness*. New York: Oxford.

Cheesman, J. & Merikle, P. (1986). Distinguishing Conscious from Unconscious Perceptual Processes, *Canadian Journal of Psychology-Revue Canadienne De Psychologie, 40*(4), 343-367.

Ciocan, C. (2008). The question of the living body in Heidegger's analytic of Dasein. *Research in Phenomenology, 38*(1), 72-89.

Clark, A. (1997) *Being There. Putting Brain, Body, and World Together Again*, London: The MIT Press.

Clark, A. (2007). Curing cognitive hiccups: A defence of the extended mind. *Journal of Philosophy, 104,* 163-192.

Clark, A. (2009). Spreading the Joy? Why the Machinery of Consciousness is (Probably) Still in the Head. *Mind, 118*, 963-993.

Clark, A. and Chalmers, D. (1998). The extended mind (Active externalism). *Analysis 58*, 7-19.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review 108,* 204-256.

Crick, F. and Koch, C. (2003). A framework for consciousness. *Nature Neuroscience 6*(2), 119-126.

Dafilis, M., Cadusch, P., Liley, D. (2011). Re-evaluating the performance of the nonlinear prediction error for the detection of deterministic dynamics, *Physica D, 240*, 695-700.

Damian, M., (2001), Congruity effects evoked by subliminally presented primes: Automaticity rather than semantic processing, *Journal of Experimental Psychology-Human Perception and Performance, 27*(1), 154-165.

Daniel, W. (1990), 'Friedman two-way analysis of variance by ranks', *Applied Nonparametric Statistics* (2nd ed.). Boston: PWS-Kent. pp. 262–74.

de Graaf, T. A., Hsieh, P. J., & Sack, A. T. (2012). The 'correlates' in neural correlates of consciousness. *Neuroscience and Biobehavioral Reviews, 36*(1), 191-197.

De Cuyper, K., et al. (2017). Using Indirect Measurement Tasks to Assess the Self-concept of Personality: A Systematic Review and Meta-analyses. *European Journal of Personality 31*(1), 8-41.

Deacon, D., Chien-Ming Y. & Nagata M. (2000), Event-related potential indices of semantic priming using masked and unmasked words: evidence that the N400 does not reflect a post-lexical process, *Cognitive BrainRresearch, 9*(2), 137-146.

Deacon, T. (2012). *Incomplete Nature: How Mind Emerged from Mater*. London, W.W. Norton & Company.

Deco, G., et al. (2014). Modeling Resting-State Functional Networks When the Cortex Falls Asleep: Local and Global Changes. *Cerebral Cortex 24*(12), 3180-3194.

Dehaene, S. & Changeux, J. (2004). Neural Mechanisms for Access to Consciousness. *Cognitive Neurosciences Iii, Third Edition*, 1145-1157.

Dehaene, S. & Changeux, J. (2005). Ongoing spontaneous activity controls access to consciousness: A neuronal model for inattentional blindness. *PLoS biology 3*(5), 910-927.

Dehaene, S. & Changeux, J. (2011). Experimental and Theoretical Approaches to Conscious Processing. *Neuron 70*(2), 200-227.

Dehaene, S., Changeux, J. P., Naccache, L., Sackur, J., & Sergent, C. (2006). Conscious, preconscious, and subliminal processing: a testable taxonomy. *Trends in Cognitive Sciences*, 10(5), 204-211.

Dehaene, S. & L. Naccache (2001). Towards a cognitive neuroscience of consciousness: basic evidence and a workspace framework. *Cognition 79*(1-2), 1-37.

Dehaene, S., Naccache, L., Cohen, L., Le Bihan, D., Mangin, J. F., Poline, J. B., & Riviere, D. (2001). Cerebral mechanisms of word masking and unconscious repetition priming. *Nature Neuroscience, 4*(7), 752-758.

Dehaene, S., Sergent, C., & Changeux, J. P. (2003). A neuronal network model linking subjective reports and objective physiological data during conscious perception. *Proceedings of the National Academy of Sciences of the United States of America*, *100(*14), 8520-8525.

De Klerk, J. (2017). "The Devil Made Me Do It!" An Inquiry Into the Unconscious "Devils Within" of Rationalized Corruption. *Journal of Management Inquiry 26*(3), 254-269.

Del Cul, A., et al. (2007). Brain dynamics underlying the nonlinear threshold for access to consciousness. *PLoS biology 5*(10), e260-e260.

Delorme, A. and S. Makeig (2004). EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis, *Journal of Neuroscience Methods, 134*(1), 9-21.

Descartes, R. (1968) *Discourse on the Method and the Meditations*, (F. E. Sutcliffe, Trans.), London: Penguin Books.

Descartes, R., (1972). *Treatise of Man.* (Thomas Steele, Trans.), Cambridge, Mass: Harvard University Press.

Dharma-wardana, C., (2013). *A Physicists View of Matter and Mind*. London: World Scientific.

Ding, S. F., et al. (2017). A Review on Feature Binding Theory and Its Functions Observed in Perceptual Process. *Cognitive Computation 9*(2), 194-206.

Dreyfus, H. (1991) *Being-in-the-World. A Commentary on Heidegger's Being and Time, Division 1*, London: MIT Press.

Duke, D. P., W. (1991). *Proceedings of the conference on measuring chaos in the human brain*, Singapore: World Scientific.

Edelman M. & Tononi G, (2000) *A Universe of Consciousness: How Matter Becomes Imagination*. New York: Basic Books.

Edelman, G. M. (2003) Naturalizing consciousness: A theoretical framework. *Proceedings of the National Academy of Sciences of the United States of America, 100*(9), 5520-5524.

Ehlers, C., Havstad, J., Prichard, D., & Theiler, J. (1998). Low doses of ethanol reduce evidence for nonlinear structure in brain activity, *Journal of Neuroscience,18*(18), 7474-7486.

Eriksson, J. (2017). Activity in part of the neural correlates of consciousness reflects integration. *Consciousness and Cognition, 55*, 26-34.

Fell, J., (1996). Surrogate data analysis of sleep electroencephalograms reveals evidence for nonlinearity, *Biological Cybernetics, 75*(1), 85-92.

Ferrand, L., Grainger, J., & Segui, J. (1994). A study of masked form priming in picture and word naming, *Memory & Cognition, 22*(4), pp. 431-441.

Fischer, M. H. (2012). A hierarchical view of grounded, embodied, and situated numerical cognition, *Cognitive Processing, 13*, S14-S15.

Forster, K. I. (1999) The microgenesis of priming effects in lexical access, *Brain and Language, 68*(1-2), 5-15.

Forster, K., Mohan, K., & Hector, J. (2003). The mechanics of masked priming. In S. Kinoshita & S. J. Lupker (Eds.), *Masked priming: The state of the art* (pp. 3–37). New York: Psychology Press.

Freeman, W. J. (2005). A field-theoretic approach to understanding scale-free neocortical dynamics. *Biological Cybernetics*, 92(6), 350-359.

Freeman, W. J. (2007). Indirect biological measures of consciousness from field studies of brains as dynamical systems, *Neural Networks, 20*(9), 1021-1031.

Frenzel, D., et al. (2002), Is the bispectral index appropriate for monitoring the sedation level of mechanically ventilated surgical ICU patients?, *Intensive Care Medicine, 28*(2), 178-183.

Friston, K. J. (2007). *Statistical Parametric Mapping: The Analysis of Functional Brain Images*. London: Academic Press.

Gaillard, R., Dehaene, S., Adam, C., Clemenceau, S., Hasboun, D., & Baulac, M. (2009) Converging Intracranial Markers of Conscious Access, *Plos Biology, 7*(3), 472-492.

Gallagher, S. (2009) Philosophical anticedents to situated cognition, In P. a. A. M. Robbins (Ed.), *Cambridge Handbook of Situated Cognition*, Cambridge: Cambridge University.

Gillies, D. (1993). *Philosophy of Science in the Twentieth Century*. Oxford: Blackwell Publishing.

Gips, B., et al. (2016). A biologically plausible mechanism for neuronal coding organized by the phase of alpha oscillations. *European Journal of Neuroscience 44*(4), 2147-2161.

Granger, H. (1996). *Aristotle's Idea of the Soul*. Dordrecht : Springer Netherlands.

Griffin, D., (2001), *Re-enchantment Without Supernaturalism: A Process Philosophy of Religion*. Ithaca: Cornell University Press.

Gruber, W. R., et al. (2005). Alpha phase synchronization predicts P1 and N1 latency and amplitude size. *Cerebral Cortex 15*(4), 371-377.

Guyer, P., and Horstmann, R. Idealism, The Stanford Encyclopedia of Philosophy (Fall 2015 Edition), Zalta, E. (ed.), URL = <https://plato.stanford.edu/archives/fall2015/entries/idealism/>.

Haar, M. (1993). *The Song of the Earth: Heidegger and the Grounds of the History of Being,* Bloomington: Indiana University Press.

Haken, H. (2006). Synergetics of brain function, *International Journal of Psychophysiology, 60*(2), 110-124.

Halgren, E., Dhond, R., Christensen, N., Van Petten, C., Marinkovic, K., Lewine J. & Dale, A. (2002), N400-like magnetoencephalography responses modulated by semantic context, word frequency, and lexical class in sentences. *Neuroimage 17*(3), 1101-1116.

Heidegger, M. (1957) 'The Way back into Metaphysics', In: Kaufmann, W. ed. *Existentialism from Dotoevsky to Sartre*. New York: Meridian Books, 270-271.

Heidegger, M. (1962) *Being and Time*, Melbourne: Blackwell Publishing.

Heidegger, M. (1976), 'The Essence of Reason', In Vittorio Klostermann (Ed.) *Wegmarken*, Michigan: Northwestern University Press, 123–75.

Heidegger, M. (1977a), 'Question Concerning Technology', In: Glenn Gray, J. ed. *The Question Concerning Technology and other essays*. New York: Harper & Row, pp.131.

Heidegger, M. (1977b) 'Letter on Humanism', In: Glenn Gray, J. ed. *Basic Writings*. San Francisco: Harper & Row, pp. 189-242.

Heidegger, M. (1977c) 'What is Metaphysicss?', In: Glenn Gray, J. ed. *Basic Writings*. San Francisco: Harper & Row, pp. 91-112.

Heidegger, M. (1977d), 'Age of the World Picture', In: Glenn Gray, J. ed. *The Question Concerning Technology and other essays.* New York: Harper & Row, pp. 115-154.

Heidegger, M. (1984) *The Metaphysical Foundations of Logic*, Bloomington: Indiana University Press.

Husserl, E. (1999). *The Idea of Phenomenology*, Boston : Kluwer Academic.

Helenius, P., Salmelin, R., Service, E., Connolly, J., Leinonen S. & Lyytinen, H. (2002). Cortical activation during spoken-word segmentation in non-reading impaired and dyslexic adults, *Journal of Neuroscience, 22*(7), 2936-2944.

Hotton, S. (2011). Extending Dynamical Systems Theory to Model Embodied Cognition. *Cognitive Science* 35**,** 444–479.

Hsieh, P. J. and J. T. Colas (2012). Perceptual Fading Without Retinal Adaptation. *Journal of Experimental Psychology-Human Perception and Performance 38*(2), 267-271.

Hunt, L., Politzer-Ahles, S., Gibson, L., Minai, U. & Fioren, R. (2013), Pragmatic inferences modulate N400 during sentence comprehension: Evidence from picture–sentence verification, *Neuroscience Letters, 534*, 246–251

Husserl, E. (1929/1960). *Cartesian Meditations: an Introduction to Phenomenology*. Translated by Cairns, D. The Hague: M. Nijhoff.

Jensen O, Gelfand J, Kounios, J, Lisman, J, (2002). Oscillations in the alpha band (9 –12 Hz) increase with memory load during retention in a short-term memory task. *Cerebral Cortex 12*,877–882.

Jensen, O. and Colgin, L. (2007). Cross-frequency coupling between neuronal oscillations. *Trends in Cognitive Sciences 11(*7), 267-269.

Kant, I. (1855). *Critique of Pure Reason*. London: Bohn.

Kantz H, S.T. (2003) *Nonlinear time series analysis*, Cambridge: Cambridge University Press.

Kelper, J. (1992), *New Astronomy*, (trans.) William Donahuem Cambridge: Cambridge University Press.

Kelso, J.a.S. (1995). *Dynamic patterns : the self-organization of brain and behavior.* Cambridge, Mass: MIT Press.

Kelso, S.E., D. (2006). *The Complementary Nature.* Cambridge: The MIT Press.

Kiefer, M. (2002). The N400 is modulated by unconsciously perceived masked words, *Cognitive Brains Research 13*, 27-39.

Kiefer, M., Ansorge, U., Haynes, J.-D., Hamker, F., Mattler, U. & Verleger, R.(2011) Neuro-cognitive mechanisms of conscious and unconscious visual perception: From a plethora of phenomena to general principles, *Advances in cognitive psychology, 7*, 55-67.

Kiefer, M., & Brendel, D. (2006) Attentional modulation of unconscious "automatic" processes: Evidence from event-related potentials in a masked priming paradigm, *Journal of Cognitive Neuroscience, 18*(2), 184-198.

Kiefer, M. & Spitzer, M. (2000). Time course of conscious and unconscious semantic brain activation, *Neuro report 11*(11), 2401-2407.

Kiefer, M. & Pulvermuller, F. (2012). Conceptual representations in mind and brain: Theoretical developments, current evidence and future directions. *Cortex 48*(7), 805-825.

Kielar, A. & Joanisse, M. (2010). Graded Effects of Regularity in Language Revealed by N400 Indices of Morphological Priming. *Journal of Cognitive Neuroscience 22*(7), 1373-1398.

Kihlstrom, J. F. (1987). 'The Cognitive Unconscious', In: Baars, B., Banks, W. & Newman, J. ed. *Essential Sources in the Scientific Study of Consciousness*. Cambridge: MIT Press, pp. 777-791.

Kim, D., Kim, J., Chae, J., Jin, S., Ahn, K., Myrick, H., Yoon, S., Kim, H. and Kim, S. (2003), Complexity changes of the EEG induced by alcohol cue exposure in alcoholics and social drinkers. *Alcoholism-Clinical and Experimental Research, 27*(12), 1955- 1961.

Kirsh, D. & Maglio, P. (1994). On Distinguishing Epistemic from Pragmatic Action, *Cognitive Science,* 18**,** 513-549.

Klimesch, W. (1996). Memory processes, brain oscillations and EEG synchronization. *International Journal of Psychophysiology, 24*,61–100.

Kotini, A. & Anninos, P. (2002), Detection of non-linearity in schizophrenic patients using magnetoencephalography, *Brain Topography, 15*(2), 107-113.

Kouider, S. & Dehaene, S. (2007). Levels of processing during non-conscious perception: a critical review of visual masking. *Philosophical Transactions of the Royal Society B-Biological Sciences 362*(1481), 857-875.

Kucera, H. & Francis, W. (1967). *Computational analysis of present- day American English*. Providence: Brown University Press.

Kutas, M. & Hillyard, S. (1980). Reading senseless sentences: brain potentials reflect semantic incongruity. *Science 207*, 203–205.

Kutas, M. & Federmeier, K. (2011). Thirty Years and Counting: Finding Meaning in the N400 Component of the Event-Related Brain Potential (ERP). *Annual Review of Psychology, 62*, 621-647.

Lau, E. et al. (2008). A cortical network for semantics: (de)constructing the N400. *Nature Reviews Neuroscience 9(*12), 920-933.

Leek, M. (2001). Adaptive procedures in psychophysical research. *Perception & Psychophysics 63*(8), 1279-1292.

Le Van Quyen, M., et al. (2001). Comparison of Hilbert transform and wavelet methods for the analysis of neuronal synchrony. *Journal of Neuroscience Methods 111*(2), 83-98.

Liley, D. T. J., Cadusch, P. J., & Dafilis, M. P. (2003). A spatially continuous mean field theory of electrocortical activity (vol 13, pg 67, 2002). *Network-Computation in Neural Systems*, 14(2), 369-369.

Liley, D. & Bojak, I. (2005). Understanding the transition to seizure by modeling the epileptiform activity of general anesthetic agents. *Journal of Clinical Neurophysiol, 22* (5), 300–313.

Liley, D. T. J., et al. (2010), Bifurcations and state changes in the human alpha rhythm, Theory and experiment, *Modeling Phase Transitions in the Brain, 4*, 117-145.

Lindman, H. (1974). *Analysis of variance in complex experimental designs*. San Francisco: Freeman.

Linkenkaer-Hansen, K., Nikulin, V., Palva, S., Ilmoniemi, R. and Palva, J. (2004). Prestimulus oscillations enhance psychophysical performance in humans. *Journal of Neuroscience, 24*, 10186–10190.

Lokhorst, Gert-Jan, "Descartes and the Pineal Gland", *The Stanford Encyclopedia of Philosophy* (Winter 2017 Edition), Edward N. Zalta (ed.), forthcoming URL =<https://plato.stanford.edu/archives/win2017/entries/pineal-gland/>.

Louwerse, M. (2011). Symbol Interdependency in Symbolic and Embodied Cognition. *Topics in Cognitive Science* 3**,** 273-302.

Lumer, E. D., Friston, K. J., & Rees, G. (1998). Neural correlates of perceptual rivalry in the human brain. *Science, 280*(5371), 1930-1934.

Maess, B., et al. (2006). Localizing the distributed language network responsible for the N400 measured by MEG during auditory sentence processing. *Brain Research, 1096*, 163-172.

Margulis, L. (2001). The conscious cell'. In P. C. Marijuan (Ed.), Cajal and Consciousness: Scientific Approaches to Consciousness on the Centennial of Ramon Y Cajal's Textura, *Annals of the New York Academy of Sciences*, 929, 55-70.

Maris, E. and R. Oostenveld (2007), Nonparametric statistical testing of EEG- and MEG-data, *Journal of Neuroscience Methods, 164*(1), 177-190.

Marr, D. (1976). Early processing of vision information. *Philosophical Transactions of the Royal Society of London B 275*, 483-524

Martens, U., Ansorge, U., and Kiefer, M. (2011) Controlling the Unconscious: Attentional Task Sets Modulate Subliminal Semantic and Visuomotor Processes Differentially, *Psychological Science, 22*(2), 282-291.

Maturana, H. (1987) *The Tree of Life*, Boston: Shambhala Publicaitons Inc.

Melloni, L., Schwiedrzik, C. M., Muller, N., Rodriguez, E., & Singer, W. (2011). Expectations Change the Signatures and Timing of Electrophysiological Correlates of Perceptual Awareness. *Journal of Neuroscience, 31*(4), 1386-1396.

Menary, R. (2010) *The Extended Mind*, Cambridge, Mass: MIT Press.

Merleau-Ponty, M. (1962) *Phenomenology of Perception*, London: Macmillian.

Meyer, S., Bonaiuto, J ., Lim, M., Rossiter, H., Waters, S ., Bradbury, D., Bestmann, S., Brookes, M., Callaghan, M., Weiskopf, N. & Barnes, G. (2017). Flexible head-casts for high spatial precision MEG. *Journal of Neuroscience Methods, 276*, 38-45.

Michael, G. & Ojéda, N. (2005), Visual field asymmetries in selective attention: evidence from a modified search paradigm. *Neuroscience Letters, 388*(2), 65-70.

Mima, T., Oluwatimilehin, T., Hiraoka, T. and Hallett, M. (2001). Transient interhemispheric neuronal synchrony correlates with object recognition. *Journal of Neuroscience, 21,*3942–3948.

Moran, D. (2014), What Does Heidegger Mean by the Transcendence of Dasein? *International Journal of Philosophical Studies , 22*(4), 491–514 .

Myles, P. S., et al. (2004), Bispectral index monitoring to prevent awareness during anaesthesia: the B-Aware randomised controlled trial, *Lancet, 363*(9423), 1757-1763.

Naccache, L., & Dehaene, S. (2001) Unconscious semantic priming extends to novel unseen stimuli. *Cognition, 80*(3), 215-229.

Nagel, T. (1974). What is it like to be a bat? *Philosophical Review, 83*: 435–456.

Neumann, O. & Klotz, W., (1994), Motor-Responses To Nonreportable, Masked Stimuli - Where Is The Limit Of Direct Parameter Specification, Attention and Performance Xv: *Conscious and Nonconscious Information Processing 15*, 123-150.

Neurath, O. (1973). *Wissenschaftliche Weltauffassung: Der Wiener Kreis.* Empiricism and Sociology. Vienna Circle Collection. N. M. a. C. R. (eds). Dordrecht: Springer. 1.

Newton, I. (1972), *Philosophiae Naturalis Principia Mathematica*, London: Cambridge University Press.

Nichols, T. & Holmes, A. (2002), Nonparametric permutation tests for functional neuroimaging: A primer with examples, *Human Brain Mapping, 15*(1), 1-25.

Nikulin, V. & Brismar, T. (2004). Long-range temporal correlations in alpha and beta oscillations: effect of arousal level and test-retest reliability. *Clinical Neurophysiology 115*(8), 1896-1908.

Nikulin, V. V. and T. Brismar (2006). Phase synchronization between alpha and beta oscillations in the human electroencephalogram. *Neuroscience 137*(2), 647-657.

Nunez, P. (1981). *Electric fields in the brain: The neurophysics of the EEG*. Oxford: Oxford University Press.

Oizumi, M., Albantakis, L., & Tononi, G. (2014). From the Phenomenology to the Mechanisms of Consciousness: Integrated Information Theory 3.0. *Plos Computational Biology*, 10(5).

Olafson, F. (1975). Consciousness and Intentionality in Heidegger's Thought. *American Philosophical Quartlery 12*(2), 91-103.

Oostenveld, R. (2011), FieldTrip: Open Source Software for Advanced Analysis of MEG, EEG, and Invasive Electrophysiological Data, *Computational Intelligence and Neuroscience*, 2011, 1-9.

Ortells, J. J., Daza, M. T., & Fox, E. (2003). Semantic activation in the absence of perceptual awareness. *Perception and Psychophysics, 65*, 1307–1317.

Ortells, J. J., Frings, C., & Plaza-Ayllón, V. (2012). Influence of spatial attention on conscious and unconscious word priming. *Consciousness and Cognition, 21*, 117–138.

Ortells, J., Kiefer, M., Castillo, A., Megías, M. & Morillas, A. (2016), The semantic origin of unconscious priming: Behavioral and event-related potential evidence during category congruency priming from strongly and weakly related masked words, *Cognition, 146*, 143-157.

Overgaard, M., Rote, J., Mouridsen, K. & Zoe¨ga Ramsøy, T. (2006). Is conscious perception gradual or dichotomous? A comparison of report methodologies during a visual task, *Consciousness and Cognition, 15*(4), 700-708.

Palva, J. et al. (2005). Phase synchrony among neuronal oscillations in the human cortex. *Journal of Neuroscience 25*(15), 3962-3972.

Palva, S. & Palva, J. (2007). New vistas for alpha-frequency band oscillations. *Trends in Neurosciences 30*(4), 150-158.

Palva, S. & Palva, J. (2011). Functional roles of alpha-band phase synchronization in local and large-scale cortical networks. *Frontiers in Psychology 2*(204), 1-15.

Park, H., et al. (2016). Formation of visual memories controlled by gamma power phase-locked to alpha oscillations. *Scientific Reports 6*,1-10.

Parkes, G. (1987). *Heidegger and Asian Thought*. Honolulu: University of Hawaii Press.

Pascal, F., & O'Regan, J. (2008). Commentary on Mossio and Taraborelli: Is the enactive approach really sensorimotor? *Consciousness and Cognition, 17*(4), 1341-1342.

Peterson, M. & Salvagio, E. (2008) Inhibitory competition in figure-ground perception: context and convexity, *Journal of vision, 8*(16), 13.

Pfurtscheller G. & Lopes da Silva, F. (1999). Event-related EEG/EMG synchronization and desynchronization: basic principles. *Electroencephalography and Clinical Neurophysiology, 110*, 1842–1857.

Plato. (1997). *Plato: The Complete Works*, (eds.) John M. Cooper and D.S. Hutchinson, Indianapolis: Hackett Publishing Co.

Plato, (2013). *Phaedrus The Republic and other Dialogues*, Benjamin Dowett, (trans.), New York: Barnes & Noble.

Portas, C. M., et al. (2000). How does the brain sustain a visual percept? *Proceedings of the Royal Society B-Biological Sciences 267*(1446), 845-850.

Postle, B. R. (2009). The Hippocampus, Memory, and Consciousness. *Neurology of Consciousness: Cognitive Neuroscience and Neuropathology,* 326-338.

Prinz, (2009). *Is Consciousness Embodied?* : Cambridge University Press.

Quiroga, R. Q., Mukamel, R., Isham, E. A., Malach, R., & Fried, I. (2008). Human single-neuron responses at the threshold of conscious recognition. *Proceedings of the National Academy of Sciences of the United States of America, 105*(9), 3599-3604.

Ramsey, W. (2007). *Representation Reconsidered*. Cambridge: Cambridge University Press.

Rosenblum, M., Pikovsky, A, Kurths, J, Schäfer, C, & Tass, P. (2001). *Phase synchronization: from theory to data analysis*. Handbook of biological physics. G. S. Moss F. Amsterdam: Elsevier Science.

Rossion, B. & Pourtois, G. (2004), Revisiting Snodgrass and Vanderwart's object pictorial set: The role of surface detail in basic-level object recognition, *Perception 33*(2), 217-236.

Ruhnau, P., Hauswald, A., & Weisz, N. (2014). Investigating ongoing brain oscillations and their influence on conscious perception - network states and the window to consciousness. *Frontiers in Psychology, 5.*

Sandberg, K., Andersen, L. M., & Overgaard, M. (2014). Using multivariate decoding to go beyond contrastive analyses in consciousness research. *Frontiers in Psychology, 5*.

Schelonka, K., et al. (2017). ERP signatures of conscious and unconscious word and letter perception in an inattentional blindness paradigm. *Consciousness and Cognition 54*, 56-71.

Schreiber, T. & Schmitz, A. (1997). Discriminatory power of measures for nonlinearity in a time series, *Physical Reviews E. 55*(5), 5443-5447.

Schufreider, G. (2001) Heidegger's hole: The space of thinking. Nihilism in the text (of philosophy), *Research in Phenomenology, 31*, 203-229.

Schürmann .M and Basar, E. (2001). Functional aspects of alpha oscillations in the EEG. *International Journal of Psychophysiology*, *39*,151–158.

Searle, J., (1984), *Minds, Brains, And Science*. Cambridge, Mass: Harvard University Press.

Seth, A. et al. (2008). Measuring consciousness: relating behavioural and neurophysiological approaches. *Trends in Cognitive Sciences 12*(8), 314-321.

Seth, A. K. (2010) The grand challenge of consciousness, *Frontiers in psychology, 1*, 5-5.

Sheets-Johnson, M. (1998) Consciousness: a natural history, *Journal of Consciousness Studies, 5*(3), 260-294.

Siebenhuhner, F., et al. (2016). Cross-frequency synchronization connects networks of fast and slow oscillations during visual working memory maintenance. *eLife 5*,1-31.

Simos, P., Basile, L. & Papanicolaou, A. (1997). Source localization of the N400 response in a sentence-reading paradigm using evoked magnetic fields and magnetic resonance imaging. *Brain Research 762*(1-2), 29-39.

Singer, B. (1988) Sein und Zeit Revisited. *Philosophy Research Archives*, 14.

Smith, E. R., & Semin, G. R. (2007) Situated social cognition, *Current Directions in Psychological Science, 16*(3), 132-135.

Stadler, F. (2015). *The Vienna Circle Studies in the Origins, Development, and Influence of Logical Empiricism*. Wien: Springer.

Stam, C. (2000), Brain dynamics in theta and alpha frequency bands and working memory performance in humans, *Neuroscience Letters ,286*(2), 115-118.

Stam, C. (2005), Nonlinear dynamical analysis of EEG and MEG: Review of an emerging field, *Clinical Neurophysiology 116*(10), 2266-2301.

Staub, A., et al. (2015). The influence of cloze probability and item constraint on cloze task response time. *Journal of Memory and Language, 82*, 1-17.

Stich, S. (Ed.), (2007) *The Blackwell Guide to Philosophy of Mind*, Chichester: John Wiley & Sons, Ltd.

Tass, P., Fieseler, T., Dammers, J., Dolan, K., Morosan, P., Majtanik, M., Boers, F., Muren, A., Zilles, K. and Fink, G. (2003) Synchronization tomography: a method for three-dimensional localization of phase synchronized neuronal populations in the human brain using magnetoencephalography. Phys Rev Lett 90: 088101.

Taylor, W. L. (1953). "Cloze Procedure": A New Tool for Measuring Readability. *Journalism Quarterly 30*(4), 415-433.

Thompson, E. (2007). *Mind in Life*, Cambridge Massachusetts: Harvard University Press.

Thompson, E., & Varela, F. (2001) Radical embodiment: neural dynamics and consciousness, *Trends in Cognitive Sciences, 5*(10), 418-425.

Tononi, G. (2004) An information integration theory of consciousness. BMC *Neuroscience, 5*, 42.

Tononi, G., Boly, M., Massimini, M. and Kock, C. (2016). Integrated information theory: from consciousness to its physical substrate. *Nature Reviews Neuroscience 17*(7), 450-461.

Tredennick, H. & Tarrant, H. (1993). *Plato. Euthyphro*. English. Oxford: Clarendon Press.

Tsujimura, K. (2008). Martin Heidegger's Thinking and Japanese Philosophy. *Epoche, 12*(2) 349-357.

Tzu, L. (2017). *Tao Te Ching. The Book of the Way and Its Power*. Berkley: Apocryphile Press.

Ulrich, M., et al. (2013). Brain Activation during Masked and Unmasked Semantic Priming: Commonalities and Differences. *Journal of Cognitive Neuroscience 25*(12), 2216-2229.

Umir, A., Ashfaq, U. & Khan, M., (2017) Recent trends, applications, and chalenges of brain-computer interfacing (BCI), *International Journal of Intelligent Systems and Applications, 9*(2), 58-65.

Van den Bussche, E., & Reynvoet, B. (2007). Masked priming effects in semantic categorization are independent of category size. *Experimental Psychology, 54*, 225–235.

Van den Bussche, E., Smets, K., Sasanguie, D., & Reynvoet, B. (2012) The power of unconscious semantic processing: the effect of semantic relatedness between prime and target on subliminal priming, *Psychologica Belgica, 52*(1), 59-70.

Van Dijk, H., et al. (2008), Prestimulus oscillatory activity in the alpha band predicts visual discrimination ability, *Journal of Neuroscience 28*(8), 1816-1823.

Van Gulick, R. 1985. Physicalism and the subjectivity of the mental. *Philosophical Topics, 13*, 51–70.

Van Petten, C. and B. J. Luka (2006). Neural localization of semantic context effects in electromagnetic and hemodynamic studies. *Brain and Language 97*(3), 279-293.

Van Veen, B. D., et al. (1997). Localization of brain electrical activity via linearly constrained minimum variance spatial filtering. *Ieee Transactions on Biomedical Engineering 44*(9), 867-880.

Varela, F., Thompson, E. & Rosch, E. (1993) *The Embodied Mind*, Cambridge, Massachusetts: The MIT Press.

Varela, F., et al. (2001). The brainweb: Phase synchronization and large-scale integration. *Nature Reviews Neuroscience 2*(4), 229-239.

Von der Malsburg, C. (1999). The What and Why of Binding: The Modeler's Perspective. *Neuron 24*, 95-104.

Vorberg, D,.Mattler, U., Heinecke, A., Schmidt, T., Schwarzbach, J. (2004) 'Invariant Time Course of Priming With and Without Awareness', In : Kaernbach, C. (Ed); Schroger, E. (Ed); Müller, (Ed). *Psychophysics beyond sensation: Laws and invariants of human cognition*. Mahwah, NJ: Lawrence Erlbaum Associates Publishers, 271-288.

Warren, W.H. (2006). The dynamics of perception and action. *Psychological Review,* 113**,** 358-389.

Wayne, D. (1990). *Applied Nonparametirc Statistics.* Boston: PWS-Kent.

Welch, P. (1967), The use of Fast Fourier Transform for the estimation of power spectra: A method based on time averaging over short, modified periodograms, *IEEE Transactions on Audio and Electroacoustics, AU-15* (2), 70–73.

Wheeler, M. (2005) *Reconstructing the Cognitive World*, Massachusetts Institute of Technology: MIT Press.

Whitehead, A. & Russel, B. (1910), *Principia Mathematica*, Oxford: Oxford University Press.

Widman, G, Schreiber, T, Rehberg, B, Hoeft, A, Elger, E 2000, 'Quantification of depth of anesthesia by nonlinear time series analysis of brain electrical activity'. *Physical Review E,* vol. 62, 4898–903.

Wilson, H. and Cowan, J. (1973). A mathematical theory of the functional dynamics of cortical and thalamic nervous tissue. *Kybernetik, 13*, 55-80.

Wolf-Devine, C. (1993). *Descartes on Seeing: Epistemology and Visual Perception*. Carbondale: Southern Illinois University Press.

Wolfe, J. & Cave, K., (1999), The Psychophysical Evidence for a Binding Problem in Human Vision, *Neuron, 24*(1), 11–17.

Zahavi, D. (2003) Intentionality and phenomenality, A phenomenological take on the hard problem. *Canadian Journal of Philosophy, 29,* 63-92.

Zeki, S. (2008). 'The disunity of consciousness'. In R. Banerjee & B. K. Chakrabarti (Eds.), *Models of Brain and Mind: Physical, Computational and Psychological Approaches*, 68, 11-13.

Zeki, S. (2015a). Area V5-a microcosm of the visual brain. *Frontiers in Integrative Neuroscience*, 9.

Zeki, S. (2015b). A massively asynchronous, parallel brain. *Philosophical Transactions of the Royal Society B-Biological Sciences*, 370(1668), 103-116.

Zeki, S., Watson, J. D. G., Lueck, C. J., Friston, K. J., Kennard, C., & Frackowiak, R. S. J. (1991). A Direct Demonstration Of Functional Specialization In Human Visual-Cortex. *Journal of Neuroscience*, 11(3), 641-649.

# Appendix 1

## Appendix 1.1. List of semantically congruent prime-target real word pairs used in experiment 3, Chapter 5.

Prime words were drawn from the left-hand list while target words were drawn from the right-hand list. This list consists of 140 word pairs. From this list, a shorter list of 80 word pairs was randomly and automatically selected for each participant, using Matlab software (MathWorks, Natick, MA).

'year' 'DAY'
'wool' 'SHEEP'
'window' 'SILL'
'web' 'SPIDER'
'verb' 'NOUN'
'vacuum' 'CLEANER'
'uncle' 'AUNT'
'turtle' 'DOVE'
'town' 'COUNTRY'
'town' 'CITY'
'tomato' 'SAUCE'
'tomato' 'JUICE'
'tiger' 'LION'
'theatre' 'CINEMA'
'tennis' 'BALL'
'teacher' 'STUDENT'
'syrup' 'TREACLE'
'swan' 'LAKE'
'street' 'ROAD'
'straw' 'HAT'
'stove' 'OVEN'
'story' 'TALE'
'spud' 'POTATO'
'spider' 'WEB'
'sparrow' 'BIRD'
'soup' 'TOMATO'
'sofa' 'SETTEE'
'slug' 'SNAIL'
'skill' 'CRAFT'
'silk' 'SATIN'

'shelf' 'CUPBOARD'
'shark' 'TEETH'
'shark' 'FIN'
'sauce' 'TOMATO'
'salad' 'LETTUCE'
'salad' 'CREAM'
'rug' 'HEARTH'
'robber' 'THIEF'
'road' 'STREET'
'road' 'CAR'
'rider' 'HORSE'
'rice' 'PUDDING'
'reptile' 'SNAKE'
'reptile' 'LIZARD'
'rabbit' 'HARE'
'pupil' 'TEACHER'
'prison' 'JAIL'
'potato' 'SPUD'
'pork' 'PIG'
'poem' 'VERSE'
'poem' 'POET'
'plum' 'PUDDING'
'pint' 'BEER'
'physics' 'MATHS'
'physics' 'CHEMISTRY'
'penny' 'FARTHING'
'pea' 'SOUP'
'pants' 'TROUSERS'
'opera' 'SINGER'
'noun' 'VERB'
'noun' 'PRONOUN'
'notion' 'IDEA'
'morning' 'EVENING'
'morning' 'AFTERNOON'
'mitten' 'GLOVE'
'meat' 'FOOD'
'meat' 'BEEF'
'lung' 'CANCER'
'liver' 'KIDNEY'
'lion' 'DEN'
'lion' 'TIGER'
'lettuce' 'SALAD'
'lawn' 'TENNIS'

'lawn' 'MOWER'
'lady' 'WOMAN'
'kidney' 'STEAK'
'kettle' 'TEA'
'keg' 'BEER'
'jury' 'TRIAL'
'jumper' 'SWEATER'
'journal' 'MAGAZINE'
'jazz' 'MUSIC'
'jail' 'PRISON'
'island' 'SEA'
'insect' 'SPIDER'
'insect' 'ANT'
'hotel' 'HOLIDAY'
'hockey' 'BALL'
'heaven' 'HELL'
'hay' 'FEVER'
'hamster' 'PET'
'grape' 'WINE'
'grape' 'VINE'
'god' 'ANGEL'
'glass' 'WINDOW'
'garlic' 'ONION'
'gallon' 'PINT'
'gallon' 'BEER'
'frog' 'TOAD'
'freedom' 'LIBERTY'
'forest' 'TREES'
'fever' 'HAY'
'falcon' 'EAGLE'
'driver' 'LORRY'
'dollars' 'CENTS'
'dollar' 'CENT'
'doll' 'BABY'
'dirt' 'FILTH'
'dinner' 'FOOD'
'den' 'LAIR'
'cricket' 'BAT'
'coffee' 'TEA'
'city' 'TOWN'
'circus' 'CLOWN'
'cinema' 'FILM'
'cello' 'VIOLIN'

'cat' 'DOG'
'cancer' 'LUNG'
'canal' 'RIVER'
'café' 'COFFEE'
'bus' 'DRIVER'
'bug' 'INSECT'
'bucket' 'SPADE'
'brother' 'SISTER'
'brick' 'MORTAR'
'bread' 'BUTTER'
'bracelet' 'WRIST'
'boy' 'GIRL'
'blade' 'SWORD'
'blade' 'RAZOR'
'ballet' 'DANCER'
'baggage' 'LUGGAGE'
'bacon' 'RIND'
'avenue' 'ROAD'
'author' 'BOOK'
'aunt' 'UNCLE'
'artist' 'PAINTING'
'army' 'NAVY'
'apple' 'PEAR'
'apple' 'ORANGE'

## **Appendix 1.2.** List of semantically incongruent prime-target real word pairs used in experiment 3, Chapter 5.

Prime words were drawn from the left-hand list while target words were drawn from the right-hand list. This list consists of 140 word pairs. From this list, a shorter list of 80 word pairs was randomly and automatically selected for each participant, using Matlab software (MathWorks, Natick, MA).

| | |
|---|---|
| 'ankle' | 'CHART' |
| 'army' | 'FRUIT' |
| 'atlas' | 'OUNCE' |
| 'atlas' | 'TABLET' |
| 'attic' | 'SEWER' |
| 'attic' | 'SPARROW' |
| 'attic' | 'MUFFIN' |
| 'axe' | 'OPAL' |
| 'baby' | 'GOLD' |
| 'bacon' | 'TAIL' |
| 'ballet' | 'RABBIT' |
| 'ballet' | 'STEAK' |
| 'ballet' | 'EAST' |
| 'barn' | 'FEVER' |
| 'barn' | 'ONION' |
| 'beauty' | 'ANIMAL' |
| 'belt' | 'PEN' |
| 'bird' | 'DOOR' |
| 'bucket' | 'BOY' |
| 'burden' | 'LORRY' |
| 'butterfly' | 'CINEMA' |
| 'captain' | 'LIBERTY' |
| 'car' | 'AUTHOR' |
| 'eve' | 'FISH' |
| 'ceiling' | 'BODY' |
| 'cigar' | 'LAWN' |
| 'cigar' | 'HERB' |
| 'circus' | 'DINGHY' |
| 'chicken' | 'BOMB' |
| 'compass' | 'THREAD' |
| 'counter' | 'BOTTOM' |
| 'dinner' | 'ITEM' |
| 'ear' | 'FREEZER' |
| 'error' | 'AUTHOR' |

'falcon' 'TULIP'
'forest' 'PRISON'
'goose' 'OVEN'
'hall' 'COLUMN'
'hamster' 'GLOVE'
'hamster' 'NEEDLE'
'heart' 'CARROT'
'hen' 'YOLK'
'hockey' 'LEMON'
'frost' 'ELM'
'fruit' 'TOUCH'
'jazz' 'SKILL'
'jazz' 'WOOL'
'journal' 'SEA'
'keg' 'WINE'
'king' 'MIXER'
'lamp' 'DOE'
'lawn' 'MOVIE'
'meat' 'NAVY'
'mitten' 'FACE'
'mystery' 'COKE'
'navy' 'TANK'
'nun' 'YEAR'
'octopus' 'WHEAT'
'office' 'BRAIN'
'orange' 'ZIP'
'pants' 'TUNA'
'pants' 'CLIFF'
'pants' 'ELM'
'parrot' 'CANARY'
'parrot' 'LEMON'
'physics' 'HONEY'
'pigeon' 'SNAIL'
'pillow' 'MUFFIN'
'priest' 'HERB'
'quantity' 'GOLD'
'rat' 'BREAD'
'reality' 'ISLAND'
'rice' 'CHURCH'
'rice' 'HORSE'
'robin' 'GRAPE'
'robin' 'HORSE'
'salmon' 'TEACHER'

'sandal' 'MOTH'
'sauce' 'CAR'
'sheep' 'BIOLOGY'
'sheep' 'OPAL'
'shelf' 'STOOL'
'sickle' 'JAIL'
'sister' 'TOILET'
'sock' 'CLIFF'
'soda' 'AVENUE'
'soda' 'SPARROW'
'sofa' 'CABINET'
'sofa' 'DOLL'
'soup' 'CELLAR'
'spade' 'ZOO'
'stereo' 'DOE'
'story' 'DOOR'
'stove' 'BIOLOGY'
'street' 'COFFEE'
'student' 'BOAT'
'summer' 'CHIMNEY'
'tea' 'OPAL'
'tea' 'BEAN'
'theatre' 'TABLET'
'toilet' 'SNAIL'
'toilet' 'DOVE'
'toilet' 'SEWER'
'toilet' 'COD'
'trunk' 'PLUM'
'verb' 'PORK'
'verb' 'LAWYER'
'wine' 'BILL'
'wine' 'DINGHY'
'woman' 'BOAT'
'wood' 'SECRECY'
'wool' 'RIDER'
'year' 'DESK'
'zoo' 'AUTHOR'
'anchor' 'SWEEP'
'anger' 'TASTE'
'arrow' 'MINUTE'
'auction' 'PRESS'
'baggage' 'PEPPER'
'banana' 'PAINT'

'battle' 'JACKET'
'beach' 'CHEST'
'beetle' 'SHORTS'
'bible' 'BRANCH'
'blade' 'TART'
'book' 'PURR'
'brain' 'EAT'
'bush' 'GLASS'
'button' 'KIDNEY'
'canal' 'SPEAR'
'chalk' 'SADDLE'
'cup' 'DISH'
'daisy' 'RUGBY'
'dollar' 'STUDY'
'iron' 'MIXER'
'knife' 'TRIGGER'
'mile' 'WORD'
'mouth' 'STONE'
'paper' 'CHILD'
'pearl' 'BEAN'

## **Appendix 1.3.** List of pseudo prime-target word pairs used in experiment 3, Chapter 5.

Pseudo words consisted of pronounceable permutations of real words. These were created by re-arranging 1 or 2 letters from words also drawn the Kučera and Francis word data set (Kučera & Francis, 1967). Pseudo prime words were drawn from the left-hand list while pseudo target words were drawn from the right-hand list. This list consists of 280 word pairs. From this list, a shorter list of 80 word pairs was randomly and automatically selected for each participant, using Matlab software (MathWorks, Natick, MA).

| | |
|---|---|
| 'murt' | 'PUILLS' |
| 'deils' | 'ROOP' |
| 'shaid' | 'SHALP' |
| 'klapes' | 'SHORLS' |
| 'sague' | 'SKANS' |
| 'ambow' | 'SUR' |
| 'stours' | 'TAUKS' |
| 'gayest' | 'TOUND' |
| 'chomer' | 'VAILIT' |
| 'reighed' | 'WAIG' |
| 'rhapen' | 'WHINT' |
| 'hude' | 'WOSM' |
| 'chairst' | 'WREAFT' |
| 'slarve' | 'WREAFS' |
| 'kraw' | 'WRIMES' |
| 'daughs' | 'WUR' |
| 'radle' | 'WRUK' |
| 'rour' | 'KNORE' |
| 'anom' | 'WREEN' |
| 'koque' | 'STED' |
| 'feis' | 'RAWD' |
| 'klum' | 'FALD' |
| 'monter' | 'ROMEST' |
| 'rete' | 'RASIC' |
| 'cipped' | 'SNIES' |
| 'clopist' | 'WEA' |
| 'sharrs' | 'JORS' |
| 'troft' | 'DREKLE' |
| 'cippel' | 'TAND' |
| 'cus' | 'WRAWS' |
| 'daughs' | 'BER' |
| 'dornd' | 'WHYMST' |

'durke' 'DRARFED'
'erd' 'PHUGS'
'foles' 'WRYPPED'
'graipsel' 'DANST'
'hited' 'HOASET'
'kales' 'GEEP'
'kan' 'TAWES'
'kordo' 'KIPE'
'kourns' 'STOSP'
'kowos' 'AUB'
'kroal' 'FLORT'
'laguen' 'SHANEM'
'newd' 'NORDET'
'norch' 'SHUR'
'pailed' 'TRAYED'
'pheys' 'STAWES'
'phyne' 'VAILST'
'puills' 'WAREL'
'roop' 'KARDS'
'shalp' 'WRUISED'
'shorls' 'ORD'
'skans' 'STILST'
'sur' 'KREPEM'
'tauks' 'WEILET'
'tound' 'POTLEM'
'vailit' 'DEILIO'
'waig' 'SKUTS'
'whint' 'VATO'
'wosm' 'JORS'
'wreaft' 'GHOOSED'
'wreafs' 'SINCH'
'wrimes' 'WRAVES'
'wur' 'FORIS'
'wruk' 'RONTER'
'knore' 'ROLEM'
'wreen' 'PUMED'
'sted' 'TURES'
'rawd' 'FERDER'
'fald' 'WEINS'
'romest' 'MAVE'
'rasic' 'GEAP'
'snies' 'KAN'
'wea' 'KLOORSO'

'jors' 'CEAPED'
'drekle' 'CIVE'
'tand' 'CIDE'
'wraws' 'KLOAKER'
'ber' 'PERGEM'
'whymst' 'LISSED'
'drarfed' 'PHILOG'
'phugs' 'JOUD'
'wrypped' 'KINED'
'danst' 'KONGST'
'hoaset' 'KUPSET'
'geep' 'CEEKS'
'tawes' 'WOARS'
'kipe' 'ZETHAT'
'stosp' 'BYNE'
'aub' 'MURT'
'flort' 'DEILS'
'shanem' 'SHAID'
'nordet' 'KLAPES'
'shur' 'SAGUE'
'trayed' 'AMBOW'
'stawes' 'STOURS'
'vailst' 'GAYEST'
'warel' 'CHOMER'
'kards' 'REIGHED'
'wruised' 'RHAPEN'
'ord' 'HUDE'
'stilst' 'CHAIRST'
'krepem' 'SLARVE'
'weilet' 'KRAW'
'potlem' 'DAUGHS'
'deilio' 'RADLE'
'skuts' 'ROUR'
'vato' 'ANOM'
'jors' 'KOQUE'
'ghoosed' 'FEIS'
'sinch' 'KLUM'
'wraves' 'MONTER'
'foris' 'RETE'
'ronter' 'CIPPED'
'rolem' 'CLOPIST'
'pumed' 'SHARRS'
'tures' 'TROFT'

'ferder' 'CIPPEL'
'weins' 'CUS'
'mave' 'DAUGHS'
'geap' 'DORND'
'kan' 'DURKE'
'kloorso' 'ERD'
'ceaped' 'FOLES'
'cive' 'GRAIPSEL'
'cide' 'HITED'
'kloaker' 'KALES'
'pergem' 'KAN'
'lissed' 'KORDO'
'philog' 'KOURNS'
'joud' 'KOWOS'
'kined' 'KROAL'
'kongst' 'LAGUEN'
'kupset' 'NEWD'
'ceeks' 'NORCH'
'woars' 'PAILED'
'zethat' 'PHEYS'
'byne' 'PHYNE'
'murt' 'PUILLS'
'deils' 'ROOP'
'shaid' 'SHALP'
'klapes' 'SHORLS'
'sague' 'SKANS'
'ambow' 'SUR'
'stours' 'TAUKS'
'gayest' 'TOUND'
'chomer' 'VAILIT'
'reighed' 'WAIG'
'rhapen' 'WHINT'
'hude' 'WOSM'
'chairst' 'WREAFT'
'slarve' 'WREAFS'
'kraw' 'WRIMES'
'daughs' 'WUR'
'radle' 'WRUK'
'rour' 'KNORE'
'anom' 'WREEN'
'koque' 'STED'
'feis' 'RAWD'
'klum' 'FALD'

'monter' 'ROMEST'
'rete' 'RASIC'
'cipped' 'SNIES'
'clopist' 'WEA'
'sharrs' 'JORS'
'troft' 'DREKLE'
'cippel' 'TAND'
'cus' 'WRAWS'
'daughs' 'BER'
'dornd' 'WHYMST'
'durke' 'DRARFED'
'erd' 'PHUGS'
'foles' 'WRYPPED'
'graipsel' 'DANST'
'hited' 'HOASET'
'kales' 'GEEP'
'kan' 'TAWES'
'kordo' 'KIPE'
'kourns' 'STOSP'
'kowos' 'AUB'
'kroal' 'FLORT'
'laguen' 'SHANEM'
'newd' 'NORDET'
'norch' 'SHUR'
'pailed' 'TRAYED'
'pheys' 'STAWES'
'phyne' 'VAILST'
'puills' 'WAREL'
'roop' 'KARDS'
'shalp' 'WRUISED'
'shorls' 'ORD'
'skans' 'STILST'
'sur' 'KREPEM'
'tauks' 'WEILET'
'tound' 'POTLEM'
'vailit' 'DEILIO'
'waig' 'SKUTS'
'whint' 'VATO'
'wosm' 'JORS'
'wreaft' 'GHOOSED'
'wreafs' 'SINCH'
'wrimes' 'WRAVES'
'wur' 'FORIS'

'wruk' 'RONTER'
'knore' 'ROLEM'
'wreen' 'PUMED'
'sted' 'TURES'
'rawd' 'FERDER'
'fald' 'WEINS'
'romest' 'MAVE'
'rasic' 'GEAP'
'snies' 'KAN'
'wea' 'KLOORSO'
'jors' 'CEAPED'
'drekle' 'CIVE'
'tand' 'CIDE'
'wraws' 'KLOAKER'
'ber' 'PERGEM'
'whymst' 'LISSED'
'drarfed' 'PHILOG'
'phugs' 'JOUD'
'wrypped' 'KINED'
'danst' 'KONGST'
'hoaset' 'KUPSET'
'geep' 'CEEKS'
'tawes' 'WOARS'
'kipe' 'ZETHAT'
'stosp' 'BYNE'
'aub' 'TURES'
'flort' 'FERDER'
'shanem' 'MURT'
'nordet' 'DEILS'
'shur' 'SHAID'
'trayed' 'KLAPES'
'stawes' 'SAGUE'
'vailst' 'AMBOW'
'warel' 'STOURS'
'kards' 'GAYEST'
'wruised' 'CHOMER'
'ord' 'REIGHED'
'stilst' 'RHAPEN'
'krepem' 'HUDE'
'weilet' 'CHAIRST'
'potlem' 'SLARVE'
'deilio' 'KRAW'
'skuts' 'DAUGHS'

'vato' 'RADLE'
'jors' 'ROUR'
'ghoosed' 'ANOM'
'sinch' 'KOQUE'
'wraves' 'FEIS'
'foris' 'KLUM'
'ronter' 'MOTRA'
'rolem' 'RETE'
'pumed' 'CIPPED'
'tures' 'CLOPIST'
'ferder' 'SHARRS'
'weins' 'TROFT'
'mave' 'CIPPEL'
'geap' 'CUS'
'kan' 'DAUGHS'
'kloorso' 'DORND'
'ceaped' 'DURKE'
'cive' 'ERD'
'cide' 'FOLES'
'kloaker' 'GRAIPSEL'
'pergem' 'HITED'
'lissed' 'KALES'
'philog' 'KAN'
'joud' 'KORDO'
'kined' 'KOURNS'
'kongst' 'KOWOS'
'kupset' 'KROAL'
'ceeks' 'LAGUEN'
'woars' 'NEWD'
'zethat' 'NORCH'
'byne' 'PAILED'
'tures' 'PHEYS'
'ferder' 'PHYNE'

# Appendix 2

## Appendix 2.1. List of prime words used in semantically congruent condition in experiment 4, Chapter 6.

Depicted here are the prime words used in the semantically congruent condition, for both SOA1 and SOA2 experimental designs. Words used in the 'Living' group precede those in the 'Human made' group, see Chapter 6, Methods section 6.2.2. In each case, the target picture paired with the given prime word was a coloured line drawing representing the meaning of the prime word. For example, where the prime word was 'fox' the target picture was a drawing of a fox. Target pictures were drawn from the ''Snodgrass and Vanderwart-like'' objects (Rossion and Pourtois 2004). The target pictures are not depicted here due to copyright restrictions.

Living Congruent

"RHINOCEROS"
"BEAR"
"ALLIGATOR"
"BEETLE"
"BIRD"
"CAMEL"
"CARROT"
"CLOUD"
"CORN"
"CRICKET"
"DUCK"
"EAR"
"CATERPILLAR"
"FLY"
"FOOT"
"FOX"
"GOAT"
"GRAPES"
"HAND"
"HEN"
"LEAF"
"LEOPARD"
"LION"
"GIRL"

"LOBSTER"
"MONKEY"
"MOUNTAIN"
"MOUSE"
"MUSHROOM"
"NOSE"
"PEACH"
"PEANUT"
"PEAR"
"PIG"
"PINEAPPLE"
"PUMPKIN"
"RABBIT"
"RACOON"
"SEAL"
"SHEEP"
"SKUNK"
"SNAKE"
"SPIDER"
"SQUIRREL"
"TREE"
"ZEBRA"

Human Made Congruent

"AXE"
"BARREL"
"BASKET"
"BED"
"BICYCLE"
"BOOT"
"BOW"
"BOWL"
"BUTTON"
"CHURCH"
"CLOCK"
"JUG"
"COUCH"
"CROWN"
"CUP"
"DESK"
"DRUM"
"FLAG"

"FORK"
"FRIDGE"
"GLOVE"
"GUITAR"
"GUN"
"HELICOPTER"
"KEY"
"KITE"
"LADDER"
"NAIL"
"PEG"
"PENCIL"
"PIANO"
"RING"
"RULLER"
"SANDWICH"
"SCISSORS"
"SPOON"
"SUITCASE"
"SWING"
"TABLE"
"TELEPHONE"
"TIE"
"TRAIN"
"TRUCK"
"VIOLIN"
"WHISTLE"
"WINDMILL"

# Appendix 2.2. List of prime words used in semantically incongruent condition in experiment 4, Chapter Six.

Depicted here are the prime words used in the semantically incongruent condition, for both SOA1 and SOA2 experimental designs. Words used in the 'Living' group precede those in the 'Human made' group, see Chapter Six, Methods section 6.2.2. In each case, the target picture paired with the given prime word was a coloured line drawing. Pictures depicted an image that was semantically incongruent, and differed with respect to the prime word in terms of whether it was a living or human made object. For example, where the prime word was 'fox' the target picture could depict a watch. Or for example, where the prime word was 'car' the target picture could have depicted an eagle. Target pictures were drawn from the ''Snodgrass and Vanderwart-like'' objects (Rossion and Pourtois 2004). The target pictures are not depicted here due to copyright.

Living Incongruent

"WATCH"
"UMBRELLA"
"BOTTLE"
"DOOR"
"DRESS"
"BOOK"
"IRON"
"CAKE"
"HAT"
"LAMP"
"GLASSES"
"CAR"
"FENCE"
"BELL"
"TELEVISION"
"BRUSH"
"HOUSE"
"PLIERS"
"TROUSERS"
"ANCHOR"
"PIPE"
"BOX"
"CHAIN"
"COAT"
"SCREW"
"TRUMPET"
"SAW"

"BUS"
"NEEDLE"
"ASHTRAY"
"BOAT"
"BELT"
"CHAIR"
"BALL"
"CANDLE"
"TOOTHBRUSH"
"BALLOON"
"TOASTER"
"HAMMER"
"POT"
"GLASS"
"CIGAR"
"STOOL"
"PLUG"
"CIGARETTE"
"BROOM"

Human Made Incongruent

"LETTUCE"
"TURTLE"
"EYE"
"GIRAFFE"
"LIPS"
"CAT"
"ORANGE"
"DOG"
"LEG"
"OSTRICH"
"OCTOPUS"
"EAGLE"
"GORILLA"
"BANANA"
"STRAWBERRY"
"COW"
"ONION"
"PENGUIN"
"TIGER"
"BEE"
"PEACOCK"

"CELERY"
"ELEPHANT"
"FROG"
"ROOSTER"
"TOMATOE"
"ARM"
"DEER"
"OWL"
"ANT"
"CAPSICUM"
"BUTTERFLY"
"FISH"
"APPLE"
"DONKEY"
"THUMB"
"ASPARAGUS"
"SWAN"
"KANGAROO"
"SNAIL"
"HORSE"
"FINGER"
"SEAHORSE"
"LEMON"
"FLOWER"
"CHERRY"