Understanding, Measuring, and, Invoking Mindfulness and Mindlessness During Human-Computer Interactions

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This thesis has not been submitted in support of an application for another degree at this or any other university. It is the result of my own work and includes nothing that is the outcome of work done in collaboration except where specifically indicated.

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Abstract

This thesis questions how Mindfulness and Mindlessness might be understood, measured and invoked in relation to Human-Computer Interactions. Current designs of user interfaces often follow a design trend, drawing upon familiar layout and icons across a broad range of applications. Designers often try to make the interface easier to understand, familiar, and more intuitive. While the use of technologies that are familiar holds qualities such as low cognitive demand and ease of use; they hold within them an intrinsic problem. The familiarity and repetition in design qualities produces habitual response and reduces the facilities of reflection and contemplation upon the interaction. Subsequently this inhibits the discovery of novel solutions to challenges and / or formation of novel goals for the user of a technology.

The primary goal of this thesis is to provide (and justify) a definition of Mindfulness and Mindlessness that is suitable to be applied in the field of human-computer interaction; and clearly describe these experiential and behavioural phenomena of the user of interactive technology. These definitions draw upon related fields to better inform understanding through the application of their methods of evaluation and advancements in understanding. Resultantly an additional goal of this thesis is to pave way for future work in this area in providing insight to, and example of, methods for the measuring of Mindfulness and Mindlessness that are suited to the field of human-computer interaction and supported in the informing related work. Lastly, this thesis holds the goal of situating the work in related literature of how the states of Mindfulness and Mindlessness might be invoked and their effect upon human-computer interaction. More broadly, this thesis seeks to provide the framing of human-computer interaction and interface design through a lens of Mindfulness and Mindlessness as a means of better understanding and designing for the distinct qualities each holds.

These goals are achieved through three stages; first this body of work provides a pragmatic definition of Mindfulness and Mindlessness that can be applied to interactions with technologies. In doing so it overcomes the problematic qualities of directly applying previous definitions and facilitates further study of the phenomenon through empirical modalities founded in cognitive science. Second, this research provides the reporting of an exploratory study conducted, and findings for future works to build upon, in the analysis of Mindful and Mindless experiences during interactions with digital technologies. This is achieved through a neuro-phenomenological methodology, combining first person reporting alongside physiological measurement highlighting Mindful and Mindless interactions. Finally, this thesis provides insight to how the design of technologies can invoke Mindful and Mindless interactions and the consequences of these, followed by design considerations in the final conclusion.

Through this the thesis addresses the *Understanding, Measuring, and, Invoking of Mindfulness and Mindlessness During Human-Computer Interactions*.

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Introduction And Outline Of Thesis and Contributions

The overarching research question of this thesis asks, *how Mindfulness and Mindlessness can be understood, measured and invoked in relation to Human-Computer Interactions?*

Mindfulness, in the context of this thesis, can be summarised as a broad reflective awareness that is receptive to new perspectives, new approaches, and context. Mindful interactions facilitate novelty in the goals and execution and so offer a broader range of outcomes and meaning generation, however they are slow in their steps, and are typically cognitively demanding. Mindlessness can be summarised as the reliance upon well-learned routines and behaviours and is low in cognitive demand and rapid in execution. However, Mindless interactions fail to develop novel meanings and solutions as they are performed as a well-learned script, intuitively or habitually (Langer, 1989).

The use of human-computer interaction in this thesis refers to a specific (human) use of digital technology(ies); following MacKenzie and Wajcman's (1985) definition of technology as ensembles of technical artefacts, activities or processes, and practical knowledge. Interaction is here considered an action through use/behaviour of (or toward) a technology concerning a particular task, benefit, or goal, or (often bilateral) conveyance of meaning and information/knowledge. This occurs at an interface - the "bridge" between technology and its "user", such as a mouse, touch-screen, or display.

The research question is developed in response to the on-going pursuit within human-computer interaction design of designing toward efficiency (Dillon, 2002). Goals for new designs and improvement on old seek to be more "intuitive", familiar, less cognitively loading, fewer action steps or "clicks", and thus faster. Such qualities are employed as a utility and exploit this feature as a *Mindless* attribute of a system. In the context of interaction used in this thesis, utility is understood to be a function, a use toward a particular benefit – specifically a conveyance of meaning and information. Though this is clearly a required attribute of any interface, this thesis proposes that utility might be augmented to provide benefits (in the right circumstance) that oppose traditional tropes of efficiency and facilitate understanding new meaning and information. However, there has been substantially less attention toward the development of interactions that challenge traditional notions of utility, those that instead encourage reflection, inquiry, novelty (in being unfamiliar); and the benefits that such *Mindful* systems might promote. Consequently, such Mindful interactive systems might open up utility through embracing interpretative qualities; encouraging reflection upon the wider affordance space and meanings offered through the interaction; and consequently, the development of appropriate schemas of meaning contextualized to the present interaction.

While considerably less common, there is growing support in movements that aim to encourage users of technologies to reconsider how they engage with technology that is often demanding, "invisible", time centric and increasingly integrated into commonplace experiences. Interactive technologies designed to make people more "efficient" now encompass a broad spectrum of activities (such as assistive, social and entertainment roles) and are "*…more or less continuously present as part of a designed environment*" (p162, Hallnäs and Redström, 2001). In response Slow Technology advocates a readdressing of traditional interaction paradigms to encourage technology designed "*…in a way that encourages people to reflect and think about it.*" (p169, Hallnäs and Redström, 2001). As noted by Grosse-Hering et al. (2013) this does not specifically mean slowing interactions (with regards to time taken) but opening up interactions to promote 'slowness' on aspects of interaction that may be more meaningful for users and in doing so "*…can be used to create more 'Mindful' interactions that stimulate positive user involvement*" (p3431). Thus, the goals of slow technology encourage "*reflection and moments of mental rest rather than efficiency in performance*" (p161, Hallnäs and Redström, 2001); and as shall be highlighted through this thesis are highly sympathetic to Mindfulness. In a similar vein to the Slow Technology movement are positions that consider the felt experience of the user as central motivations of action and design. Such concepts hold that interactive experiences focusing on functionality (understood in traditional quantifiable metrics of efficiency) only activate limited capacities of the experience of the user. Such example is found within experience-centred design (Wright, Wallace and McCarthy, 2008; Wright and McCarthy, 2010; Hassenzahl 2011); that proposes while the functional attributes of interactive systems are of great importance, they should be supported through an understanding of the emotional values that people construct through interactions with other people and technology.

These opposing positions, making interactions between people and technology experientially efficient and cultivating ongoing reflection and experience; are framed here as Mindless and Mindful interactions (respectively) in their core attributes, aims, approach and use. The use of these terms however, and the qualities that they manifest are not intended to be positioned as inherently positive or negative. For example, Mindlessness is often viewed and described as a negative experience without benefit and so regarded as something that should be avoided at all cost (Nucci, 2014); yet has qualities such as being cognitively light, rapid in execution, predictable, and, multitasking support. Consequently, in this thesis it is argued that such dichotomy has created a lack of understanding in how and when Mindfulness and Mindlessness might best be applied. This thesis argues for balanced consideration of both Mindful and Mindless interactions when designing interactive systems to understand and apply which may be most appropriate for a particular context.

The commonplace misgivings of understanding Mindlessness might stem from the widespread use of Mindfulness. Initially, and surprisingly considering the increase in popularity of 'Mindfulness' as a 'solution' and approach marketed to many varied audience, it became apparent that definitions of Mindfulness (and Mindlessness) are often lacking in their grounding and clarity of meaning. Many works keenly state they applied/explored a Mindful approach, quality, or values, yet are often are reliant upon definitions from fields such as a spiritual or clinical practice that further mystify this complex state and pay little justification to its use or meaning. This is not to say that states of Mindfulness or Mindlessness are unfathomable and beyond description, many have experienced and described moments of 'running on autopilot', actions as 'habit', or more simply put as acting Mindlessly. Likewise, many are also aware to (Mindful) moments of experience where things 'click', 'connections are made' and the 'broader picture' revealed.

Consequently, there are larger 'problem spaces' to be explored prior to formulation of specific context questions upon the topic of Mindfulness during human-computer interaction e.g. "*How can Mindfulness alter interactions with social media and 'Fake news'?*". As a result, care was given to avoid ignoring the wider complexities and problem space and sought to address the core challenge – principally; what *are* Mindfulness and Mindlessness and how might they be understood in broader human behaviours and actions through and with technologies; and furthermore, how might we measure and evaluate such qualities, and how might we implement features to invoke these qualities when interacting with digital technologies.

While Mindfulness and Mindlessness both hold beneficial and costly qualities less consideration is given to such user experiences in commonplace interaction design (Dillon, 2002). In providing a means in which designers and evaluations of interactive technologies can accommodate understandings of such qualities, opportunity to re-address the balance or appropriately design for such states is better facilitated.

This thesis seeks to address such positions through the definition, development of method of analysis, and example in design; of the states of Mindfulness and Mindlessness. Consequently, the thesis is by design in three sections in response to three lines of investigation answering the overarching research question, and described through the contributions outlined in the following.

How Can We Understand Mindfulness and Mindlessness During Human-Computer Interaction?

As will be highlighted in Section 1, existing definitions of Mindfulness and Mindlessness are unsuitable in application to human-computer interaction research through holding ambiguity in definition, lack of suitability (i.e. referring to general dispositions), and failure to accommodate complementary and well-established research findings.

Addressing this the core of this thesis seeks to provide a pragmatic definition of these states grounded in broader disciplines incorporating philosophical, psychological and cognitive science perspectives; that can be applied toward the framing and understanding of interactions with digital technology. Resultantly a definition is provided that holds as a central tenet: a reduction of the ambiguity of the phenomena (and its facets) being discussed; ability to describe specific instances and qualities of interactions with technologies; incorporation and openness to understanding and knowledge from well-established related research domains; capacity to support research methods developed in well-established related research domains i.e. facilitates further enquiry into the phenomena described. In contribution from this the thesis provides:

- Justification upon why existing definitions of Mindfulness (and Mindlessness) are problematic in their direct application to HCI research and design. (Chapter 1.1 – 1.3)
- Justification and support in the understanding and defining of Mindfulness and Mindlessness grounded in philosophical and cognitive science perspectives providing basis for further future enquiry employing methods from well-established disciplines. (Chapter 1.4 – 1.12)
- A lexicon for describing differing conscious states in the context of Mindful and Mindless to clarify ambiguities of such phenomena (Chapter 1.5)
- Differentiations of technologies affordance availability in the context of Mindful and Mindless approaches through the definitions of Tool and Equipment; to clarify framings of interactions with technologies (Chapter 1.9)
- Definitions of technologies affordance availability inclusive of the broader experiential state of the agent operating the technology in the context of Mindful and Mindless approaches; to clarify framings of subjective experiences during interaction with technologies (Chapter 1.10)

And most significantly

- The encompassing understanding and definition of Mindfulness and Mindlessness during interactions with technologies that facilitates further understanding through measurement of physiological processes supported through well-established related domains research methods. (Chapter 1.3)

How Can We Measure Mindfulness and Mindlessness During Human-Computer Interaction?

Building upon the above, Section 2 seeks to inform future work through the development of a method in which Mindfulness and Mindlessness might be empirically measured (through physiological measurement) and so bi-directional effects during interactions with technology are better understood.

This is achieved through the reporting of an exploratory study that provides novel direction for future work in the development of systems that might unobtrusively measure moments of Mindfulness and Mindlessness. Employing methods facilitated through the (previously described) definitions, a neurophenomenological approach is taken that draws upon first person accounts alongside physiological measures. This seeks to provide capacity to measure the defined states of Mindfulness and Mindlessness during interactions with technologies. Consequently this broader question directing the exploratory study, i.e. *how can we measure Mindfulness and Mindlessness during human-computer interaction?,* aims to provide; justification of the definitions and supporting literature (found in Section 1), descriptions of the successes and failures in methods of the measurement of Mindfulness and Mindlessness, and provide methods for further exploration in future work in this area.

In contribution from this line of questioning the thesis provides:

- Justification and support in the use of neurophenomenological methods (Chapter 2.0) and of the guiding statements informing study design derived from Section 1 (Chapter 2.9)
- The reporting of findings and methods from an exploratory study into the measurement of Mindful and Mindless states. (Chapter 2.5 – 2.8)
- Insights to the user perspective upon Mindful and Mindless states during interaction, how they alter interaction, and how such states are experienced. (Chapter 2.8)
- Four modalities for further exploration in view of the physiological measurement of Mindful and Mindless states during interactions with technologies. (Chapter 2.9)

How Can We Invoke Mindfulness and Mindlessness During Human-Computer Interaction?

Given the field of application (human-computer interaction design) Section 3 provides insight in distinguishing interactions as those invoking moments 'thinking' and reflectivity and those for ‘knowing’ providing transparent windows to information. This is achieved through highlighting some of the ways in which design choices can lead to Mindful and Mindless interactions and the consequences of such choices through understandings and example in HCI design.

In contribution from this line of questioning the thesis provides:

- Insight to how HCI design might invoke Mindful and Mindless engagements with digital technologies. (Chapter 3.1 – 3.5)
- Insight toward how such states might be countered (Chapter 3.1 – 3.5)
- Design considerations for facilitating Mindful and Mindless interactions with digital technologies. (Chapter 3.6)

Methodology

Through a pragmatist approach a research methodology is chosen that is best suited to purpose and aims of the research question. Tashakkori and Teddlie (p713, 2003) describe pragmatism as:

> "… a deconstructive paradigm that debunks concepts such as 'truth' and 'reality' and focuses instead on 'what works' as the truth regarding the research questions under investigation. Pragmatism rejects the either/or choices associated with the paradigm wars, advocates for the use of mixed methods in research, and acknowledges that the values of the researcher play a large role in interpretations of results."

A central tenet of a pragmatic approach is a commitment to the end-cause and practical outcomes as providing validity and value; i.e. an ideology or theory is considered to be true if it works to a satisfactory degree, the value of a theory is within the practical consequences of accepting it, and ideas which are unpractical are rejected. In the process of method selection, pragmatism advocates a mixed methods approach. Methods used in validation of a particular position are chosen not due to their epistemological implications or as an externally dictated methodology; but for the appropriateness of how well they fit and answer the research question. Consequently here, findings are given value with relationship to practical consequences e.g. contribution of knowledge that provides additional utility over previous understandings and can be verified through practical / well-established methods.

This thesis argues for a pragmatic definition of Mindfulness and Mindlessness largely influenced by a neurophenomenological approach (described in Chapter 1.11.1 and Chapter 2.0.1) in the question: "*How Can We Understand Mindfulness and Mindlessness During Human-Computer Interaction?*". It is apparent that there exist moments of sub-conscious interactions with technologies which "disappear" into phenomenological invisibility, (Weiser, 1991); conversely there are interactions with technologies which develop that draw the user to a reflective state of broader awareness. Consequently, a definition to describe these phenomena and incorporate understanding their facets from well-established domains is required. While existing framings and methods in assessment of Mindfulness (and so Mindlessness) hold utility in their respective domain (such as part of spiritual practice or cognitive based therapy); such utility does not translate to human-computer interaction. To ensure utility to human-computer interaction an operational definition is required; i.e. a definition that facilitates "some form" of inquiry to determine if an interaction falls within and can be accurately categorised and described by said definition. Understandings from well-established domains are drawn upon to firstly inform these definitions, and secondly to facilitate practical application of methods of analysis from these fields. This understanding is achieved through drawing upon existing framings and methods in assessment of Mindfulness (detailed in their corresponding publications) to inform key themes for further exploration. The resulting background research of these key themes, through seminal texts and understandings that describe the facets of Mindfulness and Mindlessness, then informed the hypothesis of how such phenomena should be understood and defined.

The informing works of Section 1 additionally guided the exploratory study design and modalities of measurement (described in Chapters 2.0 to 2.5) in questioning "*How Can We Measure Mindfulness and Mindlessness During Human-Computer Interaction?*". Through providing designers of interactive technologies understandings and methods in measuring Mindfulness and Mindlessness they will be better equipped to design support for each more suitably i.e. knowing when and where such states would be most effective. Consequently, the broader aim of the exploratory study is toward providing tools for the assessment of Mindful and Mindless states during human-computer interaction. While this broader goal remains for future work the exploratory study is intended to provide two utilities. Firstly, toward verifying the definitions developed in Section 1 and the facets described within and informing those; and secondly, expose methods that might be further refined (or those to be rejected) to achieve measurement of Mindfulness and Mindlessness during interactions with technologies. This is line of investigation was achieved through drawing upon a number of theoretical positioning's informed by the previous findings (of Section 1) as points of contrast and comparison, and analysis (described in depth in Chapter 2.2.2). Secondly the exploratory study holds a neurophenomenological approach (described in Chapter 1.11.1 and Chapter 2.0.1) in its method. This neurophenomenological approach triangulated philosophical perspectives (highlighted in Section 1), knowledges gained through cognitive sciences (highlighted in Section 1), qualitative report (derived from first-person report) and quantitative measures (physiological measurement) (gained through the exploratory study – Section 2); in combination to inform richer understandings of the phenomena of Mindfulness and Mindlessness. Methods used in this exploratory study are described in greater detail in Chapter's 2.0 to 2.5.

Finally, in Section 3, understandings from HCI design and theory are drawn upon in the development of design considerations in answer to the question "*How Can We Invoke Mindfulness and Mindlessness During Human-Computer Interaction?*". Drawing upon existing framings, theories, and example, within human-computer interaction design and design in general; evidence for the support of specific system attributes invoking Mindful *and* Mindless interactions is developed through background research.

The findings presented here are subject to refinement, alteration, and, expansion of both hypothesis (and consequently definitions) and modalities of measurement. This is expected to occur given the continual improvements in understandings of the role our bodies play in forming and shaping our experiences, and the knowledge and methods in measuring such experiences.

SECTION ONE

Understanding And Defining Mindfulness And Mindlessness During Interaction

In the following section it will be highlighted that existing definitions of Mindfulness and Mindlessness are unsuitable in application to human-computer interaction research.

Consequently, this section sets out to provide a pragmatic definition of Mindfulness and Mindlessness that can be applied in the framing and understanding of interactions with digital technology. Resultantly here a definition is required that has the following qualities or utility:

- Reduce the ambiguity of the phenomena being discussed
- Can be applied to describe specific instances and qualities of interactions with technologies
- Incorporates, and supports further incorporation of, understanding and knowledges from well-established related research domains
- Draws upon well-established related domains for which research methods have been developed and are transferable in application i.e. facilitates further enquiry into the phenomena described through established verifiable methods.

The definitions will be evaluated by their capacity to move beyond previous definitions of Mindfulness and Mindlessness. The criteria of evaluation to determine success is: a reduction in ambiguity around the phenomena, capacity to describe specific instances and qualities of interactions, facilitating incorporation of knowledge from well-established fields (and so hold capacity to incorporate future knowledges as those fields advance), supporting well-established methods of analysis from related fields, and incorporating and equally valuing philosophical learnings where cognitive science currently lacks and vice versa.

1.0.0: Introduction To Mindfulness

Throughout recent years there has been growing interest and research into the concept of Mindfulness and its application in a variety of fields (Sauer et al, 2013; Brown, Ryan and Creswell, 2007a) (see figure 1.1).

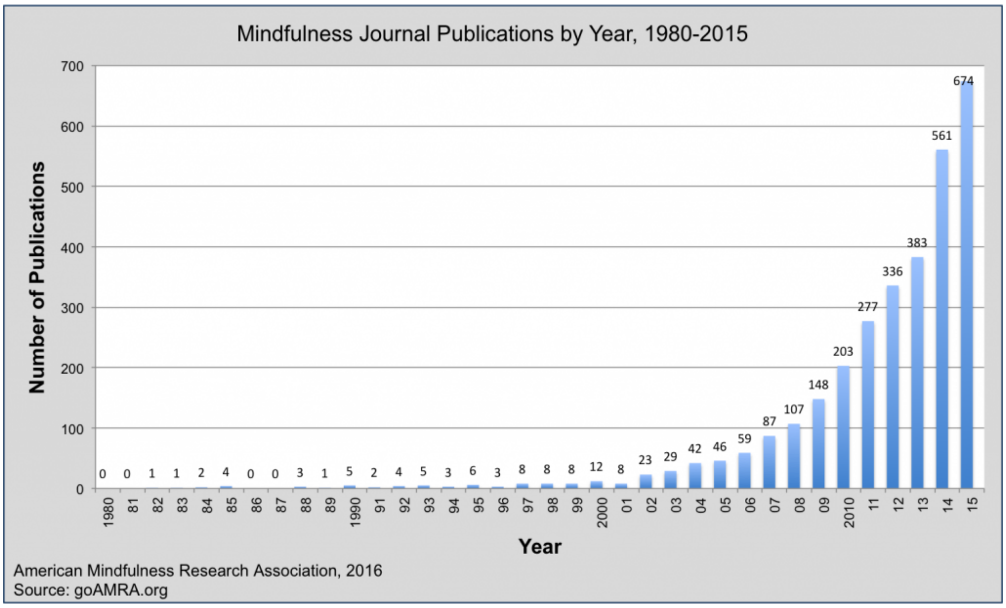

Figure 1.1; Publications in journals on the topic of Mindfulness.[1]

Originating from ancient Buddhist, Hindu and Chinese philosophies; Mindfulness can now be broadly described as falling into two categories; Eastern, centred upon traditional Buddhist practice and as a general mental disposition (e.g. that of Kabat-Zinn (e.g. 2003)); and Western (e.g. Langer (1992)), concerning creativity and understanding as a task situated mental state (transient as opposed to general disposition) (Ie, Ngnoumen and Langer, 2014; Siegling and Petrides, 2014), and may ultimately be seen as an "information processing" (Sauer et al, 2013; Schramm and Hu, 2014).

Mindfulness is considered to be a complex process of human consciousness that may be described as the process of the mind to reflecting upon itself (a reflection upon subjective experience). Mindfulness has been described as a quality of mind (p20, Kuan, 2008), a particular form of attention and awareness (Kabat-Zinn, 2003) that can be cultivated during meditation (Kuan, 2008; Thera, 1962). Although being practiced as a central tenet of spiritual practice since the earliest Buddhist teachings (Gunaratana, 2002; Nhat Hanh, 2008; Nanamoli and Bodhi, 1995); Mindfulness is

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[1] Retrieved from https://goamra.org/resources/ - 05/011/16

increasingly practiced in western culture (Kabat-Zinn, 2003; Brown, Ryan and Creswell, 2007a) and has more recently been applied in fields such as psychology, neuroscience, healthcare and business leadership. Although there is ongoing debate that western approaches (neuroscience, psychology etc.) may be inappropriate and undermine further development in the field (Williams and Kabat-Zinn, 2011; Kabat-Zinn 2003).

However, defining Mindfulness has lacked clarity and consistency (Bishop et. al., 2004; Grossman, 2008; Brown, Ryan and Creswell, 2007a; Chiesa, 2013); with understandings ranging from a simplification as "mere observing" (Sauer et al, 2013); to framing this state of experience as an undistracted awareness of the present developed from a knowing of the underlying process of our subjective experience as opposed to being in "automatic-pilot mode" (i.e. automaticity) (Hollis-Walker and Colosimo, 2011). Through the inconsistencies and mystification of definition (from Eastern approaches), existing seminal theories of mind, psychology and behaviour that may further explain particular qualities of Mindfulness and Mindlessness (and their origins) may be overlooked as considered insignificant for a particular study or application (Brown, Ryan and Creswell, 2007a). This attribute becomes problematic in defining this quality with agreement as a cross-disciplinary application and field of research; as noted by Bishop et. al.:

> "There have been no systematic efforts to establish the defining criteria of its various components or to specify the implicated psychological processes, and general descriptions of Mindfulness have not been entirely consistent across investigators"
> (Bishop et. al., 2004, P231).

As described, understandings of Mindfulness and Mindlessness have been developed through two 'schools of thought', Eastern and Western (Brown, Ryan and Creswell, 2007a; Hart, Ivtzan and Hart 2013; Ie, Ngnoumen and Langer, 2014). While these two schools share many similarities they differ through several core aspects. These differences primarily lie at their; construct, philosophy, target audience, interventions, measurement, and scope of application (Brown, Ryan and Creswell, 2007a; Hart, Ivtzan and Hart 2013). The lack of consistency in definition is further problematic as without consensus of unified attributes and selective utilisation of constituting elements, the importance of such elements and how they may be influenced is often manipulated/applied in favour of the intended application; as noted by Brown, Ryan and Creswell (2007a):

> "To a degree, the meaning that has been given to mindfulness by clinicians and researchers has been colored by these particular clinical approaches."
> (p215)

As the contribution of this thesis is of a cross-disciplinary grounding (with intended application to the field of human-computer interaction), the defining of Mindfulness (and Mindlessness) will primarily adopt a Western approach and understanding.

Western study and framing of Mindfulness approaches the topic from psychological and cognitive perspectives as states of experience and action. In doing so this approach seeks to describe Mindfulness as a naturally occurring phenomena that can be placed in opposition to Mindlessness and grounded within established theory and observable phenomena, such as *automaticity* and *habit* which may be understood as:

> "…some cognitive process whose operation is not subject to conscious control"
> (p165, Anderson, 1992)

In the context of this thesis (and in application to Human-Computer Interaction) a Western approach is most suitable as it facilitates defining Mindfulness and Mindlessness as grounded within well-established concepts that provide a broader understanding, systematic measurement and application. However, due to the number of validated empirical measures that originate in Eastern understandings (i.e. within clinical application), these will also be of consideration in understanding the core attributes and scope.

1.1.0: Eastern Practices And Definitions Of Mindfulness

While it will be demonstrated that Western perspectives of Mindfulness and Mindlessness are most appropriate in the context of HCI design it is additionally important to gain understanding of Eastern practices and definitions of such phenomena. This is due to the majority of previous applications and explorations of Mindfulness referring to the concepts origins in Buddhist practice. Similarly, equal can be said of Mindfulness and Mindless in clinical application, often drawing upon Eastern positions to guide and inform measures adapted to the context of inquiry and aims of application.

Eastern perspectives of Mindfulness typically categorise the concept of Mindfulness, as a practice for improving wellbeing, emotion regulation, and understanding of experience; cultivated through meditation as part of Buddhist spiritual practice (Hanh, 1976; Thera, 1962; Silananda, 1990). However, differing schools of thought place greater emphasis over the various constituting elements of Mindfulness (Brown, Ryan and Creswell, 2007a) further mystifying this complex state of experience.

Mindfulness can be (and has been) described in many differing ways such as Watts (1957, p53) *"… a total clarity and presence of mind, actively passive, wherein events come and go like reflections in a mirror; nothing is reflected except what is*"; Thera (1962, p32) who defines Mindfulness as *"…the clear and single-minded awareness of what actually happens to us and in us at the successive moments of perception*"; and Hanh (1976) as "*keeping one's consciousness alive to the present reality" (p11) and "…the miracle by which we master and restore ourselves*" (p16).

Bodhi (1994) describes Mindfulness as a presence of mind and form of attention or awareness. Bodhi notes while all conscious experience involves a form of awareness, Mindfulness is framed as awareness that is "*…applied at a special pitch*", a "*bare attention*" to the present moment and differs profoundly from our usual "*mode*" of consciousness (Bodhi, p70-, 1994). Bodhi further describes a Mindful state as open, quiet and alert; contemplating the present and refraining from drifting with distracting thoughts. Though it is broadly understood that we can summarise Eastern framings of Mindfulness as "*The elements of mindfulness, namely awareness and nonjudgmental acceptance of one's moment-to-moment experience*" (Keng et al., 2011). This Eastern framing of mindfulness is often associated and centralised toward the goal of a cessation of suffering (a central tenet of Buddhist practice and teachings). Grossman and Van Dam (2011) further summarise that Mindfulness encompasses several features including "*open-hearted awareness of moment-to-moment perceptible experience*", "*kindness, tolerance, patience and courage*", "*An awareness markedly different from everyday modes of attention*" (p221, Grossman and Van Dam, 2011).

These understandings have been further expanded upon to incorporate a more contemporary and commonly accepted notion of Mindfulness as a "*paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience moment by moment*" (p145, Kabat-Zinn, 2003). Such terms, however, do not give full justification or reasonable depth of explanation to this complex quality of mind. Furthermore such definition suggest that Mindfulness is only present in entirety and of utmost importance to achieve over Mindlessness. This has resulted in confusion towards the weighting and value of the constituting elements (if stated) without agreement upon definition (Bishop et. al., 2004; Grossman, 2008; Brown, Ryan and Creswell, 2007a; Chiesa, 2013).

While Eastern understandings of Mindfulness have previously served purpose in the understanding of this phenomena, such definitions pose several problems in the context of human-computer interaction:

- Primarily; they lack a consistency in what Mindfulness specifically is and so often add confusion (through mystification) to this complex state.
- The definitions are often presented as part of a framework in spiritual practice and so directly applying such understandings towards HCI presents a potential for misinterpretation (i.e. religious/spiritual association) and misappropriation in how such interventions should be received (e.g. Potentially as a spiritual intervention).
- Such definitions give little insight into how and why such states occur (in terms of the underlying processes), and more broadly how they may be applied toward human-computer interaction.
- Finally; such understandings of Mindfulness and Mindlessness pose that Mindfulness should be of utmost importance with Mindlessness avoided. This position provides little insight or attention to why Mindlessness states may occur and how these may be beneficial.

Consequently, these definitions fail to satisfy the previously outlined qualities and utility necessary for a definition of Mindfulness and Mindlessness for human-computer interaction.

The framings and understandings of experience e.g. those described by Thera (1962, p32) as "*the clear and single-minded awareness of what actually happens to us and in us at the successive moments of perception*"; do, however, offer basis form which a novel perspective to understanding our interactions with technologies may be developed and drawn upon in framing and understanding such interactions.

Within mental health practice insights of Mindfulness (Eastern philosophy) have led to the exploration of how such qualities may be applied in Cognitive Behaviour Therapy (CBT) (Brown, Ryan and Creswell, 2007a), and additionally, how such qualities may be categorised and measured as part of 'Mindfulness-Based Intervention' (MBI) and 'Mindfulness-Based Stress Reduction' (MBSR) (Cullen, 2011).

1.2.0: Clinical Applications And Empirical Measures Of Mindfulness

Many clinical applications of Mindfulness exist and attempt to build upon and apply the previously described Eastern understandings of Mindfulness towards the treatment of psychological disorders. As noted by Keng et al. (2011), the qualities of Mindfulness *"…are regarded as potentially effective antidotes against common forms of psychological distress…"*. Examples that apply a Mindfulness-based intervention include: Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 2003), Dialectical Behavior Therapy (DBT; Linehan, 1993), Self-Mutilation / Suicidal Behavior Prevention (Linehan et al; 1991); and Mindfulness Based Cognitive Therapy (MBCT; Segal, Williams, and Teasdale, 2002); and have been applied by national health organisations (e.g. NHS[2]). Such applications in therapeutic practice have proven to withstand empirical testing of the beneficial results of Mindfulness training and show a novel method in treatment for enhancing psychological wellbeing e.g. Warren, Brown and Ryan (2003). Resulting from such studies (and their application in treatment) are a number of methods for the assessment of an individual's Mindfulness (Sauer et al, 2013; Brown, Ryan and Creswell, 2007a); and supported as valid measures in cognitive behaviour therapy and psychological assessments (Haigh et al., 2010). Although these measurements/scales are proven to share commonalities, as during the validation of a methodology the tests are crosschecked to ensure consistency of results between tests (Baer et al, 2006; Siegling and Petrides, 2014); the assessments vary depending on the emphasis of the intended application (Haigh et al., 2010; Sauer et al, 2013; Brown, Ryan and Creswell, 2007a). Examples of such assessments include: Freiburg Mindfulness Inventory (Walach et al., 2006); Cognitive and Affective Mindfulness Scale–Revised, (Feldman et al., 2007); Five Facet Mindfulness Questionnaire (Baer et al., 2008); Philadelphia Mindfulness Scale (Cardaciotto et al., 2008); Southampton Mindfulness Questionnaire (Chadwick et al., 2008); Mindfulness Process Questionnaire (Erisman & Roemer, 2012). Such assessment measures are typically generalised in that they are not seeking reflection upon a specific task but rather a broader disposition on life, emotional aspects and sensory experience, and a broader life outlook than towards a specific task or time (though some consideration to present focus is questioned).

[2] http://www.cancerresearchuk.org/cancer-help/about-cancer/treatment/complementary-alternative/therapies/meditation?script=true#Mindfulness

Although these previously described measurements contain sub-groupings into differing themes it is noted that sub-groupings alone (as individual tests) do not provide an accurate measurement of a person's Mindfulness disposition and it is required that the whole test is accounted for in achieving consistency and validity of results (i.e. outcomes of the individual subgroups cross-test are not consistent, unlike outcomes of complete tests). Thus, the application of such measurements of Mindfulness necessitate the test be completed in full. While some elements of these measurements hold application towards the assessment of Mindfulness and Mindlessness during a human-computer interaction e.g. "*I rush through activities without being really attentive to them*" (FFMQ, Baer et al., 2006), large proportions of the measurements often refer to a broader disposition and emotional wellbeing e.g. *"Even when I'm feeling terribly upset, I can find a way to put it into words*" (FFMQ, Baer et al., 2006). As such measures are required to be presented in full for accuracy, their application towards HCI analysis would add confusion to participants in evaluating their interactions and would yield results of their general disposition of Mindfulness as opposed to the intended context (i.e. a specific interaction experience to be analysed). While such measurements provide argument that the concept of Mindfulness holds application beyond spiritual practice and can be empirically measured (Sauer et al, 2013), the application of these measurements is not suitable in the assessment of human-computer interactions as (similarly to previously discussed Eastern / spiritual framings):

- Such definitions lack a consistency in what Mindfulness specifically is (and its components) and so add confusion to this complex term and how it may be applied to human-computer interaction.
- The intended context of the measurements presents a potential for misinterpretation of intent when applied to evaluation and understanding of human-computer interaction.
- Such measurements assess a broader life disposition as opposed to a context specific experience/interaction.
- The framings and measurements give little insight into how and why such states occur, and how they may be applied toward human-computer interaction; and further pose that Mindfulness should be of utmost importance with Mindlessness avoided (due to its association with negative mental traits such as rumination, anxiety, worry, fear, anger etc.) and so provide little insight to why Mindless states occur and how these may be beneficial.

Consequently these definitions and framings fail to satisfy the previously outlined qualities and utility necessary for a definition of Mindfulness and Mindlessness for human-computer interaction as they introduce ambiguity of the phenomena being discussed, elate to broader dispositions, do not incorporate understanding and knowledges from well-established related research domains that might further understanding and investigation to the phenomena.

1.2.1: Measuring Mindfulness As A Transient State (Contextualised As Opposed To Trait)

Some particular approaches toward understanding and framing Mindfulness hold within them a differentiating of awareness from attention (a position advocated in this thesis); and so, position Mindfulness as a behaviour and allow for broader perspectives from cognitive science inform the understanding. As will be highlighted in the following chapters such approach provides scope to not only understand Mindfulness and Mindlessness in ways applicable to human-computer interaction but validate such understandings through well-established methods developed in specific research domains found within cognitive science.

Brown and Ryan differentiate "awareness" as "the background "radar" of consciousness, continually monitoring the inner and outer environment.", and "attention" as "*process of focusing conscious awareness, providing heightened sensitivity to a limited range of experience* " (p822, Brown and Ryan, 2003), yet note that these processes are deeply intertwined. The distinction of Mindfulness from these two interrelated states presented by Brown and Ryan as:

> "…attention and awareness are relatively constant features of normal functioning, mindfulness can be considered an enhanced attention to and awareness of current experience or present reality"
> (p822, Brown and Ryan, 2003)

Opposed to positions that frame Mindfulness as a personal trait Brown and Ryan (2003) position Mindfulness as an active "doing". In doing so Brown and Ryan position Mindfulness as a state like experience, opposed to general disposition, that one might hold. Furthermore, Brown and Ryan explicitly differentiate "awareness" and "attention". The significance of this will be increasingly apparent throughout this thesis as it is proposed that Mindless acts still involve awareness (in that one holds sensory awareness) yet Mindfulness holds a concerted attentive aspect which is consciously present and experienced. This can be exemplified though "highway hypnosis (Charlton and Starkey, 2011); when a person driving a vehicle performs complex acts; avoiding other road users, navigating to a destination, responding to traffic signals etc.. Upon arrival (if highway hypnosis occurred) the driver holds no (or little) recollection of entire series of complex events (i.e. they were not conscious of them). All of the events of driving require awareness (else there would be no responses) yet these events (during highway hypnosis) do not hold attention toward them. Some events, e.g. The car ahead suddenly braking; do call for attention and the driver holds a differing form of awareness; e.g. they can recall the event and describe it.

A truly Mindful state might be considered an enhanced form of this attention, rather than being responsive, as one that is concerted and consciously controlled and directed.

One clinical application of Mindfulness that positions the quality as a state like experience is the Mindful Attention Awareness Scale (*MAAS*) (Brown and Ryan, 2003) (See: Appendix 1.1). The Mindful Attention Awareness Scale proposes Mindfulness as an attribute of consciousness (discussed at length in chapter 1.5.0) that exists through an enhanced (attention to) awareness of what is happening in the present. Though this measure focuses on daily activities (as opposed to a specific task or instance) it does hold a closer focus upon actions and so is useful in understanding context specific moments of Mindfulness. Similarly, the Toronto Mindfulness scale (TMS) (Lau et al., 2006) (See: Appendix 1.2), later developed to the Toronto Mindfulness Scale - Trait Version (TMST) (Davis, Lau, & Cairns, 2009), was specifically directed towards assessment of Mindfulness as a state like experience in medicinal (psychological wellbeing) practice. The framing/defining of Mindfulness by Lau et al. (2006) is of two components, developed upon Bishop et al. (2004) and Hayes et al. (1999), as a "mode" or state like quality "*that is maintained only when attention to experience is intentionally cultivated with an open, nonjudgmental orientation to experience*" (p1447, Lau et al., 2006). The TMS holds the two qualities of Mindfulness as; an intentional self-regulation of attention, and as specific quality of awareness connecting all "objects" of sensation, thoughts and emotion. Closer still to the position adopted in this thesis, the State Mindfulness Scale measure (Tanay and Bernstein, 2013) (See: Appendix 1.3) is a development that seeks to address Mindfulness as "*as a mental behavior, which is statelike, context dependent, and variable*" (p1286) as opposed to a "trait" like. This is understood as a mental state of self-regulation of attention to immediate experience and orientating ones experiences towards curiosity, openness and acceptance; in addition to "*incorporating objects of which one is Mindful and the quality of how one is Mindful of these objects*." (p1287, Tanay and Bernstein, 2013).

While the previously described measures and framings of Mindfulness as a state like quality or behaviour hold closely to the position of the position of this thesis, Bodner and Langer's Mindfulness/Mindlessness scale (2001) (Appendix 1.4) provides a much stronger resonance in terms of the position taken and the validation of such position.

The Langer Mindfulness/Mindlessness scale (MMS) (Bodner and Langer, 2001) is a 21-point measurement of Mindfulness and Mindlessness. Eschewing from the Eastern understandings of Mindfulness, Langer's (1989) application of Mindfulness is considered a Western approach; centring upon novelty seeking and producing, engagement, and, flexibility (Haigh et al., 2010), in understanding and task performance while being grounded in psychology. Bodner and Langer (2001) note that while assigning meaning to events and objects is a great achievement in cognitive development, repeated strengthening (repeated assignment of meaning) leads to an automatic process of association (a position discussed at length in Chapter 1.11, and Chapter 1.12). That is to say, if object X holds meaning Y, with repeated exposure to object 'X correlating to meaning Y' the process of meaning deduction becomes automatic and the correlation becomes dominant. While meaning remains "malleable" it is noted in the context of Mindfulness and Mindlessness that:

> "Although one meaning of an object or event may be dominant for a particular situation, individuals do have the ability to consider alternative meanings for the same object or event. The cognitive state in which individuals unwittingly accept a rigid understanding of information has been called mindlessness. In contrast, when mindful, the individual actively draws novel distinctions and this increases awareness of alternative meanings."
> (p1, Bodner and Langer, 2001).

Bodner and Langer (2001) liken a person acting in a Mindless state to a "robot" acting with "programmed routines" that determine thoughts, emotions and behaviours based on previously learned distinctions and associations. Bodner and Langer (p1, Bodner and Langer, 2001) further state that such routines are triggered by environmental cues and "run" to completion without conscious control or awareness i.e. without "mind" and so are called Mindlessness. Bodner and Langer (2001) construct validation of the Mindfulness/Mindlessness Scale though several theoretically associated constructs (Described in greater detail in Appendix 1.4):

- *Openness to experience* (Digman,1990): A willingness to be open to experience and likely engage with the surrounding environment in new ways. That is, a Mindful individual will be open to and seek unfamiliar and novel experiences.
- *Capacity to entertain multiple perspectives* (Langer, 1997)*:* A capacity to view/understand the "world" form another's/multiple perspectives.
- *Need for cognition* (Cohen, Stotland and Wolfe, 1955): The degree to which an

individual enjoys and engages in "thinking" - "*… a need to structure relevant situations in meaningful, integrated ways.*" (p291, Cohen, Stotland and Wolfe, 1955)

- Thinking styles and general cognitive ability: Bodner and Langer (2001) state that a Mindful person should exhibit a "legislative-liberal" thinking style. Similarly, the should hold a "general cognitive ability" as "…*a constellation of thinking abilities designed to cope with environmental complexity.*" (p3, Bodner and Langer, 2001).

Langer's understanding of Mindfulness and Mindlessness will be discussed at greater length in the following chapters as its positioning is of a central tenet and contribution to the definition of Mindfulness and Mindlessness during interactions with digital technologies.

1.2.2: Suitability Of Mindfulness State Measurements Towards Understanding, Defining And Measuring Mindfulness And Mindlessness During Human-Computer Interaction

The intended application of this thesis is toward the understanding of Mindfulness/Mindlessness during interaction with technologies as opposed to a persons general disposition, and so positions approaching Mindfulness with specific focus upon this state as a transient experience of attentive awareness are better suited toward such understanding.

While the MAAS measurement (Brown and Ryan, 2003) focuses upon attention and awareness it does contain questions that would not be suitably adapted toward human computer interaction. The framing of Mindfulness taken by Brown and Ryan (2003) is of particular importance to the research and of framing interactions with digital technologies i.e. awareness as "the background "radar", and attention as "*process of focusing conscious awareness, providing heightened sensitivity to a limited range of experience*" with Mindfulness being "*considered an enhanced attention to and awareness of current experience*". Such positioning is of particular interest to the broader understanding of the thesis, allowing us to frame some actions within the "background" of awareness and others in the centre stage of attention (akin to the position of Baars' *global workspace theory* (1993, 1996, 1997) described in chapter 1.12.5), Mindful interactions facilitating both attributes (broader awareness and centred attention). However, the application of the MAAS measurement to understanding human-computer interaction would still introduce a degree of confusion to the participant and reveal a broader life disposition e.g. "*I forget a person's name almost as soon as I've been told it for the first time*".

Likewise, TMS (Lau et al., 2006) and State Mindfulness Scale measure (Tanay and Bernstein, 2013), contain elements that may confuse participants when applied in the context of human-computer interaction e.g. "*I was more concerned with being open to my experiences than controlling or changing them*" (TMS, Lau et al., 2006). However, the State Mindfulness Scale measure (Tanay and Bernstein, 2013) adds further understanding of how Mindfulness can be framed "*as a mental behavior, which is state like, context dependent, and variable*" (p1286). This positioning is of particular use to this thesis as it specifies an orientation toward context and a specific task, as opposed to previously discussed measurements and framings that understand Mindfulness as a broader and general disposition.

The Mindfulness/Mindlessness scale (Bodner and Langer, 2001) provides the richest understanding of how Mindfulness might be understood and measured in relation to human-computer interaction. The measurement is framed and validated through several measures and theoretical positioning's that are situated outside of research of Mindfulness (as a specific focus). This provides not only additional validation to the field of study but furthermore facilitates a broader understanding, justification and explanation of this complex state. Furthermore, the position of Bodner and Langer (p1, 2001) states that *"…one meaning of an object or event may be dominant for a particular situation", and that "Environmental cues trigger these behavioral routines*". In the context of HCI this may be understood as cues (from an interface) invoking dominant reactions where a user interacts in ridged and pre-learned understandings developed through repetition (and where meaning deduction has become automatic).

While the measurements for Mindful and Mindless states (above) is not directly applicable toward HCI analysis they do provide understandings that frame Mindfulness as a state like experience that is capable of change and reactionary to environmental stimulus and situations. This provides opportunity for adaptation toward a more suitable line of questioning that may be used in the assessment of peoples Mindful and Mindless states when interacting with technology.

1.2.3: Appropriateness Of Mindfulness Measures In The Study Of Human-Computer Interaction.

Though the study of Mindfulness can easily be said to hold roots within Eastern Buddhist philosophy the direct application of this philosophy toward HCI research is inappropriate. As highlighted, such philosophies hold a degree of mysticism and thus interpretation toward them; with potential to leave the nature of study at risk of misinterpretation (between understanding user experience and understanding spirituality). Similarly, such framings of this complex state, though attempting to understand it, give little insight as to how or why such states occur. Furthermore, in the context of Buddhist spiritual practice, Mindfulness is promoted as the ideal state and disposition to maintain (over Mindlessness) with little insight to the beneficial qualities that a state of Mindlessness might hold. Perhaps most importantly to the aims of this thesis, such framings lack a consistency of what Mindfulness is with definitions varying between schools of thought and context of delivery.

Similarly, clinical applications and measurements of Mindfulness that are informed by such Eastern Buddhist philosophy again hold several key issues that invalidate them as a modality for HCI analysis. Inconsistencies in definition of Mindfulness between study (Brown, Ryan and Creswell, 2007a), presents a mixed notion of what aspects of Mindfulness are truly of question when viewing the broader spectrum of studies (i.e. the concept being tailored toward intended outcome). As with Eastern practice there is also little insight toward how and why such states might occur and possibility of how the opposite state (Mindlessness) may be of benefit.

As highlighted, some methods of Mindfulness assessment attempt to take findings from the field of cognitive science as a means of which to better understand and explain why such attributes of experience occur and how they may be influenced. Most appropriate to the context of this thesis are measurements that not only consider better understanding though support from related fields, but additionally consider the phenomena of Mindfulness and Mindlessness as state like experiences influenced by events, actions and environments. Such perspectives of Mindfulness as a state like quality influenced by our interactions and experience of our environment, may be summarised by Tanay and Bernstein (p1286, 2013) as "*a mental behavior, which is state like, context dependent, and variable*", and highlighted by Bodner and Langer:

> "Environmental cues trigger these behavioral routines and their programs run their course. Crucial to mindlessness is that these routine behaviors operate without conscious control or awareness (hence the name)."
> (p1, Bodner and Langer, 2001)

Such perspectives are closely inline with the overarching aim of this thesis, understanding Mindfulness and Mindlessness during human-computer interaction. However, the proposed measurements of Mindfulness as a result of the work from the above authors would again require amendment to ensure they are appropriate for the study of human computer interaction.

One of the most prominent features of all the previously described studies (and definitions) is the variability of definition and framing of Mindfulness used between them. Of these, Western perspectives hold the greatest coherence as they are often supported through widely accepted literature and theory within well-established research domains (e.g. psychology and cognitive science) with the intended application that differs. Similarly, with grounding the definition of what exactly it is that is of question allows for a better understanding and evaluation of its validity. Therefore, the remainder of this section of the thesis will develop and justify a pragmatic definition of Mindfulness and Mindlessness, supported within broader related fields, that such phenomena might be better framed within human computer interaction. In doing so this provides further utility of validation through well-established methods drawn from related fields which inform the defining of the phenomena. As will be highlighted and noted by Brown and Cordon (p59, 2009) such a first step is necessary in that it "*…concerns the basic scientific principle that a phenomenon can be studied only if it can be properly defined and measured.*"

1.3.0: Developing A Definition Of Mindfulness And Mindlessness During Interaction.

It is recognised that "*Mindfulness is not an easy concept to define*" (Langer and Moldoveanu, 2000). While the concept in terms of Eastern and clinical understandings and constructs provides insight it has been noted that:

> "…that literature's characterization of mindfulness has not been clearly translated into contemporary research psychology. The psychological literature reveals considerable variance in descriptions of the nature of mindfulness on both theoretical and operational levels."
> (p214, Brown, Ryan and Creswell, 2007a).

Brown, Ryan and Creswell (2007a) further expand on this explaining the two primary reasons such variance has occurred, most significantly here being the result of "*different clinical approaches*" resulting in different definitions and operationalization's that follow particular treatment perspectives and more significantly "*the outcomes they seek to foster*" (p215, Brown, Ryan and Creswell, 2007a). Brown, Ryan and Creswell (2007a) indicate that clinical applications and constructs of Mindfulness (and their measures) seek to facilitate the by-products of Mindfulness (e.g. self-control, emotion regulation, compassion) that, though may hold application within the field of human-computer interaction, are here beyond the scope of this thesis. While the utilisation of Mindfulness and its resulting properties has been tailored toward specific aims in clinical application (e.g. emotion regulation) it is noted there is a need for agreement so that this complex state may be further studied, as stated by Brown, Ryan and Creswell:

> "There is a clear need for conceptual agreement on the meaning of mindfulness, not only to facilitate communication about the construct but, most pragmatically, to create a stable platform of basic and applied research in this still young area of investigation."
> (p214-215, Brown, Ryan and Creswell, 2007a)

Mikulas (2011) further simplifies this point by stating "…*it is very important to be clearer on what we are talking about. And this clarity will significantly improve the effectiveness of our programs and the usefulness of our research.*" (p1), "*People can define mindfulness as they wish, but they should be very clear about what they are saying.*" (p5); further highlighting the need for a conceptual agreement and clarity of the construct of Mindfulness.

This thesis proposes to overcome such concerns and confusion through the development of a pragmatic definition of Mindfulness and Mindlessness that can specifically facilitate further inquiry and future incorporation of relational theories; as exemplified through validation of the construct of Mindfulness within the Langer Mindfulness/ Mindlessness Scale (Bodner and Langer, 2001). In doing so this seeks to not only clarify the concept definition within its application toward interaction; but expose how it may be further understood, analysed and applied in HCI design.

The shared themes, descriptions, and definitions of Mindfulness (and Mindlessness) from existing measurements and framings (Chapters 1.0, 1.1 and 1.2) was treated as a corpus of data. Descriptions and definitions that were deemed unsuitable and too ambiguous for applicability to human-computer interaction, e.g. "*…the miracle by which we master and restore ourselves*" (p16, Hanh 1976), were rejected. Upon the remaining data, thematic analysis was conducted following Braun and Clarke (2006) at a sentence to paragraph level to summarize contents semantic and latent meaning. Lens was restricted toward the ways in which the authors specifically described/defined Mindfulness (and/or Mindlessness). For example, "*Mindfulness can be viewed as a mode or state-like quality that is maintained only when attention to experience is intentionally cultivated with an open, nonjudgmental orientation to experience*" (p1447, Lau et al., 2006); was coded as an *openness to experience*, and further categorised under the encompassing theme of *Presence of "mind" (i.e. Conscious awareness of experience)*, as awareness of experience is a central tenet in discussing the mind and consciousness. Similarly *openness to experience* is also placed in the encompassing theme of *Openness to novelty* as such an orientation is assumed to hold a degree of rejection of predetermined mind-sets (and acceptance of novel mind-sets). From this the following encompassing categories informed the further areas of investigation:

- Presence of "mind" (i.e. Conscious awareness of experience) (Chapter 1.5 and 1.12)
- Directed / controlled attention and / or awareness (Chapter 1.6 and 1.12)
- Contextualisation to present moment (Chapter 1.7)
- Openness to novelty (Chapter 1.12)
- Habit / repetition / automatic behaviour (Chapter 1.12 & 1.8)
- Cognitive state (Chapter 1.11)

(Sub categorisations can be found in Appendix 1.5)

It should be noted however that while the broader themes are here as distinct they inherently overlap and are deeply interconnected.

The initial premise to guide the research was drawn that Mindfulness involves a directed / controlled awareness that exists as a presence of mind (an active awareness toward experience) facilitating contextualisation and an openness toward novel distinction and creativity. Mindlessness can be framed as a lack of such qualities existing as a habitual, repetitive or automatic behaviour. Both of which are understood as a state like experience.

1.3.1: Defining Mindfulness And Mindlessness For Human-Computer Interaction

As previously discussed the direct application of existing measures and definitions of Mindfulness towards understanding human-computer interaction is not suitable; i.e. holds mystification and ambiguity, focused upon resulting properties intended for a clinical application addressing a broader "life" disposition.

The defining of Mindfulness (and Mindlessness) and its application holds importance for several reasons as noted by Brown and Cordon (though framed in relation to Mindfulness based interventions and behavioural science):

> "The first concerns the basic scientific principle that a phenomenon can be studied only if it can be properly defined and measured.
> Second, investigation of mindfulness creates opportunities to investigate the specific role of this quality in subjective experience and behavior through methodologies derived from basic science that can complement applied, intervention research.
> Third and relatedly, it is assumed that the efficacy of mindfulness interventions is due, in large part, to the enhancement of mindful capacities through training; but only with clear definitions and operationalization's of mindfulness can this claim be tested.
> Fourth, and more fundamentally, the study of mindfulness can help to widen the window into the study of human consciousness and its modes of processing experience. In this way, the study of mindfulness can help to inform about the nature of consciousness, its fundamental role in human functioning, and how its processes can be refined to enhance that functioning."
> (p59, Brown and Cordon, 2009)

To apply the study of Mindfulness and Mindlessness in the context of HCI such phenomena requires a definition that facilitates opportunity to classify and measure such states. Such positioning (as Brown and Cordon (2009)) is here understood as the requirement of a definition that overcomes the ambiguity of Eastern (i.e. Buddhist) framings that mystify such qualities of experience and behaviour, and holds a broader understanding of the state than a focus upon specific desirable outcomes (as with many clinical interventions). As such this thesis grounds the definitions of Mindfulness and Mindlessness with support from the fields and understandings of philosophy of the mind (Chapters 1.5-1.8) and cognitive-sciences (Chapters 1.11-1.12), that such qualities may be better framed through supporting and established understandings. While Brown and Cordon (2009, above) frame the necessities for such understanding in Mindfulness based interventions and behavioural science, the same conditionals are required in the field of human-computer interaction. Thus, the development of the definitions of Mindfulness and Mindlessness (presented in this research) in HCI are not only intended to clarify ambiguity but additionally seek to incorporate (and encourage) further investigation and measurement of such states. In doing so it is hoped that opportunities for investigation of this state (as subjective experience and behaviour) may better facilitate understandings of human-computer interaction that might otherwise be overlooked in favour of a particular quality (e.g. Intuitiveness of a system). Furthermore it is understood that through grounded definition and methods in analysis of Mindful and Mindless states the efficacy of such states may be fully realised and appropriately applied.

As previously described, existing measures and definitions provided initial areas of investigation to understand the concept of Mindfulness and Mindlessness and facilitate the development of definitions (stated below).

The contribution of these definitions are to provide an initial understanding of Mindfulness framed toward interaction that may facilitate further study and measurement of such phenomena. It should be noted that through future work such definitions are open (and expected) to develop to reflect advancements derived from contributing fields of research. The constituting elements that have informed the understandings and provide rational to the definitions are discussed at length in the following sections.

1.3.2: Mindfulness

The following is the contribution of this thesis of how Mindfulness can be defined in relation to human-computer interaction and is justified in the proceeding chapters.

***Mindfulness*, is defined as a state of broad *reflective-conscious* awareness upon the present context and content of information and stimulus. Information and technologies are explored and combined through concerted deliberation in novel categorisations of distinctions and action potentials as an *abstract-tool*.**

During interaction Mindfulness is slow yet analytical whilst being receptive to change, whereby constituting elements are *consciously* present through use and application of a *fluidic-tool*.
This mental state is understood as an opposite and in flux with Mindlessness.

A pictorial example (designed to be interpreted by the reader) of how we might understand Mindfulness is provided in the following Figure 1.2.

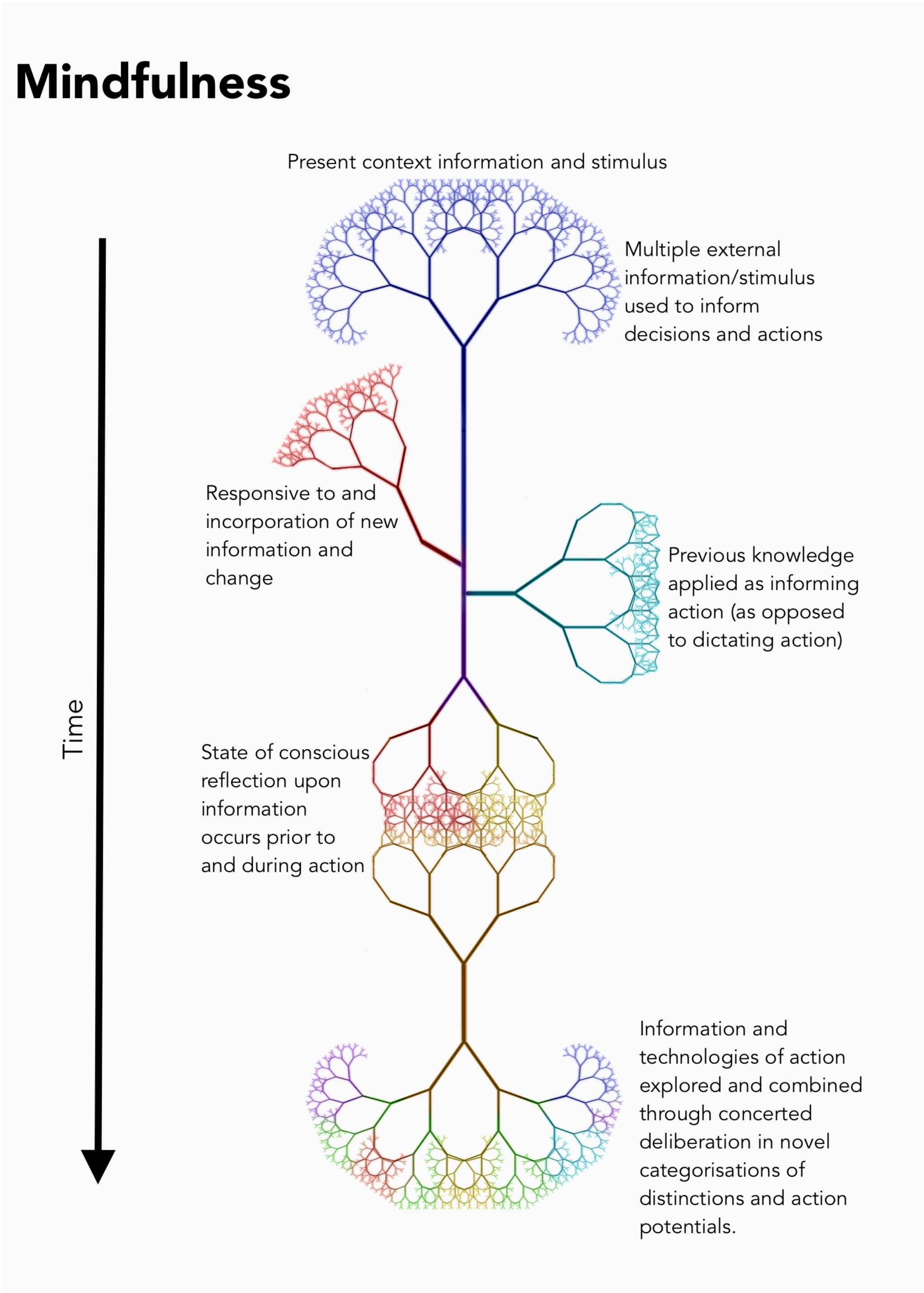

Figure 1.2; Graphical depiction of Mindfulness. Differing colours represent different understanding and knowledge gained or developed e.g. the point

at which conscious reflection occurs develops new understanding that differs from the external stimulus, previous knowledge, and new information.

1.3.3: Mindlessness

The following is the contribution of this thesis of how Mindlessness can be defined in relation to human-computer interaction and is justified in the proceeding chapters.

***Mindlessness* is defined as an intuitive understanding that exists in *non-conscious* processes, with failure to account for contextual dependencies through premature cognitive commitments; where information and technologies hold a functional fixedness viewed as absolute through *equipmental-fixedness*.**
During interaction, Mindlessness is without conscious deliberation through *sub-conscious* automaticity, developed from a cognitive fixation upon previous well-learned solutions. Such actions are performed before, faster than or without concerted conscious awareness in phenomenological invisibility; resulting in the inability to develop novel solutions and the application of technology through *equipmental-transparency*.
This mental state is understood as an opposite and in flux with Mindfulness.

A pictorial example (designed to be interpreted by the reader) of how we might understand Mindlessness is provided in the following Figure 1.3.

Mindlessness

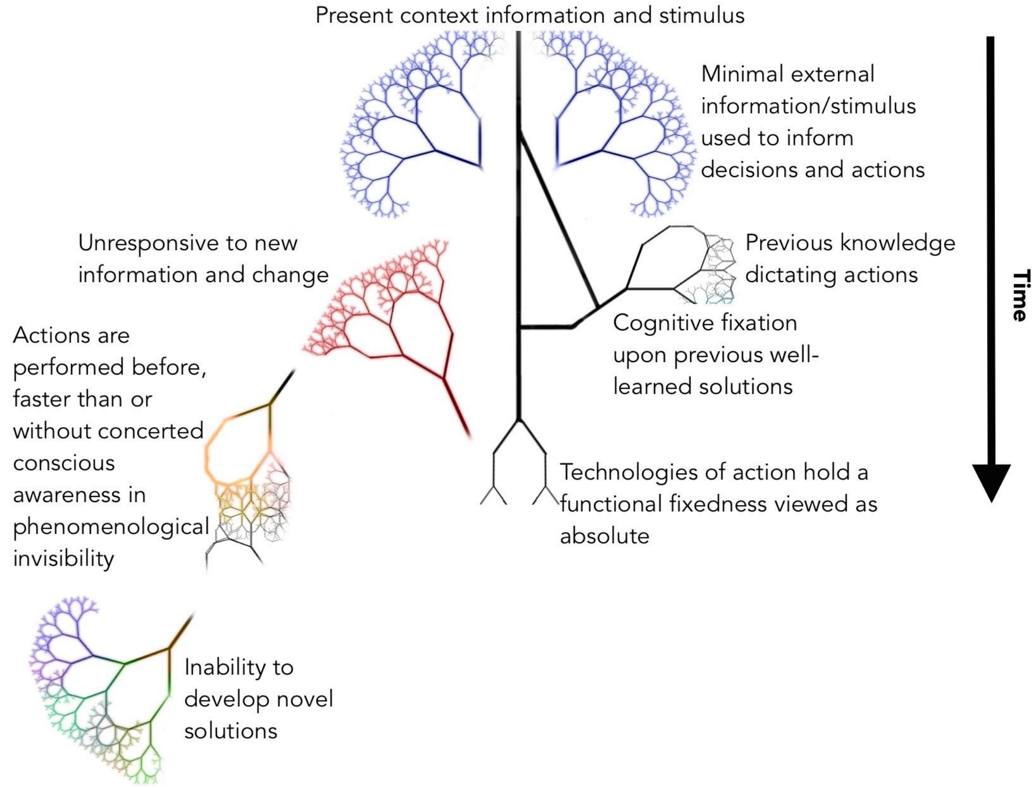

Figure 1.3; Graphical depiction of Mindlessness. Differing colours represent differing knowledges. Solid black lines represent automatic processes of knowledge deduction whereas breaks in these lines represents potential incorporations (i.e. additional knowledges), yet lacking in adoption of thought and knowledge production.

1.4.0: Grounding Of Mindfulness And Mindlessness Definitions

While the previous chapters have outlined limitations in clinical framings of Mindfulness and Mindlessness (toward human-computer interaction) there are others who frame these states in ways applicable to the context of interest to this thesis.

Langer (1992) proposes that Mindfulness and Mindlessness are central to cognitive functioning, though this position is furthered by Mayer (2000) who suggests that a knowledge of Mindfulness may facilitate a deeper comprehension of consciousness, how it may be structured, and its role in human understanding and functioning. Mikulas (p1, 2011) expands upon this suggesting that Mindfulness may be understood in terms of "behaviours of the mind" (as opposed to the "contents of the mind" such as perceptions, memories, thoughts, and feelings), i.e. Mindfulness as a behaviour rather than a felt experience.

Langer (p289, 1992) defines Mindfulness as "a state of conscious awareness in which the individual is implicitly aware of the context and content of information"; contrasted by Mindlessness as "compared to more familiar concepts such as habit, functional fixedness, overlearning, and automatic (v's controlled) processing". This position is supported by Hollis-Walker and Colosimo (2011) who describe Mindfulness and Mindlessness as a:

> "...Buddhism-derived concept and practice that involves an undistracted awareness of the here-and-now. A lack of Mindfulness means unknowing of underlying processes in our subjective and objective worlds. An example of this is seen by automaticity (Anderson, 1992), where a person goes into automatic pilot-mode during a complex, well-learned activity. Likewise is the 'unknowing' of absorption in a daydream or rumination while driving and the state of flow, characterized by complete engagement, balance between challenge and expertise, and time seemingly to stand still (Csikszentmihalyi, 1997)."
> (p222, Hollis-Walker and Colosimo, 2011)

Although Hollis-Walker and Colosimo suggest that Mindlessness arises when engaging well-learned activities, Langer (1992) proposes "… *that mindlessness may result from a single exposure to information.*". Langer suggests that this Mindlessness state may occur when information (objects etc.) is/are presented or perceived in such a way they appear as absolute and require little or no reason to critically examine further. When such assumption is made the person viewing the information fails to see "contextual dependencies" that may alter the meaning of the information, and in its place permanently fix the meaning of what was originally assumed. This is understood as developing and enacting a "*Premature Cognitive Commitment*" (Chanowitz and Langer, 1981). That is, Mindlessness is enacted as a lack of conscious awareness upon information/events regarding their "*Semantic Variability*" (Langer, 1989), having no reflection upon content and context. Langer and Imber's (1979) earlier studies suggest that even though tasks may initially be performed with concerted effort, potentially as Mindfully, with increased familiarity the ability to keep a Mindful awareness of the task becomes increasingly inaccessible.

A pictorial example (intended to be interpreted by the reader) of how we might compare Mindlessness and Mindfulness is provided in the following Figure 1.4.

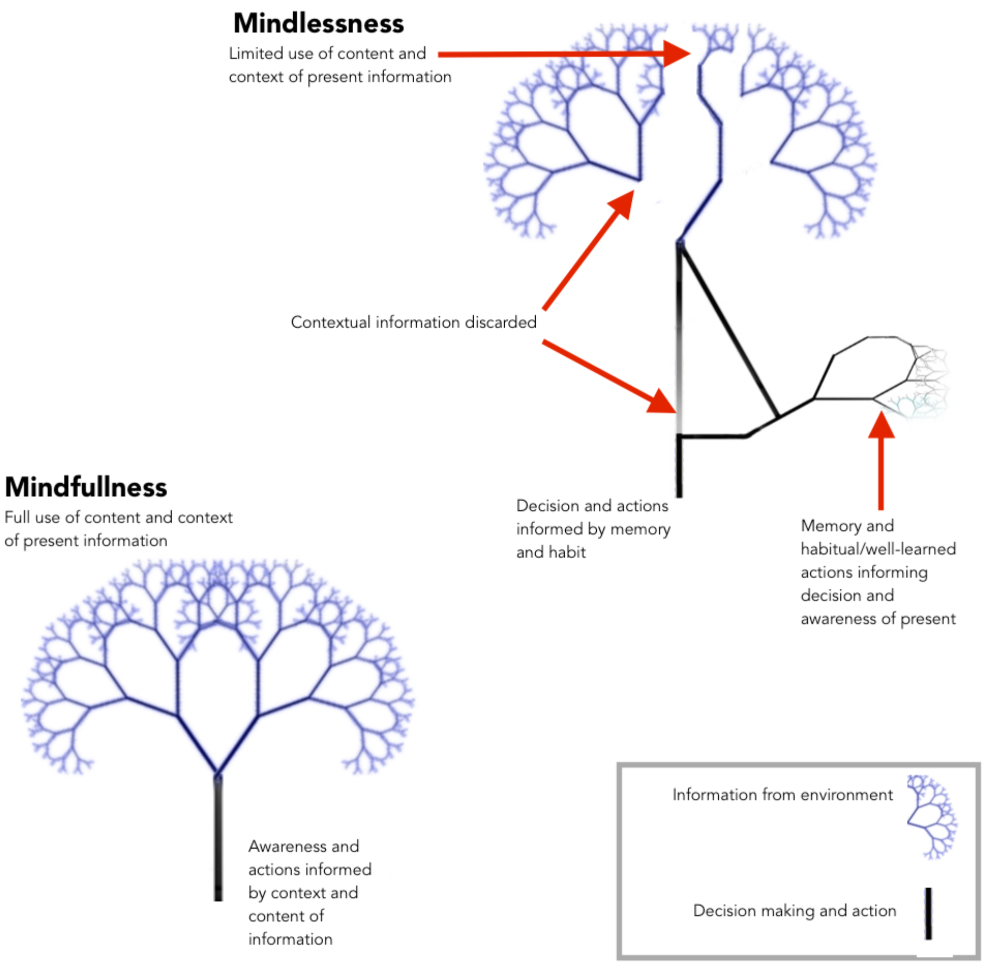

Figure 1.4; Comparison of Mindfulness and Mindlessness in relation to the adoption and incorporation of cotent and context informing discision making and action.

Langer and Imbers positioning is significant here as not only does it suggest that our approach towards activities (and so technologies) may become habitual but furthermore, our approach toward interactive objects may also carry a decontextualised fixed meaning. That is to say, we may develop a fixed meaning and use of technologies (MacKenzie and Wajcman, 1985), regardless of their additional potential functionalities and contextual dependencies, derived from their presentation or previous usage. Within HCI there has been much ongoing work in understanding how objects communicate their potential utilities (known as affordance – discussed at length in Chapter 1.8).

Through Langer and Imbers understanding it is suggested that such communication of how an object may be used (its affordances or rather our subjective-understanding them) can be altered through a Mindful (i.e. seeing multiple use) and Mindless (i.e. fixed use) approach. Therefore it is important that we understand our experience of such communication and/or relationship toward technologies (i.e. their affordances) in the broader understanding of Mindful and Mindless interactions as a core attribute of these states. In this thesis this is achieved through a philosophical understanding supported through findings in the field of cognitive science.

1.5.0: Mindfulness And Consciousness

> "Time and effort are required to integrate our positivist psychological tradition with a Buddhist phenomenological orientation based upon thousands of years of systematic investigation of subjective experience."
> (p1039, Grossman, 2011)
> "It is also challenging to discuss the concept of mindfulness; research on the topic is comparatively new to the field of behavioural science but more deeply, mindfulness concerns consciousness…"
> (p272, Brown, Ryan, Creswell, 2007: b).

The concept of Mindfulness can be understood through a framing of consciousness; "*Mindfulness is a state of conscious awareness…*" (p289, Langer, 1992).

Consciousness is a term that is often used to describe several states, such as a "wakefulness" (i.e. the opposite of asleep or a coma), to be 'aware of' something (e.g. Visual or auditory perception), and as a mental state (e.g. emotion and thought) (Rosenthal, 2009). In the context of this thesis the 'wakefulness' of a person is not of focus as it is assumed that a person interacting with digital technologies is capable of interaction (i.e. Has the capability to be responsive to stimulus or environment). For this thesis the context in which consciousness is used is in relation to a "first-person view" of the world, a subjective experience one holds as a sentient being and *observable* through introspection (the '*observation*' or '*paying attention toward*' ones thoughts, feelings and perceptions).

While emotional and mental states exhibit a physiological change in the body, the uncovering of consciousness as biological function (often assumed as a product of brain function) has proven difficult (Blackmore, 2007). This has led to a number of understandings of consciousness, often through a mental and physical relationship (often referred to as mind-body problem) in attempt to resolve the "problem of consciousness" i.e. the difficulty in explaining 'experiential consciousness' (Kügler, 2013). This mind-body problem (of experiential consciousness) can be understood (as simplified example) that we may observe how the brain functions when holding a cup, e.g. different areas of the brain show activity such as the motor-cortex controlling voluntary arm movement etc. (as measurable physiological changes); but the *experience* of the cup (the '*qualia*' of experience), its felt texture, perception of how 'deep' a shade of orange it is, the *pleasure* it produces; is subjective and does not exhibit distinct 'physiological presence' that is (currently) measurable or quantifiable (as conscious 'felt' experience).

Attempts to answer this 'problem of consciousness' and how such experiences arise have yet to be satisfactorily addressed and has often lead to a dualistic understanding reliant upon ‘unknowns’; furthering disagreement between disciplines and schools of thought (see: Vimal, 2010 for overview). Indeed the complications and difficulty of understanding such phenomena has previously been noted; e.g. Chalmers:

> “Consciousness poses the most baffling problems in the science of the mind. There is nothing that we know more intimately than conscious experience, but there is nothing that is harder to explain. All sorts of mental phenomena have yielded to scientific investigation in recent years, but consciousness has stubbornly resisted.”
> (p200, Chalmers, 1995)

And so conscious experience still remains ‘inexplicable’ through an empirical answer of complete understanding (i.e. Consciousness is produced by “*x*”), prompting much on-going discussion. However, as noted by Brown and Cordon, this does not need to dismiss the study of consciousness as a facet of Mindfulness and Mindlessness, rather the inclusion of such debate can further our understanding:

> “[…] the annals of philosophical and psychological discourse are replete with discussions of consciousness that can help to inform the construction of a well-specified theory about the meaning and functional consequences of mindfulness.”
> (p60, Brown and Cordon, 2009)

Thus, the understanding of Mindfulness and Mindlessness, as states of experience, necessitates the inclusion of the discourse of consciousness.

It is important to note that this thesis draws upon the study of consciousness as a central and integral part in the understanding of Mindfulness however, it does not claim to demonstrate or explain consciousness as a function or product of an organ (e.g. brain). While the “how it is produced” of consciousness remains elusive it will be demonstrated that the “when it is produced” can be observed through introspection and measurement of physiological process.

1.5.1: Consciousness And Scientific Inquiry

Chalmers states “*“Consciousness” is an ambiguous term, referring to many different phenomena.*”(p200, 1995); which he divides into two sets of “problems”; *easy,* which can be understood through conventional cognitive science relating to the "computational" or neural mechanisms of the body (such as reaction to stimulus, difference between wakefulness and sleep) and *hard,* processes of conscious organisms that pose much greater challenge to detect, measure and isolate. As noted by Chalmers:

> "The really hard problem of consciousness is the problem of experience. When we think and perceive, there is a whir of information-processing, but there is also a subjective aspect."
> […]
> "…there is something it is like to be a conscious organism. This subjective aspect is experience."
> (p201, Chalmers, 1995)

We can understand Mindfulness as a property of consciousness as many of the 'easy problems' (i.e. those that can be understood as cognitive aspects of an organism (Chapter 1.11)) are directly related to the areas of inquiry and framings previously discussed in the methods of measuring Mindfulness. Yet Mindfulness may also be categorised as a form of 'hard problem' involving *introspection* and *subjective experience* of such 'easy problem' qualities. Consequently this requires a deeper understanding and defining (performed in the following Chapter 1.5.2)

This thesis draws upon and integrates cognitive science and philosophy to provide a thorough understanding of how the constituting elements of Mindfulness and Mindlessness may be classified, measured and utilised in the use of digital technologies. However, while drawing upon fields such as neuroscience this does not intend to state that consciousness is purely a product of the brain; as noted by Vimal (2010) and Pepperell (2000) such a claim would be, and often is, unfounded and heavily contested. It is, however, recognised that many aspects of subjective experience (i.e. consciousness) are closely correlated with observable physiology of the body; e.g. brain activity (see Kügler (2013), Baars (2002) and Valera (1996) for examples). And so, the broader positioning of this thesis adopts that as stated by Pepperell (2000) that "*Consciousness is the function of an organism, not an organ*". In doing so, this thesis supports the position that one cannot frame consciousness as reducible to physiological processes and distinct from the context (environment) of the agent in question; a position sympathetic to that of *embodiment* (Varela, Thompson and Rosch; 1991).

In its approach this thesis' position does not seek to reduce consciousness as a phenomenon of physiology, but seeks to apply findings in related fields (e.g. neuroscience) to further understandings of Mindfulness and Mindlessness while remaining aware of the limitations of such applications. Thus the integration of philosophy and science in this thesis aims to facilitate better understandings and perspectives that are unachievable by conventional scientific methods, that attempt to reduce such phenomena to physiological processes, alone.

Therefore the contribution of this thesis draw upon philosophy of the mind but should not be considered as promotion or denial that consciousness exists as a measurable physiological manifestation; yet observable correlations of such a phenomena (to physiological manifestations) can improve our understanding.

1.5.2: Mindfulness, Mindless And Between: Four Forms Of Consciousness

To clarify understanding of consciousness, four terms are introduced to frame different conscious experiences within the context of this thesis and its contribution of how Mindfulness and Mindlessness can be understood in human-computer interaction. In doing so it provides the utility of explicitly stating what 'form' of consciousness is discussed and avoids common language / clinical understandings e.g. conscious being responsive, or as an opposite to unconscious (or comatose). In doing so this facilitates broader distinctions when referring to specific phenomenological states of interaction, yet still adheres to the concepts presented. This follows in line of Chalmers point that "*"Consciousness" is an ambiguous term, referring to many different phenomena.*"(p200, 1995). As previously described (chapter 1.2.1) Brown and Ryan differentiate "awareness" as "the background "radar" of consciousness, continually monitoring the inner and outer environment.", and "attention" as "*process of focusing conscious awareness, providing heightened sensitivity to a limited range of experience* " (p822, Brown and Ryan, 2003). Both of these properties are understood as properties of consciousness in that they are an experience of sensing the environment; though both hold a differing degree or range of experience. Brown and Ryan state that Mindfulness might be considered an even further range of experience to normal functioning:

> "…attention and awareness are relatively constant features of normal functioning, mindfulness can be considered an enhanced attention to and awareness of current experience or present reality"
> (p822, Brown and Ryan, 2003)

From reflection upon our own experience we can see that our experiential consciousness is not continually present as a singular state. While reading you may turn a page without concerted attention toward doing so yet hold awareness of the action; when driving people often arrive to a destination with no recollection of the act of driving. But these are not permanent qualities, breathing is an automatic behaviour, yet can be 'consciously' controlled, sensed and interrupted.

Here, the distinction of the differing states of consciousness aims to clarify ambiguity and confusion when discussing these subtle different states.

1.5.3: Reflective-Conscious (Mindful):

Awareness of external stimulus *and* internal thought processes present at the forefront of subjective-experience. Introspection and abstraction upon the meanings and values of such stimulus and subjective-experience is facilitated in this state. This may be understood as paying attention towards potential and actual objects, actions or experiences as goals and meanings at a meta level.

For example, When observing a coffee table and appreciating its aesthetic qualities while recognising its constituting elements, meaning and affect, and affordances. This state of consciousness may be understood as a high-level abstraction. Such states of consciousness is that which is required to resolve the *Two Rings Problem* (McCaffrey, 2012) (described in chapter 1.7.1), whereby an abstract reflection upon objects as "raw" elements towards a broader goal is required.

This state is represented in pictorial example (designed to be interpreted by the reader) in the following Figure 1.5.

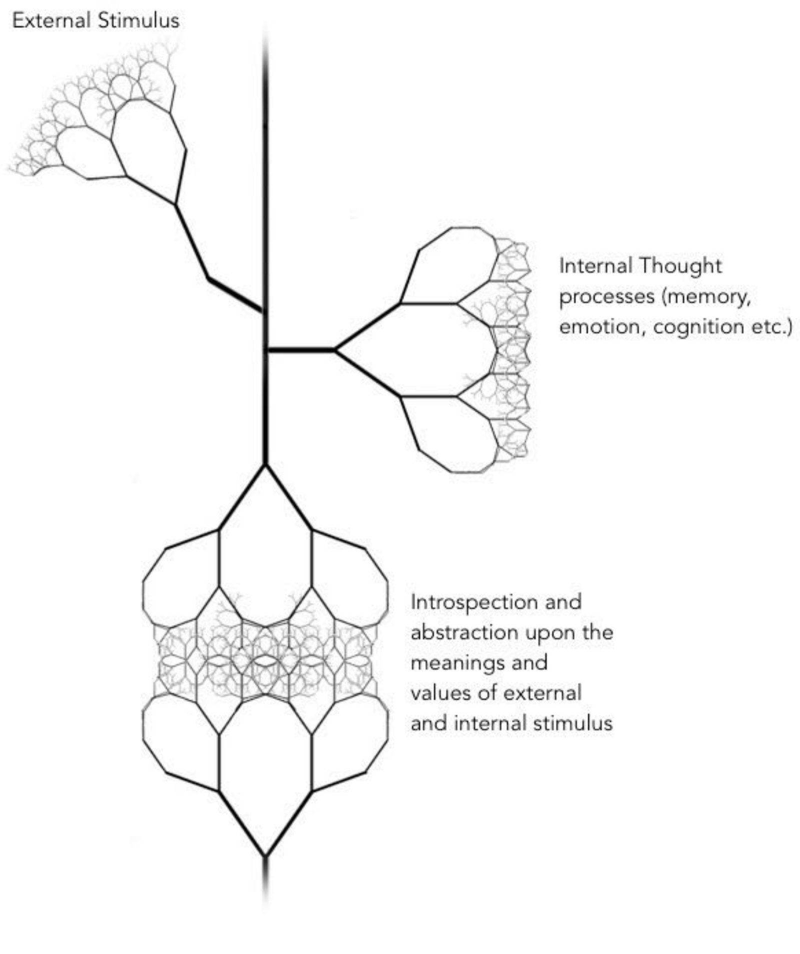

Figure 1.5; Pictorial example (designed to be interpreted by the reader) of how we might understand reflective-conscious knowledges. External stimulus, internal thought processes, and introspection (as reflection) all shape knowledge production.

1.5.4: Conscious (Mindful):

Awareness of external stimulus present at the forefront of subjective-experience. This may be understood as paying attention towards a particular action or experience e.g. Deliberately running one's hand over a table to feel its texture and listen to the sound it makes, or being aware of the surrounding environment and its context.

This state is represented in pictorial example (designed to be interpreted by the reader) in the following Figure 1.6.

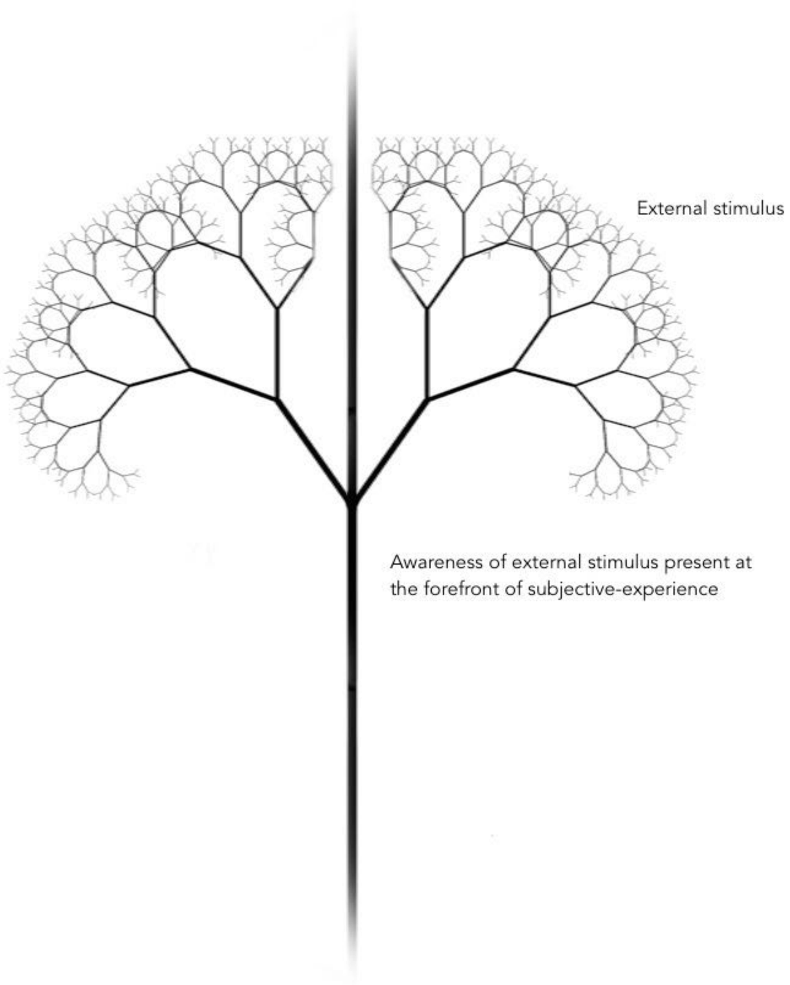

Figure 1.6; Pictorial example (designed to be interpreted by the reader) of how we might understand conscious knowledges. External stimulus informs and shapes knowledge production and subjective-conscious experience as awareness to external stimulus.

1.5.5: Sub-conscious (Mindless):

Termed as 'un-conscious' within some literature; experience, emotions and actions not in, yet accessible to conscious awareness through deliberation. This state is typically exemplified through "driving without awareness" (also referred to as highway hypnosis):

> "…a sudden realisation that you have no recollection of the past several minutes of driving, and that you have arrived at this point in the journey with little or no conscious attention to the surrounding traffic."
> (p456, Charlton and Starkey, 2011).

This state is represented in pictorial example (designed to be interpreted by the reader) in the following Figure 1.7.

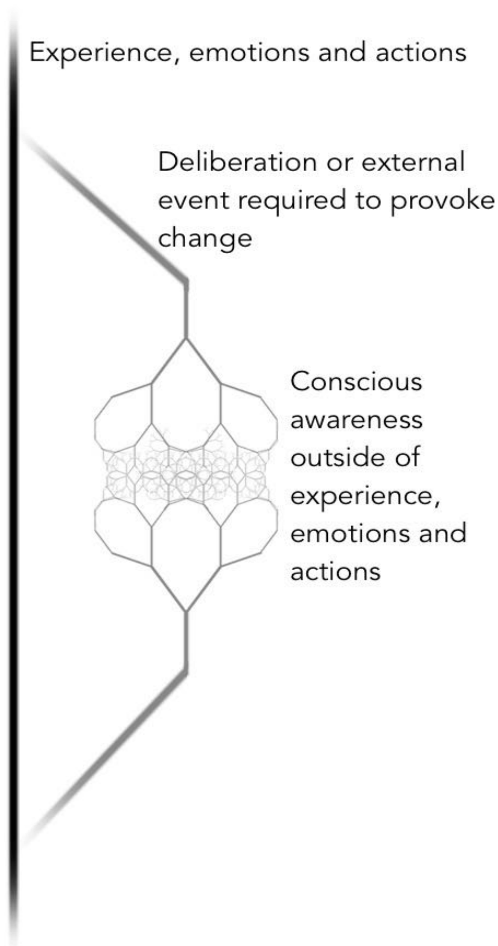

Figure 1.7; Pictorial example (designed to be interpreted by the reader) of how we might understand sub-conscious knowledges and actions. External stimulus exists outside of subjective-conscious experience; though can be drawn into knowledges and actions following a breakdown of normal functioning forcing deliberation.

1.5.5: Non-conscious (Mindless):

Awareness and actions that exist beyond conscious control (as involuntary). Many non-conscious actions may hold a degree of ability to be considered sub-conscious e.g. Breathing is largely non-conscious though may be influenced, but is often understood as 'instinctual'. An example of non-conscious action may be a sneeze in reaction to sniffing spilt pepper or a visceral response to a film (e.g. Laughter, fear, excitement).

This state is represented in pictorial example (designed to be interpreted by the reader) in the following Figure 1.8.

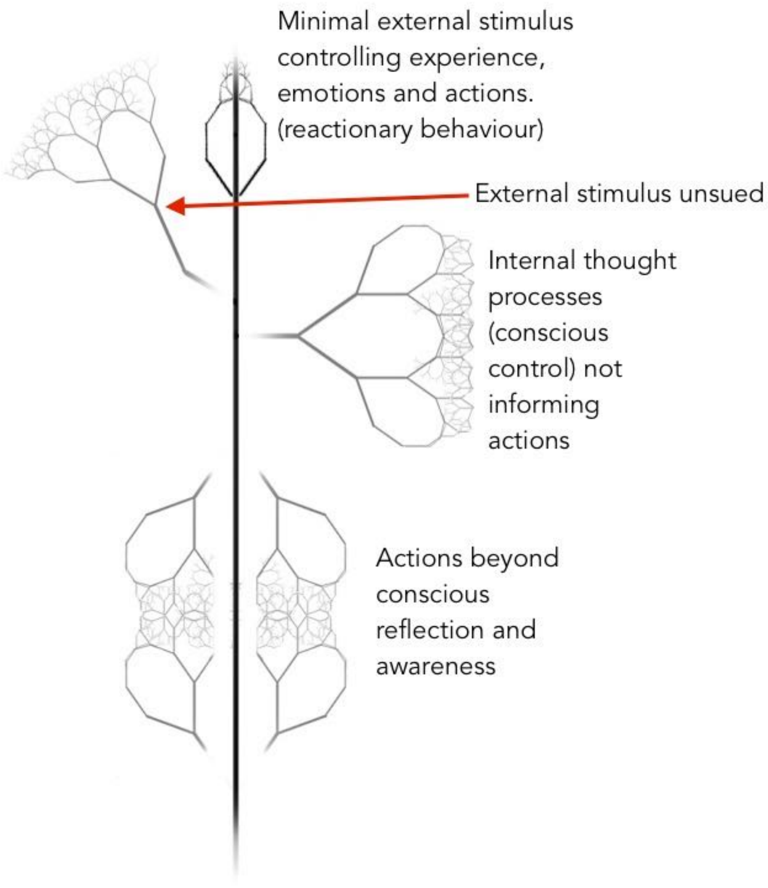

Figure 1.8; Pictorial example (designed to be interpreted by the reader) of how we might understand non-conscious knowledges and actions. Minimal external stimulus informs knowledges and behaviours. Much external stimulus is ignored, conscious control does not occur, and actions are performed without conscious reflection and awareness.

Such distinctions of consciousness will later be further justified, though are presented here as a lexicon to aide in understanding the presented concepts.

1.6.0: Phenomenology And Its Relevance To Understanding Mindfulness And Mindlessness During Interaction With Technology

Phenomenology is a branch of philosophy that studies the structures of consciousness as experienced from a first-person (subjective) point of view; i.e. the subjective aspect: *conscious experience*.

When understanding Mindfulness as originating through a Buddhist phenomenological orientation (Grossman, 2011) that deeply concerns consciousness (Brown, Ryan, Creswell, 2007b), and through phenomenological perspectives, the positioning of the research in understanding this phenomena as a state of experience of (and through) interactive digital technologies (as opposed to a general disposition) is justified. Furthermore, the application of phenomenological philosophy of technology use and experience may also be applied to broaden understandings of Mindfulness and Mindlessness during human-computer interaction.

As noted by Smith (2013) the literal understanding of phenomenology is the study of "phenomena": *"… appearances of things, or things as they appear in our experience, or the ways we experience things, thus the meanings things have in our experience*". Phenomenology can be understood as the consideration of not only the perception of objects, tools or information but centric upon how such qualities manifest as the knowledge experience of these; "*phenomenology is given a much wider range, addressing the meaning things have in our experience, notably, the significance of objects, events, tools, the flow of time, the self, and others, as these things arise and are experienced in our "life-world"* " (Smith, 2013).

The 'school' of phenomenology (as a 20th century 'Western' philosophical movement) is often attributed to stemming from the thoughts and works of Edmund Husserl (and developed from that of Franz Brentano). Husserl placed "*intentionality*" as the central concept in his philosophy of mind, as a fundamental property of consciousness (McIntyre and Smith, 1989). Intentionality is the concept of consciousness as a "*directedness*" "*of*" or "*about*" something. The facility to read Mindfulness through a "*Husserlian*" lens has previously been noted by Brown and Cordon:

> "While the concept of mindfulness appears to have been first described in Asia, its phenomenological nature is strikingly familiar to Western philosophical and psychological schools of thought. Phenomenology,

particularly in the Husserlian school (e.g., Husserl, 1999), has a considerable literature of relevance to the experiential nature of mindfulness."
(p61, Brown and Cordon, 2009)

1.6.1: Heidegger And The Phenomenology Of Tools And Equipment

Martin Heidegger is regarded as a highly influential philosopher whose work can be seen as a continuation of the questions raised through phenomenology posed by Husserl. Heidegger's hermeneutic phenomenology can be understood as in opposition to Husserl's transcendental phenomenology (p2, Dreyfus, 1991). As noted by Winograd and Flores (1986) Heidegger's writing, and the broader understanding and questioning of 'Being' ('*Dasein*'), are both important yet difficult in the understanding interactions with technology. Dasein is translatable from its German origins as 'being-there' or 'being-here' (more commonly known as being-in-the-world), but more broadly meaning an existence or 'presence' of an entity or agent capable of conscious experience and phenomenological contemplation (reflective-consciousness).

Here focus is directed toward the understanding and interpretation of two interrelated concepts within Heidegger's philosophy, *Ready-to-hand* and *Present-at-hand*; including the expansion upon these two terms found upon Koschmann, Kuutti, and Hickman's (1998) *"un-ready-to-hand"* and *"purely-present-at-hand"* (an adaption of p210, Dreyfus, 1991). The application of such understandings directly addresses the notions of Mindfulness and Mindlessness as they may be understood in contemplative (conscious and reflective-conscious) and automatic / non-reflective actions (sub/non-conscious) toward and through technologies.

1.6.2: Heidegger On Functioning And Breakdown

As noted by Koschmann, Kuutti, and Hickman (1998) Heidegger posed that the "resources" though which we live our daily life (normal day-to-day activities) do not require our conscious awareness (though here understood as not requiring a "full concerted" or effortful reflective-/conscious awareness), there is a "*transparency of equipment*" (Dreyfus, 1991) whereby equipment in use "disappears" and so "*we are not aware of it as having any characteristics at all*" (p94, Dreyfus, 1991). For example: a postal worker may enter their vehicle and begin a journey to the place of delivery, while they are aware of the experience (to a degree) they are not fully conscious toward the vehicle they are operating. They operate the controls of vehicle, though none needs to be effortful and thought through or deliberated upon (i.e. Does not require reflective-/conscious awareness). It is as though the vehicle is an extension of their body, the actions of how to interact with the vehicle are transparent to the experience of the user. This is often, in common use language, understood as being 'at one' with an object, an intuitive (discussed at length in chapter 1.12) or 'natural' knowing, as an effortless interaction.

That is, once effortful interactions or tasks, with repetition and practice become less effortful to the point of becoming sub-conscious (i.e. without concerted conscious consideration) or instinctive. As described by Heidegger in relation to a hammer:

> "…the less we just stare at the hammer-Thing, and the more we seize hold of it and use it, the more primordial does our relationship to it become, and the more unveiledly is it encountered as that which it is—as equipment. […] The kind of Being which equipment possesses—in which it manifests itself in its own right—we call 'readiness-to-hand'."
> (p98, Heidegger, 1962)

That is to say, when we stop viewing the hammer as an object and assessing its qualities (i.e. its 'outward appearance' ["Aussehen"] (p98, Heidegger, 1962)) and put it to use in the act of hammering; we develop a relational understanding toward the hammer as an action.

The use of the hammer further exposes how 'it is' in use. Thus, when the hammer is in this state of "Being" it holds a property to which equipment possess that is beyond the hammer as a viewed and contemplated object; and becomes a state of being in its own right and in relationship to the environment. As noted by Winograd and Flores:

> "To the person doing the hammering, the hammer as such does not exist. Its is part of the background […] taken for granted without explicit recognition or identification as an object. It is part of the hammerer's world, but it is not present any more than are the tendons of the hammerer's arm."
> (p36, Winograd and Flores, 1986)

Heidegger defines such a state as "Ready-to-hand" where objects (e.g. A hammer) in use (e.g. Hammering in a nail) are not in the reflective-/conscious experience of the user, they are "transparent" to introspection.

> "If we look at Things just 'theoretically', we can get along without understanding readiness-to-hand. But when we deal with them by using them and manipulating them, this activity is not a blind one; it has its own

> kind of sight, by which our manipulation is guided and from which it acquires its specific Thingly character… "
> (p98, Heidegger, 1962)

This form of "experience" that one holds of an equipment that is ready-to-hand, is without explicit concentration or contemplation upon it; and as such, where the equipment recedes from reflective-/conscious awareness, it is no longer available to be 'theorised' upon. Yet in this state it is experienced *through;* as though '*it*' (the equipment) is an extension of the '*self*' (the subjective experience, the *Dasein* of a "hammerer" and experience of hammering).

While ready-to-hand is in relation to understanding the equipment as purely functional and in use, there is logically the opposite of such a state, *Present-at-hand*, whereby a 'breakdown' occurs and the equipment becomes theorised upon.

A breakdown within the context of this thesis is understood as that defined by Koschmann, Kuutti, and Hickman:

> "…a disruption in the normal functioning of things forcing the individual to adopt a more reflective or deliberative stance toward ongoing activity."
> (p26, Koschmann, Kuuti and Hickman, 1998)

Thus a "breakdown" here provides a point of comparison; in opposition to the sub-/non-conscious states of interaction, as a contemplative reflective-/conscious state whereby "things" are brought to our awareness and available for theorising upon. As described, an equipment may be ready-to-hand and this may be understood as normal "day-to-day" existence or functioning. However, there are times when a breakdown occurs, when equipment once ready-to-hand becomes unusable (as normal functioning) and "*not properly adapted for the use we have decided upon*" (p102, Heidegger, 1962). When such events occur our perception of the equipment is altered:

> "We discover its unusability, however, not by looking at it and establishing its properties, but rather by the circumspection of the dealings in which we use it. When its unusability is thus discovered, equipment becomes conspicuous."
> (p102, Heidegger, 1962)

Thus the equipment becomes a state of "*un-readiness-to-hand*". It reveals itself as an "*equipmental Thing which looks so and so*" (p103, Heidegger, 1962), as such it shows itself as *present-at-hand*. As noted by Koschmann, Kuutti, and Hickman, such a breakdown can fundamentally alter our experience, understanding, and use of technologies:

"Resources for Heidegger can present themselves in different modes of being - that is to say, they can assume different states with respect to our ongoing activity. The status of an entity can, in turn, affect the nature of our activity and our understanding of the object in use."
(p26, Koschmann, Kuutti, and Hickman, 1998)

Koschmann, Kuutti, and Hickman expand upon understandings of ready-to-hand and present-at-hand (in an adaption of p210, Dreyfus, 1991):

Heidegger's Modes of Being and Understanding

Status of Entity	*Nature of Activity or Stance*	*Mode of Understanding*
ready-to-hand (*Zuhandenheit*)	absorbed, coping	primary
un-ready-to-hand (*Unzuhandenheit*)	deliberating	interpretive
present-at-hand (*Vorhandenheit*)	reflection	theoretical
purely present-at-hand (*pure Vorhandenheit*)	pure contemplation	abstract

(Koschmann, Kuutti, and Hickman, 1998, p27)

Thus, as stated by Koschmann, Kuutti, and Hickman (1998) when an entity (equipment) is ready-to-hand the nature of the activity (experienced by the agent interacting) is through a primary understanding, where such a state is experienced non-reflectively and sub-/non-consciously. However, there exists a transitory state where an equipment is no longer ready-to-hand but *un-ready-to-hand*. This state facilitates deliberation whereby the activity does not encounter a full "breakdown", as the context of the activity remains the same; however, it does not maintain full absorption to the task. That is to say, there is a change in the phenomenological relationship and the once sub-/non-conscious activity is made aware of and enters conscious awareness. Such a state may be exemplified as a delivery worker reaching to change a gear of the van he/she is driving and "finding" the wrong gear; the ready-to-handness of the driving is momentarily interrupted, the correct gear needs to be selected, where its (the relationship between driver and van) ready-to-handness is restored and the driving act continues. Figure 1.9 provides an interpretive understanding of how we might conceptualise such transitioning of conscious states.

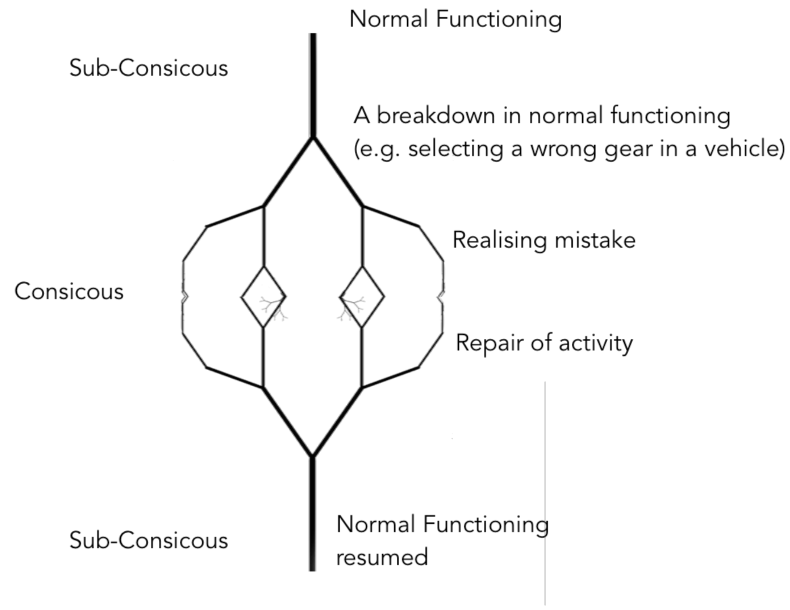

Figure 1.9; Pictorial example (designed to be interpreted by the reader) of how we might understand transitional moments between sub-conscious and conscious events. Thought processes (vertical) run from top of figure. When encountering breakdown thought processes become more complex, until repair of activity and normal functioning.

However, there exists a present-at-hand state that is considered a resultant of a breakdown of an equipment. For example, should the delivery drivers van breakdown unexpectedly, the once ready-to-hand (and so extension of the self as transparent equipment), calls itself into question and reflection, it is theorised upon. When in this state the "Thing" is viewed as a separate object and available to consciousness. This presence-at-hand occurs from the event of a breakdown, the "*interrupted moment of our habitual, standard, comfortable 'being-in-the-world*'". (p77, Winograd and Flores, 1986). The equipment at hand becomes exposed from its phenomenological transparency and resolve is required, as noted by Koschmann, Kuutti, and Hickman:

> "In this way, aspects of the situation that were previously tacit, such as the causal connections among actions and goals, now become explicit."
> (p28, Koschmann, Kuutti, and Hickman, 1998)

Further to this state of present-at-hand exists a state of reflective-consciousness, *pure-present-at-hand*:

> "In this mode, it is possible to contemplate concepts in an entirely abstract way, independent of any context."

(p28, Koschmann, Kuutti, and Hickman, 1998)

Where the delivery van was once ready-to-hand and an extension of the driver's "self" is broken, in a state of pure-present-at-hand it becomes an object without action and it can only be theorised upon. As defined by Heidegger (when referring to equipment once ready-to-hand yet now observed in terms of its properties):

> "Pure presence-at-hand announces itself in such equipment, but only to withdraw to the readiness-to-hand of something with which one concerns oneself - that is to say, of the sort of this we find when we put it back into repair"
> (p103, Heidegger, 1962)

The following figure (figure 1.10) provides a pictorial representation of how these varying states of phenomena might be understood comparatively.

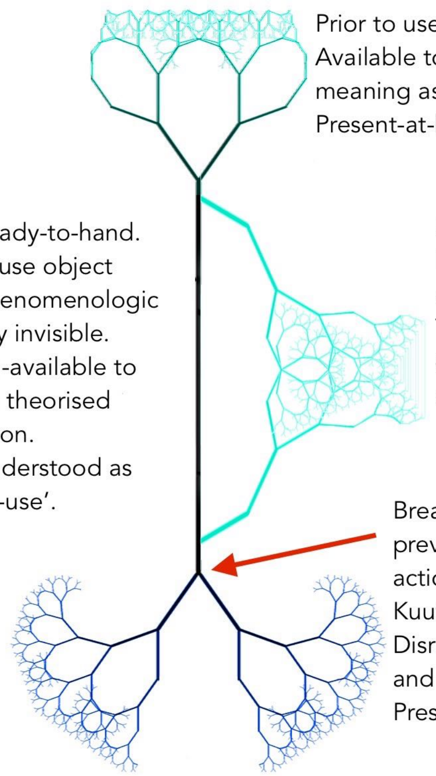

Figure 1.10; Pictorial example (designed to be interpreted by the reader) of how we might understand technology use (when functional as black) from prior to object use (top), as unready to hand (right) whereby actions and knowledges increase in complexity, ready-to-hand (black verticle) simplistic knowledges and actions without contemplation, and when encouring a

breakdown event (bottom) when a number of actions and knowledges are provoked. During breakdown the previous action (black) is no longer fostered as knowledges become too complex.

And so, in Hiedeggerian understandings, technologies, objects, tools, or equipment may be understood as holding properties that may only exist and be understood through; their use, as *a posteriori*, dependent upon experience, "*habitual, standard, comfortable*" (p77, Winograd and Flores, 1986); and toward the opposing end of the spectrum, specifically through their contemplation, as *a priori*, and purely abstract until their functionality is restored. Koschmann, Kuutti, and Hickman (1998) draw upon these philosophies of Heidegger and place them in comparison to Leont'ev and Dewey to provide a broader understanding of "*…the role of breakdown or failure as a means of revealing the nature of the world around us.*" (p25). This position is particularly useful as the paradigms they offer are developed in differing fields, phenomenology, behavioural psychology, and, psychology of education. This, here, provides broader grounding and supports the approach of this thesis as fundamentally interdisciplinary. While Koschmann, Kuutti, and Hickman acknowledge they are not the first to compare the three bodies of work, in being focused toward the understanding of breakdown between the work they provide a novel contribution.

1.6.3: Leont'ev On Functioning And Breakdown

Koschmann, Kuutti, and Hickman (1998) compare the work of Leont'ev to that of Heidegger with regard to breakdown. Leont'ev poses three hierarchical levels in that of *Activity Theory*; *Activities, Actions,* and, *Operations*. *Activities* (an object or motive of the activity) consist of a number of *Actions* (a sub-set of goals) that in turn consist of a number of *Operations* (conditions) (Koschmann, Kuutti, and Hickman,1998). An interpretive comparison between the positions of Leont'ev and various conscious states (previously defined Chapter 1.5) can be found in figure 1.11.

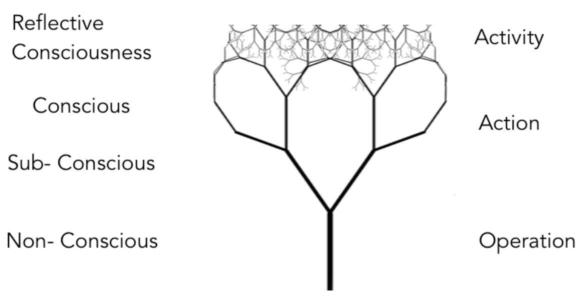

Figure 1.11; Comparison of position of Leont'ev toward the previously defined various conscious states

For example, a postal worker may enter their vehicle and begin a journey to the place of delivery (the delivery of the parcel being the motive or activity). As with the previous example they turn the steering wheel to navigate obstacles, alter their speed to the flow of traffic etc. (i.e. a number of actions are required in the activity). To turn the steering wheel the postal worker must coordinate their hand and arm movements etc., indeed the broader actions (such as navigating around obstacles) involve a further subset of actions, yet these are routinised and so understood as operations. Thus, as Koschmann, Kuutti, and Hickman (1998) state, as we go further "down" through the levels of actions and the goals of such actions become increasingly smaller, we reach levels where actions are no longer performed consciously:

> "…that level, and levels below that, are called Operations. Operations, therefore, lack conscious goals but are instead triggered by conditions faced during an Action. They are employed in adapting an Action to actual conditions."
> (p29, Koschmann, Kuutti, and Hickman, 1998)

While Koschmann, Kuutti, and Hickman (1998) initially state that operations are unconscious they do note that there are two forms of operations; *Adaptive* through sub-/non-conscious adaptations to conditions of the larger objective conditions and performed as "*involuntary, initially unconscious, and rigid (e.g. bodily movements needed for balancing on a bicycle)*" (p29), and, *conscious* operations formed through the course of learning and are typically a planned model of action, understood as possessing an orienting basis.

However, it is noted that:

> "When a model for a conscious Action is good enough, the Action has been practiced long enough, and the situation is sufficiently stable, the Action loses its "orienting basis" and becomes "routinized" into an Operation. […] The process of "routinization" of independent Operations and the subsequent broadening scope of associated Actions are fundamental features of human development. […] At the beginning, every step in the process […] is a conscious Action that requires planning, sequencing, and decisions. As these conscious Actions become routinized, however, the planning and decision making eventually fade away, resulting in a smoothly integrated Action. Ultimately, this […] Action becomes an embedded Operation in more complex […] Actions."
> (p29-30, Koschmann, Kuutti, and Hickman, 1998)

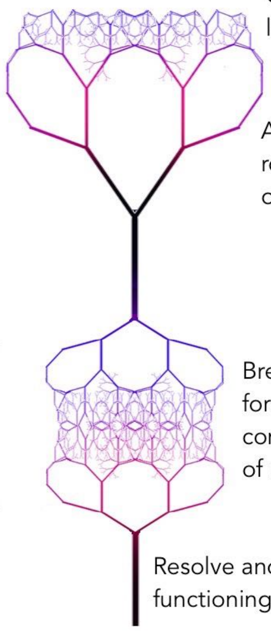

Figure 1.12, interpretation of Leont'ev's position of how breakdown might be consceptualised into normal functioning.

Thus, when engaging in skilled and complex actions there are routinised sub-/non-conscious operations that facilitate a broader emergent and complex action.

However, it is noted that should there be a breakdown (an interruption in normal functioning), previously developed (sub-conscious) operations will revert to requiring a conscious or reflective-conscious action to resolve (see figure 1.12). For example, when learning to drive a van a reflectively-conscious planning of how to achieve the meta motive is thought out, the necessary equipment is collected and planned out, the agent learning to drive will learn all of the smaller steps (operations) such as how to control the breaking, balance starting, change gear, follow what the eye sees and translate it to a movement of the vehicle through the steering wheel through dexterity of hand and arm movements; all of which require reflective-conscious to consciously focused attention. Once the agent has acquired sufficient skill, the once conscious operations become sub-conscious and amalgamate toward a singular action and activity. Yet should the activity encounter a breakdown, e.g. the vehicle stalls and looses power, the activity shifts back towards the action and calls the operation into consciousness, potentially shifting to a new activity (that of repair of the fault or breakdown). It is understood that Leont'ev places conscious operations as a primacy of knowing as all operations were once reflective-/conscious actions, running in opposition to Heidegger who places the transparency of equipment as the primacy of knowing (Koschmann, Kuutti, and Hickman, 1998); yet both explain the breakdown of tools in analogous understandings i.e. Resorting to a reflective-/conscious awareness upon the point or place of breakdown.

1.6.4: Dewey On Functioning And Breakdown

The third comparison raised by Koschmann, Kuutti, and Hickman (1998) is upon the works of Dewey. Dewey distinguishes stimulus from *sensory excitation* exemplified as an animals sensing toward a scent where the response is localised to the sensory organs (nostrils dilate, inhalation draws scent to olfactory receptors etc.). This is understood as localised "*Because there is no disequilibration, there is no need for readjustment of the organic and environmental factors of the total experienced situation.*" (p31, Koschmann, Kuutti, and Hickman, 1998). However, should the animal experience a *global disequilibration* a more demanding "stimulus-and-response" event occurs and provokes a motive or action to return to equilibration. Thus disequilibration exists as a tension of motives or stimulus to be resolved, with the degree to which the disequilibration exists as leading toward action or inhibition of action.

It is understood that while the above may present the role of disequilibration as a totality, a task or goal may hold several minor disequilibrations during the course toward achieving equilibrium (the broader primary goal). Yet as noted by Koschmann, Kuutti, and Hickman (1998):

> "…Dewey thought that organic reequilibration is sequential and not merely serial. It therefore plays an essential role in the formation of new habits. Even though an organism may experience repeated occurrences of excitation-response behavior, such behavior does not contribute to readjustment within a total experienced situation. For there to be readjustment, there must first have been a breakdown of organic energy relations. The consequent struggle for reequilibration is then the basis for reformation of habits. In such cases, closure or consummation involves a consolidation of past experiences with a view to their potential use in future breakdowns of relevant types. In the case of nonhuman animals, habit formation is "pushed from behind", unreflectively. Among humans, however, habit formation is "pulled from beyond" by reflectively constructed ends-in-view. For Dewey, life, especially life that involves complex organizational factors, is a continuing process of breakdown and reconstruction of habits.
> Dewey observed that humans often attempt to recover equilibrium in ways that do not promote growth. Faced with a breakdown, they often retreat to more primitive levels of behavioral response rather than moving forward onto behavioral plateaus that are more richly meaningful."
> (p32, Koschmann, Kuutti, and Hickman, 1998)

Thus, for Dewey a human is capable of a reflective-conscious understanding that often addresses a longer (temporality) or wider encompassing goal as opposed to resolving sensory excitation (primitive levels of behavioural response). Such perspectives of actions developing from sensory excitation are parallel to cognitivist views as will be discussed later in chapter 1.11 (see: Århem and Liljenström (1997)).

Many actions are reliant upon previously developed habitual responses in resolving equilibrium, with challenges presented being the breakdown and reconstruction of habits. However, humans often attempt to recover equilibrium through means that do not promote growth and fall reliant upon previously developed habits; they respond sequentially through previously learned methods, and so do not develop practices that are more richly meaningful. To achieve growth a level of "inquiry" is required that is a reflective level of action (and thus reflective-conscious) and facilitates development and improves the response towards a required action. Therefore, a breakdown for Dewey is not only an obstacle in an objective but is additionally "*…the occasion for the formation of new habits, including enriched technologies of all sorts, …*" (p32, Koschmann, Kuutti, and Hickman, 1998).

A visual interpretive example of how Dewey's position compares to the previously defined differing states of conscious awareness is provided in the following figure 1.13.

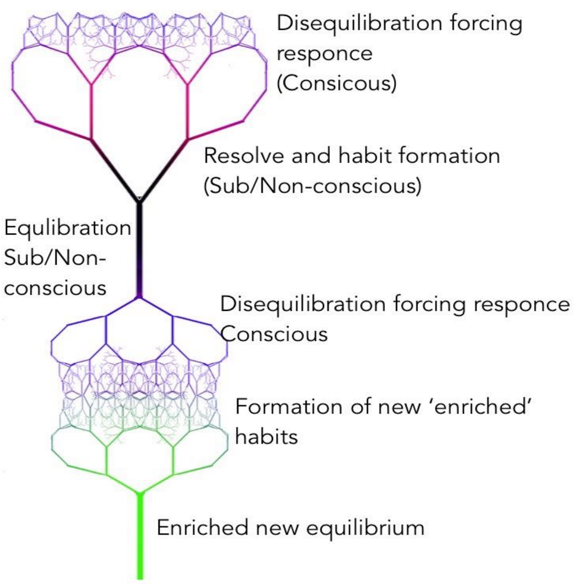

Figure 1.13; Interpretation of how the position of Dewey might be understood in terms of the previously defined (Chapter 1.5) differing states of consciousness. To be noted is that enriched new equilibrium state is of a different colour to the previous habit as it is of a new and modified habit.

Thus, through Dewey's understanding, while challenges and breakdowns may pose difficulties towards agents should they move beyond habitual and pre-learned responses the breakdown or challenge offers opportunity to develop a broader understanding and growth.

Using the example of a delivery driver responding to the vehicles engine struggling to maintain speed or achieve acceleration requiring a gear change; a level of inquiry and growth is required to ease such situation i.e. Learning to change gear prior to such events e.g. seeing an approaching roundabout and adjusting the vehicles gears and speed to ease efficiency and manoeuvrability.

Through Dewey's understanding instances of breakdown are seen as observable facts of life (and learning) in the formation and improvement of habits toward cessation of disequilibration and opportunities facilitating enriching experiences.

1.6.2: Heidegger, Leont'ev And Dewey Agreements And Disagreements

While the three understandings (Heidegger, Leont'ev and Dewey) differ in their framing of breakdowns there are commonalities that are applicable to the research presented here. Specifically this can be understood as a breakdown causing a deliberate contemplation upon a tool or task as a disruption to non-reflective and habitual (sub-conscious) processing. Additionally each of the models of breakdown hold intentionality toward a goal as a congruent theme, thus a breakdown can only occur in the context of a directed activity. Should a breakdown occur outside of the aims of a goal (in that it does not impact the immediacy of the activity) then it will not alter the actions of the agent or their experience in the activity. Therefore, here normal functioning and breakdown are understood as necessitating a context in the directedness toward "something" (i.e. a goal or technology) rather than abstract experience. As Mindfulness and Mindlessness are here understood as states of consciousness it further supports the positioning that an agent can be Mindful or Mindless toward a goal or technology (as a state as opposed to a trait).

These philosophical understandings are useful toward a pragmatic definition of Mindfulness and Mindlessness as they facilitate understanding the phenomena within well-established domains, through modalities accessible beyond constrains of empirical investigation (given the challenges of understanding consciousness through conventional scientific inquiry), and in ways applicable to the use of technologies and so the field of HCI. Through situating Mindfulness and Mindlessness alongside these philosophies we are equally able to reduce the ambiguity (through richer descriptions) of what phenomena is being described and where.

While the positions of Heidegger, Dewey and Leont'ev are not directly framed within Mindfulness and Mindlessness they are able to be compared through examples of Mindfulness and Mindlessness in the following chapter.

1.7.0: Mindfulness And Functioning And Breakdown

As noted by Langer (1989) those who are able to undertake a once concerted and effortful task (e.g. Knitting) are often able to multitask (e.g. Knit while watching T.V.) and so "*...knows how learned tasks drop out of mind.*" (p20). That is to say, through repetitive practice of a task or skill (use of a technology) and with improvement "*...the individual parts of the task move out of our consciousness. Eventually, we come to assume that we* <u>can</u> [original in italics] *do the task although we no longer know* <u>how</u> [original in italics] *we do it.*" (p20, Langer, 1989). This framing of knowledge acquirement and use, as presented by Langer, would agree with Leont'ev and Dewey in that initially there is a degree of learning, a conscious directed awareness toward the task or object to which later becomes inaccessible without concerted introspection (see figure 1.14); as noted by Langer:

> "If something or someone makes us question our competence on a task that we know moderately well but is *not* overlearned in this way, we can search our minds for the steps of the task and find them"
> (p20, Langer, 1989)

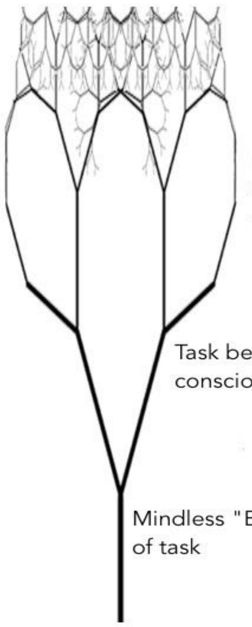

Figure 1.14; example of formation from effortful novice activity performance might transition toward 'Mindless expert' performance. This figure is interpretive of such action and draws upon the previous images of conscious states (Chapter 1.5)

Langer proposes such a state as that which may be understood as a "*Mindless*

"*Expert*"". That is, when a task is performed with so much repetition and proficient ability it can be understood as being performed expertly (Mindlessly) whereby such steps or process may no longer be consciously required. Such a positioning is parallel towards that of Leont'ev and Dewey.

Langer recalls an experience where she observed a highly competent typist who had built up such advanced skills over time. Langer enquired if he (the typist) could teach her (Langer); in doing so the typist:

> "… Began to take apart each skill, his quick fingers slowed way down and so did his memory for how and what he typed. Becoming conscious or mindful incapacitated him"
> (p20, Langer, 1989)

Thus, when engaged in a well learned activity that does not require concerted conscious awareness to the elements of the activity it could be understood to be performing as ready-to-hand, a routinised operation, and habitual; and in the research presented here (and that of Langer, 1989) sub-consciously and Mindless. Yet should a person engaged with an activity (as ready-to-hand) be required to perform a concerted awareness toward the activity a breakdown occurs; contemplation is required (or invoked) and the tool or activity becomes present-at-hand, is drawn into reflective-/conscious awareness and, as framed in the research here (and by Langer, 1989), Mindful. This is exemplified in figure 1.15.

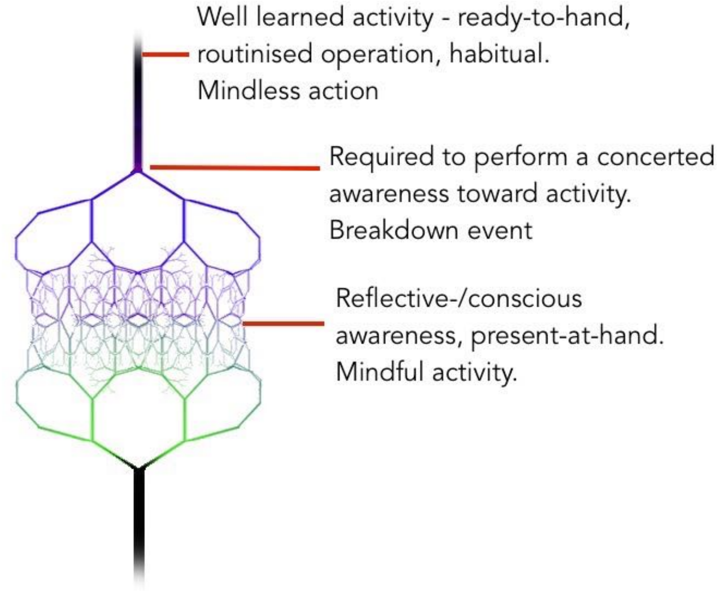

Figure 1.15; Example of the effect of concerted effort toward a task invoking reflective-/conscious awareness.

It should be noted that the previously described understandings of Heidegger, Leont'ev and Dewey, are framed as a non-intentional *malfunction* of a technology;

and defined by Koschmann, Kuutti, and Hickman as "*…a disruption in the normal functioning of things forcing the individual to adopt a more reflective or deliberative stance toward ongoing activity.*" (p26, 1998). Langer's example, however, demonstrates that a "breakdown" (or rather the effects and experience of a breakdown) can additionally be caused through self-directed contemplation whereby the technology retains its functional qualities but the primacy of knowing (as ready-to-hand) of a routinised and sub-conscious act becomes inaccessible.

And so here, the understanding of breakdown includes this recognition; that is, a breakdown can occur through a failure or inability of a device or apparatus in addition to a forced contemplation upon the abilities and process of an activity (as present-at-hand). Therefore, when a task or activity once ready-to-hand is required to be performed as present-at-hand the contemplation upon functionality forces the primacy of "knowing" to become inaccessible and as such a user/self-induced breakdown occurs; agreeable to the understandings of Heidegger.

Langer provides an additional example of Mindlessness developed through repetition that moves beyond that of Leont'ev and Dewey (previously described). The example suggests that a novice may perform a task better (or rather adapt quicker) than an expert should there be a modification to an original task of which the expert holds much experience and performs as a repetitive behaviour (where a task can be performed Mindlessly). Langer states that should a novice typist be asked to type yet remove the spaces between words (e.g. totypelikethis) they will be able to modify their behaviour and adapt their practice more easily than that of the proficient typist (who may Mindlessly insert spaces and so struggle to perform). As noted by Langer:

> "When any much-repeated task is slightly modified in an unusual way, the novice may do better.
> A familiar structure or rhythm helps lead to mental laziness, acting as a signal that there is no need to pay attention. The rhythm of the familiar lulls us into mindlessness"
> (p21, Langer, 1989).

Thus, Langer's understanding of the Mindless expert is further sympathetic to that of Dewey and breakdown.

1.7.1: Premature Cognitive Commitments And Functional Fixedness In Learning And Breakdown

While the previously highlighted positioning of Langer (1989) suggests that

Mindlessness exists in a well learned activity or behaviour (as opposed to directed towards an object) Langer additionally provides a framing that may be applied to unfamiliarised encounters of objects and tasks. Langer proposes that there are instances whereby an individual may encounter "something" and form a "*particular mindset*", enacting a Mindless disposition whereby the meaning or use becomes fixed upon the initial understanding. When reencountering the "something" the initial mindset or understanding is reapplied prior to reflection upon potential contextual meanings or uses, the user / agent enacts a *Premature Cognitive Commitment*. This is explained by Langer as:

> "When we accept an impression or a piece of information at face value, with no reason to think critically about it, perhaps because it seems irrelevant, that impression settles unobtrusively into our minds until a similar signal from the outside world - such as a sight or smell or sound - calls it up again. At that next time it may no longer be irrelevant, but most of us don't reconsider what we mindlessly accepted earlier. Such mindsets, especially those formed in childhood, are premature because we cannot know in advance the possible future uses a piece of information may serve. The mindless individual is *committed* to one predetermined use of the information, and other possible uses or applications are not explored."
> (p22, Langer, 1989)

Such a positioning parallels that of Dewey in that a stimulus may invoke a sequential behaviour that is routed in a habitual reaction / action. A person performing Mindlessly will perform this reaction / action without reflection and will therefore fail to see or explore the potentials for creative growth; akin to the previously highlighted position of Dewey:

> "…humans often attempt to recover equilibrium in ways that do not promote growth. Faced with a breakdown, they often retreat to more primitive levels of behavioral response rather than moving forward onto behavioral plateaus that are more richly meaningful."
> (p32, Koschmann, Kuutti, and Hickman, 1998)

Furthermore and noted by Langer and Chanowitz (p1051,1981) "…the context in which one is introduced to environmental cues for behaviour affects the ability of the individual to use those cues on a subsequent occasion."; and so a premature cognitive commitment exists as an assumption toward a context or situation based upon initial understandings. And so, when in a Mindless state an agent may resort to a premature cognitive commitment (a primitive unreflective habitual response) that is exhibited without contemplation or reflection, i.e. as ready-to-hand. The pervasive extent of this state is further explained by Langer and Chanowitz:

> "[…] much [of] complex social interaction is accomplished mindlessly, without an awareness of the relevant details that would seem necessary in order to accomplish that interaction successfully. […] This perspective stands in marked contrast to other views of humans as interacting almost exclusively on the basis of active, ongoing processing of incoming information made available by the environment. […] as the individual's experience with certain situations accumulates, a structure of the situation and a sequence of behavior are formed […]. On subsequent occasions, the individual will regularly encounter elements in the environment that resemble the structure typical of the earlier situations. The individual then responds to these elements as cues for maintaining the typical sequence of behavior. The theory of mindlessness further maintains that when in this "mindless" state, the individual is no longer engaged in actively constructing his or her environment; instead, the individual responds to an already constructed environment."
> (p1051 - 1052, Langer and Chanowitz, 1981)

Thus, a premature cognitive commitment exists in opposition to how we may view much of our "lived" life i.e. as experienced and intentional in reaction to ongoing environmental or situational information. Instead premature cognitive commitments indicate that a large proportion of our activities (and interactions) are routed in our previous exposure to similar experiences and environments without contextualisation and exploration to new modalities of understanding. This additionally supports the positioning of Dewey that a breakdown, one that forces a contemplation, facilitates creative adaptations (as opportunity to "grow") to otherwise habitual actions.

While Langer frames premature cognitive commitments as behaviour toward environmental cues, the position may be additionally framed through *Functional Fixedness*. Functional fixedness (Anderson, 1962) is understood as an inhibition to problem solving through the use of "solution objects", whereby the previous use or framing / presentation of the solution object limits the "visibility" of a novel use required for the solution toward a problem (This is discussed at greater length in chapter 1.12 on Automaticity). One such example of functional fixedness can be found in Anderson's findings of Dunker's "Box" problem (Anderson, 1952). The box problem (Dunker, 1945; Anderson, 1952) consists of a study whereby the test subject (participant) is instructed to mount three candles vertically to a screen so that they do not drip wax below. Objects are provided to achieve this within three "pasteboard" (cardboard) boxes of differing sizes containing the candles, some tacks / drawing pins, and a matchbox. The solution to the problem requires emptying the contents of the boxes, melting some wax to the inside of a box and bonding the candle to this; then fixing the box (and candle) to the vertical surface via the tacks. Functional fixedness here prohibits the immediate visibility of the solution as the boxes are not viewed as a component of use but as a storage of the objects. An additional example of functional fixedness may also be found through the *Two Rings Problem* (McCaffrey, 2012). The Two Rings problem requires a participant to fasten together two weighty steel rings in a figure-eight. The participant is provided with a long candle, a match, and a two-inch steel cube. The immediate functional fixedness driven answer would be to melt the wax over the two steel rings to form a bond, however this is not strong enough to hold the rings together. The solution requires a deconstruction of the objects provided to the constitutional parts. The candle is the source of the solution, however, it requires the use of the steel cube to remove the wax and reveal the wick, a piece of string. When this becomes apparent the solution is clear, the string wick may be used to tie the rings together.

Here the example of functional fixedness further promotes the understandings of breakdown as proposed by Dewey, Heidegger and Langer through a broader framing. Rather than applying, the habitual knowing (as described by Dewey), a primacy of action (as Heidegger's ready-to-hand), or a Mindless / premature cognitive commitment (as described by Langer (1989), and Langer and Chanowitz (2000)); a novel abstract contextualisation is required. The habitual and routinised behaviour (as described by Leont'ev and Dewey (Koschmann, Kuutti, and Hickman (1998)) must be overcome, the ready-to-hand primacy of knowing must be prevented and drawn toward contemplative present-at-hand (as described by Heidegger Koschmann, Kuutti, and Hickman (1998)), and the premature cognitive commitment must be blocked and an orientation towards *openness of novelty* of information and objects fostered (as described by Langer, 1989). Thus, in overcoming functional fixedness and premature cognitive commitment a breakdown must be facilitated to encourage the person to engage with actively constructing his or her environment, i.e. a Mindful action.

1.7.2: Toward Understanding Design And Interaction Within Mindfulness And Mindlessness

As previously described, Langer proposes instances whereby an individual may encounter “something” and form a “particular mindset”. That is to say, there may be times when an agent holds a specific understanding of an object. This could be, for example, seeing a pen and knowing it to facilitate writing. These instances are similar to that of the *Two Rings Problem* (McCaffrey, 2012); a candle is for burning, that is its “property”. We (conscious agents) have an approach toward specific objects whereby the opportunities of action are “revealed“ to us by their properties, stairs for climbing, pens for writing etc.. It can be said that these objects hold “affordances”; a communication of the actions of an object toward an agent perceiving it. Though an object reveals to us its potential uses though its properties, these do not normally “come at us” in a barrage of ideation, a specific use or action is often contextual or relational to a goal. A knife may be a replacement to a screwdriver, a lever for opening a tin of paint, or a doorstop when needed but is not understood in these actions during normal functioning (e.g. At a dinner table). As previously described and through the understandings of Heidegger, Dewey and Leont'ev; our actions and relations toward technologies are always in correspondence or oriented toward a goal. Though the properties (of an object) remain the same our understanding and experience of the object changes in response to our motives and action. The agent becomes active in constructing his or her environment as opposed to responding in an already constructed environment. Thus, the properties of objects can reveal their functioning toward us and we can “see” or be “blind” toward this in relation to our goals and desires. As this thesis concerns the design of interactive technologies, the understanding of such qualities holds importance toward the framing of our experience of the object.

That is to say, the understanding of design revealing / communicating multiple or singular use’s of interactive technologies is equal to that of understanding designing for Mindful or Mindless interactions with technology.

Through drawing upon such knowledges we are again better able to describe the phenomena of Mindfulness and Mindlessness and validate such position through verifiable “real world” example (such as *Two Rings Problem* (McCaffrey, 2012)).

1.8.0: Knowing What To Do - Affordance

In this chapter and the following (1.9.0) I present the distinction between that of a 'tool' and 'equipment'. Such differentiation is intended to provide a distinct understanding of an interaction in terms akin to that of ready-to-hand and present-at-hand, and presented here for relating such concepts through a broader construct of Mindfulness and Mindlessness. While these contrasting states are heavily informed through on-going wider discussion of affordance they are equally informed through perspectives such as Langer's "premature cognitive commitments" (Langer, 1989) and examples such as the transition toward 'Mindless expert' (p20, Langer, 1989); considering the understanding of technology as a transitory spectrum (dependant upon Mindfulness and Mindlessness) as opposed to a linear fixed 'learnability'.

The framing of tool and equipment presented here should be understood as not solely bound to physical objects (e.g. Such as a hammer or a nail) but encompassing the broader understanding of a "technology" such as through Heidegger's "equipment" (see: p95-97, Heidegger, 1962), a "something-in-order-to" (p97, Heidegger, 1962). This positioning follows that of MacKenzie and Wajcman (1985) who understand technology as ensembles of technical artefacts, activities or processes, and practical knowledge. That is to say, here tools and equipment are understood as encompassing specific knowledge's, methods or devices to achieve specific goals or resolve problems. As noted by Dreyfus (p63, 1991) Heidegger's equipment (p97, Heidegger, 1962) is always in relation to a broader nexus of other equipment in which it functions and defined in terms of what it is used for and so understood as "*…an assignment or reference of something to something*" (p97, Heidegger, 1962).

Indeed such framings of technologies (and the understanding of experience through these technologies) may be applied to non-physical technologies e.g. language:

> "Language is a totality of words-a totality in which discourse has a 'worldly' Being of its own; and as an entity within-the-world, this totality thus becomes something which we may come across as ready-to-hand. Language can be broken up into word-Things which are present-at-hand."
> (p204, Heidegger, 1962)

Though Heidegger's understanding of ready-to-hand as a primacy of knowing (occurring before reflective contemplation i.e. Present-at-hand) would appear to contradict this in that language must first be contemplated and reflected upon in its learning (we are not born with innate knowledge of our language); the positioning of

Leont’ev and Dewey is more inclusive of language as an equipment or tool as noted by Koschmann, Kuutti, and Hickman:

> “Language use for Leont'ev was just another form of Action, and as a result, his model by which linguistic skills are acquired resembles that by which one acquires a physical skill or learns to use a tool. […] the production of a single utterance, even a single word, initially requires conscious attention and only becomes routine with extensive practice.”
> “Dewey viewed the acquisition of skills broadly and, as a consequence, developed a model of breakdown that is comparably broad. Because he, like Leont'ev, considered tools and media to be extensions of the organism (Hickman, 1990), his analysis applies not only to organismic forms of breakdown, but also to the equipmental forms discussed by the other two authors. “
> (p35, 1998)

The reasoning that such understandings of technologies as encompassing more than a physical object is significant, is we are able to apply insight from cognitive-science that do not necessarily discuss human-object relations but rather concepts, capabilities and facilities relationships. Such example can be found in memory recall, which here can be understood as a technology of relating current experiences and challenges within a context of previously learned actions or experiences.

More significantly, such distinctions aid in the understanding that tools and equipments are not objective properties of objects, such as a scrollbar or button; but a subjective experience of a technology drawing upon qualities such as cultural practice, memory, perceivable attributes. The transition of tool to and from equipment is therefore not of a physicality but of an experience to be invoked, occurring “within us” and concerning the phenomenal.

1.8.1: Affordances And The Openness Of A Technology

As previously described a technology in the context presented here does not refer to a specific 'physical object' but a technology (MacKenzie and Wajcman, 1985) such as technical artefacts, activities or processes, and practical knowledges (i.e. conceptual or physical attributes); all of which facilitate '*Affordances*’.

Gibson's Affordances

Originally coined by Gibson (1977) the concept of affordance was used to denote what an environment offers an animal, for either positive or negative effect. It

(Gibsons affordance) is an action possibility offered to an animal from the environment (in which the animal resides) and is existent should the animal perceive it or not (McGrenere and Ho, 2000) (i.e. Gibson's affordances exist beyond perception). The affordance does not change dependant on the animals goals or needs, yet, it is dependant on the animals capabilities. For example, the top of a cliff face affords fatal injury to an animal who falls from it; thus additionally affording primitive hunters a means to drive animals over the edge and toward death, the same affordance is true of the animals who fall though they are not aware of such a quality of environment; this affordance does not exist toward a bird who has capabilities of flight. Thus the affordances as described by Gibson are both objective (in that they exist without meaning or interpretation requirements) and subjective in that they are dependant upon the frame of reference to (capabilities of) an actor.

Norman's Affordances

Norman's (1988) use of the term has led to a degree of ambiguity in its understanding and use in the field of HCI research, though Norman has made efforts to correct such misuse (McGrenere and Ho, 2000).

Norman previously stated:

> "...the term affordance refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used."
> (p9, Norman, 1988)

Norman has sought clarification upon these statements above (as a correction to that described within *Psychology Of Everyday Things* [POET], Norman, 1988) and to address the misuse in HCI and design research:

> "POET was about "perceived affordance." When I get around to revising POET, I will make a global change, replacing all instances of the word "affordance" with the phrase "perceived affordance.""
> (p39, Norman, 1999)

As noted by Norman (2013) we inhabit a world full of objects that are both natural and artificially created. In Norman's framing, affordance is the relationship between such objects and an interacting / observing agent (a person, creature, and / or machine etc.). Norman states that a *perceived* affordance is dependant upon the capabilities of the agent perceiving the object *and* their perception of how it may be used (p11, Norman, 2013). Thus a perceived affordance is not a property held by an object but the relationship between an object and agent; it is the 'visual' cues for how an object may be used or its behaviour. An example of an affordance in

Normans understanding is often provided through consideration of a chair. A chair affords ("is for") support and so affords sitting. If the chair is lightweight and free to move then most people are able to lift the chair and so it additionally affords being lifted (and moved). Should the person try and be unable to lift the chair (e.g. they are too old or young and so too weak), the chair does not (and cannot be perceived to) afford them this facility of movement. Such properties may be understood (through Norman) as a "real affordance" (Hartson, 2003) and akin to Gibson's understanding of affordance being physical attributes of an object, and so affordance is dependant toward the agent's capabilities. Yet Norman's understanding seeks to move beyond that of Gibson's and is inclusive of the notion that an object may hold many affordances and will 'communicate' this to the agent through its perceivable properties *and* an agents familiarity to such properties. For example, doorknobs communicate the *perceived* affordance of turning to open a door yet vary in design attributes, buttons communicate the affordance of 'pressing' and are for pressing but vary in design and end result. Thus a *perceived affordance* is a visual property of an object (characteristics of its outward appearance) that reveals or indicates an action possibility (how it should be used). Norman (1988) furthers the position that it is the perceived affordances of an object that hold the greatest importance over the 'real affordances' (the actual actionable properties of an object); as these tell the user what can be performed and how to do this.

1.8.2: Expanding Upon Forms Of Affordance: Cognitive, Physical, Sensory, And Functional

In recognition of the complex nature surrounding the concept of affordance Hartson (2003) proposes affordance be understood as divided into four differing yet relational framings (Cognitive, Physical, Sensory, and Functional affordances). This draws upon Norman's and Gibson's basic precepts, and inclusive of Gaver (1991) and McGrenere and Ho's (2000) additions to the concepts, and seeks to extend them in more useful ways through a richer and more consistent vocabulary (Hartson, 2003). Hartson (2003) notes that during interaction a user will perform cognitive, physical and sensory actions and so requires affordances to aide with each. Further to this Hartson places the affordances in relation toward task oriented contexts, as opposed to Gibson who places the concept of affordance as being relational to objects in the environment both with and without need for interacting.

Cognitive Affordance

Cognitive affordance can be understood as the design for the cognitive element of usability in a system's learnability. Defined by Hartson (2003, p319) as "*a design* *feature that helps, aids, supports, facilitates, or enables thinking and/or knowing about something*"; and provides the example of a button graphic having a clearly worded label indicating its meaning, function and consequences of clicking it. Hartson notes that cognitive affordances are likened to perceptual information about an affordance / perceived affordances (as described by Gibson (1977), Norman (2013), Gaver (1991), and, McGrenere and Ho (2000)); yet are to be considered distinct from a sensory affordance. A plate on a door that states "push" provides the cognitive affordance of indicating the direction of movement required to open a door.

Physical Affordance

A physical affordance is a design element that helps, aids, supports, facilitates, or enables physically doing something (Hartson, 2003); and is relational to Gibson (1977) and McGrenere and Ho (2000) as affordance, Norman (2013) as a real affordance, and, Gaver (1991) as the perceptibility of an affordance. An example of a physical affordance can be seen in a graphic interface button (to be clicked), the physical affordance is relational to the size and position to which it can be clicked. A doorknob holds the physical affordance to be grasped and turned.

Functional Affordance

A functional affordance is an affordance that helps or aids the user in doing something and can be considered as being for a purposeful action (Hartson, 2003). More simply put, the functional affordance "*ties usage to usefulness*" (p316, Hartson, 2003), such as a button to arrange files in alphabetical order or in date of creation. When a door is operated it provides the functional affordance of entry in-to and out-from a room.

Sensory Affordance

A sensory affordance is an element of design that "*helps, aids, supports, facilitates, or enables the user in sensing (e.g., seeing, hearing, feeling)*" (p322, Hartson, 2003). A sensory affordance includes the features of a design that consist of a visual, auditory, haptic/tactile etc., presence; and works alongside cognative and physical affordances in that a user must be able to sense such affordances. This affordance is not the perceptual affordances as described by Gibson (1977), Norman (2013), Gaver (1991), and, McGrenere and Ho (2000); as there is no cognition of action in that the sensory affordance does not help with thinking. A door of a differing colour to the surrounding wall features as a sensory affordance, enabling a user to sense a different area.

While these four distinct forms of affordance draw upon differing human capabilities (such as cognitive skills, physical abilities and sensory capabilities) they additionally work in harmony to support each other in much the same way a sentence is formed form individual words to provide meaning.

Though the work of Hartson (2003) combines the work of many authors in the field of affordance theory and might be considered a more comprehensive understanding of the multifaceted nature of affordances; it is often the work of Gibson (1977) and Norman (1988, 1999) that is drawn upon when discussing affordance in HCI design and evaluation.

1.8.3: Affordance As Application Of Prior Knowledge: Familiarity Of Equipment

It is the combination of Hartson's four-forms of affordance that will facilitate a learning of action potentials and ease in applying them, as noted by Hartson:

> "The user's path from sensing to cognition to action shows how each affordance role is involved in both learning about (ease of learning) and using (ease of use) artefacts."
> (p322, Hartson, 2003)

However, while affordances facilitate learning of an action potential they additionally require a prerequisite knowledge as noted by Norman:

> "I believe that affordances result from the mental interpretation of things, based on our past knowledge and experience applied to our perception of the things about us."
> (p219, Norman, 1988)

This can be exemplified in the understanding of the affordances offered by a door handle. Though the design may differ previous exposure and knowledge of the function of a door handle (and the general design / features) assists in a knowledge and utilisation of the door handle. If, for example, an alien species that perfectly matched a human in terms of size and strength, graspable limbs, and sensory apparatus (i.e. Hands and eyes capturing the visible light spectrum) arrived to earth the same affordances offered to a human would not be available. A sign that offers cognitive affordances would not apply; use of language would be meaningless; and sensory affordances that hold significance to us may appear as decoration rather than indicators of action.

As explained by Norman:

> "…designers greatly rely on conventional interpretations of the symbols and placement. Much of the discussion about the use of affordances is really addressing conventions, or what I call cultural constraints."
> (p40, Norman, 1999)

While physical constraints limit potential actions of an object through the physical properties (e.g. Being too heavy to lift); there additionally exists logical constraints whereby rules of logic (e.g. Being instructed to scroll down indicates additional content and scrollable page) allow users to (logically) deduce action (Norman, 1999). Further to these affordance constraints exist cultural constraints that are dependant on social / cultural norms. A scroll bar or a "drag and drop" are learned conventions that exist as cultural constraints. Such affordances require specific knowledge of a form action, one that is culturally learned and not available to those without such knowledge, and may be understood as involving cognitive and functional affordances (as previously described; see: Hartson, 2003). Thus some affordances are dependant toward cultural constraints (Norman, 1999) and so previous knowledge.

Turner (2005) proposes the understanding in the operation of affordances through a binary state of "simple" and "complex" affordances.

A "simple" affordance (as understood by Turner, 2005) may be described as a real and objective property of an object, such as its physical attributes. This is relatable to a Gibsonian understanding of affordance as they are communicated to an animal (or agent in an environment) as "stimulus information". Thus a simple affordance is objective in that the affordance is a referral to the physical properties of the object and the animal interacting. However, Turner (2005) notes that while objects may implicitly hold affordances "*Even if an animal possesses the appropriate attributes and senses, it may need to learn to detect this information"* (p790, Turner, 2005). And so, though an object may hold latent properties (of affordance) it is only once these are detected and acknowledged as significant (by an agent) that it holds (actionable) meaning to an animal and value as a technology in order to do "*x*". While simple affordances may be understood as directly perceivable there additionally exists a "complex" affordance. As noted by Cole (1996) some artefacts inherently embody a meaning through a reflection of their use; such artefacts may be understood as manufactured or produced as part of and relational to an intentional action or use (Turner, 2005). These artefacts, objects, or more broadly, technologies, draw upon cultural constraints (Norman, 1999) to facilitate their intended affordances.

Turner (2005) places familiarity and *equipment*, as described by Heidegger, into the understanding of affordance. As previously described, in Heidegger's use of "equipment" (p95-97, 1962) it is understood as a "something-in-order-to" (p97,

1962) and is always in relation to a broader nexus of other equipment in which it functions (p63, Dreyfus, 1991); and defined in terms of what it is used for, and so understood as "*…an assignment or reference of something to something*" (p97, Heidegger, 1962). This broader nexus of equipmental "things" is presented to us (or rather *experienced* by us) as a referential whole (p797, Turner, 2005); e.g. When entering a room we initially see the room as a whole and this is developed from our familiarity with the equipmental "things" that make up the room (Heidegger, 1992). Thus as noted by Turner (p797, 2005) a world according to Heidegger is comprised of three characteristics:

1. The totality of inter-related pieces of equipment; with each piece of equipment being used toward a specific task.
2. A second component of a world exists through a set of purposes to which these tasks are performed to achieve. (A higher level goal)
3. The characteristic that in performing these tasks we acquire or assume an "identity" (or identities) (such as doctors, mechanics, students etc.). "*Thus by worlds we mean cultural worlds*"

(p797, Turner, 2005).

Thus, the ability to draw upon familiarity allows us to view the world in an unconscious and unintentional (p189, Heidegger, 1992) combining of a broader nexus of equipment that we may use (presented through affordances) that is relational to an existent understanding and framing. And so our experience of the world is through equipmental things (and as a nexus of such equipmental things) specific to a contextual purpose and through a nexus of cultural and pre-existing knowledge. Such perspective "*also forces us to conclude that an affordance cannot exist in isolation*" (p798, Turner, 2005).

Therefore, as noted by Turner (p798, 2005), "*…from a holistic or phenomenological perspective, affordance, use and context are one*"; dependent on the visibility to our subjective (phenomenal) experience and capabilities to reflect upon and find meaning (i.e. as present-at- hand) or directly apply in use (i.e. ready-to-hand).

1.9.0: Understanding Of Affordances Through Mindfulness And Mindlessness - Defining Tool And Equipment

As previously described there are several understandings of affordances developed from the original usage by Gibson (1977). While Norman's (1988,1999) understanding of affordance (as both real and perceived) is perhaps the most commonly understood and applied in research, there have additionally been attempts upon clarification and expansion of the term to include a broader dimension of human cognitive processing and deeper understanding of our interaction (and application) with technologies.

As noted by Turner:

> "An affordance thus exists, whether it is perceived or used or not, furthermore it may be detected and used without explicit awareness of doing so.
> (p790, Turner, 2005)

The significance of Turner's statement in that affordances (though commonly described as apparent perceptible qualities of an object) hold a dynamic property within them is of particular interest to the concept of Mindfulness and Mindlessness during interaction. Objects may be used (their affordances applied in action) without explicit awareness of their presence. For example; the pushing of a door, a drink from a cup, typing of a password on a keyboard; all of these activities exploit the affordances offered of the object to the user, yet some of those affordances do not "appear" to the user. Thus, the relationship of affordance is between the agent and its environment (akin to that described by Gibson), however this may be considered the agents subjective environment, their phenomenological world, an *Umwelt* that is coupled to their experience.

While there exists an objective reality/environment for an agent it is experienced as their "Umwelt" (p174, Varela, Thompson and Rosch; 1991). The Umwelt of an agent is the way in which the world exists toward them, how the environment is constructed in subjective experience and dependant upon the capacities in which they perceive the world. It is presumable that an agent would believe their experience (of their Umwelt) must be the objective reality shared by all as it requires questioning of the normal experience (how we "know" the world) to challenge such assumption. For example, a person who is colour blind yet does not know of such a condition will assume that it is how the world appears to all, that it is "how the world is" – we cannot know the experience of what it is we do not know the experience of.

As noted by Varela, Thompson and Rosch (on critique of Merleau-Ponty[3]), this Umwelt dictates how we act within the world:

> "…perception is not simply embedded within and constrained by the surrounding world; it also contributes to the enactment of this surrounding world. Thus as Merleau-Ponty notes, the organism both initiates and is shaped by the environment. "
> (p174, Varela, Thompson and Rosch, 1991)

The connection between how we experience the world and how we act upon (and within) the world are interrelated – consciousness is, according to Varela, Thompson and Rosch (1991), '*embodied*' in the world, our actions are '*embodied actions*' in which we perform '*enaction*'. Varela, Thompson and Rosch (p172-173, 1991) highlight that to be '*embodied*' refers to two qualities. Firstly; that to be embodied requires having physicality and presence in an environment and with this the ability to sense and navigate or respond to said environment (e.g. sensations of sight or touch, movement or reactions); and secondly, that these qualities themselves are embedded in broader encompassing biological, psychological and cultural contexts e.g. adrenaline to increase heart rate (and so release/allow greater muscle energy for faster movement), fear to increase adrenaline, and dangerous situations to cause fear. Varela, Thompson and Rosch (p172-173, 1991) further highlight that these events of '*action*' are intrinsically linked; to see perceive and sense and to act are in themselves "…*fundamentally inseparable in lived cognition*". Varela, Thompson and Rosch (p172-173, 1991) note that '*enaction*' is consequently referring to two qualities of an agent in an environment; perception guided by *and* guiding action, and '*cognitive structures*' (knowledge/memory) develop from recurring patterns of action (described above) and allow for such actions to be guided by perception. Thus it can be said perception exists in and as action and with repetition of such actions knowledge is gained that allows action guided by perception.

Thus for Varela, Thompson and Rosch; our Umwelt is not only a biologically dependent one (of our perception) but additionally shaped by a psychological and cultural context (and the meaning we perceive and knowledge we gain). Furthermore, they suggest that Umwelt is dependent upon and guided by action (and potential for action) and our perception of our actions; i.e. perception is primarily for the guidance of action and the recurrent patterns in our perceptions

[3] Quote of Merlau-Ponty: "…The environment *(Umwelt)* emerges from the world through the actualization or the being of the organism…" (In p174, Varela, Thompson and Rosch)

develop cognitive structures (e.g. a knowing, memory or learning) so that our actions may be guided by our perceptions. Such position is highly sympathetic to those discussed at greater length in chapters 1.11.0 and 1.12.0.

Embodiment suggests that we can hold a form of consciousness distinct to environments and, more significantly here, the *affordances* we perceive (as opposed to the ones they may offer) as a reciprocal state of being, yet developed over repeated exposure. In recognizing using such affordances it is the act of "enaction", as noted by Stoffregen, Bardy and Mantel (2006):

> "[…] people often exhibit accurate knowledge of their action capabilities and that in many cases this knowledge appears to be perceptual, that is, based on immediate perceptual information, rather than being based on secondary, cognitive operations." (p5);
> "In ordinary life, affordances are perceived, and this perception is enactive." (p6)

For Stoffregen, Bardy and Mantel's (2006) we primarily, or most commonly, see (experience) action (affordance) in our environment enactively prior to a thoughtful deconstruction ("cognitive operation"). These understandings of Stoffregen, Bardy and Mantel (2006), and Varela, Thompson and Rosch (1991); are considered to be of normal functioning ("*in ordinary life*"), non-contemplative ("*based on immediate perceptual information*"), and well learned. As such, enaction here is understood as guided by the immediacy of perceiving the environment as opposed to a consciously guided action of deconstruction.

It is important to note, as the previous chapters described (1.6 and 1.7), such unreflective operation of technologies is not of a permanent state. Technologies may encounter a breakdown, e.g. through malfunction or intended contemplation, that invokes a reflective state whereby the technology becomes apparent and the attributes available to be studied. As the perception of the object (technology) changes so does the perception of its affordances, as previously noted by Norman:

> "I believe that affordances result from the mental interpretation of things, based on our past knowledge and experience applied to our perception of the things about us."
> (p219, Norman, 1988)

Such differentiations regarding affordances are here highlighted and drawn upon through the defining of *tool* and *equipment*. Where as one state an agent is active in perceiving and creating the ensembles of their latent environment (the tool), the other is lead through enaction (the equipment); thus the *tool* is to be considered Mindful use of technology and the *equipment* Mindless.

1.9.1: Mindfulness: Of Tool

While Norman (2013) states that affordances exist between 'physical' objects, here the concept is applied to the broader understanding of a *tool* i.e. inclusive of knowledges, technique, or conceptual or physical attributes. This can be exemplified as: a voice having the affordance's of complex communication of ideas (spoken language), defence from predators (through volume to intimidate) etc.; the concept of numbers holding the affordance of communication of volume / size and distinction (labelling), and affordance of mathematics. In much the same way as Norman's affordances, tool affordances (as proposed here) would additionally require a level of perceptibility and ability (enaction); vocal ability no-longer affords communication to the deaf or an agent who is unfamiliar/not fluent in a specific language, the concept of numbers does not hold the facility of mathematics should the agent not understand the required equation or lack the cognitive capacity to perform such a task.

Accordingly a tool here is understood as knowledges, techniques, concepts or physical objects whose attributes hold affordances to an agent with the capability to perceive and apply them. Consequently a tool may exist beyond an agent as a 'separate entity', e.g. A hammer as a paperweight continues to perform the same way with an agents control or not, it continues to perform independent of direct manipulation. Though a technology in a tool state may appear self-governing from an agent, they are not latent in the objective environment but form part of an active construction of an agents subjective world as situated within (yet not consuming totality of) actions, goals, attention and awareness. Tools form constituent parts in an ensemble of artefacts in an agents phenomenologically present environment in relation to a goal.

Furthermore a tool may be understood as holding a semantic variability towards its being. That is to say, a tool possesses qualities in action of Mindfulness, a broader contextual meaning beyond the immediate perception. The tool does not hold a premature cognitive commitment or functional fixedness and so is "experienced" as a range of possibilities, its constituent parts, and how they may be adapted or applied.

The greatest quality of a tool state is holding multiple affordances and is contrasted by *equipment* discussed in the following chapter (see figure 1.16 below).

1.9.2: Mindlessness: Of Equipment

'Equipment' is explained by Heidegger as a 'something-in-order-to' (Heidegger, 1962); though equipment here can be understood as a development of this concept. Heidegger framed equipment as relational:

> "In the 'in-order-to' as a structure there lies an *assignment or reference* of something to something."
> (p97, Heidegger, 1962).

Heidegger stated equipment "*always is* in terms of (aus) [original in italics] *its belonging to other equipment*" (p97, Heidegger, 1962). Here this is broadened to an equipment only being 'present' in relation as an *assignment* to a goal, task or intent (i.e. in use by an agent). As previously described a tool holds the potential of multiple affordances (visible to the user as potential uses and applications); an equipment, here, can be understood to be affordance (singular) in application by an agent. As noted by Dreyfus (p93, 1991) "*A piece of equipment is* defined [original in italics] *in terms of what it is used for*". Thus the equipment is the application of a specific affordance of a tool oriented toward a goal, it is the enacting of an affordance and not the tool itself. Whereas a tool holds multiple affordances (and so it's relation to the agent is in the revealing *as a tool-of-facility-to…*'*x*'), an equipment is directly dependant upon enaction and so does not support affordances exterior to the goal or task (as such support would alter the equipment to a new 'something-in-order-to'). Consequently, whereas a tool can exist beyond an agents control, equipment cannot as it is dependant upon enaction, therefore when equipment breaks down it resorts to a tool like state revealing (and requiring contemplation of) its potential affordances.

And so, a tool can be conceptualised and reflected upon as a separate entity but an equipment can only be experienced as the something-it-is-to. Consequently an equipment can be considered as holding a premature cognitive commitment or functional fixedness, guided by perception without concerted awareness. It holds a single apparent use and the constitutional parts hold transparency within the whole object use. Therefore, an equipment may be considered as the application of a technology in a Mindless manner.

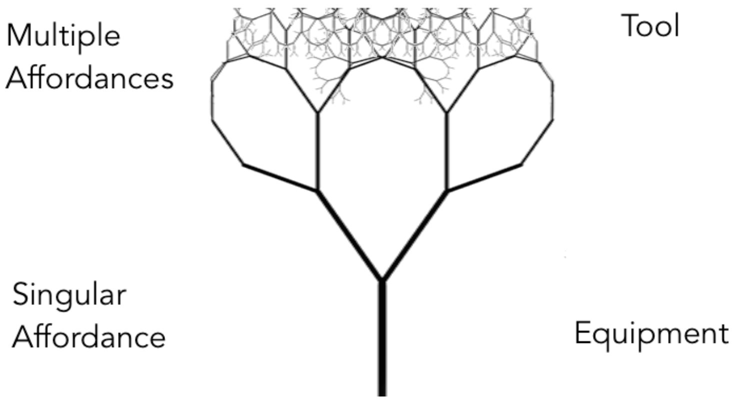

Figure 1.16; Comparison between Tool and Equipment in terms of Affordances and conscious availability and complexity (to be interpreted alongside previous pictorial representations of conscious states – Chapter 1.5)

The introduction of Tool and Equipment here provides utility describing technologies in more specific terms (reducing ambiguity) and within well-established understandings. This provides capability to refer to specific interactions with technologies in terms of a reciprocal relationship to the experiential qualities of the user, thus Mindful and Mindless technologies can now be understood as state like attributes as opposed to objective properties of a technology. In doing so this overcomes problematic qualities of previous definitions of Mindfulness and Mindlessness holding a high degree of ambiguity; and positioned in broader trait-like dispositions. Consequently definitions that frame specific *interactions* with technology, as opposed to the technologies themselves, are facilitated.

1.10.0: Tools And Equipment As Experience In Use

While the previous definitions of tool and equipment provide a means of categorisation of how technologies may be perceived by an agent, they are here incorporated within a broader phenomenological state classification of how an agent may experience an interaction. This is achieved through building upon notions of ready-to-hand and present-at-hand discussed previously in chapter 1.6. The aims of the following definitions are to provide such categorization of interaction with technologies, as a phenomenological agent-technology relation, within the framing of Mindfulness and Mindlessness. While understanding the state of a technology to an agent (i.e. tool or equipment) provides indication to how it may be approached the following seeks to clarify how it may be "experienced". This builds upon the previously described understandings (chapters 1.5 - 1.9) and in particular expands upon the notions of *Ready-to-hand* and *Present-at-hand*.

1.10.1: The Incorporation Of Tool And Equipment As States Of Mindfulness And Mindlessness

Equipmental-transparency

Equipmental-transparency is an expansion upon *Ready-to-hand* as described by Dreyfus (p210, 1991). When an *equipment* in use is 'invisible' to the user, not in terms of its visual presence but in subjective awareness (it is phenomenologically invisible); and consequently, when in this state, is not in the subjective experience of the user as a separate entity or object. As such, the user of the equipment is able to focus toward the 'goals' facilitated through the use of said equipment.

Through this use of equipment the broader goal may additionally be understood as sub-conscious, the goal itself is maintained but the awareness of how this is achieved is without introspection of reflective-/conscious awareness. These actions are typically performed as a rountinised act. Such an experience of the equipment may be considered sub-conscious though this may develop toward non-conscious through instinctual or habitual use.

An example of this may be understood as Langer's expert typist. They perform their typing task without conscious awareness towards the activity. Should they be required to alter their behaviour then a breakdown occurs and they are forced into consciously performing the act.

Equipmental-fixedness

Equipmental-fixedness is an expansion upon *Un-ready-to-hand*, as described by Dreyfus (p210, 1991). When an equipment performs as a functional fixedness. Deliberation upon the equipment does not occur even though the equipment is not in use. Its affordances are masked behind a premature cognitive commitment and its utility as equipment is non-consciously perceived. Such equipment can be understood as experientially present (i.e. available for conscious reflection and the equipment understood as distinct from the self) yet does not hold the properties of a tool (holding multiple affordances). This state, though involving awareness, can be viewed as Mindlessness as noted by Gantman, Gollwitzer, and Oettingen:

> "In defining mindfulness, it is important to note that it is not just self-awareness (e.g., Duval & Wicklund, 1972); when objects in the environment such as a mirror, tape-recorder, or the sound of one's own voice, are present in the environment, they are reminders of the self-as-object and so draw the focus of attention of the individual as "Me." The highly objectively self-aware individual regards the self as an entity in the environment that can be evaluated as any other. Mindfulness is a state of conscious awareness in which the individual as "I" actively constructs categories and distinctions. In contrast, mindlessness is a state of mind characterized by an over-reliance on categories and distinctions drawn in the past—it is not simply taking the "I" out of experience. The individual is context-dependent and as such oblivious to novel (or simply alternative) aspects of the situation."
> (p237, 2014)

Thus, though the "*I*" or "*me*" is distinct from the equipment the reliance upon the previously drawn categorisations exposes the interaction or understanding as Mindlessness.

Fluidic-tool

Fluidic-tool is an expansion upon *Present-at-hand*, as described by Dreyfus (p210, 1991). When an *equipment* has encountered a 'breakdown'. Such breakdown may be drawn from a failure of the equipment or through self-deliberated observation. As such the *tool* '*reveals itself*' to the entity using it, it becomes 'consciously present' (we consciously are aware of the *tool* as a separate entity). Thus a *tool* in this state is phenomenologically visible, we can 'see' the *tool* as distinct from ourselves and so can reflect or theorise upon its meaning and range of equipments facilitated through its affordances. As such, the user of the *tool* focuses toward the *tool* itself and not a specific goal facilitated through the *equipment*. Such an experience is conscious and is considered Mindful as there is active formation of novel categorisations toward a present given context.

Abstract-tool

Abstract-tool is an expansion upon *Purely present-at-hand*, as described by Dreyfus (p210, 1991). When a tool is understood through purely abstract categorisations whereby constitutional elements are exposed. In this state the tools affordances are not only bound by its immediacy but additional modification, deconstruction and combination with other affordances and/or technologies toward a broader goal or activity. As such, this state of experience is purely contemplative and beyond the immediacy of the context the tool is presented in.

1.11.0: Understanding The Body In Mindfulness And Mindlessness

While the previous chapters of this thesis have explored Mindfulness and Mindlessness through a philosophical lens, here associated concepts from the field of cognitive science are explored to provide further insight toward how and why such experiences may occur.

In doing so the thesis takes scope form the field of neurophenomoenology as a methodology in understanding these complex states of experience with aim to situate such topics within a contemporary scientific discourse. This seeks to improve understanding and inform the development of systems for the direct measurement of such experiences and provide support in the development of a grounded definition of Mindfulness and Mindlessness in fields beyond a spiritual association.

1.11.1: Neurophenomenology

Building upon phenomenology Varela (1996) proposed that the 'hard problems' (as described by Chalmers (1995)) may be answered through "Neurophenomenology" in that "*…the field of conscious phenomena requires a rigorous method and an explicit pragmatics for its exploration and analysis.*" (p330) in a direct addresses to Chalmers 'easy' and 'hard' problems of consciousness (1995). Thus, Varela sought to combine cognitive science and a "disciplined approach" (incorporating phenomenological understanding and enquiry) to understand human experience. Varela places neurophenomenology through phenomenology yet does not ascribe it to a particular school or sub-lineage and so provides his own understanding:

> "My position cannot be ascribed to any particular school or sub-lineage but represents my own synthesis of phenomenology in the light of modern cognitive science and other traditions focusing on human experience. Phenomenology can also be described as a special type of reflection or attitude about our capacity for being conscious. All reflection reveals a variety of mental contents (mental acts) and their correlated orientation or intended contents. Natural or naive attitude assumes a number of received claims about both the nature of the experiencer and its intended objects. The Archimedean point of phenomenology is to suspend such habitual claims and to catalyse a fresh examination"
> (p335-336, Varela, 1996)

Varela (1996) provides a "*Working Hypothesis of Neurophenomenology*", with aim to provide help toward guiding and shaping scientific investigation of consciousness experiences (and vice-versa), which he described as:

> "Phenomenological accounts of the structure of experience and their counterparts in cognitive science relate to each other through reciprocal constraints."
> (p343, Varela, 1996).

That is to say, first person accounts of subjective experience should be integral to cognitive science studies and proposals of physiological function, "*…only a balanced and disciplined account of both the external and experiential side of an issue can make us move one step closer to bridging the biological mind - experiential mind gap.*"(p343, Varela, 1996).

By the means of Neurophenomenology Varela suggests that all accounts of subjective experience may eventually be explainable by a thorough understanding of physiology developed through the merging of disciplined first-person accounts and rigorous neurobiology studies, as described below:

> "Φ looks like $\Psi \Rightarrow \Phi$ explains Ψ
> where Φ are neural-psychological terms and Ψ are phenomenal terms, and the implication operator has a conditional sense: if the empirical events 'look like' the phenomenal events, then these are explained. "
> (p344, Varela, 1996)

In the context of this research such positioning is recognised as contested, as previously stated there remains on-going debate with regards to the physiology of consciousness. The approach of neurophenomenology, however, still facilitates a better understanding that though the "experiential mind" may be beyond measurement, the physiological process that support or correlate such phenomena may be utilised in enhancing understanding of and classification such states. And so the research of this thesis builds upon the notion that if empirical evidence within cognitive science (Φ) looks like the philosophical understanding (Ψ) then cognitive science can help understand, support and explain the particular philosophical understanding. Here it is understood that: through rigorous inquiry and disciplined first person accounts of Mindfulness and / or Mindless, supported by the observation and understanding of physiological process accompanying such states; a better-grounded understanding of Mindfulness and Mindlessness may be achieved that furthers application in the field of HCI (through providing potential modalities of measurement).

> "This can hardly be otherwise, since any science of cognition and mind must, sooner or later, come to grips with the basic condition that we have no idea what the mental or the cognitive could possibly be apart from our own experience of it."
> (p331, Varela, 1996)

Accordingly, here the 'science' of Mindfulness and Mindlessness during human-computer interaction is framed through not only a philosophical understanding but additionally supported by observable measurements (from findings of related fields) *and* justifiable first-person accounts.

1.11.2: Understanding Of Cognition And Mindlessness:

> "At every moment, the natural environment presents animals with many opportunities and demands for action. […] Information is used along with representations of current needs and memories of past experiences to make judgements and decide upon a course of action. "
> (p1585, Cisek, 2007)
> "Continuous interaction with the world often does not allow one to stop and think or to collect information and build a complete knowledge of ones surroundings. To survive in a hostile environment, one must be ready to act at short notice, releasing into execution actions that are at least partially prepared.
> (p1586, Cisek, 2007)

While the previous chapters have addressed Mindfulness and Mindlessness through phenomenological and philosophical understandings (i.e. subjective, 'felt', first-person experience) they have not addressed cognition as a distinct quality. In the previous chapters it was established that we (humans) hold capacity for moments of reflective-conscious and conscious awareness toward and through technologies, yet also states where these forms of awareness are not present, i.e. Sub- and non-conscious actions and behaviours. Therefore, logically there must a process that 'fills in the blanks' when we are not 'looking in' (through conscious awareness as introspection) and 'takes over' as sub- and non- conscious actions and behaviours. This can is described through the previous example (of Langer (1989)) of those who are able to undertake a once concerted and effortful task (e.g., Knitting) yet are then able to multitask (e.g. Knit while watching T.V.) as the *"…learned tasks drop out of mind*" (p20). The once effortful task performed with concerted conscious awareness becomes sub-conscious as *"[…] the individual parts of the task move out of our consciousness*" (p20, Langer, 1989); there is a part of the action where the conscious “me” stops thinking upon the how and sub-consciously knows to do. Shanahan (2010) comments on this difference:

> “[…] an important distinction needs to be drawn between thought and cognition. Our immediate concern is thought in humans, and human thought, as the term is used here, is necessarily conscious. We can report what we are thinking and recall what we have thought in the past,
> […]
> Cognition might (conventionally) be described as, say, a combined process of gathering information from the senses, storing it, processing it, and using whats been gathered, stored, and processed to guide behaviour.
> According to such characterisation, a cognitive process may be conscious, or it may not. Likewise it is commonplace in philosophy of mind to gloss over the conscious/unconscious distinction altogether — to speak, for example, of a mental state without declaring weather the mental state in question is conscious or not."
> (p42, Shanahan, 2010)

For Shanahan (p42, 2010) cognition is to "know" as he points out: "Contemporary scientific usage has strayed away from the Latin root of the word 'cognition' which is <u>cognosecre</u>, to know (rather than <u>cogitare</u>, to think)". That is to say, cognition is an act of knowledge processing and application whereas consciousness is an active 'thinking' act, such as a formation of new knowledge; a distinction analogous with the previously discussed Western understandings of Mindfulness and Mindlessness. As Langer has previously described (Langer, 1989) the more we know how to perform an act the less we need to think of it, until the process has completely removed from our conscious awareness. Further to this, when thinking (concerted conscious awareness) is placed upon a well-known act (that is routinised and performed sub-consciously) it adds an additional burden, and the task cannot be as easily performed. For example, when Langer requested a skilled typist to deconstruct his typing where he "… Began to take apart each skill, his quick fingers slowed way down and so did his memory for how and what he typed. Becoming conscious or Mindful incapacitated him" (p20, Langer, 1989).

1.11.3: Biological Basis Of Cognition And Evolutionary Perspective Upon Conscious-Cognition

Århem and Liljenström (1997) provide further insight to cognition and consciousness framed within an evolutionary based positioning. Their work parallels and builds upon that of Humphrey (1992) and Lindahl (1997), and provides insight toward the classification of animals degree of capacity to hold conscious experiences (e.g. Chandroo, Duncan and Moccia (2004) and, Butler and Cotterill (2006)) and in the classification of artificial life (Moreno and Etxeberria, 2005). They (Århem and Liljenström) define cognition as a knowledge processing mediated by a centralised nervous system and based upon the same principles as non-neuronal adaptive processes. Through this positioning they argue that *conscious-cognition* may be a major transitioning point in the evolution of life, appearing in differing degrees at different stages of evolution.

Århem and Liljenström (1997) describe that to survive every organism needs to react and adapt to its changing environment. In order to successfully adapt the organism must have capability of learning and problem solving and so, all (successful) organisms must possess a knowledge about their immediate surrounding environment. While all successful organisms do not require a nervous system (e.g. Trees); Århem and Liljenström (1997) explain that having a nervous system increases the speed and capacity in which an animal can perform adaptation to, and interaction with, the environment; and so increase its survival probability. Thus, knowledge gained of the environment facilitated by and mediated through a nervous system (sensory perception/stimulation) is therefore regarded as cognition. The context of cognition for this thesis refers to cognition of organisms with a central nervous system with capabilities to sense and store information.

Conscious cognition differs from cognition as it is not only cognition but cognition associated with subjective experience. While Århem and Liljenström (1997) do not provide a definition of consciousness (other than being a subjective experience) they state that thinking and describing of consciousness in purely "computational terms" would not be fertile, and stress "*…the subjective aspect of our mind cannot be fully understood in terms of computations*" (p602, Århem and Liljenström, 1997) i.e. Through nervous system activity as input/output alone. Through this a distinction is made that conscious-cognition is not consciousness itself but subjective experience (consciousness) upon knowledge (cognition). While Århem and Liljenström (1997) do not hold the position that consciousness is the produce of the brain or central nervous system, they do note that a role of the brain is to prioritise this sensory information (from nervous system) and so filter the "nonsense" (the mediation between sensation and perception) of continual sensory input and leave significant stimulus. Furthermore, they hold the position that the capacity for conscious cognition (e.g. reflection upon sensation and perception) is presumably advantageous to an animal over solely possessing non-conscious cognition; and would require a highly complex nervous system capable of change; as noted:

> "A high flow rate of information may not be sufficient for mind, it is very likely a prerequisite for it. Also the dynamical state of the brain is of great importance for how the information is being processed, and what the result of this processing will be."
> (p603, Århem and Liljenström,1997)

It is important to remember that here, and as with this thesis, Århem and Liljenström's positioning is not concerning *how* consciousness is 'produced' (as this remains beyond current knowledge) but *that* it exists when understanding conscious-cognition and cognition.

1.11.4: Complex Nervous Systems Allow Complex Cognition

There is some form of knowledge processing before events in the environment (as stimulus) cause a responsive behaviour/action (sensation to action). Through evolution different strategies have emerged to optimise this process in terms of speed, energy used, and balance between a flexibility or stability of the responses. Though each requirement has its benefits they are not necessarily compatible and often require a sacrificing of the balance of one trait over another. Humans, for example, have developed and drawn upon flexible response patterns necessitating a highly complex centralised nervous system (Liljenström, 1994) at a cost of greater energy use. The range of complex flexible responses requires interneurons, neurones that mediate the impulses between sensory and motor neurones; with the larger the number of interneurons the larger potential number of responses to stimulus (with humans holding the largest number of interneurons) (Århem and Liljenström,1997). In addition to this, complex network nervous systems evolved to process and store information in efficient ways; facilitating maximal processing rate; or maximal information storage capacity (Århem and Liljenström, 1997). It is assumed that the central nervous system (of all animals) evolved primarily as a means of facilitating rapid information transfer from sensation to action; with the ability for high degree of information storage being a later development facilitating more complex interaction behaviours with the environment (Århem and Liljenström, 1997). Århem and Liljenström (1997) describe how the complexity of a nervous system alters the speed in which interaction with the environment occurs. They note that the shortest time of information transfer (sensation to action) is found in the more simple nervous systems (such as primitive invertebrates), providing example of (certain) flies that can react to a single cell's stimulus and respond within a few milliseconds. Larger networks, such those found in mammals, normally have a millions of cells involved in any activity with several synaptic steps between the sensory and motor control; and so the time between sensation to motor control is in the order of hundreds of milliseconds (Århem and Liljenström, 1997). While it may initially appear that a simpler system (with fewer synaptic steps) holds advantage (being far faster and more energy efficient) a complex nervous system (with more synaptic steps) though slower holds additional capabilities to store more information and allow for longer periods of learning, facilitating adaption over the mammals lifetime. A greater number of synaptic steps additionally allows for a far more robust and richer interaction with the environment (stimulus to multiple potential responses) (Århem and Liljenström, 1997). Such biological basis of complex and routinized responses provides an evolutionary requirement and development of a duality between Mindful (conscious cognition) and Mindless (cognition) states of action and response (figure 1.17 below).

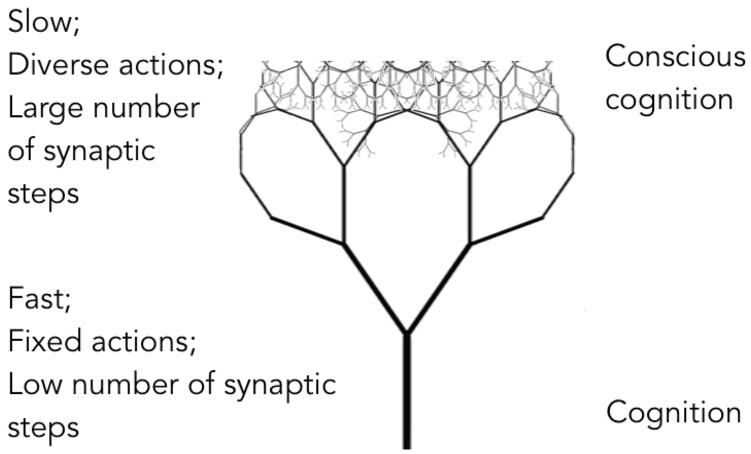

Figure 1.17; Comparison between conscious-cognition and cognition, this is intended to be interpretive and should be understood alongside previous images of this section (Chapter 1.5 to present)

1.11.5: Conscious-Cognition v's Cognition

The previously described understanding of cognition does not require or include conscious-cognition as it only addresses the more simple of interactions. Human cognition is evidently multi-level with some knowledge processing occurring outside of the conscious level and others inclusive of the subjective experience (Århem and Liljenström, 1997; Ashby, Turner, and Horvitz, 2010; Anderson 1983, 1992, 1996) (though it is suggested that most of knowledge processing occurs outside of conscious awareness) (Shanahan, 2010; Baars, 1993). Further to this, Århem and Liljenström (1997) state that even conscious processes differ in their levels of complexity (as previously described in chapter 1.5):

> "A capacity for selective attention and simultaneous processing characterises consciousness, while higher-order consciousness is accompanied by a sense of a person, of a self."
> (p608, Århem and Liljenström, 1997)

Århem and Liljenström propose that consciousness is required for the higher levels of cognitive functions; marking a major transition in our (human) evolution. This reasoning is that through an awareness of self, one can understand themselves as an actor in an environment (distinct from it), other agents (others with abilities of action), and situate this knowledge in a period of time (past, present, and/or future as opposed to solely reacting to the immediate). In doing so, an agent with capabilities of knowledge of the environment, recall of previous interactions (memory), and, understanding of their capabilities of interactions; is able to develop and apply increasingly complex behaviours such as plans (predictions) and complex interactions (multiple level goals that extend to future events and/or inclusive of others actions).

To explain this more simply; a fly does not possess the capabilities of (highly) complex behaviours and planning, it reacts to the environmental stimulus on a purely cognitive level and can thus make minor behaviour changes far faster than more complex mammals (such as humans) e.g. Evading a moving object. These are cognitively 'hard-coded' through the flys (relatively) simple nervous system e.g. If event *X* occurs react with action *Y*; the fly *knows* (cognitively) what to do and does not need *think* (consciously) upon it. Humans however have a much more complex nervous system, environmental stimulus invokes a high number of synaptic (cognitive) steps, some of which may enter or provoke a conscious-cognitive state whereby a reflection upon the event can occur. While this process is far slower than the fly, the human is able to react with a much broader range of actions that are contextualised from multiple stimulus information (as opposed to more generic and singular stimulus as with the fly); and draw upon and apply previous knowledge to *think* e.g. does the event *X* require *Y* or *Z,* and which will be an optimal solution (what will be the consequence). As noted by Århem and Liljenström (1997):

> "Predictions and expectations that bring cognitive processes into a (distant) future, also open for a more advanced planning and setting up of goals" (p607, Århem and Liljenström, 1997)

But as Århem and Liljenström state not all cognition of those with conscious-cognition capabilities and complex nervous systems is slow and reflective, there still remains rapid cognition as "…*Some specific pathways, like those involved in simple instinctive sensation-reaction schemes, may be very fast*" (p605, 1997).

Consequently actions that necessitate rapid or routinized reactions are often performed without a slow Mindful contemplation and are reliant upon previously gained and stored knowledge (enacted and Mindless). However, complex decision making (and reactions) requiring a sense of planning and broader contextualisation and of self are often slow and can be considered novel and so Mindful.

These understandings allow for supporting the philosophical grounding of the definitions alongside verifiable and well-established knowledges that can provide a richer understanding of Mindfulness and Mindlessness; and consequently, facilitate the introduction of established methods of validation from cognitive science (as will be demonstrated in Section 2). The clear division between cognition and consciousness additionally allows for a clearer division of the properties of Mindfulness (a conscious experience) and Mindlessness (sub-/non-conscious) in ways that enrich understandings from and for other domains (e.g. cognitive science), and provides insight into how and why such states may occur (as described in the following).

1.11.6: Streamlining Of Brain Activity - Development Of Specific Pathways

Described here in simplicity (for fuller account see: Hallihan and Shu, 2011), a mammalian brain is composed of billions of interconnected neurones that communicate via changes in electrical potential at synaptic connections (the points at which connected neurones meet). A neurone will not send a charge, known as action potential, until it has received enough stimulus (electric charge potential) to surpass a threshold (where the "information"/charge is then passed along through the network). Long-Term Potentiation (LTP) is "…*an increase in the efficiency of* *synaptic connections between neurones, due to their repeated and synchronous firing*" (p491, Hallihan and Shu, 2011), increasing the sensitivity and so achieving the threshold faster. It is this development of LTP that facilitates the development of "specific pathways" and allows for greater sensation-reaction times (as described by Århem and Liljenström, 1997) and faster enacting of learned skills (and considered the major mechanism in learning and memory). Although there is relocation in the areas of dominant activity within the brain for early skill learning v's well-learned action (Ashby, Turner, and Horvitz, 2010); the LTP development from repetition will facilitate and strengthen the recall and speed of stimulus-to-response for a given stimulus (i.e. learning). The process of neuronal plasticity (Hallihan and Shu, 2011), produced by mechanisms such as LTP allows the rapid reaction to stimulus from the environment (improving the chances of survival for an organism). However, fixation develops as an inability to activate new neuronal networks that do not have dominance over pathways formed through LTP (Hallihan, and Shu, 2011). That is to say, the LTP strengthening imposes the inability to see beyond well-learned solutions and generate novel or unconventional solutions. Conversely inhibition mechanisms (an opposing to LPT) can impede neuronal connections. As novel and appropriate solutions and actions (i.e. creativity) are dependent upon the extent of the spread of activation in the neuronal network (Gabora, 2010; Hallihan and Shu, 2011); cognition that avoids the mechanisms of "specific pathways" and calls upon a larger neuronal network may prove more advantageous. Through drawing upon such larger neuronal network an organism can evaluate present stimulus and better contextualise the information to the present environment (as opposed to a reflexive response) facilitating more robust reactions (Anderson, 1992; Århem and Liljenström, 1997; Baars, 1993; Shanahan, 2010).

It should be noted here either of the traits (conscious-cognition and cognition) would furnish an animal with a differing competitive edge and prove necessary in evolutionary development, and so neither are here considered as an absolute optimal condition or superior. Humans have thus developed, through evolution, different strategies for cognition. A 'lower level' of cognition optimal in terms of speed and energy use, where learning develops specific and dedicated neuronal pathways for actions to be performed quickly and with less energy expenditure. This process occurs without a conscious reflection (and so should be considered as sub-/non-conscious). As this process is the re-application of previous/existing knowledge it comes with the trade off of being rigid and non-adaptive, it is routed in previous knowledge and so is decontextualized and reactionary. Additionally humans posses the ability of a 'higher level' of cognition (conscious-cognition) in which highly complex and flexible responses and actions can be performed. This process is slow and draws upon many resources (i.e. widespread brain activity through multiple neuronal pathways (Baars, 1993)). This higher level process involves a conscious aspect (and so should be considered conscious / reflective-consciousness); and draws upon previous *and* present knowledge and applies these with consideration to future events (broader goal and aims). Thus, conscious-cognition can be understood as a process in which novel and creative solutions (thinking) to problems reside.

We can therefore understand and frame cognition as a Mindless process and conscious-cognition as Mindful.

1.12.0: Cognition And Affordance

> "…Cognition helps an animal decide what to do when the possibilities afforded to it by the environment are combinatorially structured. It helps by exploring the space of affordances. This can be done either 'on-line' - through play, with the aid of training, and so on - or 'off-line' - that is to say by means of purely internal operations."
> (p44, Shanahan, 2010)

Shanahan (2010) clearly links cognition to affordance, though does not differentiate distinct forms of cognition. Shanahan (2010) states that though an environment is full of objects the affordance they offer are reliant upon the agents psychological propensities (as previously described in chapter 1.8-on affordance). Thus the affordance is often *potential* as it requires the agents application of cognition to expose (to think how) the potentials that are masked (as equipment) may operate as a combinatorial structure (as a tool). Combinatorial structure here refers to the means in which technologies 'fit' together to produce a technology greater than the sum of its parts; e.g. Photography captures a specific scene in time, a system of trip wires could be applied to trigger a camera shutter relating to a specific moment in time, compiling these moments provides a capture of a series of time (e.g. stop motion or motion film, exemplified in figure 1.18 below).

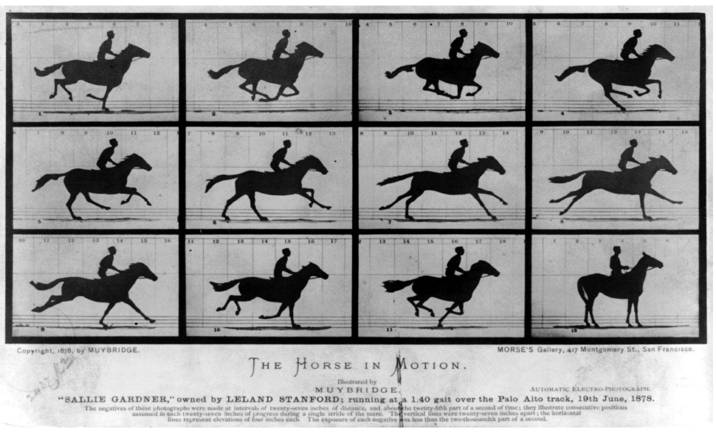

Figure 1.18; Example of a combinatorial technology to form a new technology – multiple cameras harnessed together to capture multiple images of a horse in motion in time as opposed to 'still'.[4]

The complete apparatus is viewed and understood in a summation of parts as a singular (novel) technology. Therefore we can understand that cognition in

[4] Image retrieved 03/02/2017 - https://tinyurl.com/hmemx57

developing combinatorial structures requires a move beyond the immediacy of the equipment (as previously defined chapter 1.9.2) and expose the technologies potential combinatorial qualities (as a tool; previously defined chapter 1.9.1) toward becoming new technology. Here we can assume that this will be in relation toward a goal or motive ('off-line' in the future as planned as opposed to reactionary in the present). And so, this cognition being reflective (thinking) toward future goals as opposed to reactive toward the present (i.e. beyond reflexive) and distinguishing/deconstructing objects and their qualities (and our action toward them); is a conscious-cognition and Mindful.

1.12.1: Minimising Competition For Cognitive Resources - Mental Schemas

As previously described, Bodner and Langer (2001) state:

> "In a complex environment, individuals use a variety of cognitive tools to minimize the competition for precious cognitive resources. One such tool is a reliance on cognitive structures (e.g., prototypes, schemas, scripts) to organize experience."
> (p3, Bodner and Langer, 2001)

The process of experiencing the environment through combinatorial structures can be understood through the application of prior knowledge as mental "schemas". As previously described cognition, both cognition and conscious-cognition, plays a critical part in an organisms ability to survive and adapt in a given environment; and this is reliant upon the organisms previous knowledge. The application of knowledge however is often required to be performed in circumstances that are less than identical to the previous knowledge, there is often something that is different, added or missing; and a process is required to 'fill in the blanks'. For example, not all drinking glasses are identical (e.g. Figure 1.19 below) but I *know* that they are all drinking glasses without much *thinking* upon why; the properties of a technology as affordances (a range of 'stimulus') together with the context in which they are presented inform me that the most probable type of object it could be is a drinking glass (without needing to explore all of the affordances). There are a set of rules or requirements that also inform me that the object is not a bucket (e.g. Size, placement in environment etc.).

Figure 1.19; Example of various drinking glasses[5]

Psychologist theorise that this may be due to knowledge being organised as cognitive structures within long term memory, known as *schemas* (Arbib, 1992). These schemas are formed as central concepts during interaction with the environment and organise experience as mental representations and understandings of others, events, and technologies (Piaget, 1962). Chalmers (2003) states Piaget's notion of knowledge and interaction with the environment as founded upon schemas with the adaption of existing schemas to incorporate new information playing a central role:

> "Piaget proposed that learning is the result of forming new schemas and building upon previous schemas. He proposed that two processes guide learning: (1) the organization of schemas, and (2) adaptation of schemas. He further proposed that adaptation of schemas involves: (a) the assimilation of new information into existing schemas, or (b) the accommodation of schemas to new information, which may not fit into existing schemas."
> (p596, Chalmers, 2003)

As described above, when experiencing external stimulus a process of *accommodation* or *assimilation* occurs. Accommodation is the process whereby new cognitive structures are formed, e.g. The first time you experience an ice-cream. Assimilation is the process where the current experience is compared to existing schemas to understand the experience of the world around e.g. The second time you encounter the same stimulus (an ice-cream) you recognise it against the previous experience (mapped schema) of ice-cream. Should there be a mismatch, e.g. it is of ice but does not taste of ice-cream (e.g. snow); the process of accommodation again occurs and either creates a new schema e.g. of snow, adapts

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[5] Image retrieved 03/02/2017 - https://tinyurl.com/y9td2mx4

the existing schema e.g. Not all ice-cream is good; or places restrictions upon it e.g. ice-cream does not come from the floor. As noted by Wachtel (1980) a human is not just "stimulus-bound", responding to the environment in a solely reflexive capacity, but selectively organises and makes sense of the input in relation to past experiences and structures (schemas). Humans, stated by schema theory, do not primarily learn new information or approach all stimulus as novel; but apply existing knowledge (cognitive structures) toward novel information, stimulus, environment, and contexts; and adapt to ill-fitting models. Therefore, when encountering new information and stimulus that maps close enough to an existing schema (to be functional) the pre-existing schema is applied without need to consciously reflect (think) upon the situation; as noted by Fischer, Itoh, and Inagaki (2009) in describing interaction with a familiar interface:

> "Schema theory postulates that perception, interpretation, specification and execution can be shortcut when prior schemas are triggered. Action is direct, automatic - we might here say intuitive - if each stage benefits from prior schemas. Conversely, when no schema is triggered, the user has to analyze the interface content. This effortful mechanism is necessary until new *ad hoc* schemas are constructed."
> (p36, Fischer, Itoh, and Inagaki, 2009)

Fischer, Itoh, and Inagaki's (2009) understanding of the execution of schemas, above, is comparable to cognition as stated by Århem and Liljenström (1997). Therefore we can think of assimilation schemas in the same understanding as cognition; and so here are understood as a Mindless state when performed based on environmental stimulus as automatic and intuitive, bypassing an analytical stage. When a schemas do not fit, a new mode of action or behaviour is required (accommodation), a slow process whereby the 'user' analyses the information, which here is assumed to be a conscious-cognition and so Mindful.

1.12.2: Automaticity And Intuition

Fischer, Itoh, and Inagaki's (2009) introduce specific terms for the application of schemas (or cognition) without requiring conscious reflection or awareness; "*automatic*" and "*intuitive*" (as previously quoted).

<u>*Intuition*</u>

Intuitive is often understood as analogous to "familiar" (Blackler, Popovic, and Mahar, 2010; Raskin, 1994), in that a person "knows" how to achieve a goal, or initiate / react to specific stimulus, without conscious effort through drawing upon previously gained knowledge and experience (enacted as "implicit memory" (Blackler, Popovic, and Mahar, 2010)). This "intuitive interaction" (Blackler, Popovic, and Mahar, 2010) is sub-conscious processing of information and facilitates rapid learning/utilisation of how systems of interaction operate (Löffler et. al., 2013; Naumann et al, 2013) and can be understood as "*knowing without reasoning or conscious processes*" (p379, Sinclair, 2010). It has been noted that this is not just "*wild guessing*" of potential actions, but is the application of a previous experience and knowledge towards a current perceived similar situation (Blackler, Popovic, and Mahar, 2010).

The most apparent effect of intuition is the speed at which meaning or significance occurs (being sub-/ non-conscious) as opposed to slower more analytical (predominantly conscious and reflective-conscious) processes (Baars, 1993; Blackler, Popovic, and Mahar, 2010). Intuition here is understood as the process of assimilation of mental schemas toward novel experiences operating without inhibition or failure i.e. Do not require amendment. A conscious or reflective conscious thought is not required or applied and previously existing knowledge is applied sub-consciously. As such, intuition can be regarded as a Mindless act.

Automatic behaviours (Automaticity)

Automatic behaviours are (broadly) described as occurring quickly without the need for conscious monitoring/attending (Wheatley and Wegner, 2001); seen as performing "efficiently" (Bargh,1994) they are fast in action whilst requiring little (if any) effortful conscious thought or control (Moors and Houwer, 2006; Wheatley and Wegner, 2001). As noted by Anderson (1992), automaticity has previously been understood to be the "*effortless extraction of features in perception*" (p165), though this expression is not accurate. Rather, the automaticity that is discussed here is in reference to "*…some cognitive process whose operation is not subject to conscious control*" (p165, Anderson, 1992). Differing from intuition, automatic processes are learned actions that following significant repetition (consistent practice) become enacted sub- to non-consciously (Moors and Houwer, 2006, Wheatley and Wegner, 2001), and are performed during the majority of daily tasks (Hikosaka and Isoda, 2010) e.g. familiar password entry, responding to greetings, and typical daily operations such as tying shoelaces. The process of a task becoming automatic is easier if there is consistent stimulus-to-response mapping (Anderson, 1992), whereby new schemes are not required, and existing schemas do not require conscious adaption. And so, automatic processes are considered to be triggered sub- / non-consciously by stimulus from the environment (operating beyond conscious control, such a visceral reaction), or may be consciously motivated (Wheatley and Wegner, 2001) as part of a larger goal (as a nested action). This can be seen, for example, where a familiar password entry is required and a "conscious automaticity" (Wheatley and Wegner, 2001) is enacted. Much like Langer's (1989) skilled typist before being asked to reflect on the process, the key presses that compose the password are pressed in rapid succession with no conscious control (as the action occurs faster than conscious recall of the individual key combinations and conscious hand movements); this is, to an extent, "conscious" in the fact the knowledge of a goal exists (password entry) yet "automatic" in the processes of achieving that goal (for a fuller account see (Moors and Houwer, 2006)). This automatic process (password entry) may be nested in the further goal of e.g. sending an email. While automaticity is beneficial in that it reduces the cognitive effort and time to perform a repeated action it holds central a consequence. The repeated action/thought, previously consciously initiated, becomes so embedded that it becomes the default action for the given stimulus (and any stimulus that maps the schema close enough to function), and initiated non-consciously (Wheatley and Wegner, 2001) and reflexively (Hikosaka and Isoda, 2010). This is further problematic in that the 'priming effects' (the stimulus that initiates an automatic behaviour and schema) require effortful processes to inhibit (i.e. A Concerted conscious awareness). Priming effects have been previously described (two-rings problem and Dunker's "Box" problem chapter 1.7). If the automatic action is initiated and performed faster than a conscious inhibition (or any conscious awareness) the automatic action will continue till its completion.

Though intuition and automaticity are differing in their application context, as described above, we can understand them as similar in their process (the application of previously learned schemas).

Automaticity is here proposed as a basis and enactment of Mindlessness.

1.12.3: Adaptive Control Of Thought Theory - Automaticity As Skill Development And Enaction

Anderson (1983, 1992, 1996) proposes an understanding of automaticity (automatic behaviours) during skilled activity through the ACT theory (Adaptive Control of Thought (Anderson, 1983); and subsequent additions * (Anderson, 1992) and -R (Anderson, 1996)). ACT theory suggests a model of understanding complex cognition arising from an interaction of procedural (represented by units of production rules) and declarative (represented by units called chunks) knowledge (Anderson, 1996). Individual units are formed by simple encodings of objects as chunks or adaptations of the environment (the context) as production rules (Anderson, 1996). Here Anderson's ACT theory is understood as a simile to schemas.

Within ACT Anderson (1992) proposes 7 qualities of automaticity development during skill learning and performance. These qualities will be discussed at greater length in the following sections (2.0 describing an exploratory study and 3.0 on design in human-computer interaction):

1. The acquisition of skilled performance speeds up with a reduction in error rate with practice.
2. Well learned skills decay over time; however this is minimal in relation to the rate of improvement with practice (i.e. It is easier and faster to relearn that to initially acquire).
3. Spaced practice is more beneficial to the learning process than mass practice.
4. As a skill becomes more practiced, there is less interference with concurrent tasks; and furthermore it is less interfered with by a concurrent task.
5. "It is relatively difficult to inhibit an automatic process, and thus an automatic process can be more interfering to another on-going task." (p166). That is to say, should an action require a new schema but holds the qualities that map to an existing schema, the existing schema will attempt to apply itself over the intent to develop new schemas. This is exemplified through the "Stroop test", where by a participant is required to announce the colour of a word (its font colour) as opposed to the word itself that is of a colour (e.g. RED would correctly be answered with "Green"). The automaticity of reading words presented to us over-rides the instruction to announce the colour.
6. Automatic processes are less slowed down by the number of alternatives. For example: p1 and p2 have identical skill levels; if p1 is presented with options a + b and has automaticity to choose a, and p2 is presented with options a + b + c + d and has automaticity to choose a; then p1 and p2 will perform this with the (near) same speed. Adding more options does not prevent automaticity.
7. "It is easier for a task to become "automatic" if there is a consistent stimulus-to-response mapping. In the context of this statement, the term automatic connotes fast processes, little interference by concurrent processes, and little effect of number of alternatives." (p167). This can be understood as an action holding less adaptations to a schema being more easily made automatic.

Anderson notes (p170, 1992) that every time a production rule (understood here as an enacted schema) is practiced it receives an increment in strength (its power to become enacted in future). Furthermore, a consistency of mapping conditions; when a stimulus is associated with the same response or interpretation, further increases the strength of the behaviour (enacted schema) in becoming automatic (enacted sub-/non consciously). This can be understood as the process of tool's (chapter 1.9.1) becoming equipment (chapter 1.9.2), The significance of this will be more apparent later when discussing replication and imitation of designs.

The introduction of automaticity here allows for a much richer understanding of Mindlessness from well-established domains with a number of methods for assessing, and means of describing its properties.

1.12.4: Automatic Behaviours As Nested Actions

Anderson (1983) proposes central themes of framing memory (and its recall in enaction). Firstly he proposes that memory is formed of *cognitive units*, understood as units of memory. These cognitive units are formed in associative links, existing as a *unit node* plus a set of *elements (as arguments/augmentations of the node)*. As stated by Anderson (1983), when part of a cognitive unit is formed in long-term memory, all of it is (i.e. The node and its elements); and so when it is recalled it is recalled in full. For example, a node of the word train, may have element of -station, and so the memory recall or trigger will draw this association. However, the introduction of the new element (augmenter) e.g. Train-ticket, will create a new cognitive unit in memory. Reuse of the cognitive unit will increase its "strength" (its availability of recall). Anderson further states that there is a *retention* whereby the cognitive unit once formed is not lost, though it looses its strength as a decay over time. Thus a cognitive unit once formed may have a strength of e.g. 1, though with additional (successful/meaningful) recalls calls this increases e.g. "train-station" here now has 2, and "train-station" now has 3.

Here I present a thought experiment that can be used to exemplify the operation of such cognitive units, their recall and decay:

> Think of your last journey by train and suggest an augmenter to the word "train-".

"train-station" would be most obvious, as would "train-ticket", a previously established cognitive unit e.g. *See footnote 6*, is probably not the one that was most obvious choice.

As noted by Anderson (1983), working memory contains information currently available for "processing". This combines current environment, inferences, current goal information, and traces of long term memory (p263). A "spreading activation process determines the level of activity in long term memory"(p263). Working memory elements are sources of activation, e.g. As perceptual events or internal concept processing's. These activation events spread form the corresponding cognitive unit node to associated elements as a network of elements and cognitive units i.e. Current stimulus triggers a network of associated long-term memories. An automatic process is the making of information (long-term memory) available on the basis of an associative relatedness (to present working memory) (p264, Anderson, 1983). This can be understood through the process of priming, i.e. a suggestive primer (in the previous thought experiment "journey" in combination with "train") activates a network of associative memory ("Train-station", "train-ticket", "taxi", "travel"). The primer activates the network of associations without need for conscious control or concerted thought. As previously described, the cognitive units of most frequent use present as the stronger association, though strength decays over time. Anderson (p263, 1983) additionally states that the activity (strength) of associative nodes (working memory elements) will determine the speed in which they are processed i.e. The less strength a node has the longer it will take to be processed, or more simply put; the least commonly used association will take the longest amount of time to become apparent. As noted:

> "… ACT clearly makes the prediction that overlearning will increase the probability of retention and speed of retrieval - predictions which are equally clearly confirmed"
> (p623, Anderson, 1983)

In summary of ACT (Anderson, 1983); an "…experience establishes a network of nodes connected by links of varying strength. This network consists of cognitive units encoding various facts." (p627). The activation of a network of nodes reflects the relationship to the source node (of activation). "The speed with which information in any part of the network can be processed is a function of its

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6 *Train-of-thought*: by drawing upon 'locomotive train' associations in the preceding paragraph there is a priming for that area of thinking, consequently the 'train-of-thought' is less prominent as an option.

activation" (p627).

From this we can understand that over repeated application a network of activation gains strength and so also gains speed in its processing (or execution). This network is dependant upon a combination of triggers composed of incoming activations (stimulus) as current environment, inferences, current goal information, and traces of long-term memory. The more that an action/behaviour/information recall is performed from a specific stimulus the faster it is to perform in future and the more dominant (and automatic) it becomes. As previously described, the strength of an activation / cognitive unit fades over time without re-activations. When the source nodes changes (i.e. A new greater strength stimulus or activation of cognitive unit) a spreading activation adjusts the levels of activation to achieve a new asymptomatic network pattern of activation. Thus, we do not become inert to all stimulus that falls below any previously established maximum strength, and so we can adapt to new stimulus or context that do not fit the current network of activation (i.e. Forget and move on to new challenges and goals).

This understanding through ACT is consistent with Århem and Liljenström's (1997) understandings of cognition and conscious-cognition and the role of the brain (and central nervous system) as prioritising differing sensory information (from nervous system) and filtering the "nonsense" toward a selection of the most appropriate and significant stimulation (the mediation between sensation and perception).

ACT theory holds to the positioning of this thesis in that it establishes a foundation that cognition (schemas as concepts and understandings) may form automatic learned behaviours that become deep-routed in our capabilities of reaction and action. The more that we repeatedly use a technology in a specific manner toward a specific goal the less available the options toward conceiving novel alternatives are. Thus, where once a new technology revealed a vast range of actions, with repeated use it moves beyond the tool toward equipment. While "conscious conditions" facilitate a flexibility of behaviours, automatic processes are "rigid and stereotypic" and so less able to manage such novelty (p85, Shanahan, 2010); i.e. Flexibility to novelty will not be incorporated into an automatic act but will require a conscious element to facilitate / initiate flexibility. Thus, Mindless actions do not hold an active conscious element (sub-/non- conscious) and so are fixed and rigid; but a Mindful positioning toward such actions (conscious/reflective-conscious) introduces a contextualisation (through incorporating more sensory and mental elements) and facilitates flexibility and novelty.

1.12.5: Global Workspace Theory

The *global workspace theory* of Baars (1993, 1996, 1997) proposes a specific information processing architecture comprised of multiple sets of parallel specialist processes within a global workspace (through a similar framing to that of ACT). The specialist processes (which are sub-/non-conscious) work together and compete to enter dominance/control of the global workspace (as a conscious event). This global workspace then *broadcasts* (Shanahan, 2010) back outward through the network (directing toward action) (See figure 1.20 below and figure 1.21 following). Therefore, consciousness (in global workspace theory) directs action, attention and awareness toward specific events or goals. As noted by Shanahan (p96, 2010) the global workspace theory holds two central tenets; 1) the human brain (and that of some other animals) "*conform to this architectural blueprint*"; and 2) "[…] *the conscious/unconscious distinction mirrors the division between processing that is mediated in the global workspace and processing that is localised within the specialist*". That is to say, processes when localised and specialist will not enter conscious/reflective-conscious awareness until they hold dominance over the global workspace. Furthermore, multiple specialist processes unconsciously and continually happen at the same time.

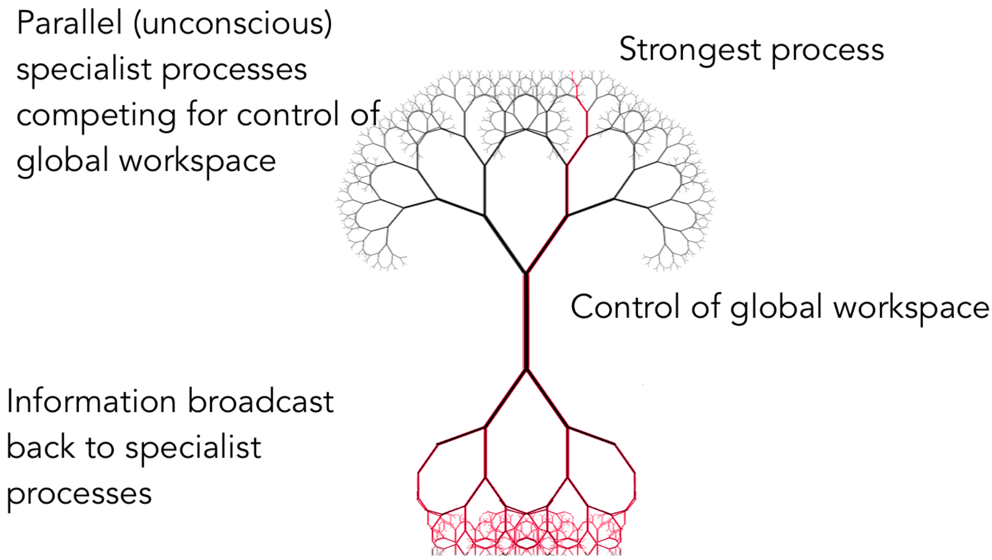


Figure 1.20; interpretation of strongest process (red) amoung many dominating control of the global workspace and broadcastings it back out to the wider network, this is an interpretive image and should be understood alongside the previous image examples (Chapter 1.5 -)

As noted by Shanahan:

> "A major attraction of the theory is that it supports the intuition that the conscious condition promotes flexibility in the face of novelty, because the

> blend of broadcast and competition at its core fosters integration among otherwise segregated brain processes."
> (p96, 2010)

The specialist processes are not and do not need to always be consciously processed, if all input, actions and potential actions are held within this network it would be impossible for them all to be conscious; i.e. with every possible action and stimulus at the forefront of awareness we would not be able to decipher quickly enough the possible actions. This can be exemplified through recall of a simple task such as riding a bike, not only would conscious awareness be required of gripping handle-bars, moving legs (and each of the individual muscles), breathing (and awareness of CO2 in the blood stream and so appropriate rate of breathing); but further conscious awareness of bodily temperature (and sweat production, dilation or contraction of blood-vessels to maintain), intestine control (as the digestive system is functional) etc.. What we actually experience (when conscious of events) is an orientation toward limited (or singular) events or sensations e.g. an obstacle in our path, the sound of our name being called. The processes held in conscious awareness forms part of the continual competition to control and direct the global workspace and further guide the supporting specialist processes toward the optimal action. Should a process in conscious experience be of lesser importance (activation) than a stronger competing event it will be replaced. Thus, the specialist processes competition informs the requirement of conscious attention moving the most critical/dominant process from sub-conscious (automatic) to consciously deliberative and potentially further toward reflective-conscious; or as put by Baars (p292, 1997) "[…] *focal consciousness acts as a 'bright spot' on the stage, directed there by the selective 'spotlight' of attention*". Thus, while events may be in our awareness they do not necessarily feature in the spotlight of attention; the environment is the theatre, awareness the stage, but attention is the spotlight to what we see potentially focused toward one actor or case wide upon the stage.

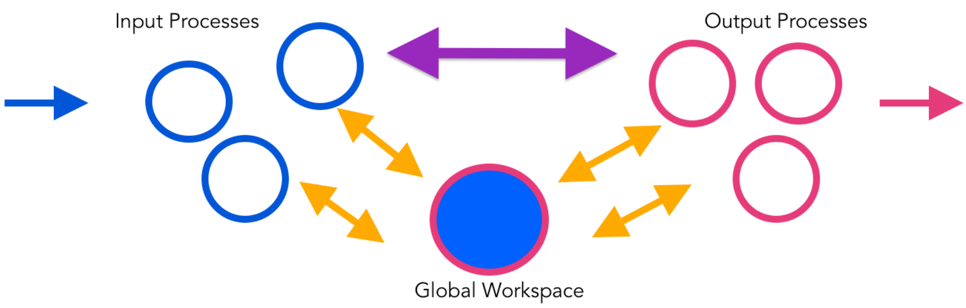


Figure 1.21: "The global workspace architecture with separate sensory and motor processes, and accommodated within a sensorimotor loop. Direct

> *connections between the conscious condition is mediated by the global workspace" (p102, Shanahan, 2010)*

As noted by Shanahan (previous above) this system allows rigid or fixed automatic behaviours but additionally facilitates novelty as the specialist processes may be focused upon to inform new behaviours (opposed enacting automatic) that integrate all available competing information (elements of the wider stage) which is then broadcast back into the network through conscious deliberation as guided thought and voluntary action. As highlighted by Baars (1997):

> "One dramatic contrast is between the vast number of unconscious neural processes happening in any given moment, compared to the very narrow bottleneck of conscious capacity. The narrow limits of consciousness have a compensating advantage: consciousness seems to act as a gateway, creating access to essentially any part of the nervous system. […] Conscious experience creates access to the mental lexicon, to autobiographical memory, and to voluntary control over automatic action routines. […] All these facts may be summed up by saying that consciousness creates global access."
> (p292, Baars, 1997)

This notion of global workspace theory is highly supportive to the positioning of Mindfulness and Mindlessness and informs how such systems are conceptualised to operate in duality, drawn upon to unify the qualities found in the position of Århem and Liljenström (1997, Chapter 1.11) and Anderson (1983) (Chapter 1.12.4).

1.12.6: Empirical Evidence Toward Global Workspace As A Capacity Of The Central Nervous System And Brain

As noted by Baars we are facilitated empirical study of consciousness not through its direct measurement (as it has been previously established there is little evidence of "how" consciousness "happens") but through understanding and comparing its presence and absence through "*contrastive analysis*" (Baars, 2002):

> "In science, after all, we can only study something if we can treat it as a variable, comparing its presence to its absence. A number of historic breakthroughs in science emerged from the realization that some previously assumed constant, like atmospheric pressure or gravity, was actually a variable. We can make use of this classic scientific strategy to explore consciousness."
> (p293, Baars, 1997)

> "Research traditions on subliminal priming, automaticity, and implicit cognition have made it clear unconscious comparison conditions for conscious processes are often available."
> (p47, Baars, 2002)

The evidence of such global workspace existing can be seen in human brain structure and activity where specific areas are more active and prominent toward a specific activities or processes, e.g. Speech or vision; yet these do not operate in solitude. The brain itself has cross communication between such specialised areas and exists as a highly networked organ. Sensory information (e.g. Vision) is distributed across multiple areas that give rise to different behaviours. This can be exemplified in *Blindsight* (Danckert & Rossetti, 2005) where a patient has loss of visual experience (e.g. through damage to the occipital lobe or neuronal pathway to the lobe, which "processes" vision) yet is able to "guess" visual cues presented to them better than by chance alone (Danckert & Rossetti, 2005). In the example of *blindsight,* visual sensory information is held in an entirely sub-/non-conscious level yet informs conscious/reflective-conscious decisions.

Thus, the global workspace architecture facilitates rapid actions/behaviours that are processed as sub-/non-conscious (automatic) and compete to inform conscious/reflective conscious awareness, e.g. the visual awareness of a change in light can inform pupil dilation prior to the conscious reflection upon experience of brightness (or darkness). Furthermore, for example, an awareness of fast moving objects can invoke bodily movement to avoid injury prior to conscious experience and reflective decision making (e.g. is running away appropriate), yet if the dominant process is a conscious inhibition then this can control the sub-conscious processes (e.g. not running and remaining calm); as noted by Baars, Ramsøy & Laureys (p671, 2003) the "[…] *conscious visual brain activities can influence unconscious ones, and vice versa*". Such positioning is analogous with the findings of Århem and Liljenström (1997) in "*dedicated pathways*" (which facilitate rapid action) in addition to wider networks facilitating more information, memory, novel decisions, planned actions, and ultimately conscious-cognition. Baars (2002) understands dominant information as widely distributed activity within the brain with the nervous system functioning as a massively distributed set of specialised networks.

Baars, Ramsøy & Laureys (2003) further provide insight to indicators of when information of the central nervous system might be raised to conscious awareness:

> "[…] Although unconscious visual words activate known word-processing regions of the visual cortex, the same stimuli, when conscious, trigger widespread additional activity in frontoparietal regions. This general result has now been replicated many times, using vision, touch, pain perception,

> and conscious versus automatic skills. Together, these findings suggest that conscious access to a stimulus involves a frontward spread of activation beyond the sensory regions of the posterior cerebrum."
> (p672, Baars, Ramsøy & Laureys, 2003)

While initially empirical work, such as Baars', was controversial in acceptance, more recent neuroimaging techniques and research have added validity to global workspace theory supporting the positioning that consciousness might "mobilise" and integrate otherwise independent and separate neuronal brain processes (Baars, 2002); for an overview see: Baars, 2002. Further work has been conducted using *functional Magnetic Resonance Imaging* (fMRI) to gain insight of brain activity during: stimulus-independent thoughts (McKiernan et al., 2006), introspection (Goldberg et al., 2006), monitoring of the "mental self" (Lou et al., 2004), integration of cognitive processes (Greicius et al., 2003), resting state networks and conscious states (Heine et al.2012), and mind-wandering (Mason et al., 2007). All of which point to increased and widespread brain activity as empirical measure in understanding aspects of deliberative action and reflective consciousness.

Baars (p47, 2005) posits 6 theoretical claims of capacities enabled by consciousness:

- Conscious perception enables access to widespread brain sources; unconscious sensory processing is much more limited
- Conscious perception, inner speech, and visual imagery enable working memory functions; there is no evidence for unconscious access to working memory
- Conscious events enable almost all kinds of learning: episodic and explicit learning, but also implicit and skill learning
- Conscious perceptual feedback enables voluntary control over motor functions, and perhaps over any neuronal population and even single neurons
- Conscious contents can evoke selective mechanisms (attention) and be evoked by it
- Consciousness enables access to the ''observing self'' — executive interpreters, involving parietal and prefrontal cortex

It is noteworthy that while Baars closely relates consciousness with brain functions he does not propose that the brain (or specific part of the brain) is the producer of consciousness, rather consciousness is the observer and controller of brain function and sense making.

Thus, in the perspective of Baars, the primary functional role of consciousness is to allow and operate the workspace architecture in the brain, directing and calling the actors (specialised regions of the brain) and pointing the spotlights (guiding attention and awareness) of the 'theatre' of experience. In doing so, consciousness can direct the brain to integrate, access, and coordinate the functioning of multiple specialised networks in harmony toward a task, that would otherwise operate autonomously and independently. While this may initially appear to be an unnecessary intervention, i.e. preventing otherwise autonomous actions; such intervention facilitates novel and richer forms of interaction with and from the environment. From a neurological perspective, such reflective consciousness may be therefore be evident in the activation of large, widespread, and or synchronised activity in the brain activating or inhibiting regions of brain function that would otherwise work in autonomy.

This knowledge allows for the positioning of Mindfulness and Mindlessness in broader terms than solely philosophical perspectives and marries the concepts (as presented in this thesis) to the cognitive sciences. This additionally provides support for the measurement of these qualities through verifiable methods taken from related disciplines (as described in Section 2), and encourages the revision of the definitions with the future advancement of knowledge and understandings in the relationship between physiology and the phenomenon of consciousness.

1.12.7: Reporting On Automatic Actions - Implications For The Study Of Mindful Interactions

Shanahan (p71, 2010) reflects on the availability of automatic actions to consciousness. When processes are automatic, they are beyond introspection i.e. they exist and are performed outside of and without need of conscious awareness. Many of the elements of a process may be available to recall, however, many are not. As Shanahan points out, when recalling automatic processes and "facts" about them (the specifics involved) "*Some are accurate, but some are just guesses, and some are plain wrong*" (p71, 2010). Baars (2002) further supports this position in the distinction of non-conscious v's conscious activities by their report (non-/sub-conscious being non-reportable), and using self-report (of the participant) in understanding if a task is sub-/non-conscious or conscious/reflective-conscious. The availability of automatic processes to be reported upon (or rather their non-availability) highlights the need to consider these distinct states of behaviour as contrast to consciously mediated actions.

Particularly of importance here is the effect this holds toward understanding automatic interactions during human-computer interaction. If we are to understand that some of our interactions with technology are automatic, then we must also understand that our ability to recall such interactions are fallible as we try to fill in the blanks with best guesses. This poses a challenge to investigation of interaction; specifically, if an interaction was performed Mindlessly (as an automatic action) recall upon it will be inaccurate and founded upon the previous assumed knowledge (a guess based on memory) i.e. a description of the premature-cognitive commitment and not the unconscious action performed. This understanding is particularly important as will be described in (and motivating) Section 2 (exploring the physiological correlations of Mindful and Mindless states during interaction).

While the above holds focus toward automatic action and behaviours as a refined singular "stored" process it additionally suggests the alternative; a wide spread activation and incorporation of processes.

1.13.0: Section 1 Discussion and Conclusion

The previous section (chapters 1.1.0 – 1.3.0) highlighted that existing definitions of Mindfulness and Mindlessness are unsuitable in application to human-computer interaction research and often included ambiguity in their meaning (or would introduce ambiguity in application to HCI research). This ambiguity, a symptom of its broader use in therapeutic application and spiritual practice, has been furthered through a lack of systematic effort given toward establishing the defining criteria of Mindfulness, its various components and specifying its implicated psychological processes, as highlighted by Bishop et al. (2004). Often definitions of Mindfulness and/or Mindlessness lack clarity and/or consistency (Bishop et. al., 2004; Brown, Ryan and Creswell, 2007a; Grossman, 2008; Chiesa, 2013) which may be in part to specific facets being overlooked as considered insignificant toward (or alternatively promoted in favour of) a particular study or application (Brown, Ryan and Creswell, 2007a). Consequently, previous definitions of Mindfulness, and the methods of measurement associated with those definition's, often carry with them a centring upon a specific (often undesirable) trait, typically of therapeutic focus. It was highlighted that methods applied in clinical 'Mindfulness based intervention' similarly failed to address Mindlessness and understanding its potential sources and benefits. Such oversight disregards great potential in utilising naturally occurring 'optimisation' in terms of speed and cognitive efficiency in performing tasks.

As such the remainder of the Section 1 sought to provide a pragmatic definition of Mindfulness and Mindlessness for the field of HCI that overcomes the pitfalls of reliance upon and application of existing measures, definitions and framings of Mindfulness and Mindlessness (as highlighted above). It is hoped that in such approach, and providing a novel grounding accounting to the specific needs of the field (as opposed to application in favour of a position), a more unified field of investigation can be established than that currently existing in clinical based applications of Mindfulness and Mindlessness. This aim is largely influenced by critique of Brown, Ryan and Creswell (2007a); Mikulas (2011); and, Brown and Cordon (2009); all of whom highlight the importance of developing a clear and consistent definition of Mindfulness to better aide in research, measurement, and application of the concept.

Consequently Section 1 (Chapters 1.3 through 1.12) provided the grounding and facets of a pragmatic definition of Mindfulness and Mindlessness that is applicable to Human-computer Interaction. These definitions provided the following qualities and utility:

- Reduced the ambiguity of the phenomena being discussed

- Can be applied to describe specific instances and qualities of interactions with technologies
- Incorporate, and allows for further future-, understanding and knowledges from well-established related research domains
- Draws upon well-established related domains for which research methods have been developed and are transferable in application i.e. facilitates further enquiry into the phenomena described.

Defining Of Cognitive and Conscious States within Mindfulness and Mindlessness

Mindfulness and Mindlessness is here understood as various states of consciousness and cognition. This distinction of consciousness and cognition, though perhaps counterintuitive to how we think of ourselves, is not of oversight but intention (as outlined in the later chapters of this first section). In making explicit the division of these states and their position in Mindfulness and Mindlessness richer understandings and methods for evaluation (e.g. from cognitive science) are facilitated, a utility lacking in previous definitions. Here the distinctions additionally allow for richer descriptions of interactions with technologies (with relationship to the subjective state of the user) that move beyond binary polarisations of these subtle qualities.

Consequently, as highlighted, the study of Mindfulness and Mindlessness here holds conscious and cognitive variability as a central tenet in its inquiry and defining. Of a more critical understanding (for the following Section 2) is that many aspects of such variations (though often less subtle) can be correlated with observable physiological changes in the body; e.g. brain activity (Kügler (2013) and Valera (1996)). Thus in part contribution to the definition of Mindfulness and Mindlessness four distinctions of consciousness states were provided (Chapter 1.5.2). These seek to provide a clear lexicon for use in discussing Mindful and Mindless states and how an agent experiences them. These distinctions (of consciousness in philosophical perspectives and cognition in scientific perspectives) facilitate the positioning of Mindfulness and Mindlessness within related well established-domain understandings and encourage the application of those domain's methods of analysis, specifically supported here as a neurophenomenological framework, as will be demonstrated in Section 2.

Defining of Tools and Equipments and their state in Mindful and Mindless interactions

As the primary focus of this thesis is of understanding Mindfulness and Mindlessness during interaction, considerations of how agents "see" or experience tools and equipment's during use were drawn upon from phenomenological perspectives and the concept of affordances. Through this it is understood that often use of technologies in normal functioning hides their distinction from ourselves in a phenomenological invisibility, we experience them as an extension of ourselves and do not hold contemplation to their alternate use or meaning (their *multiple* affordances outside of the immediate application). Consequently, these occurrences exist in our sub-/non-conscious and so Mindless experience. Counter to this are events of breakdown, not necessarily of a literal failure of the technology but of a disruption to the "normal functioning" of the technology. During such events the technology "reveals itself" within our experience and we become aware (conscious) of the technology and its properties and meanings; we (Mindfully) see such technologies as distinct and can theorise upon such properties (through a reflective-conscious awareness). When able to theorise upon technologies properties and meanings novel and multiple uses become apparent, that is to say the technologies multiple affordances become available.

Of importance here is the understanding that an interruption to 'normal' (Mindless) functioning, promotes a reflective (Mindful) engagement; bringing the technology forth from a phenomenological invisibility (Mindless) to the centre of (Mindful) reflective conscious awareness. Thus, of particular interest to the understanding of Mindfulness and Mindlessness during interaction is the notion of interruption to "normal" functioning, and the ways in which technologies reveal themselves through such events. This positioning is highlighted in the study design of the following Section 2, where a purposeful interruption to an on-going activity is introduced through the event of a randomised "pop-up" (following a prolonged engagement). Similarly in Section 3 the notion of 'breakdown' is drawn upon in positioning alternate framings and alterations to 'normal' interactions through design as prompting novel engagements and opportunities for reflective (and Mindful) experiences.

As previously highlighted it is important to maintain clarity when discussing specific elements of Mindfulness and Mindlessness (here in relation to technologies), thus in contribution to the understanding of Mindfulness and Mindlessness during interaction, the distinctions of *Tool* and *Equipment* were provided to clarify how an agent perceives the capacities (meanings and potential uses – i.e. affordances) of a technology. Building upon the definitions of tool and equipment (Chapter 1.9), and in further part contribution to the understanding and clarification of Mindfulness and Mindlessness; four definitions of technologies *in use* are provided – namely *Abstract-tool*, *Fluidic-tool, Equipmental-fixedness*, and, *Equipmental-transparency* (Chapter 1.10). While the use of tool and equipment refers to the subjective availability of a technologies affordances, the extending definitions build upon these to include the broader experiential state of the agent operating the technology.

Such categorisations provide clarification when describing and understanding interactions with technologies within the context of Mindfulness and Mindlessness during interaction, a utility lacking in previous definitions of Mindfulness and Mindlessness.

Understanding Mindfulness and Mindlessness

While the previously described contributions attend to Mindfulness and Mindlessness in philosophical understandings, centred around experiential qualities of consciousness; these are further supported through findings in the field of cognitive science. As described through neurophenomenology, richer understandings of such complex phenomena can be gained through a comparison of both findings in cognitive science and philosophical and phenomenological understandings; or more simply as described by Varela (p344, 1996) if "*Φ* [an observable phenomena] *looks like Ψ* [a reported phenomena] *⇒ Φ explains Ψ*". In the following Section 2, neurophenomenology provides the basis of methodology in development of physiological measurements of Mindful and Mindless states during interaction.

This division (and specific inclusion) of consciousness and cognition in the provided definitions and their grounding serves as the distinction between Mindful and Mindless actions and provides (a partial) biological and evolutionary basis for such qualities, an understanding lacking in previous definitions of Mindfulness and Mindlessness. Such understanding (and incorporation to the definitions of Mindfulness and Mindlessness) additionally facilitates the application of objective methods of analysis from cognitive science in measuring such states.

While the above holds position for understanding Mindfulness and Mindlessness in a broader sense of human (or indeed any conscious agent) processes, here the specific interest is how these states inform and alter actions with technologies, namely through their influence upon how technologies affordances are revealed and utilised. As noted by Shanahan (2010) affordance ***is*** "cognition", a position echoing that of Varela, Thompson and Rosch's (1991) notions of *Enaction*, whereby we assume action from the perception of specific action possibilities (here described as equipment – Chapter 1.9.2). Shanahan (2010) further proposes the use of a combinatorial structuring of objects in our environment (applied as tools Chapter 1.9.1) that draws upon a higher level of cognition including a sense of 'self'; here assumed to be a Mindful act of conscious-cognition according to that described by Århem and Liljenström (1997).

Such positions strengthen the argument for Tools and Equipment as differing states of action within an environment; Tools revealing a combinatorial structures and planning (conscious-cognition) and so Mindful; and Equipment drawing upon rapid cognition and the previously known (i.e. memory) and Mindless. Consequently their utility in the pragmatic definitions provided offers support to the philosophical perspectives, though draws upon learnings from well-established domains (i.e. cognitive- and neuro-science) which may be validated through methods of those domains, such as observable physiological changes and characteristics.

In the same vein, *global workspace theory* of Baars (1993, 1996, 1997) is drawn upon to provide a broader integration of consciousness and cognition akin to that of Århem and Liljenström (1997) and Anderson (1992). It is proposed that a specific information processing architecture exists in all agents with cognitive and conscious capacities. This is comprised of multiple sets of parallel specialist processes (which are sub-/non-conscious optimised cognitive processes) working and competing together to enter a state of control over the global workspace, which is a conscious (potentially Mindful) event. This global workspace then *broadcasts* (Shanahan, 2010) back outward through the network (directing toward action) as conscious intent guiding actions (as opposed to solely reactionary). Indeed the segregated and specialist human brain processes conform to such physiological architecture as noted by Shanahan (2010).

Such positions strengthen the biological underpinning of how Mindfulness and Mindlessness might be measured through physiological observation, and consequently further justify the application of methods of analysis derived from cognitive and neurosciences (as performed in Section 2). This attribute of their inclusion and utility is lacking in previous definitions of Mindfulness and Mindlessness and here offers potential for the objective measurement of these states. Equally significant here, cognitive science perspectives, such as the positions of Baars (1993, 1996, 1997), Århem and Liljenström (1997) and Anderson (1992) (and others), draw a balance between Mindfulness and Mindlessness in terms of their positive and negative functional attributes. This balance is often overlooked or skewed heavily toward Mindfulness as optimal in all circumstance in previous perspectives; yet through the supporting literature (of Section 1) it is evident that Mindlessness offers an equally significant and beneficial role, should the situation be appropriate.

It was highlighted use of consciousness (and unconsciousness) in cognitive science is easily replaced by Mindfulness (and Mindlessness) respectively. Mindful perception enables access to widespread cognitive sources of information and (and to the "observing self" – reflective consciousness. However, and significant to the following Section 2, when in states of automaticity, Mindlessness, the ability to self-report on sub-/non-conscious events becomes diminished as noted by Shanahan "*Some are accurate, but some are just guesses, and some are plain wrong*" (p71, 2010).

From the above contributions of Section 1 support is given to the overarching contribution of the first section of this thesis - *the defining of Mindfulness and Mindlessness within human-computer interaction*:

> *Mindfulness*, is defined as a state of broad *reflective-conscious* awareness upon the present context and content of information and stimulus. Information and technologies are explored and combined through concerted deliberation in novel categorisations of distinctions and action potentials as an *abstract-tool*.
> During interaction mindfulness is slow yet analytical whilst being receptive to change, whereby constituting elements are *consciously* present through use and application of a *fluidic-tool*.
>
> *Mindlessness* is defined as an intuitive understanding that exists in *non-conscious* processes, with failure to account for contextual dependencies through premature cognitive commitments; where information and technologies hold a functional fixedness viewed as absolute through *equipmental-fixedness*.
> During interaction, mindlessness is without conscious deliberation through *sub-conscious* automaticity, developed from a cognitive fixation upon previous well-learned solutions. Such actions are performed before, faster than or without concerted conscious awareness in phenomenological invisibility; resulting in the inability to develop novel solutions and the application of technology through *equipmental-transparency*.

Both of these states are defined as the opposing ends of a spectrum of which activities may move from one to another end and between. While these definitions are presented here as grounded within the previously described findings (of Section 1) they are expected to develop with future research and further inquiry to the field, and through the advancement of knowledge in the contributing disciplines.

As previously stated the definition's hold a number of criteria for which they can be evaluated. The definitions produced in this first section of this thesis sought to reduce the ambiguity of previous definitions of Mindfulness and Mindlessness. This was achieved through grounding from supporting and well-established fields. Similarly, a number of lexicon are provided (e.g. for differentiating conscious and cognitive states; *Abstract-tool*, *Fluidic-tool,* *Equipmental-fixedness*, and, *Equipmental-transparency*) to better describe Mindful and Mindless interactions and engagements with technologies. Finally, ambiguity of the phenomena is reduced through ensuring the definitions hold interaction as a central tenet in their formation. Consequently, the definitions are equally centred toward describing specific instances and qualities of interactions. Through the incorporation of supporting knowledges from well-established fields further understanding of Mindfulness and Mindlessness is also provided as those fields advance their understandings. Primarily the division of cognition and consciousness, within an approach akin to a neurophenomenological methodology, allows for understandings gained through philosophical learnings support where cognitive science currently lacks. Through this methods for analysis of these qualities from their respective fields can be applied (as demonstrated in the following section) and enhanced as knowledge in these areas increases.

Consequently, the definitions provided in this section of the thesis not only meet the previously described criteria needed in offering a greater suitability in describing Mindful and Mindless interactions; but additionally (as described above and demonstrated in the following) provide utility in methods of analysis and understanding previously missing.

SECTION TWO

<u>*Study To Explore The Physiological Correlates Of Mindfulness And Mindlessness During Interaction*</u>

> "[…] the most complicated achievements of thought are possible without the assistance of consciousness"
> (Freud, 1900, p. 593)

In this section an exploratory study is reported. The goal of this study is to guide future work upon methods in analysis of Mindful and Mindless interactions. As this is an exploratory study its aim is not to produce a final method of analysis but to highlight potentially useful methods that can be refined through future work. Consequently, an additional goal of this study is to "rule out" methods that are unsuitable or fail to yield indicators of the phenomena in question. That is to say, reject those used in related fields or in the analysis of Mindfulness and Mindlessness in different contexts that fail to indicate specific moments of Mindful or Mindless interaction. Accordingly, this exploratory study should be considered as laying the groundwork for future work in this emerging area. Here it is considered that a useful method of analysis will hold the capabilities of being easily integrated into interactive technologies (and their evaluation) and accessible by common place/commercial technologies (i.e. non-specialised medical equipment such as fMRI technologies). Most significantly a useful method would provide indicators of specific moments of Mindful and/or Mindless interactions, and would work toward the future aim of an unobtrusive and objective method/system for the analysis of Mindful and Mindless interactions with technologies. The development of such a tool will allow for better understanding design implications (and more specifically points of interaction) that invoke Mindfulness and Mindlessness and the effect these hold upon the user of technologies.

The success of this exploratory study is evaluated not upon the production of a finalised method of analysis but on: the ruling out of existing methods unsuitable in the analysis of Mindful and Mindless interactions, highlighting of useful methods of analysis that might be further refined, capability of being easily integrated into interactive technologies (and their evaluation) and accessible by common place/commercial technologies, ability to provide indicators of specific moments of Mindful and/or Mindless interactions, contribution toward the development of an unobtrusive and objective method for the analysis of Mindful and Mindless interactions with technologies.

2.0: Introduction to Measuring Mindful and Mindless Interactions

> "*The most profound technologies are those that disappear* […] *Such a disappearance is a fundamental consequence not of technology but of human psychology.*"
> (Weiser, 1991, p94)

Notions of interactions with computing technologies "disappearing" into phenomenological invisibility, as presented in Weiser's (1991) pivotal vision; and reliance upon familiar design to improve 'usability' (Poole et al., 2008) and 'intuitiveness' (Naumann et al., 2007) is now practiced through much of HCI design. That is to say, there is an emphasis toward designing technologies as 'equipment' (Chapter 1.9.2). While such design choices (e.g. implementing familiar design elements) hold benefit in terms of speed of learning and performing interactions, and low cognitive loading; they additionally reduce the capacity of an agent to contextualise interactions to the present, apply new meanings, and develop novel solutions and approaches (as will be discussed in greater length in Section 3).

As such, it is particularly important draw better balance to the consideration, understanding, and subsequently the design; of how technologies work:

- *'For'* us, sub-consciously, 'invisibly' and autonomously

and

- *'With'* us, exposing and encouraging opportunities for novel solutions and interactions through reflective-/conscious engagements as (Mindful) 'tools' (Chapter 1.9.1).

The following section details an exploratory study that investigates potential for the objective measurement of Mindful and Mindless states during interactions with digital technologies that might be applied in future evaluation of human-computer interactions. As will be described further in the following (see: *Limitations and Support* Chapter 2.0.2) the objective measurement of such phenomena:

- Might help reveal and distinguish one physiological process form another and broaden our understanding of the phenomena in question;
- Facilitate triangulation of sources of information to provide more accurate evaluation of how and when such states arise;

And furthermore;

- Would provide a grounding from which evaluation of subjective experiences (of interactions with technology) can occur that overcomes the limitations of first-person reporting on experiential/subjective events that transpire outside of conscious and reflective-conscious experiences.

The aims of this study firstly, seek to understand *if* Mindful and Mindless states can be measured through current "public domain" technologies; and if so, what are the appropriate modalities with which to measure these states. Furthermore, this study seeks to provide further insight and support toward the theoretical foundations and definitions of such phenomena as outlined in previous Section 1. Finally, it is hoped this study will inform future development in the objective evaluation of Mindful and Mindless states during interactions with technology.

Consequently, the broader goal of this study is to pave way toward providing tools with which designers of digital technologies can better understand and evaluate how their design choices might alter the Mindful and Mindless experiences of users, the value and cost of such choices and alterations, and, when and where best to invoke Mindful and Mindless interactions.

While it might be assumed that directly questioning participants on their experience while evaluating interactions with technology might prove most beneficial in terms of speed and accuracy, there is an inherent difficulty with such method (as will be described in *Limitations and Support* Chapter 2.0.2). Specifically, questioning users of technologies their degree of immersion or awareness of surroundings (i.e. if they are Mindless or Mindful during an interaction) will invoke a reflection upon their state of awareness and draw attention toward and awareness upon the experience in question (altering any sub-/non-conscious process to conscious and reflective conscious experience). Thus, such line of questioning will be biased by the very act of probing on such state – i.e. asking if someone is not aware of his or her actions during an interaction breaks the interaction/immersion itself and draws attention toward it and so any answer given can be assumed to be false reporting of an assumed previous state. And so, it is imperative that measurements of Mindfulness, and more significantly Mindlessness, are supported through discreet and subtle modalities. Consequently, this furthers the need for objective (technologically supported) means of measuring such states.

Here the reporting of an exploratory study provides guidance to the development of future methods in the understanding and classifications of Mindful and Mindless interactions.

2.0.1: Applying A Neurophenomenological Methodology

As previously described in section 1.11.1, Varela (1996) proposed that we might better support philosophical perspectives upon the phenomena of experience through understandings gained through differing disciplines such as through advancements in cognitive science and physiological measures. As Lutz (p134, 2002) describes: "*The neurophenomenological program encourages researchers to pay attention not only to neuronal or physiological data but also to the data produced by accounts of subjective experience*"; as a "*methodological answer*" (p134, Lutz, 2002) to the on-going debate of how the brain (and body) works not only in terms of functional attributes (objective - third person) but in relationship toward subjective experiences. This neurophenomenology uses phenomenological information (first-person reporting of the subjective experience) to help reveal and understand the relationship toward, and complexity of, physiological changes. In this study physiological measures are gained through eye-gaze and pupillometry, and Q/EEG (Qualitative/Electroencephalogram – a measurement of brain activity). In doing so, such methods offer promising tools for addressing the challenges of understanding conscious experience (Fazelpour and Thompson, 2015). This merging of objective measures and self-reporting has been previously applied in similar ways in related fields e.g. the work of Kahneman (2011) and the subsequent work on cognitive bias. However, it should be noted System 1 and System 2 "thinking" (Kahneman, 2011) while similar to Mindlessness and Mindfulness (respectively) differ in that they are inherent behaviours (as opposed to Mindlessness as learned through routinisation).

As Lutz notes (p143, 2002) a neurophenomenological methodology holds advantage of allowing a more complete understanding of the abstract and theoretical framework typically inherent within studies of phenomenology through applying a *pragmatic* approach. This pragmatic approach is "*explicitly anchored in lived experience and open to scientific inquiry*" (p143, 2002). Where one might study "experience" (first-person subjective) though questioning people on various general events, neurophenomenological method requires a specific and rigorous technique that may be reproduced. In this study this is achieved through the application of several "conditions" through which an experience is invoked. This was followed by questionnaire, and responsive open-ended interview that queried several specific topics to better understand and probe specific experiential qualities held by the participants during interaction. Similarly (as previously described) this is supported through objective physiological measures of brain and eye activity (captured during the activity of enquiry); through reproducible conditions. It is important to note in a neurphenomenological approach:

> "The key point is that both forms of evidence are granted an equal importance and therefore need the same attention"
> (p145, Lutz , 2002).

That is to say, both first-person account of experience *and* physiological data hold equal importance and value.

Given the complex nature of studying phenomena of experience such as Mindfulness and Mindlessness, as will be described in the following *Limitations and Support* (Chapter 2.0.2), a neurophenomenological methodology is most valuable; as advocated by Fazelpour and Thompson:

> "[…] neurophenomenology can be employed to produce more fine-grained first-person reports of the variability of moment-to-moment experience (such as fluctuations of attention, metacognition, emotion, bodily sensation, and memory) in a given individual from trial to trial in an experiment, and such reports can be used to reduce the noise of the neural signals, thereby providing a tighter coupling between the variability of the network dynamics and that of experience."
> (p225, Fazelpour and Thompson, 2015)

As noted by Varela and Shear (p6, 1999) such methods require two central elements. Firstly a clear and consistent procedure for accessing the phenomenal domain, and secondly, a clear means for an expression and validation within a community who have familiarity with such procedures (i.e. study and findings reporting through commonly practiced methods).

Respectively, this following section reports an exploratory study to detect (empirically) Mindful and Mindless states during interaction with digital technologies. This firstly seeks to outline a procedure used and secondly provide empirical measures for the expression and validation of Mindful and Mindless states supported through first-person reporting. In doing so this section seeks to move toward addressing the previously described requirements in the study of Mindfulness as suggested by Brown and Cordon (p59, 2009):

- A phenomenon may only be studied if it can be properly defined and measured;
- The investigation of Mindfulness facilitates understanding in the role of this quality in subjective experience and behaviour through methods derived from basic science;
- The effects of Mindfulness can only be measured through clear definitions;

and finally,

- The study of Mindfulness can help inform understanding of consciousness and its fundamental role in human functioning and its processes can be refined to enhance such functioning.

As section one provided definitions of Mindfulness and Mindlessness, this study builds upon these findings and draws upon the methods of inquiry used in the validation of the main concepts previously discussed (in section one) with aim to provide empirical measurement. This holds several tenets guiding the methods used:

- First (and most significantly), those with capacity for introspection (specifically reflective-consciousness) and experience of consciousness are equipped with capability to report on such phenomenal state (or realisation of a previous lack of such state).
- While reporting on phenomenal states holds a degree of fallibility (as will be described in the following *Limitations and Support* Chapter 2.0.2), with rigorous investigation and cross-question of statements this fallibility can be reduced.
- Cognitive and conscious states that occur within a bodied being are both affected by and effect said body (e.g. sensory experience as an affect toward, reactions as effect upon).
- Through measurement of the external influence upon such body (environmental affect), its correlation with introspective report, and its correlation with a physiological change the effect upon the body, an empirical understanding of the phenomena can be made.
- And finally, through a corpus of such empirical understandings a means of expression, measurement, and validation of these phenomenal states can be made.

In providing the definition and tools for measurement of Mindful and Mindless states during interaction, methods for the study and understanding of such phenomena in human-computer interaction are developed. With further exploration and development upon the definitions and methods of study (as a field of enquiry), an informed understanding of Mindfulness and Mindlessness and their fundamental role during human-computer interaction can be refined to better facilitate and enhance such interaction experiences with technologies.

2.0.2: Limitations and Support

Prior to the application of a neurophenomenological methodology it is important to recognize the limitations and support for, and challenges in, use of such method.

Understanding mechanisms of (and so the mapping between) experience and brain activity remains an "outstanding challenge" (Fazelpour and Thompson, 2015). This is due in part to the connectivity between functional neuronal networks and larger brain structures being of a complex "many-to-many" nature (Pessoa, 2014), as opposed to dedicated (singular) processing structures. For example, while the visual cortex is understood to be vital for processing of visual information its function in 'seeing' is not of a solitary or independent nature. In actuality many substructures of the brain become active in unison during visual processing. The challenge of understanding brain activity is further increased when seeking to understand the role of consciousness within such processes (Cosmelli, Lachaux and Thompson, 2007) e.g. to produce the experience of 'seeing'. This is, in part, due to the complexity of our experience including sight, sound, smell etc. coupled with our attentive state toward relevance and motivators (e.g. emotions, goals and actions) all forming and shaping our conscious experience, 'presented' not as singular units of experience but in a unified whole (Fazelpour and Thompson, 2015); thus necessitating the 'many-to-many' perspective in understanding such physiological affect. To experience is coupled with many accompanying facets such as memories, goals, contemplation etc.; as noted by Fazelpour and Thompson, (p224, 2015) "[…] *we should not expect there to be the kind of one–one mapping between brain regions and mental functions predicted by the view of the brain as a stimulus-driven device*". In understanding brain functions we are required instead to remember that while context and task dependent regions may be active in one process they may also serve functionality in others; e.g. the visual cortex is additionally active in imagination, spatial awareness, and even in blind humans during auditory tasks (Kujala et al., 1995). This should not be understood as contradicting the previously described (chapter 1.11.3) understandings of Århem and Liljenström (1997), but as cognition and conscious-cognition consisting of a broadcasting of differing information (e.g. from the nervous system or internally driven) across the brain and toward multiple 'centres' of processing. As highlighted by Århem and Liljenström (1997), Anderson (1983, 1992 and 1996), and Baars (1993, 1996, 1997); it is this broadcasting of multiple centres of processing that becomes refined over time to remove centres unnecessary for completion of the task or response to the stimulus i.e. the event moving toward a purely cognitive, automatic, and thus Mindless task. Therefore we might understand a conscious event as having many multiple regions of activation (e.g. 15 centres of high processing) though over time as such event becomes increasingly cognitive this may reduce toward fewer centres of specialized processing (e.g. 5).

While such complexity initially appears prohibitive to understanding specific conscious experiences in relation to physiology, triangulation of sources of information might help reveal and distinguish one physiological process form another. This is the standpoint from which neurophenomenology presents the argument that while such phenomena, outlined by Chalmers' 'hard problems' (1995) are illusive; determining their 'physiology' maybe facilitated through a balanced and disciplined account of both the 'internal' (experiential) and 'external' (physiological) elements of an experience and so move "[…] *one step closer to bridging the* *biological mind - experiential mind gap.*"(p343, Varela, 1996). This neurophenomenological approach holds first-person reports, gained through methods provoking implicit experiences, as both bounding an experience to an event while simultaneously revealing (and bounding) its evidence within a physiological process; which might be further refined over multiple observations. These first-person accounts and reporting are upon the 'felt' and subjective experience of an agent with capabilities of introspection. This is often understood as 'looking into our inner world' comprised of thoughts, feelings, and ultimately our sense of 'self'. Commonly these subjective qualities are hidden as there is no explicit communication 'outward' to others. However, through linguistic description, physiological expressions of emotion, or expression through other medium (e.g. as with many works of art), we are offered a degree of communication. While these communications may be of a 'truer' nature (of sharing subjective experience) in comparison to purely physiological measurements; they remain subjective and so are constrained by limitations in the mode of communication. For example, the communication of what red 'feels like' might be ineffable to those not having experienced the colour red itself (an argument heavily debated through Jackson's (1982) thought experiment of Mary). Likewise, to subjectively describe a non-conscious event might also be ineffable; though it is suggested that subjects might more accurately report on moments of automatic inattentiveness (moments of Mindlessness) upon realization of such events i.e. present awareness as comparator to a previous lack of awareness, as discussed by Van Dam et al. (2010), Baer (2011), and Grossman (2011).

In the context of Mindfulness and Mindlessness, such limitations of first-person reporting must be taken into consideration when developing a study design and analysis of results. Specifically, in asking someone if they are immersed or have awareness of their surroundings (i.e. if they are Mindful or Mindless during an interaction); the very act of asking one to reflect on such state of awareness draws attention toward and awareness upon the phenomena. Thus, while such first-hand accounts hold value, such direct line of investigation would not prove fruitful when seeking to measure Mindless states (i.e. asking a participant to report if they have lost awareness toward a task would encourage them continually maintain awareness toward the task waiting for a lack of such experience). While first-person post-event reporting is useful in overcoming challenges of bounding experiential states to objective measurements, such feedback is likewise delicate; specifically, persons reporting upon interactions might wrongly report a level of attention and awareness they held during a specific interaction (only revealed upon in-depth and cross questioning). And finally, there is further care needed in post-event reporting upon interactions, as such action leaves the timeframe of when a participant is Mindful or Mindless unbound to specific events or elements of interaction. This is not to say that such first-person accounts should be disregarded however, as previously described such insights provide a bounding of subjective experience to empirical measurement, though acknowledgement of such limitations is required alongside thorough enquiry into the nature of the experience being reported. To help overcome the limitations in first person reporting, third-person accounts provide objective descriptions of first-person experiences. This is often understood to be of scientific method whereby a corpus of first-person accounts informs objective descriptions and regulated knowledge (Varela and Shear, 1999). As noted by Varela and Shear (1999) such corpus ultimately remains part subjective, dependent on individual's observation and experience, and part objective defended and controlled through empirical understandings. Thus, objective detailed descriptions of the phenomena of inquiry here (Mindfulness and Mindlessness) necessitate both qualitative first-person accounts and objective third-person understandings, supported through a neurophenomenological methodology.

2.1: Study Design

The underlying hypothesis in study design was that a repetitive task could (or would) become automatic and as such Mindless, unless or until a 'breakdown' occurs forcing a Mindful engagement. That is to say, initially tasks require concerted effort and necessitate a Mindful approach and interaction as previously described by Langer (p20, 1989); though with enough repetition of a task the "... *learned tasks drop out of mind*", as "*...the individual parts of the task move out of our consciousness. Eventually, we come to assume that we* <u>can</u> [original in italics] *do the task although we no longer know* <u>how</u> [original in italics] *we do it.*" (p20, Langer, 1989). Similarly, and as previously described, Anderson (1992) proposes several qualities of automaticity development during a task:

- The acquisition of skilled performance speeds up with a reduction in error rate with practice.
- As a skill becomes more practiced, there is less interference with concurrent tasks; and furthermore it is less interfered with by a concurrent task.
- "It is easier for a task to become "automatic" if there is a consistent stimulus-to-response mapping. In the context of this statement, the term automatic connotes fast processes, little interference by concurrent processes, and little effect of number of alternatives." (p167)

Concurrently, Koschmann, Kuutti, and Hickman note the effect of 'breakdown' upon a task as "...a disruption in the normal functioning of things forcing the individual to adopt a more reflective or deliberative stance toward ongoing activity." (p26, 1998). A position supported by Langer further describes that: "If something or someone makes us question our competence on a task that we know moderately well but is not overlearned in this way, we can search our minds for the steps of the task and find them" (p20, Langer, 1989).

2.1.1: Procedure

The study design was developed with aim to understand *if* Mindful and Mindless states can be measured through current "public domain" technologies, using a number of theoretical positioning's informed by the previous findings (Section 1) as points of contrast and comparison, and analysis. This study comprised of seven conditions that vary in their degree of difficulty and 'steps' in completion (described in detail in *Comparative Conditions* Chapter 2.3.0 (outline Chapter 2.2.1). Each condition was presented in the same modality; a 23" 1080p resolution colour screen displaying the condition's test (Tobii TX300[7]), with four answers presented in fixed locations along the bottom of the screen. Four 100mm white physical buttons (with high speed switches) in fixed positions of an equal distance apart on which answers were to be given were placed in front of the screen (see figure 2.1 below). Each test had a single correct answer. Participants were allowed prior to the test to adjust the buttons positions to a place where they were both comfortable and able to press all buttons freely. The screen was then adjusted to a position that was again comfortable for the participant and at a distance that allowed eye-tracking detection (i.e. approximately 65cm and at a horizontal level not exceeding 30° angle) (see figure 2.1 below). Participants were informed of the condition they were about to undertake and that they should answer as quickly and as correctly as possible prior to each condition. It was ensured that each participant understood what the condition tests would require to provide a correct answer. Each participant was informed that their data would be fully anonymised and that they were free to withdraw from the study at any time without reason (and could request their data be destroyed within the 30 days following their participation), and this study was in no way a medical exam (or replacement to), and signed consent of participation (see appendix 2.1) prior to undertaking the study. Prior to agreement of participation, participants were informed of the ways in which the technologies for capturing physiological data worked and their capabilities, and provided opportunity to have any questions answered they might have about the study and technologies, e.g. if the EEG device could tell they were thinking of personal information.

Figure 2.1; Participant during study (*facial features hidden for anonymity).

Each of the seven conditions had a custom written software controlled using Cycling '74 – MaxMSP; a visual programming language for developing multimedia interactive software. This custom software additionally controlled randomization of

[7] http://www.tobiipro.com/product-listing/tobii-pro-tx300/

testing (i.e. stimulus shown), recorded input of participant responses from the four input buttons, events log (e.g. between stimulus presentation and response), recording of test shown, and provided correct or wrong audio response. Each condition had a total of 200 tests with a 500ms blank screen between an answer being provided and display of the following test. Audio feedback was provided through the computer operating the custom study software and was ensured to be audible to the participant. The audio feedback was demonstrated to participants prior to presentation of the first condition tests and was used to represent correct and wrong answers through generic ‘ding’ and ‘beep’ (i.e. non-linguistic) sounds of the same length; this was consistent across all conditions and participants, and was the only metric of performance given to participants during each condition. Conditions varied in presentation order cross-participant informed by a Latin Square configuration to account for accumulative effects (i.e. length of study) across conditions (see following *Condition Presentation Ordering* - Table A2.2 in Appendix 2.2). In total there was 11 participants[8]. The remainder population comprised of 2 female, 9 male; 3 left-handed (8 right-handed); and an average age of 34 years. All participants were proficient in English language (i.e. English first language or use in higher degree level).

[8] In total 12 participants were recruited, one participant (P2) was removed mid study due to health and so their data is not included in the final analysis.

2.2: Study And Condition Design Grounding

2.2.1: Comparative Conditions Of Study Outline

While the seven conditions for comparison used in the study are explained in greater length in *Comparative Conditions* (Chapter 2.3); an outline is provided here for context of the following statements informing study and condition design and how they relate to / inform the choice of these conditions.

Outline of Condition 1:

Condition 1 of the study can be considered the simplest of the seven conditions. This condition presented participants with one of four stimulus – a (Green) X, O, (Red) X, O; randomly presented. As shown in figure 2.3, 4 potential answers were displayed onscreen in fixed positions (in order: X, X O, O). Participants were instructed to provide the correct answer to the corresponding stimulus.

Outline of Condition's 2 and 3:

The basis of conditions 2 and 3 are developed from the well-established Stroop testing (Stroop, 1935) that has been noted to provide testing of the effects of Automaticity (Saling and Phillips, 2007). The two condition's test's presented participants with the (literal) word of a colour (e.g. Blue) presented in either an incongruent colour (e.g. Blue), or congruent colour (e.g. Blue). Each test stimulus for this condition was randomly selected from a pool of 16 – 4 words (Red, Blue, Yellow, Green); each in 4 differing colour's (Red, Blue, Yellow, Green). During these conditions participants were instructed to provide either the word (Condition: Stroop Word - e.g. Blue would answer "Blue") or the colour (Condition: Stroop Colour e.g. Blue would answer "Red"). As shown in figure 2.4, 4 potential answers were displayed onscreen in fixed positions (in order: Red, Green, Blue, Yellow[9]).

Outline of Condition's 4 and 5:

The conditions 4 and 5 again follow the underpinning concept of the Stroop test (Stroop, 1935); however this is provided with the removal of the linguistic portion of the test (Wühr, 2007; Eriksen and Eriksen, 1974). While the Stroop test provides stimulus based on words and colours, conditions 4 and 5 rely upon symbolic direction (i.e. an arrow pointing in a direction) and spatial orientation (i.e. the arrows

[9] Red, Green, Blue, Yellow – font in corresponding colour

position is relative to a centric indicated position), as shown in figure 2.5. The arrows point in four directions (Left, Right, Up and Down) and are displayed around a centre marker (a red square) that indicates their position (Left, Right, Above, Below; the centric point). Each test stimulus for this condition was randomly selected from a pool of the potential 16 – 4 directions (Left, Right, Up and Down); each in 4 differing positions relative to a centric red square (Left, Right, Above, Below). During these conditions participants were instructed to provide either the position of the arrow relative to the centric point (Condition: Stroop Arrow Position) or the direction the arrow is pointing (Condition: Stroop Arrow Direction). Potential answers were displayed onscreen in fixed positions displaying arrows pointing Left, Right, Up, and Down.

Outline of Condition 6:

Condition 6 draws upon a "familiar" informational display (Blackler, Popovic, and Mahar, 2010; Raskin, 1994), i.e. an "analogue" clock face with standard numeral designation of hour positions (with the 12^{th} hour on top) (see figure 2.8). Each test in this condition would randomly generate a time: an hour and minute (in five minute increments), displayed on the clock face with only one of the possible answers matching the time in a twelve hour numeric format (e.g. 10:45). Participants were presented with four options of answer along the bottom of the display that corresponded to the physical input buttons. As the condition had a pool of 144 differing times (12 hours with 12x5 minute increments), the four potential answers displayed along the bottom of the screen would randomize (the correct answer being one of those); consequently the answer display positions were not permanent. This condition is referred to as Fixed Clock Face.

Outline of Condition 7:

Condition 7 was the most complex of all conditions and specifically sought to hinder potentials for automaticity learning (Mindless interaction). In a similar design to condition 6, condition 7 displayed an "analogue" clock face; however, designation of hour positions was randomly rotated per test i.e. the 12^{th} hour (and following hours in normal ordering) would rotate their position on the clock face (though the digits themselves remained upright) (see figure 2.9). As with condition 6 each test in this condition would randomly generate a time: an hour and minute (in five minute increments), displayed on the clock face with only one of the possible answers matching the time in a twelve hour numeric format (e.g. 10:45). Participants were presented with four options of answer along the bottom of the display that corresponded to the physical input buttons. As the condition had a pool of 1728 differing times (12 variants of 12 hours with 12x5 minute increments), the four potential answers displayed along the bottom of the screen would randomize (the correct answer being one of those). As with condition 6 the answer display positions were not permanent. This condition is referred to as Rotating Clock Face.

Outline of Pop-Ups:

Five Pop-Ups, displaying the text "Retry?" (see figure 2.2), were additionally introduced for each of the conditions (randomized between tests 180 – 200). These were specifically intended to introduce a disruption to the ongoing condition and were unrelated to preceding answer correctness. Participants were informed prior to each condition that a pop-up may occur and this would allow them to change their answer if they wished to one they felt was correct (though the stimulus and potential answers were hidden) or they would be required to re-enter the answer they felt was correct.

Table 2.1 below provides a comparator of the conditions.

Condition	Number of tests	No. of pop-ups (between test 180-200)	Time between Answer and next test	Number of potential answers on display	Answer display position permanent	Number of potential stimuli (i.e. stimulus pool size)
1	200	5	500ms	4	Yes	4
2 and 3	200	5	500ms	4	Yes	16
4 and 5	200	5	500ms	4	Yes	16
6	200	5	500ms	4	No	144
7	200	5	500ms	4	No	1728

Table 2.1: Comparison of Condition design.

2.2.2: Statements informing Study and Condition Design

The study and conditions design was informed by a number of findings as described in Section 1. These positioning statements (drawn from the key texts and positions in agreement) informed the inclusion of elements and positions form which analysis of data should occur.

With enough repetition a task will become automatic (sub-conscious).

(Langer, 1989)

Each condition of the study would require a sufficient number of tests to allow a high degree of familiarity and opportunity for the task to become automatic. Following a pilot study it was determined that 200 tests was sufficient to allow many of the conditions to be performed automatically.

A novel task will require concerted effort (conscious cognition), and so require more time (or incur more errors) than when the task is automatic.

(Århem and Liljenström, 1997; Anderson, 1992).

As noted by Baars (1993, 1996, 1997), global workspace theory proposes information processing architectures (within the brain) comprised of multiple sets of parallel specialist processes within a global workspace. The specialist processes (which are sub-/non- conscious) work together and compete to enter dominance/control of the global workspace (as a conscious event); which is then broadcast back outward through the network (directing toward a dominating action and/or goal) (Shanahan, 2010). Should an event or task be novel it will not have a 'specialist process' that may be called upon to complete the event or task sub-consciously and in entirety. Consequently novel tasks draw upon multiple (sub-conscious) resources to complete as the task itself directs the workspace as a conscious/reflective-conscious event; all of which requires an additional time resource. Århem and Liljenström (1997) state purely cognitive processes, e.g. sub-conscious and automatic tasks, are performed (or initiated) faster than conscious awareness or interruption. This is due to strengthened neuronal connections facilitating a faster (and perhaps dedicated) network of response to stimulus (e.g. repeated events result in faster recall), and a reduction of the resources needed – i.e. sub-conscious specialist processes not requiring control of the global workspace (and so multiple specialist processes) for execution. Such position supports the hypothesis that conscious and reflective-conscious tasks require additional effort, resources, and subsequently time to complete in comparison to those performed sub-consciously.

Consistent stimulus-to-response mapping will better facilitate automatic responses.

(Anderson, 1992)

The seven conditions can be understood to hold varying degrees of consistency of stimulus to response requirement.

Firstly, condition 1 (Green X O - Red X O) contained a pool of four stimulus and four potential answers (consistently displayed on screen in fixed positions). This provided a very limited number of potential stimulus to response.

Secondly, conditions 2 through 5 (variations of Stroop test) contained a pool of sixteen stimulus and four consistently displayed potential answers (i.e. response positions fixed in same location). This decreased the directness of the stimulus to response as each condition held 4 variations of stimulus that would require a specific response (e.g. the word blue would appear in four stimulus though each would require answering with the correct response 'blue').

Thirdly, each of the conditions 2 through 5 additionally contained a counter part (Stroop Word Text V's Colour, Stroop Arrow Position V's Direction) that would require a differing response to that previously learned e.g. the word blue would appear in four stimulus though now only one (coloured in blue) would require answering with the correct response 'blue' and three additional text (coloured in blue) would also require the response blue.

The fourth variation can be found in the Fixed Clock condition (6). While the clock face itself drew upon a familiar stimulus (i.e. an analogue clock face) the response mapping varied as the answer, even should the stimulus be the same, would likely differ in the four potential response positions (i.e. answers would be inconsistently displayed on screen). Similarly with 144 potential stimulus an intentional inhibition to develop a 'mapping' of stimulus to response was created (and can be understood as in opposition to the simpler condition 1 - Green X O - Red X O).

The final variation in conditions is facilitated through condition 7, the rotating clock face. This condition (as with 6 – Fixed Clock) held inconsistently displayed answers on screen. However, in the further attempt to prevent automatic responses the clock face in itself would additionally randomize its position, generating a potential 1728 potential stimulus. Thus, the stimulus could be understood to require a remapping of the stimulus upon each presented test.

Thus it was expected that the conditions would increase in their difficulty to become automatic ranging from condition 1 (easily facilitating Mindlessness) to condition 7 (preventing automaticity).

In addition to the above, consistency in stimulus-to-response was encouraged in the testing presentation, each being separated with a 500 millisecond blank following answer; to prevent influence upon automatic response. That is to say, should the presentation of stimulus be a randomized event (varying in time between answer to next test presentation) then it is understandable that this could prevent or hinder responses being automatic.

Likewise, each response was consistently indicated as correct or incorrect with prediction that the majority of answers would be correct. Thus, when an incorrect answer was provided following a series of correct answers a breaking of the familiar stimulus-to-response (i.e. answer – correct answer sound) would occur. It was predicted that this would cause a brief period of reflection or contemplation upon why an answer was incorrect alongside a re-evaluation of the mental schema being applied (potentially drawing into question if the schema needs adapting). Similarly, randomized pop-ups were introduced as a means of breaking the 'answer – correct answer sound' stimulus-to-response.

A task with fewer 'individual parts' or steps of processing (i.e. a simpler task with lower cognitive and conscious requirement) will better facilitate a transition toward automaticity.

(Langer, 1989; Koschmann, Kuutti, and Hickman, 1998)

As previously described (Section 1.6) Koschmann, Kuutti, and Hickman (p30, 1998) note that initially each step in a process of action is initially performed as a conscious action. Through routine these steps become conglomerated into singular chunks of action that require little to no planning or decision making (i.e. automatic). This process of combining steps or 'chunks' of action continues until, ultimately, the action becomes an embedded automatic operation within larger actions and goals, which in turn become automatic operations. Similarly, as noted by Langer tasks that may have previously required concerted conscious awareness become sub-conscious as the individual parts of the task move from our consciousness (p20, Langer, 1989); until the agent performing the part of an action is no longer thinking of 'how' that action is performed and instead 'knows'. As Shanahan (p42, 2010) describes, cognition (from the Latin 'cognosecre') is to "know" rather than cogitare, to think; cognition being a sub-/non-conscious act of knowledge processing and application opposed to a reflective-/consciousness 'thinking'.

From this understanding of smaller units of an action combining and becoming sub-conscious operations it is hypothesized that a simpler task with fewer elements of action/processing will more easily become automatic. Thus, condition 1 Green X O - Red X O with the fewest elements would be more quickly transformed into a sub-conscious (and Mindless) action as opposed to the far more complex condition (7) of a rotating clock face with a much higher number of steps within the stimulus-to-response action.

Disruption to an automatic task will force the individual to adopt a more reflective or deliberative (i.e. Mindful) stance toward the task.

(Langer, 1989; Koschmann, Kuutti, and Hickman, 1998)

<u>*Automatic tasks will be less interfering with concurrent automatic tasks.*</u>
(Anderson, 1992)

As noted by Anderson (p167, 1992) automatic task are less interfered with and interfere less with concurrent tasks. From this position it stands to reason that to understand if an agent is sufficiently proficient in performing an automatic process one could observe how the process is performed alongside a concurrent task. This is exemplified by Langer's (p20, 1989) observation of a person who is able to knit while simultaneously watching T.V.; performing two concurrent tasks without apparent interference to either. While this is not to say that both actions will merge as a new singular automatic act (as a merged / new mental schema), they do not hold conflict or force adaption (to the schema's); and more significantly do not require reflection upon the actions. Should interruption occur the task's would be drawn to the fore of consciousness and the actions revealed; as previously described by Koschmann, Kuutti, and Hickman (1998), facilitating review and contemplation upon the 'steps' of the actions (p20, Langer, 1989) to resolve the breakdown. Actions providing less interruption to existing performed schema's are more easily enacted automatically; and so "rules" of the schema might be broadened to encompass the additional automatic action without interruption to either. For example, in the context of the study described it might be assumed that the answering of test may become automatic and a response to a pop-up may also become automatic. While a novel pop-up event interrupts the on-going automatic answering of test (forcing contemplation upon their relationship), when both tasks are sufficiently automatic they may be performed alongside each other without interference to one another. As such neither are treated as events prompting breakdown, though trigger their own schema to fit around the existing enacted schema, while both simultaneously occurring.

Similarly, to observe the characteristics described above it is expected that over the course of study participants will get a number of answers wrong. When such an event occurs it is assumed that it will cause a sufficient breakdown of the task and force a reflective state and questioning upon the validity of the mental schema being applied (i.e. the alert to a wrong answer will disrupt an automatic/ sub-conscious action and provoke a conscious interaction). Over time, as the wrong alert becomes incorporated into the mental schema of the condition, it is expected that the effects of this breakdown will decrease until there is little to no effect upon the task. Likewise, it is expected that the introduction of pop-ups will invoke a breakdown as a direct interruption toward the task. Following a sufficient number of exposures to pop-ups the interrupting breakdown effect will also lessen. While it is understandable that incorrect answer alerts and pop-ups will be handled by the participant in similar ways (i.e. being forced into a reflective state); it is also important to note the subtle difference between the two forms of breakdown.

Wrong answers are an element of an on-going task and so would require modification of the mental schema for the automatic action to remain valid. Conversely, pop-ups are concurrent to the on-going task and so would require the creation of a new mental schema to accommodate.

2.2.3: Points Of Unobtrusive Analysis

The previous positions (repeated below) provide several marker points from which to measure Mindfulness and Mindlessness.

- With enough repetition a task will become automatic (sub-conscious)
- Consistent stimulus-to-response mapping will better facilitate automatic responses.
- A task with fewer 'individual parts' or steps of processing (i.e. a simpler task with lower cognitive and conscious requirement) will better facilitate a transition toward automaticity.
- Disruption to an automatic task will force the individual to adopt a more reflective or deliberative (i.e. Mindful) stance toward the task.
- Automatic tasks will be less interfering with concurrent automatic tasks.

These events can be inferred from the interaction data and so viewable within the empirical data unobtrusively i.e. the broader ongoing condition is not interrupted to generate the data. This allows for an empirical data collection of Mindful and Mindless events without influencing such states through an explicit enquiry of the participant (causing introspection).

It is expected that a comparison of the conditions start and end's will provide an indication of automaticity occurring. Initial tests will be novel and so will not be automatic where as a strong familiarity will exist by the end of the condition (should the condition allow). That is to say, one point of analysis is comparing early tests with later tests in each condition for each participant. Time required to answer early tests in comparison to the later tests will provide indication as to weather the task has become learned and may provide insight to automatic enacting.

Consistent stimulus to response additionally provides points for comparison. Pop-ups break an expected stimulus i.e. the participant is not presented with a familiar blank but with a new stimulus that does not fit the previous experience of the condition. Likewise wrong answers provide a point for analysis, should the participant be achieving a number of correct answers, as this will break the expectation of correct answer alert. Thus pop-ups and wrong answers can be used comparatively against the more commonly occurring stimulus (i.e. test being shown and correct alerts). Conditions also increase in their inhibiting automaticity, ranging from Green X O, Red X O (easily facilitating Mindlessness) to the Rotating Clock Face (preventing automaticity), as the variation of the stimulus and potential answers (i.e. with the two clock conditions) increases. This variation in conditions will also provide facility for comparison that moves beyond cumulative effects (e.g. being exposed over time of study or accumulative effects of condition).

As with increasing the degree of variation of stimulus, increasing the number of steps involved in a condition (i.e. its complexity and difficulty) will also provide opportunity for comparison between conditions. Thus it is expected that an easier condition will better facilitate Mindlessness in comparison to more challenging and complex conditions.

Disruption to the on-going task will also provide points for analysis. As previously described this will occur at two points; where a 'wrong' answer alert occurs, and, where pop-up events occur. These two events hold comparison to 'correct' answer alerts and regular test display correspondingly. However, it is also expected that as these events become more familiar (and so automatic) they in themselves can be used as a comparator. That is to say, the first 'wrong' alerts and pop-ups will likely be experienced as more Mindful than when such events have been experienced several times.

2.3.0: Comparative Conditions

The comparative conditions described below are suitable for application in a neurophenomenological methodology as they provide a range of comparative activities that facilitate or inhibit the phenomena in question. Furthermore, such conditions provide a high degree of control in comparison to more familiar interactions with digital interfaces (such as webpage navigation) as the interaction is reduced in the number of potential options and information displayed or directions that may further interaction. Some of the conditions are well established (though applied in differing context) though all are easily reproducible. The order of presentation to participants can be found in Appendix 2.2 - Condition Presentation Ordering.

2.3.1: Pop-Up (total of 5 per condition):

Though not a condition in the same sense as the more substantial 7 conditions; the Pop-Up events introduced in the study are comparable in that they facilitate an on-going concurrent task during each (and all) condition. The introduction of Pop-Up's is intended to invoke a breakdown of the on-going condition and force a reflective positioning toward the activity taking place.

Participants were informed prior to commencement of each condition that a 'pop-up' might appear (stating "Retry?", see figure 2.2) at a randomized time during the test. They were informed that this 'pop-up' would be in relation to the immediately preceding test and appeared immediately following answer of the test that it was in relation to. When such pop-up occurred they would be given chance to change their previous answer (if they felt it was incorrect) or they would be required to re-enter their answer (if they felt it was originally correct). No audio response was give for the preceding test, however, feedback was provided on the pop-up answer. Pop-up randomization occurred following test 180 for each condition with a total of 5 pop-ups per-condition and increasing likelihood of occurrence from tests 180 and 200 (ensuring all 5 pop-ups would occur before the end of the condition tests).

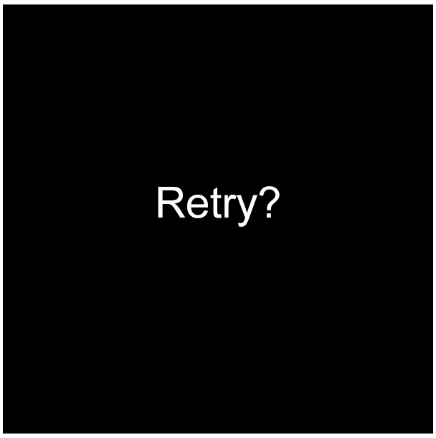


Figure 2.2; Pop-up presented to participants during each condition.

2.3.2: Condition 1 (Green X O - Red X O):

The first condition (see figure 2.3) was designed to be a simple symbol match. The symbols presented consisted of a Green circle, a Green 'X', a Red circle, and a Red 'X'. The presentation of the tests was randomized with a 500ms blank between providing an answer and the next test appearing. It was aimed that such symbol matching would require a very low (relatively speaking) cognitive loading and so is considered the simplest of conditions. It was also assumed that this test would best facilitate automatic responses. Participants were instructed to press the button corresponding to the test e.g. below would require the button second from right to be pressed.

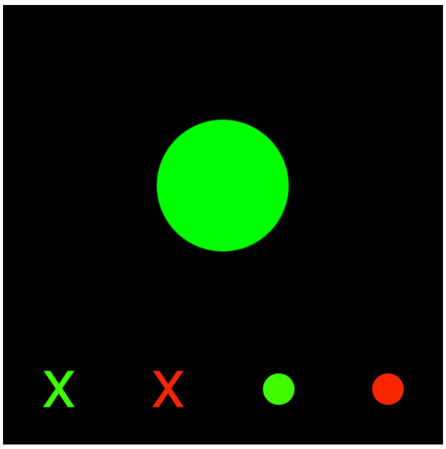


Figure 2.3; Figure showing a typical test presentation for the Green X O, Red X O condition. The correct answer for this test being a Green circle

2.3.3: Condition 2 and 3 (Stroop (Word) and Reversed Stroop (Colour)):

Conditions 2 and 3 were based on adaptation of Stroop testing (Stroop, 1935).

The Stroop effect is a psychological test on interference upon reaction time of a task. It has been noted that the Stroop test is the testing of automatic phenomenon (Saling and Phillips, 2007). A Stroop test presents participants with the word of a colour (e.g. Blue) that may be in an incongruent colour (e.g. Blue), or a congruent colour (e.g. Blue). A participant of the Stroop test is required to provide the colour of the word and not the word itself e.g. Blue would require the correct answer "red". The Stroop effect demonstrates that congruent stimulus is answered faster than incongruent stimulus i.e. interference of task increases reaction time. Thus the Stroop test reveals and invokes an interference example in which the participant is required to perform one task (e.g. provide the colour of a word) yet performs another (provides the word itself). In doing so the Stroop test reveals automatic phenomenon (the reading of a word) against the instructed and controlled process (providing the colour of the word). Stroop's test is subsequently often used in the investigation of mechanisms in cognitive control and selective attention as participants have to selectively attend to one particular stimulus element (e.g. the word colour) and reject another stimulus information (e.g. the word itself). As noted by Saling and Phillips, (2007) the context and instruction with which the Stroop test is provided greatly modifies the 'automaticity' of the process (i.e. controlled or uncontrolled reactions) and automatic processes are learned; i.e. participants learn the how to perform Stroop tests and mitigate effects of incongruent stimulus. Similarly, in Section 1 it was highlighted that automatic processes are a product of repeated stimulus – reaction / goal – action learning. Thus it is understandable that prolonged testing of the Stroop test, though initially may reveal automatic tendencies, will invoke a learning that will overcome task interference i.e. both congruent and incongruent testing will reveal automatic tendencies. Such position is also supported through Anderson (1992) who states that automatic skills hold less interference with concurrent tasks and less interfered with by a concurrent task; thus if e.g. automaticity is developed in the skill of naming the colour of a word rather than the word itself then this will be less effected by the match/mismatch of the Stroop test stimulus.

Given the length of time in existence and notoriety of the Stroop test, much work has been done upon the exploration of physiological measurement (of particular interest here in relation to EEG recordings) during such test across a wide range of conditions. Such examples include Schack et al. (1999) who revealed a higher degree of coherence across the frontal lobe of the brain (in the frequency bandwidth of 13-20Hz) during incongruent stimulus in comparison to congruent stimulus in a study of ten participants; suggesting a greater and unified workload in the frontal lobe during the processing of mismatch stimulus. Similarly West and Bell (1997) found a greater magnitude of activity (in the lateral frontal and parietal regions of the brain) in the processing of mismatched Stroop test in older (healthy) adults in comparison to younger (healthy) adults – yet found similar workload during congruent stimulus, supporting the hypothesis that the anterior attention system is more effected by increasing age than the posterior attention system.

Given the previously described position that the Stroop test may become a learned automatic response (both congruent and incongruent stimulus) and overcome with contextual manipulation such as setting a task to ignore additional stimulus (Saling and Phillips, 2007), and the wealth of existent research on the test and its physiological correlations the Stroop test is here used as a conditional stimulus for learning as opposed to testing congruent/incongruent effects.

The Stroop test informed two conditions - one where participants were instructed to provide the colour of the word (e.g. Blue would require an answer of Red); and a second reverse Stroop where participants were instructed to provide the word itself and not the colour it is presented in (e.g. Blue would require an answer of Blue). To ensure consistency across conditions there was four potential answers (one correct per test) displayed in a fixed location across the bottom of the display that corresponded to the physical buttons for answer input. Sixteen stimuli were randomized in presentation across 200 tests per condition. It should be noted that all participants reported the ability to recognize and distinguish the colours presented prior to testing. Example of a typical test for Condition 2 and 3 can be found in figure 2.4 below.

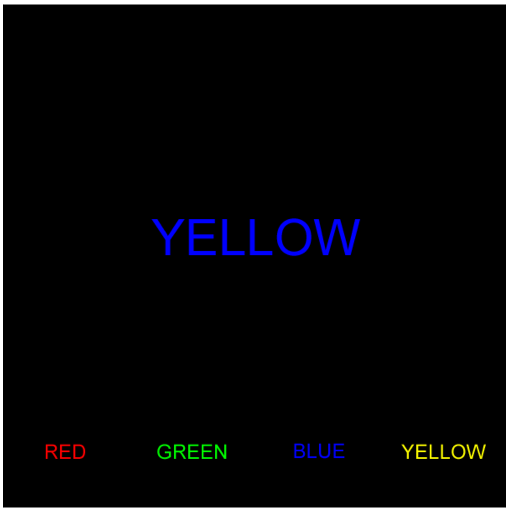


Figure 2.4; Showing a typical test for the Stroop Colour (Blue) and Word (Yellow) conditions.

2.3.4: Condition 4 and 5 (Stroop Arrow (Direction) and Reversed Stroop Arrow (Position)):

The fourth and fifth condition presented is an adaptation of the Stroop test that removes the linguistic portion. These conditions are an adaptation of two variants of the Stoop test, the Spatial Orientation Stroop test (Wühr, 2007), and the Eriksen Flanker Task (Eriksen and Eriksen, 1974). To overcome the linguistic portion of the traditional Stroop test, these conditions draw upon a spatial reasoning using arrow direction and their relationship to a central point. The arrows point in four directions (Left, Right, Up and Down) and are displayed around a centre marker (a red square) that indicates their position. A congruent stimulus here would be e.g. an Up arrow displayed above the centre point, where as an incongruent stimulus might display e.g. a Right pointing arrow positioned to the left of the centre marker. As with the previously described conditions four answer options were provided in a fixed location (i.e. did not alter cross testing/condition) along the bottom of the screen in relation to the physical input buttons. The two conditions consisted of variants of this test; one condition would require participants provide the arrows direction (e.g. below (figure 2.5) would be an answer of Left); and another 'reverse' equivalent where participants would provide the arrows position (e.g. below (figure 2.5)) would be an answer of Up). As such, these two conditions are comparable to the adaptation of the traditional Stroop test (described above), both in the number of potential stimuli and answer, and the interference upon task; yet differ in the mechanisms used to complete i.e., non-linguistic, non-colour dependent, symbolic matching, spatial reasoning.

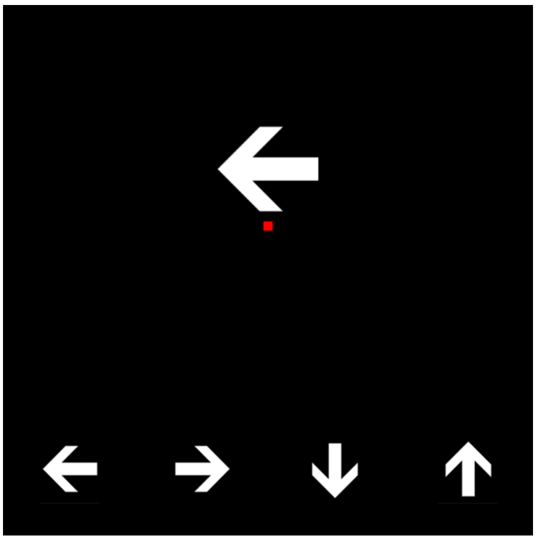


Figure 2.5: Showing a typical test for the Stroop Arrow position (Up) and direction (Left) conditions.

2.3.5: Condition 6 & 7 (Fixed Clock Face and Rotating Clock Face):

As previously described (Chapter 1.12.2) interfaces are often described with terms such as intuitive. The use of the term intuitive in this context, describes a specific form of “familiar” (Blackler, Popovic, and Mahar, 2010; Raskin, 1994), in that a person “knows” how to interact (toward a specific goal) without conscious effort. This is achieved through drawing upon previously gained knowledge and experience (enacted as “implicit memory” (Blackler, Popovic, and Mahar, 2010)). This sub-conscious processing of information as an “intuitive interaction” (Blackler, Popovic, and Mahar, 2010) and can be understood as “*knowing without reasoning or conscious processes*” (p379, Sinclair, 2010). One such example of this might be found when viewing an (or digital reproduction of) analogue clock (Figure 2.6 below). As noted by Norman (p249, 2013), through a standardization of the design of a clock we can confidently read a vast array of such clocks. This standardization states that the (normal) clock face will display the time for twelve hours of a day (twenty four when doubled) – represented by a shorter ‘hour hand’, the same clock face (often) will display a sixty minute / hour representation where one full rotation equals an hour and each of the 12 segments from the previous hour will equal five minutes – represented by a longer ‘minute hand’, and some may have a second hand following the same format as the ‘minute hand’ though for seconds (e.g. Figure 2.6 ‘left’ below). So effective and familiar is this standardization that many clocks may use Roman numerals to depict the hours and still many people can read the time as being e.g. twenty-three minutes past one (e.g. Figure 2.6 ‘middle’ above), though they are unfamiliar to reading numerals in such form. However, we can understand the clock-face as an intuitive interface as even when the numbers are removed, as with many clocks and watches (e.g. Figure 2.6 ‘right’ above), we can still make an approximation of the time; we draw upon our implicit memory of clock faces and know how to achieve the goal of telling the time without considerable conscious effort through drawing upon previously gained knowledge and experience; i.e. we know that 12 hour is at the top and six at the bottom.

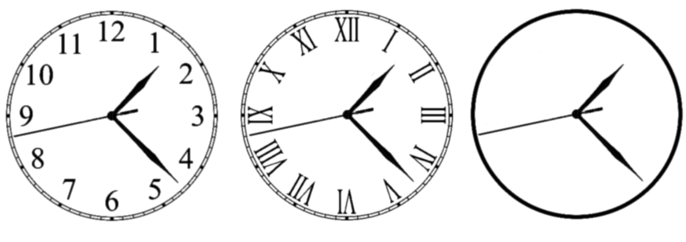
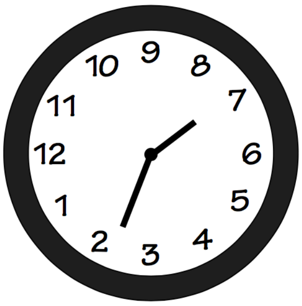


Figure 2.6: clock, left - numeric, middle - Roman numeral, right – blank face.

This is not strictly an ‘intuitive’ interaction as we might consider the term in commonplace usage, i.e. we are not born with clock reading abilities as we are with holding our breath when being submerged under water. However, the familiarity to the clock face allows us to ‘intuitively’ know it, with minor amendments to the rules of how clocks behave removes such intuitiveness (for those used to the current standardization) as noted by Norman in his demonstration of “The Nonstandard Clock” (Figure 2.7 below):



Fiure 2.7. Norman's Nonstandard Clock, (p249, Norman, 2013)

"What time is it? This clock is just as logical as the standard one, except the hands move in the opposite direction and "12" is not in its usual place. Same logic, though. So why is it so difficult to read? What time is being displayed?" (p249, Norman, 2013)

It is this widespread familiarity with analogue clock face's that informed the final two conditions of the study. Condition six presented participants with an analogue clock face in a standardized format (i.e. with the twelfth hour at the top). Participants were presented with four options for answer along the bottom of the display that corresponded to the physical input buttons. Each test in this condition would randomly generate a time to be displayed on the clock face with only one of the matching the time in a twelve hour numeric format displaying an hour and minute (in five minute increments). For example, in figure 2.8 (following) the correct answer would be the furthest right – 3:55. As the number of potential stimulus was randomly drawn from a pool of 144 for each of the 200 tests the answers along bottom would also vary in their display (i.e. each test would produce four new potential answers). It was felt that this would add an additional processing 'step' in the test and reduce the capacity for the process of solving the test becoming automatic. The final condition was identical to condition six with one additional factor to decrease to the potential for the task to become automatic.

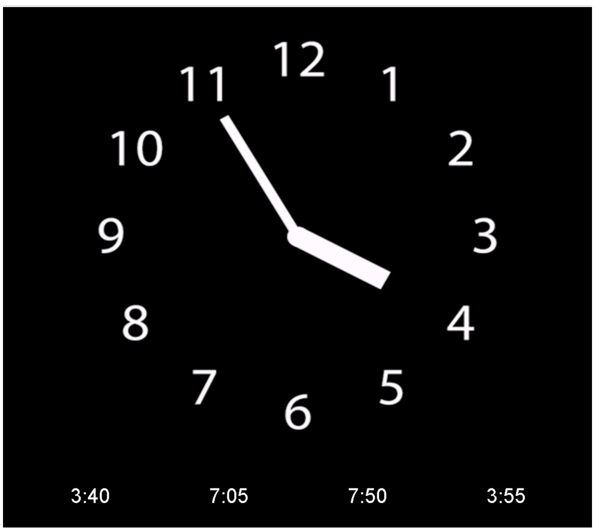


Figure 2.8; Showing a typical test for the Fixed Clock condition.

Inspired by Norman's Nonstandard Clock (Norman, 2013), the final condition removed the intuitiveness of how one might traditionally read a clock face. For this condition upon each test the clock would rotate to a randomized orientation e.g. as with figure 2.9 the orientation for this test placed two at the normal position for twelve. Aside from this difference the clock would read normally (i.e. not as with Norman's Nonstandard clock which moved counter-clockwise), e.g. the correct answer for the test figure 2.9 would be 9:10 (where as a standard orientation would read 7:00). It was hypothesized that this condition would hold the least capacity for the test becoming automatic (of all the condition in the study) as the variation of the clock face and answer position would require an overcoming of familiarization with clock faces.

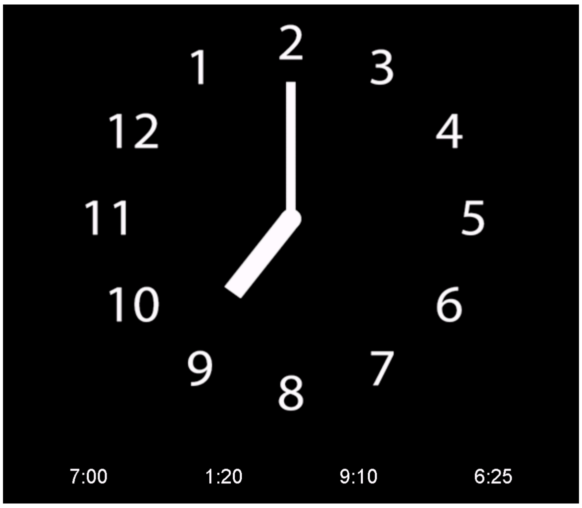


Figure 2.9: Showing a typical test for the Fixed Clock condition.

2.4: Data Collation

As previously described the study described here adopts a neurophenomenological methodology (Varela, 1996; Lutz, 2002; Fazelpour and Thompson, 2015) in seeking to better understand and measure Mindful and Mindlessness states during interaction. Here the neuro-phenomenological methodology employed uses phenomenological information (first-person reporting upon subjective experience – as subjective '*A posteriori*' data) to support and understand the relationship and measurement of empirical physiological information (as objective '*A priori*' data).

2.4.1: Subjective data

Questionnaire

Following each condition participants were asked to complete a brief questionnaire (informed by the preliminary findings of section 1) based on the condition they had just completed. Answers were given through a five-point Likert-type scale (from "Agree completely" to "Disagree completely"), and had option to provide comment following each statement (participants were informed this was entirely optional and not constrained to a particular form of comment). Participants were informed that they may skip a statement or discuss it following completion of the questionnaire. The statements provided were:

- I was intentionally aware of my thoughts and feelings
- My mind wandered off and I was easily distracted
- I knew the correct answer and made my choice quickly without needing to think too much
- I paid attention to the environment around me
- I was completely absorbed in the display/audio; so that all my attention was focused upon it
- I found myself watching/listening to the display/audio but thinking of something else at the same time

* Space to leave broader additional comments

See Appendix 2.3

Open-ended Interview

To gain a broader understanding of the participants subjective experience during each condition a brief open-ended interview was conducted following completion of the questionnaire (described above). This was intended to be a responsive probe to participant answers and thoughts, and explore themes as they arise and provide deeper enquiry into topics of discussion that were unpredictable prior to study. There were however several prompting questions to initiate conversation with focus upon the participants attention and awareness, perception of time, thoughts and feelings, reaction to pop-ups, perception of challenge (ease of completion of test), mind wandering, and any strategies they employed or developed through the condition. As this line of enquiry varied between participants (being responsive to their answers and points raised) the specific prompts and questions also varied yet followed the previously outlined themes.

2.4.2: Objective data

Interaction metrics

As the interaction of the broader study occurs with digital technologies, objective data can be easily gathered that relates specifically to metrics of the interaction occurring. Such metrics include; time between a condition stimulus being shown and answer, correct v's wrong answers, when a pop-up stimulus is shown (and time to answer) and if the answer provided changed.

Video Analysis

Participants consented to video recording of the study. While video analysis facilitates analysis following a condition i.e. of the open-ended interview, it additionally allows for analysis of the participant during interaction. In this study video analysis of the participant *during* interaction provided a metric of *hesitation*. A hesitation here is understood as an act of altering an action prior to a final choice in action. Here a hesitation was regarded as a self-induced (i.e. by the participant) interruption to prevent an action (i.e. provide answer to stimulus) or change an answer. While such events cannot be linked to specific time points (such as with the digitally produced or recorded events) they offer additional insight to the subjective aspects of the interaction and provide stimulus test numbers where an event of reflection might have occurred.

EEG (Electroencephalography – Brain Activity)

While (as previously stated) this thesis does not claim consciousness to be a product of brain activity; there is strong evidence and accounts of correlation between conscious and/or sub-conscious events and brain activity (e.g Baars, 1993, 1996, 1997, 2003; Chalmers, 1995; Varela, 1996; Århem and Liljenström, 1997; Saling and Phillips, 2007; Cosmelli, Lachaux and Thompson, 2007; Shanahan, 2010; Fazelpour and Thompson, 2015). Electroencephalography (EEG) is a process of recording brain activity as a "non-invasive" measurement in that it does not break the skin of the subject and does not enter the body in anyway.

To understand how EEG works and what it is measuring it is important to understand some fundamental aspects of the brains physiology; this can be found in appendix 2.4 *Brain Activity, EEG and QEEG*.

The EEG data was captured using an Emotiv EPOC EEG neuroheadset[10]. The EEG headset provides 14 channels (electrodes) with a sampling rate of 128Hz per channel; and so a range of 1-64Hz measurement following FFT. As noted by Debener et al. (2012) the Emotiv EPOC provides an affordable and accessible EEG hardware device, though it should be noted that the standard saline pads (for conductivity of electrical current from the scalp to the electrodes) reduces signal quality, and the placement of electrodes is approximate (i.e. does not adjust to compensate for head shape and size). As with Debener et al. (2012) these limitations were overcome through the use of a third-party stretchable EEG cap (Mitsar medical MCSCap[11]) that when placed over a participant head provides correct 10/20 placements of electrodes. To allow for mating the EPOC to the MCSCap sintered Ag\AgCl electrodes were connected to the EPOC electrode fittings using silver solder (for reduced signal noise). EEG signals were validated through comparison of the adapted headcap and original saline electrodes, assessing signal amplitude, noise, and original software signal analysis. Through the use of this cap custom electrode positioning was allowed that moved beyond the EPOC standard position, in addition to a reduced sensitivity to artifacts in the EEG signal from body movements. The final 12[12] electrode positions can be found in figure 2.10.

EEG raw data recording was performed using the Emotiv Test Bench software (v1.5.1.2). Communication between the custom software (controlling stimulus, input, and interaction metrics) and Emotiv Test Bench was facilitated using Eterlogic VSPE[13], a virtual serial port emulator. Events (such as start of study, end of study, stimulus shown) were sent form the custom software through the serial port emulator and to the Test Bench software so that markers could be used in data analysis off-line (i.e. after the study).

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[10] https://www.emotiv.com/product/emotiv-epoc-14-channel-mobile-eeg/
[11] http://www.mitsar-medical.com/eeg-accessories/
[12] While the MCSCap provided correct placement of electrodes, due to differing head shapes and participants hair, several of the participants had intermittent 'noisy' EEG signals from the placement of electrodes at positions O1 and O2. For reasons of cross condition comparability and to prevent erroneous data effecting evaluation, these electrode recordings were removed from the data following recording and prior to final data processing.
[13] http://www.eterlogic.com/Products.VSPE.html

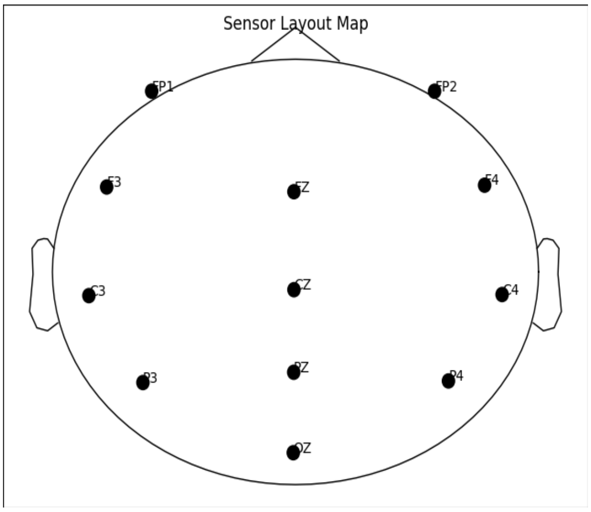

Figure 2.10: EEG electrode positioning used in analysis: Fp1&2; F3,z,4; C3,z,4; P3,z,4; Oz. Reference electrodes (CMS and DRL) were connected to the left and right ears respectively via sintered Ag\AgCl electrodes in a spring clamp. Ten20 conductive paste was used for skin-electrode conductivity.

EEG data, following each condition testing, was saved and exported in .EDF format[14]; a common exchange file format for multi-channel biometric recordings. Due to the nature of EEG and the sensitivity of the electrodes, it is common that artifacts from body movement, eye-blinks, speech etc. produce spikes in the recording. To improve signal quality the EDF recordings were imported to EEGLab[15] extension of MATLAB (Version R2013b), and 'cleaned' using the clean_rawdata[16] toolbox plugin. This plugin utilized Artifact Subspace Reconstruction to reconstruct missing data using a spatial mixing matrix (with assumed volume conduction). To facilitate this, prior to each condition participants were asked to remain still for two minutes to provide a baseline of clean data from which calibration would occur; an example of this processes effect can be seen in figure 2.11. While performing artifact rejection two electrodes (O1 and O2) showed intermittent excessive artifacts (i.e. signal amplitudes excessive of brain activity from muscle and head movement) during several recordings of conditions and so were removed for all participants and all conditions (with a new artifact rejection being performed on the raw/ original data excluding O1 and O2 electrodes). The positions O1 and O2 are typically

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[14] http://www.edfplus.info
[15] https://sccn.ucsd.edu/eeglab/
[16] http://sccn.ucsd.edu/eeglab/plugins/ASR.pdf

utilised in the understanding of visual association processing of the secondary visual cortex. The data from those electrodes are excluded from dataset processing and analysis to prevent erroneous data effecting evaluation and allow cross condition/participant comparability. Following artifact rejection the raw EEG files were exported and analysed using MNE package for Python (v2.7) (Gramfort et. al., 2013; Gramfort et. al., 2014). Specific methods of analysis are discussed in greater length in the results chapter.

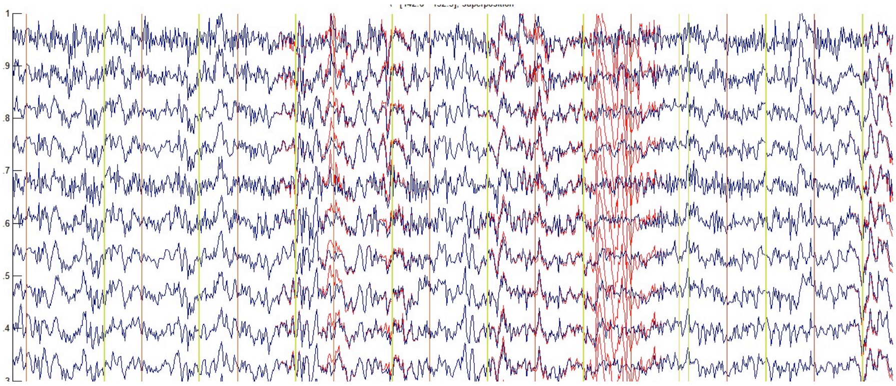

Figure 2.11: Artifact Rejection can be seen in red (large spikes in the raw EEG signal), these deviate from normal (blue) EEG signal. Corrected signal (used for analysis) can be seen in blue (i.e. an EEG signal with large contaminate artifacts caused by bodily movements removed).

<u>Eye Tracking and Pupil Dilation metrics:</u>

To compliment the EEG data, eye tracking and pupil metrics were additionally captured. As noted by Liversedge and Findlay (2000), saccadic eye movements (how the eye move between fixation on different objects) can provide indication toward cognitive processes; likewise, Kahneman (1973) found strong correlation between pupil size and cognitive loading. Eye-gaze and pupilometry were captured using a Tobii TX300 system capturing both eye gaze position and pupil dilation (at 300Hz sampling frequency of both eyes). Eye data was recorded using the Tobii Studio Professional v3.2 software[17], which exported eye-tracking data into a CSV format for analysis in Python (v2.7). Participants performed a 9-point calibration of the eye-tracker prior to each condition. Data was exported using the recommended settings of the Tobii Studio Pro software, specifically applying the Tobii Fixation filter and saccade analysis (Olsson, 2007; Komogortsev et al. 2010). Specific methods of analysis are discussed in greater length in the following chapters.

[17] http://www.tobiipro.com/product-listing/tobii-pro-tx300/

2.5: Results and Analysis – Interaction Metrics and Questionnaire

2.5.1: Interaction Metrics – Time to Answer

Basic metrics of interaction were captured during each condition. Figure 2.12 shows the average (across participants) answer time per test per condition for the initial 25 test in each condition (Figure 2.13 – showing the same data minus the two Clock Face conditions). While there were 200 tests per condition, evidence of learning can be seen within the first 25 responses. It can be seen across the data collected for each of the conditions that the speed in which the ability to perform the task plateaued for many of the conditions following an initial learning period (e.g. the first 10 test stimulus). However, this true to a lesser extent of the Clock Fixed condition and even lesser to the Clock Rotate (showing erratic timings across the whole condition). This is unsurprising as it was hypothesized that these two conditions would limit the degree to which automaticity can occur. This observation follows the position upon Automaticity and Intuition (Section 1.12.2) being most apparent in the speed at which meaning or significance occurs (being sub-/ non-conscious) as opposed to slower more analytical (predominantly conscious and reflective-conscious) processes (Baars, 1993; Blackler, Popovic, and Mahar, 2010). That is to say, the conditions that were predicted to facilitate automaticity (Mindlessness) allowed for a 'learning' period where the action became sub-conscious / non-reflective where there was an increase in speed of completion.

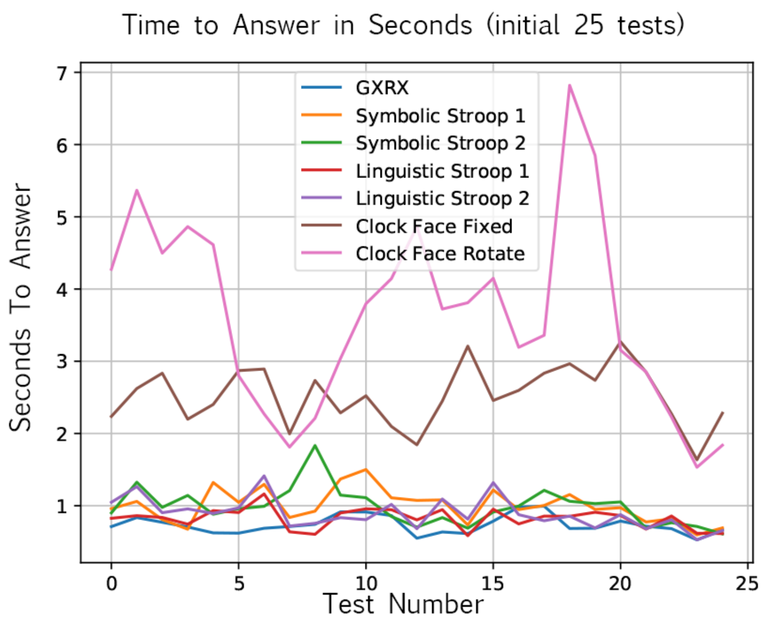

Figure 2.12; average (across participants) answer time per test per condition for the initial 25 tests in each condition

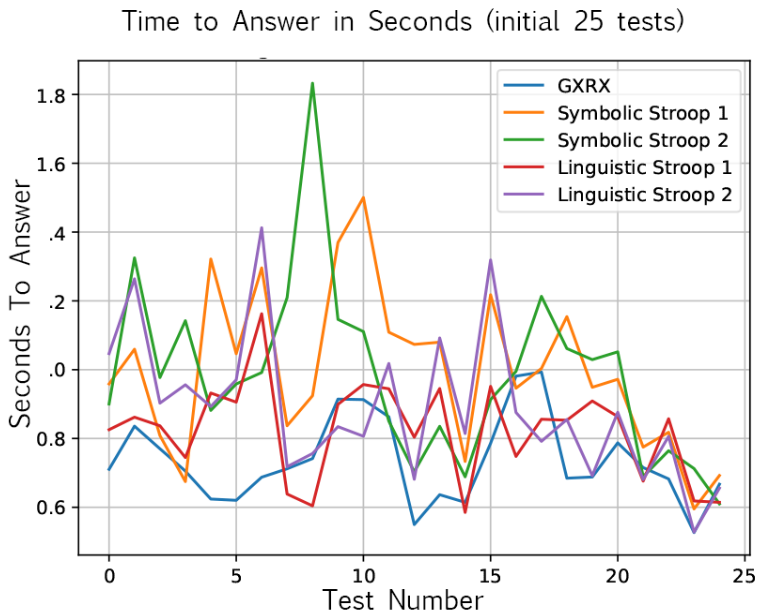

Figure 2.13; average (across participants) answer time per test per condition for the initial 25 tests in each condition excluding the two Clock based conditions

The utility of "time to answer" as a method for the analysis of Mindful or Mindless interactions is small when viewed in this broader understanding; however, as will be shown in the following chapters when looking into specific events (such as pop-ups or following wrong answers) "time to answer" can provide unobtrusive insight to potentially Mindful moments.

2.5.2: Interaction Metrics – Time to Answer (Pop-Up Stimulus)

This learning period of how to answer to a stimulus was most evident when viewing the 'Pop-Up' answer time (Figure 2.14 below). While there is some non-conforming data points in Set 1, 4, and 5 first Pop-Up's; this shows a gradual quickening across each of the repeated exposures.

Pop-Up set[18] 1's first Pop-Up was dramatically larger than the additional sets as one participant (Participant 1) did not know how to respond. While they had been

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[18] Pop up Set's refer to the order in which Pop-ups were presented e.g. Set 1 (1 set of 5 Pop-Ups) being for the first condition, Set 2 (1 set of 5 Pop-Ups) being for the second condition.

informed of the Pop-Ups and how to respond (and acknowledged this) during the first condition they had forgotten. However, other participants, remembering how to resolve/respond to Pop-Ups, still took longest to answer the initial Pop-Up for the first set in comparison to the later Pop-Ups sets. During first Pop-Up in the 4th set of Pop-Ups participant 10 reported confusion over the event of the Pop-Up and why it occurred: "*I think I made a mistake and it asked me for a different one, I'm not sure if that happened… of if its just… I couldn't tell you…*" (Participant 10, interview 4). Consequently participant 10 took considerably longer to respond to the Pop-Up. Similarly participant 9 used the first Pop-Up in the 5th set of Pop-Ups to try and remember if they should change their answer, to "think" if they were correct initially and realized that they were.

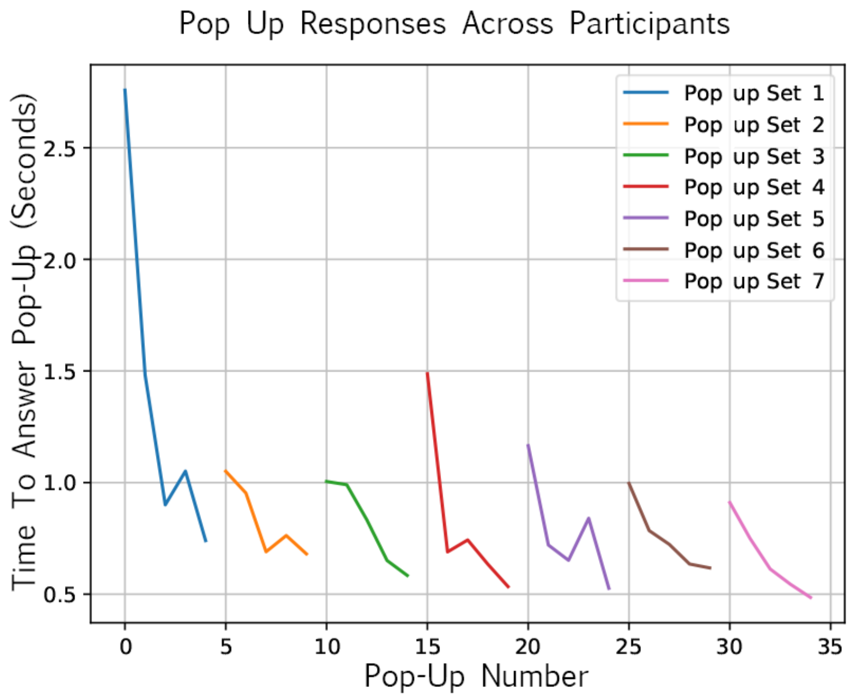

Figure 2.14: Pop up Set's refer to the order in which Pop-ups were presented e.g. Set_1 (1 set of 5 Pop-Ups) being for the first condition. Due to the differing order of conditions these are presented in the order in which Pop-Ups occurred (e.g. condition A, condition B etc.), rather than in relation to a condition type (e.g. Linguistic Stroop, Symbolic Stroop etc.).

As can be seen the "time to answer" of pop-ups reveals a trend of reducing. This might be integrated into common place systems (e.g. that contain system alerts) to evaluate if the user of the system has automatically responded or has become habitualised to the message form. Consequently this method of analysis holds usefulness in providing points of comparison to physiological data and potentially might be integrated into systems as a sole factor in understanding Mindfulness and Mindlessness during interaction with technologies.

2.5.3: Interaction Metrics – Time to Answer (Wrong Answers and Hesitations)

While the previous Chapter's (2.5.1 and 2.5.2) has looked at the time to provide answer to a stimulus for a condition (or 'Pop-Up'), it is also important to look at the impact of hesitations and wrong answers (or rather the subsequent wrong alert) on following test stimulus. Table 2.2 below provides an overview of the number of wrong answers and hesitations as an average per-participant per-condition.

Condition	*Average No. Wrong Answers per Participant*	*Average No. Hesitations per Participant*
Green X O - Red X O	*4.8*	*28.0*
Linguistic Stroop 1	*4.4*	*38.7*
Linguistic Stroop 2	*9.4*	*39.5*
Symbolic Stroop 1	*9.5*	*31.6*
Symbolic Stroop 2	*11.8*	*35.1*
Clock Face Fixed	*13.8*	*31.6*
Clock Face Rotate	*23.9*	*37.1*

Table 2.2; overview of the number of wrong answers and hesitations as an average per-participant per-condition.

As can be seen in figure 2.15 (below) both hesitation and wrong answers had effect on the time to answer following tests. Figure 2.15 (below) shows the averages for all wrong answers and hesitations across all participants and conditions. It should be noted that the 'Wrong' answer times are substantially higher than 'Hesitation' due to a higher number of wrong answers occurring in the conditions that took longer in general to answer in comparison to the conditions with faster and easier solutions (as can be seen in table 2.2 above). Where the hesitations occurred in a more generalizable number across conditions (thus lowering the average times).

As can be seen in figure 2.15 below, 'Wrong' answers highly influenced the answer time to the following stimulus (i.e. '+1','+2'). This can be seen as an increasing following the '0' test (the test that was answered incorrectly). As previously described this increase in answering time may be caused by a reflective process interrupting the sub-conscious process of performing the condition; the wrong alert sound interrupting the on-going process and invoking a breakdown. However, 'Hesitations' additionally effected the following answering time. While the test incurring the hesitation (understandably) took longer, the proceeding tests ('+1','+2') additionally required more time in comparison to the preceding tests.

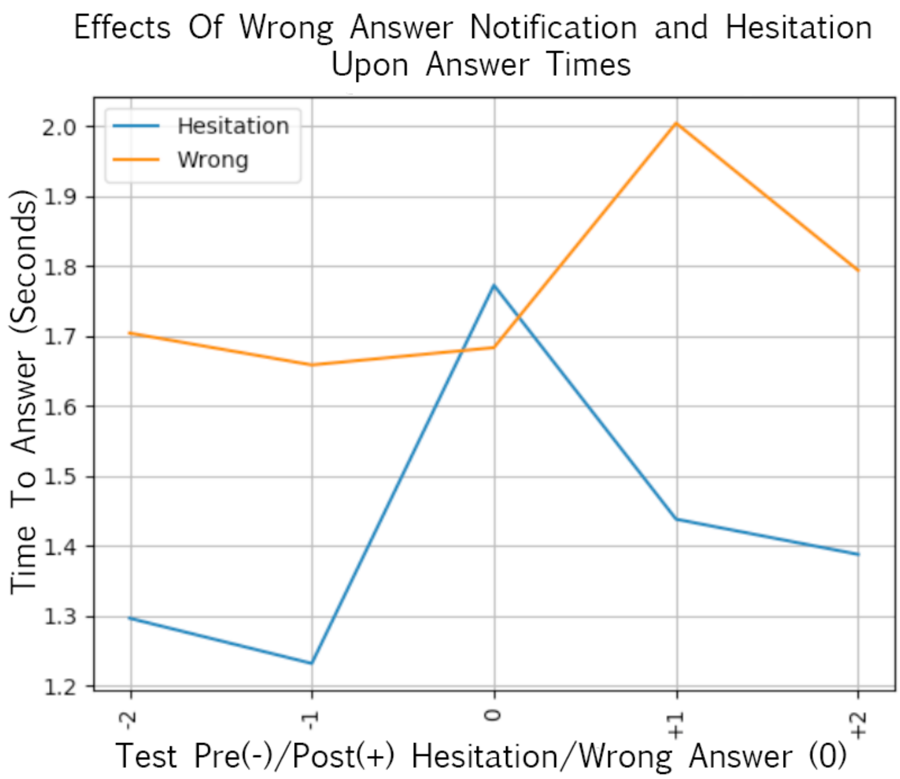

Figure 2.15: Effect of Wrong answers and Hesitations on proceeding tests answer times.

Wrong answer or hesitation toward stimulus occurs at 0. Increase in response time in following two stimulus can be seen following (+1, and +2) in comparison to preceding stimulus responses (-1, and -2).

The effect of 'Wrong' and 'Hesitations' on the proceeding answer times suggests a degree of reflectivity or preventative / slowing effect upon the less interrupted and 'normal' completion of condition tests. This also warrants their use as points of enquiry and analysis and suggests a utility for future methods.

2.5.4: Questionnaire Data

As previously described following each condition participants were asked to complete a brief questionnaire (See appendix 2.3 for Questionnaire, See appendix 2.5 for questionnaire results). Answers were given through a six-point Likert-type scale (from "Agree completely" to "Disagree completely"), and had option to provide comment following each statement. Scoring ranged from 1 =Agree Completely, to 6 = Disagree Completely.

Questions:

A. I was intentionally aware of my thoughts and feelings. Lower scores indicate Mindfulness
B. My mind wondered off and I was easily distracted. Higher scores indicate Mindfulness
C. I knew the correct answer and made my choice quickly without needing to think too much. Higher scores indicate Mindfulness
D. I paid attention to the environment around me. Lower scores indicate Mindfulness
E. I was completely absorbed in the display/audio; so that all my attention was focused on it. Higher scores indicate Mindfulness
F. I found myself watching/listening to the display/audio but thinking of something else at the same time. Higher scores indicate Mindfulness

Comparison of Conditions

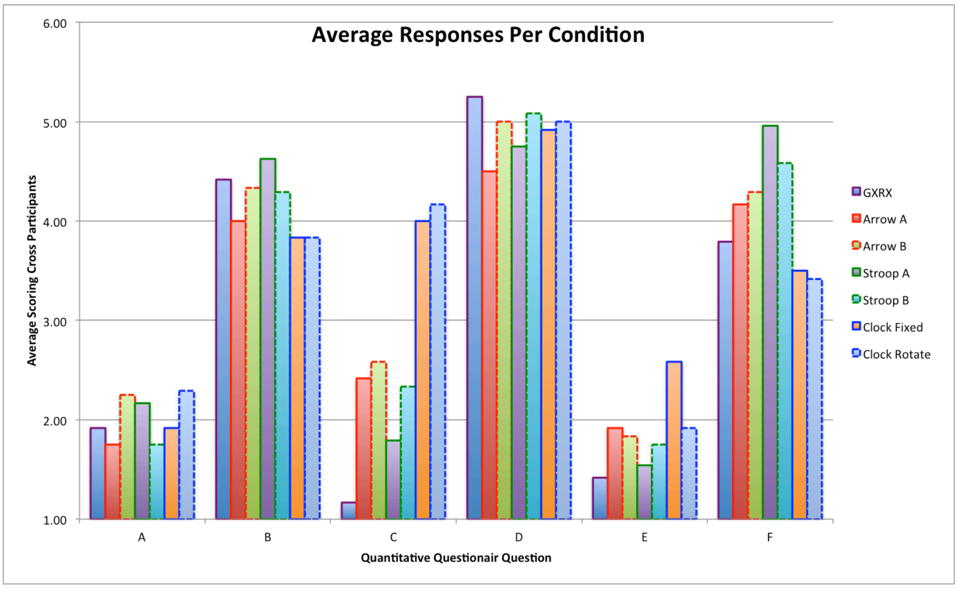

Figure 2.16; Comparison of responses to quantitative questionnaire

When comparing the averages (across participants) of the questionnaire results (figure 2.16 above) the most obvious disparity was found in question C: '*I knew the correct answer and made my choice quickly without needing to think too much*'. This question provided an understanding of the perceived difficulty (how much the participant needed to 'think' of the answer). Not only does this, perhaps unsurprisingly, show the Clock Face conditions being perceived as (by far) the most difficult; but also reveals the Stroop conditions (both linguistic and symbolic based) as holding a greater difficulty when 'reversed' in comparison to the previously learned answer requirements i.e. when the answer required is opposite to the previously learned Stroop condition.

Conversely question F: '*I found myself watching/listening to the display/audio but thinking of something else at the same time*'; showed a diversity across conditions. However, this appears to place the simplest task (Green X O - Red X O) alongside the more difficult Clock Face conditions. This may be explainable through theory of Flow (Csikszentmihalyi, 1992). Csikszentmihalyi (1992) found while observing artists during creation of their works they would devote an intense amount of dedication and immersion to the task, ignoring food, sleep and other distractions; receiving an intrinsic pleasure "reward" from the act of making as opposed to the final outcome (to which they had comparatively little interest). Csikszentmihalyi (1992) proposes that this experience, *Flow*, exists in any tasks that require some form of engagement where there is a balance between possessing the skills needed to achieve a task and the demands of that task (Figure 2.17). Should a challenge outweigh an individuals skillset (i.e. be too difficult) they will experience anxiety; should a task hold little challenge in comparison to the skillset of the individual (i.e. too easy), they will experience boredom.

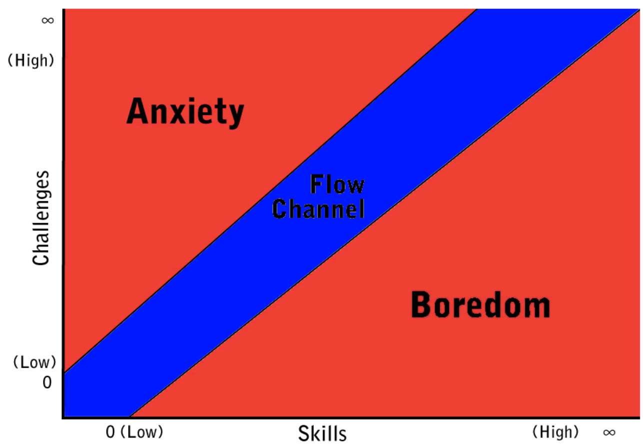

Figure 2.17: Adaptation of an image taken from Flow: Optimal Experience (p74, Csikszentmihalyi, 1992)

Kane et al (2007) note those experiencing boredom often report the related condition of 'mind-wandering', i.e. thinking of unrelated events/thoughts during a specific event/activity. As suggested by Csikszentmihalyi (1992) low challenge tasks require little impetus of flow states. While this explains a lack of focused engagement upon the easier task (Green X O - Red X O); inducing boredom and so facilitating mind wandering, it suggests that the same 'boredom induced mind wandering' state would not be achievable in the more difficult Clock Face conditions. In contradiction to Csikszentmihalyi (1992) understanding of how boredom might arise Acee et al (2010) report on experiences of boredom in under- and over- challenging situations in academic environments, and frame boredom as a multidimensional and situation-dependent construct. Through this it is suggested that while the Clock Face conditions were intended to prevent Mindless engagements, they may also facilitate such experiences (Mindlessness) when the challenge is perceived as too great and induces states of boredom.

2.6: Methods, Results and Analysis - Physiological Measurement

One of the primary aims of this presented study is to pave development of subtle systems for the analysis of Mindful and Mindless states during interactions with technologies. In doing so such systems seek to discriminate Mindful and Mindless from ongoing physiological processes, e.g. motor control, to allow for the evaluation of when the users of interactive systems experience these states and how they may be best augmented or employed.

As previously described (Chapter 1.11), the brain is assumed to be an essential requirement in (human) cognition and consciousness (Anderson 1983, 1992, 1996; Århem and Liljenström, 1997; Ashby, Turner, and Horvitz, 2010; Baars, 1993, 2003; Liljenström, 1994; Shanahan, 2010). It has been very long understood and established that measuring brain activity (e.g. the frequency and amplitude of brainwave data captured via EEG) can reveal aspects of a persons subjective experience. Such findings and understandings suggest EEG providing a suitable modality for the measurement of Mindfulness and Mindlessness.

In compliment of the EEG data capture eye tracking and pupillometry were additionally drawn upon as a data source to better understand how subtle measurements of a person's Mindful or Mindless state during interaction might occur. This is performed through three modalities; saccadic eye movements (how the eye move between fixation on different objects), eye fixations (the eye holding gaze upon a specific location), and pupil dilation (variations in pupil size).

Methods of analysis are described prior to analysis findings, which are reported alongside qualitative interview data to facilitate comparison (Chapter 2.8).

2.6.1: Previous Measurements Of Mindful States

As found by Banquet (1973) subjects invoking states of meditation exhibited a prominent 40Hz or gamma frequency band. Further to this differing meditative states have been observed to invoke activation in differing areas of the brain as Lou et al. (1999) found. Meditative states characterized by detached attention (loss of conscious control or direction of experience) but focusing on different contents-elicited / content-specific activation (i.e. focus toward experience itself as opposed to guiding/directing said experience) were revealed in e.g. higher parietal and superior frontal activation for bodily sensations; and higher occipital and parietal activation during attention toward visual imagery (Lou et al., 1999). However Langer

(1989) found that those practicing transcendental meditation report restful yet alert consciousness and exhibit highly correlated alpha coherence across the frontal regions. However, with the practice of mediation and Mindfulness holding a focus upon attention to experiential stimulus Lehmann et al. (2001) may offer further insights. Lehmann et al. (2001) found gamma frequency range to be present (and may indicate) a focus upon sensory experience. The distinguishing conscious experience is often by a recognized importance of the 40Hz range present both in animals (Gray et. al. 1989) and humans (Singer et al. 1997) when problem solving. Baars et al. (2003) also claim the fronto-parietal cortex to play a role in the abstract aspects of experience such as social, emotional and self-evaluation, and suggest the higher "executive" part of the cortex as looking at and interacting backwards (to where the brain processes sensory information). The claim of Baars et al. (2003) is substantiated by their findings that fronto-parieral metabolism was increased in subjects when experiencing inward reflective moments opposed to outward directed cognitive tasks. In addition to these findings Philippi et al. (2012), Moran et al. (2011) and Mitchell et al. (2005) have found many links to the medial pre-frontal cortex (mPFC) showing strong association with self-referential thoughts and behaviour. However, the medial prefrontal cortex is located between the two hemispheres (right and left) extending from the forehead rearwards, and as such proves difficult to read using EEG within a localized area (and so prevents real-time portable equipment for use in a range of studies).

The measurement of emotional valence, the intrinsic attraction or averseness towards an event or object, has also gained interest in EEG analysis. While this is often referred to as a positive/negative experience (as an emotional state) (Bos, 2006) some have argued that the previous measurements may be better understood in terms of motivational direction (Harmon-Jones, 2003); that, is an approach or withdrawal of attention to stimulus. Consequently, given Mindfulness and Mindlessness' connections with attentive processes it was assumed emotional valence as motivational direction might be used to measure such states. Motivational direction shows itself in EEG studies by an imbalance in the frontal regions of the brain; it is commonly assumed the left hemisphere frontal lobe with raised activity compared to the right is associated with positive/approach behaviours, whereas raised activity in the right frontal hemisphere is associated with negative/withdrawal behaviours. Choppin (2000) however argues that a high level of frontal lobe coherence in alpha frequencies alongside right parietal lobe displaying higher amplitude beta frequency indicates a positive emotional response (and vice-versa). As claimed by Bos (2006) the position that returns the most correct and stable results when measuring valence is the F4-F3 (Frontal lobe) comparison (additionally supported by Niemic, 2002). In a similar vein to emotional valence is the measurement of arousal. Arousal can be broadly described as interest or excitement and manifests as a higher beta amplitude and coherence across the parietal lobe (Fp1-Fp2) (with the addition of lower alpha activity) (Choppin, 2000). However, Bos (2006) reports of a 97.4% accuracy upon measuring beta amplitude from the F3-F4, and Fpz positions. In addition Lehmann et al. (2001) suggest that rhythmic synchronization of gamma activity may represent a focused arousal during tasks and may act as a link between areas in a given network. Alertness and relaxation can be determined by the ratio between beta and alpha frequencies; beta wave dominance indicates alertness and alpha wave dominance is present during relaxation. Given the nature of Mindfulness being an attentive awareness, such perspectives of general alertness in comparison to relaxation were also given value in evaluation.

While performing EEG data analysis a focus toward specific frequency bands and lobes (specifically frontal) as 'markers' for Mindful and Mindless states, as outlined by the previously cited authors (where possible), showed little discernable states or correlation to the interaction data. This is exemplified by Figure 2.18 (below) whereby the participant reported that this condition got easier, and so Frontal amplitude (as per Bos (2006)) would be expected to reduce (though participant reported an event near the middle of the condition where they stopped to think). Figure 2.19, similarly shows inconsistencies as events such as wrong answers and initial hesitations (following a period of no hesitation or wrong answers) provoke an expected increase in Frontal Beta activity (as per Bos (2006)). However, unexpectedly the very first pop-up event in the first condition (a startling event requiring attention) held little or no influence in comparison.

Such dissimilarities in findings may be due to a differing context of study (e.g. Mindful Meditation V's Mindful interactions) and states invoked (e.g. bodily awareness V's contextual). Notably the ambiguity of what 'states' were being measured, exemplified by the many perspectives of specific frequency range and areas of interest, in highly comparative mental states additionally highlights the need for more precise definitions between Mindful, Mindless, attention and awareness; an aim of the first section of this thesis. Frontal lobe activity however was used in comparison to Parietal lobe activity analysis of Flow, engagement, overload and boredom states, specifically at 10/20 position's of Fz and in a frequency range of Theta in comparison to Alpha power at position P4; as described by Ewing, Fairclough and Gilleade (2016) (See: Chapter 2.7.1).

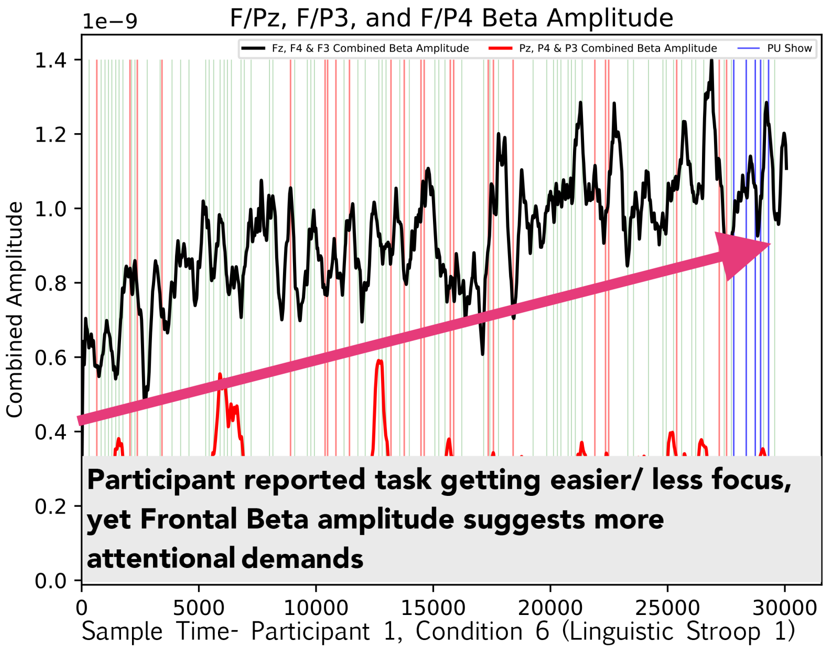

Figure 2.18: Frontal Beta amplitude (Black) rises across condition though based upon participant feedback this would be expected to fall.

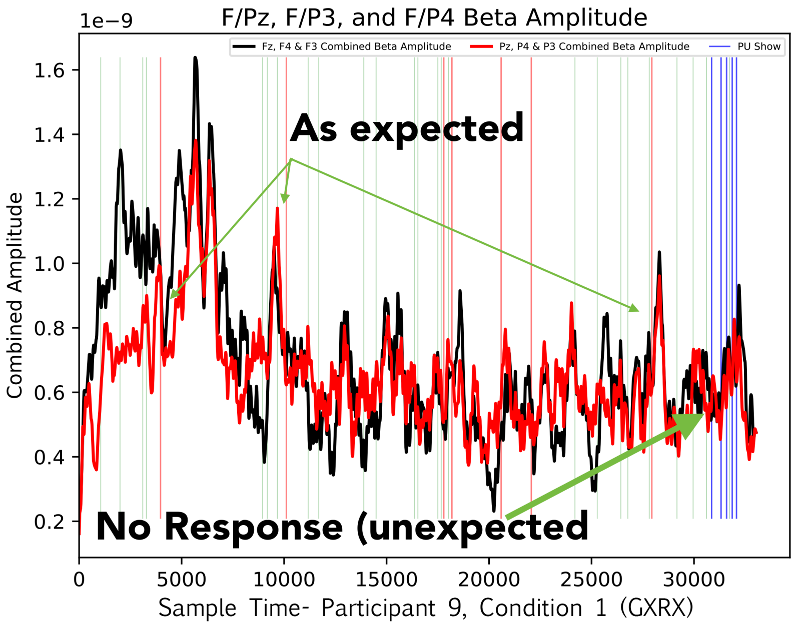

Figure 2.19: Frontal Beta activity (Black) is rapidly increased following events demanding attentional resources as expected (Wrong answer alerts (Red vertical), initial hesitations (Green vertical) following periods lacking wrong answers or hesitations), yet pop-up events (Blue vertical) (reported as surprising/unexpected) hold little comparative influence (though does increase over a longer period).

2.6.2: Event Related Potentials – Measurement of brain activity in relation to specific events

Perhaps of a longer and more established lineage than the previously described states of enquiry is the measure of alertness and awareness via EEG e.g. Loomis, Harvey, and, Hobart, (1937), and Davis et al. (1938) – measuring changes in brain activity during wakeful, drowsiness, and sleep cycles. Jung et al. (1997) propose measuring the EEG spectrum (i.e. QEEG- differing frequencies (cycles) of neuronal firing alongside their amplitude) for real-time information upon workers using autonomous systems (e.g. air traffic controllers) in assessing their attention via real-time analysis in changes to EEG power spectrum. Their focus was toward the analysis of error rates during prolonged activities derived from responding to an auditory stimulus. In their study Jung et al. (1997) held focus toward two electrode positions (Central and Posterior midline (Cz and Pz)). While (as with many EEG study) the results varied across participants (e.g. differences in amplitude and specific frequencies of activity) they recognized a consistent findings within participants. Jung et al. (1997) argue that while many understandings have held particular focus toward specific pre-selected frequencies of EEG power (as previously described); their analysis revealed a more favorable measurement through understanding the full EEG spectrum i.e. power across all frequencies (a position supported by Makeig and Inlow (1993)). Additionally, Jung et al. (1997) findings suggest that understanding responses in brain activity as a whole may provide more reliable measurements when understanding evoked responses; that is to say, view the multiple brain areas response to events as opposed to limited areas of observation.

What is apparent from all of these studies (described above and previously (chapter 1.11)), beyond the potential of EEG in the analysis of subjective experiences, is a marked increase in brain activity during moments of what may be considered Mindfulness in comparison to moments that may indicate Mindlessness. However, the specific regions of this increased activity are evidently up for debate as differing studies place emphasis on differing areas. What is understandable is the substantial role the pre-/frontal regions of the brain hold in directing or alerting toward conscious experiences and events; and a relational broader activity across the brain. As noted by Baars:

> "Conscious perceptual input to [or from] frontal regions might lead to executive interpretation and control, which enables working memory, voluntary action, voluntary selective attention, and accurate report.
> […]
> Thus conscious access to self-systems of the prefrontal cortex might enable the other functions"

(p51, Baars, 2003)

Baars here is specifically describing a *global workspace theory* (1993, 1996, 1997, 2003) (as previously discussed: chapter 1.12.5); a brain architecture of specific information processing comprised of multiple sets of parallel specialist (sub-/non-conscious) processes within a global workspace; which work together and compete to enter dominance/control of the global workspace (as a conscious event). This workspace is then broadcast (Shanahan, 2010) back outward through the network (across the brain) as an orienting of action, attention and awareness toward a specific task. In this way, we may also understand and observe a broader (correlated) brain activity as the recognition and activation of such a global workspace.

In addition to observing areas of activation and the frequency of activity (as a brainwave oscillation), is the measurement of peaks in brain activity following an event of significance i.e. an externally driven stimulus that provokes an noticeable brain response. These are known as *Event Related* (brain) *Potentials* (or ERP's) (Donchin and Coles, 1988); the most common of which is classified as a 'P300' (sometimes referred to as P3) that can be recognized by a positive (P) spike in brain activity approximately 300 milliseconds following a stimulus. As Donchin and Coles (1988) note; though the specific intracranial sources of the ERP's are unknown, and the ensembles of neurons that produce these sources may not be responsible for the broader activity in which the ERP relates; the measurement of ERP's has produced a variety of insights. This is exemplified in P300 amplitude as a marker of cognitive processes such as attention and working memory (Donchin, Kramer, and Wickens, 1986), and of its dysfunction (such as delays in P300) in neurologic and mental disorders that might indicate broader psychological factors such as psychosis and dementia (Linden, 2005). The P300 is often measured with regards to amplitude comparable to ongoing measures, and its amplitude (though measureable in expected events) is greatly magnified during unexpected events (Donchin and Coles, 1988). In Donchin and Coles work (p355, 1988), they propose that we view the P300 as a form of "*context updating*", "[…] *a manifestation of activity occurring whenever one's model of the environment must be revised*". Similarly, Gray et al's (2004) findings reveal that larger amplitude P300 ERP's (most notably in the 10/20 positions Cz,3,4 and Pz,3,4 though additionally in Fz,3,4) provide an index of self-relevant stimulus (e.g. ones own name) in comparison to irrelevant stimulus (e.g. random words).

The most relevant position (of the previously discussed) to this study is the Jung et al. (1997) and the position of Baars' global workspace theory, which suggest that rather than observing specific lobes and frequencies (of brain activity gathered through QEEG) a broader understanding of the brain activity as a whole would provide more useful indication of Mindful awareness during a task; though the interplay of activity between lobes should also be of interest. Likewise, Donchin and Coles work (1988) additionally highlights that observation of the P300 would serve as indication of a potentially Mindful act whereby a revised mental schema of an action is forced into effect and revealed following a causal stimulus. This suggests a valuable source of analysis in understanding specific events during the conditions that may be fixed to a specific time point, namely condition test shows, right and wrong alerts, and, pop-up event shows.

Findings of cross channel average power of brain activity and event related potentials responding to specific events (differing conditions being shown, correct and wrong alerts, and pop-ups) are described in detail in the following.

2.6.3: Findings of Cross Channel Average Power of Brain Activity and Event Related Potentials

The following chapter provides the results of the average power (measured in µV - microvolt) across the 12 electrodes used in the study for the differing conditions and points of analysis (as an average across participants also). As indicated in the works highlighted in chapter 2.6.2 an increase in EEG amplitude often indicates an increase in cognitive loading and effort or experience of significant events. Thus it is expected that events that provoke a higher cognitive demand (or hold higher significance as an event of recognition) will yield higher amplitude of activity (i.e. higher µV). Consequently events with a higher µV might be those draw upon a larger network of brain activity that invoke or indicate a conscious response (as suggested by Århem and Liljenström (1997), Anderson (1983, 1992, 1996) and Baars (1993, 1996, 1997)). Each condition/event is offset to an average of 0 µV (average of the first 500ms pre-event). Each graphs shows a total of 1.5 seconds – 0.5 seconds pre-event and 1 seconds post. This time period is chosen as EEG averages are required to be performed within a fixed timeframe relative to an event (though each test varied in length) and to allow for comparison across conditions and events. Displayed is the average for each test shown (per condition) as an average across all participants (0.0 on the x-axis is the point at which the condition test was shown).

Condition 1 - Green X O – Red X O Event Related Potential (On Test Show)

The following (Fig. 2.20) shows the ERP for the Green X O – Red X O condition. This highlights the P300 amplitude as expected with recognition of a stimulus (as previously described).

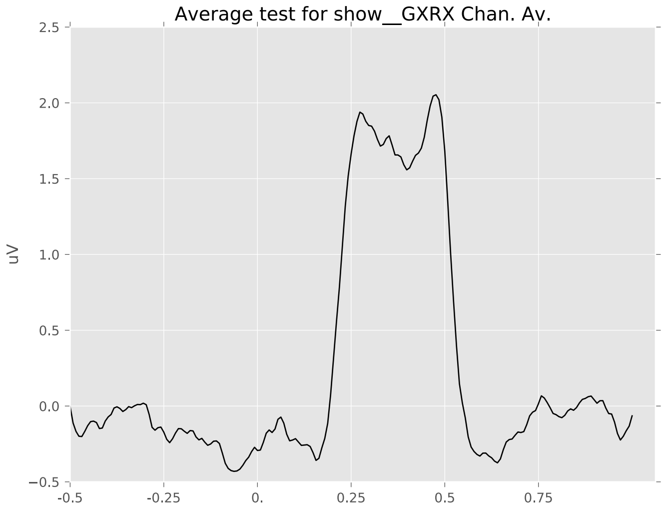

Figure 2.20: 'Green X O – Red X O' cross participant average Event Related Potential. 0 on the x-axis is the point at which the test stimulus was initially shown.

Condition 2 and 3 - Stroop (Word) and Reversed Stroop (Colour) Event Related Potential (On Test Show)

As the two linguistic Stroop conditions were conducted in a mixed order across participants these are presented in the 'First' Stoop presented (STR_1; Figure 2.21) and 'Second' Stroop presented (STR_2, Figure 2.22).

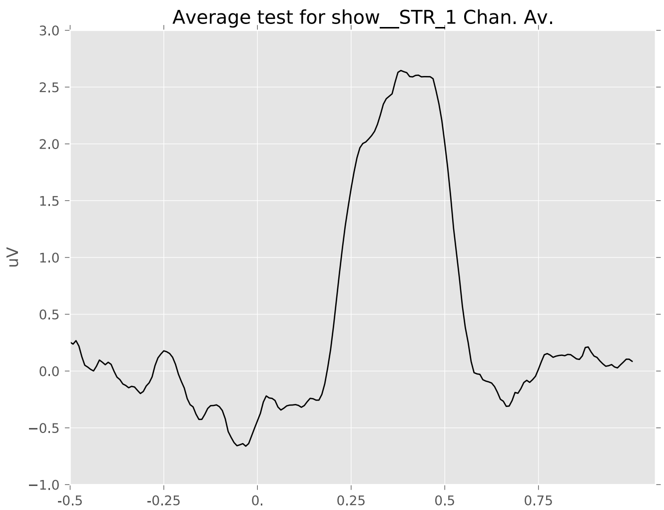

Figure 2.21: 'Linguistic Stroop (First)' cross participant average Event Related Potential. 0 on the x-axis is the point at which the test stimulus was initially shown.

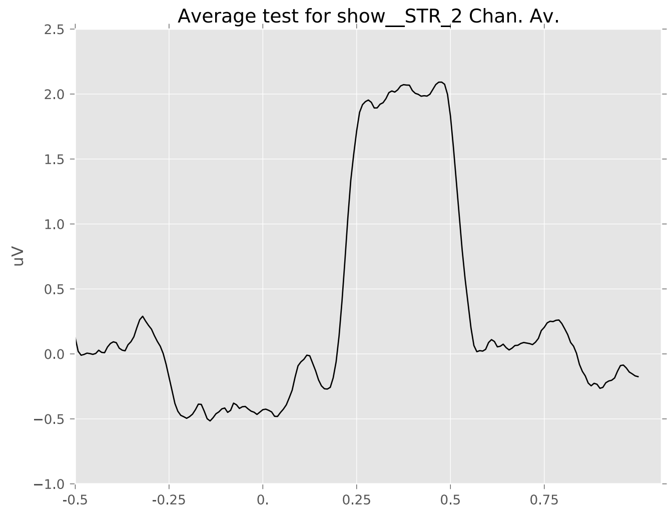

Figure 2.22: 'Linguistic Stroop (Second)' cross participant average Event Related Potential. 0 on the x-axis is the point at which the test stimulus was initially shown.

<u>Condition 4 and 5 - Stroop Arrow (Direction) and Reversed Stroop Arrow (Position) Event Related Potential (On Test Show)</u>

As with the linguistic based Stroop, the two symbolic based Stroop conditions were conducted in a mixed order across participants these are presented in the 'First' Stoop presented (ARR_1; Figure 2.23) and 'Second' Stroop presented (ARR_2, Figure 2.24).

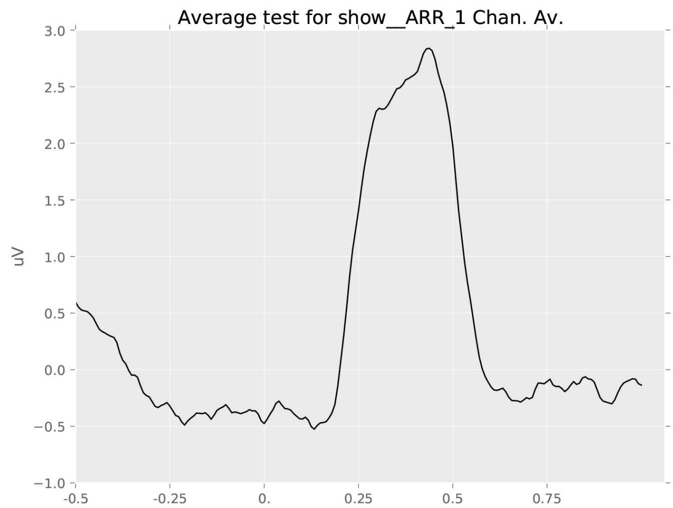

Figure 2.23: 'Spatial Stroop (First)' cross participant average Event Related Potential. 0 on the x-axis is the point at which the test stimulus was initially shown.

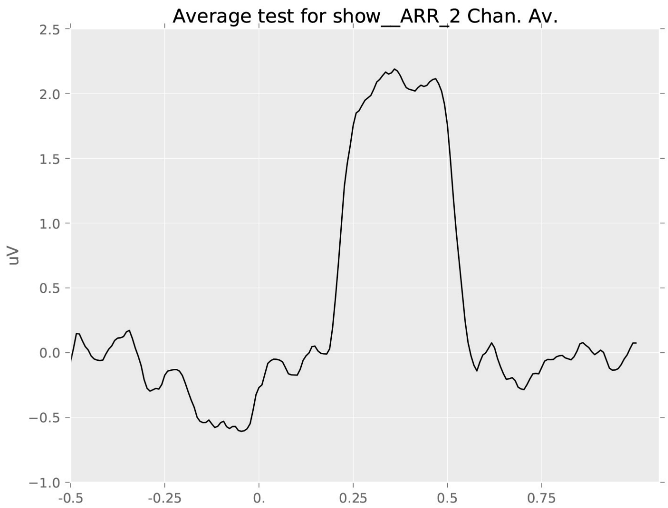

Figure 2.24: 'Spatial Stroop (Second)' cross participant average Event Related Potential. 0 on the x-axis is the point at which the test stimulus was initially shown.

Condition 6 & 7 - Fixed Clock Face and Rotating Clock Face Event Related Potential (On Test Show)

As the Clock Face conditions are largely different (in comparison to the Stroop conditions and their reversal) these are analysed as separate conditions regardless of the order in which they were presented to participants.

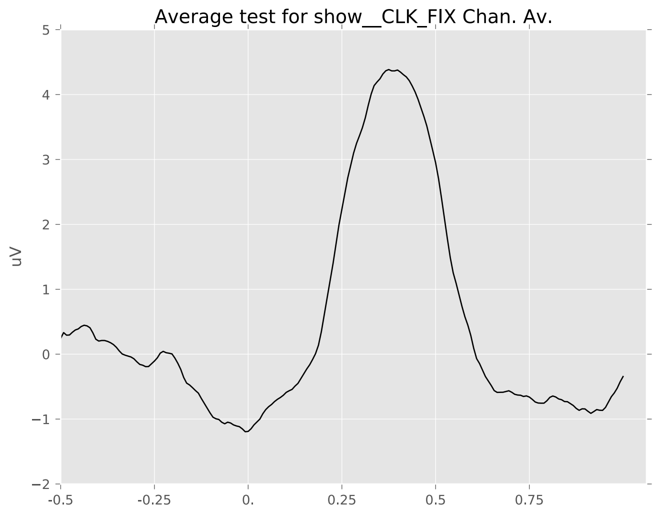

Figure 2.25: 'Fixed Clock Face' condition cross participant average Event Related Potential. 0 on the x-axis is the point at which the test stimulus was initially shown.

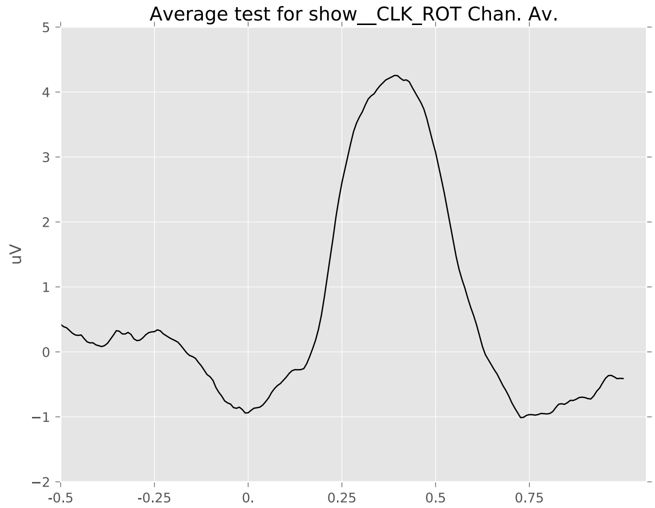

Figure 2.26: 'Rotating Clock Face' cross participant average condition Event Related Potential. 0 on the x-axis is the point at which the test stimulus was initially shown.

Condition Show Event Related Potential Analysis

It can be seen each of the conditions varied in their effect upon a P300 ERP. This is observable in the comparison of 'Green X O – Red X O', with an averaged amplitude of 2μV, the initial Linguistic and Spatial Stroop conditions being of a slightly higher average activation (approximately 2.5μV) in comparison to the reversed conditions (approximately 2μV), and both Clock Face conditions being considerably higher in average amplitude of approximately 4μV. From this it is observable that the 'easier' tasks (i.e. cognitively less demanding) produced a lower widespread activation in comparison to the more demanding Clock Face conditions, producing both higher amplitude and a more gradual return to 0/ negative μV.

2.6.4: Pop-Up and Wrong Answer Alert Event Related Potential (On Pop-Up Show / Wrong Answer Alert Sounding)

While understanding how participants processed the tests shown, it is also of use to observe events that were unexpected and less periodic. It should be noted that the (visually) more irregular ERP for each of the following data, in comparison to the smoother ERPs found in the previously described 'test shows', is a result of a lower number of stimulus (e.g. 5 per Pop-Up 'set' per participant – total 55 ERP's per Pop-Up set) in comparison to 2200 test shows per condition (across participants). This lower number of stimulus recordings holds effect of distorting the averaged ERP through differing latencies of P300.

As the Pop-Up stimulus was intended to observe the development of automatic behaviors (as it was assumed that responses to the Pop-ups would become automatic) these are averaged into sets of pop-ups (i.e. 5 Pop-Ups per condition (set), for 7 conditions). The first set of Pop-Ups encountered is represented by the dark blue line, and the last set is represented by the brightest red line (sets between are varied in colour from blue to red as a gradient between) (0.0 on the x-axis is the point at which the Pop-Up was shown). The influence on participants from the Pop-Ups can be seen in figure 2.27.

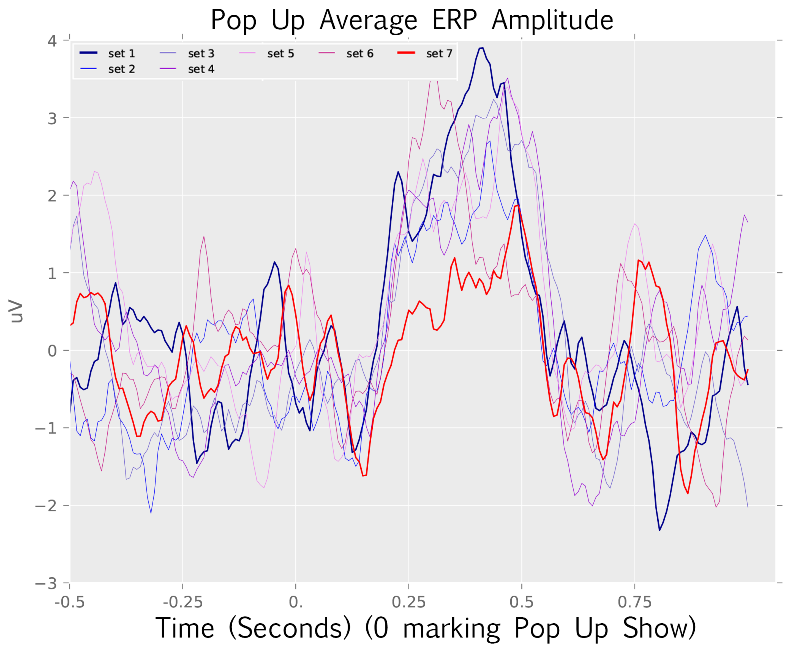

Figure 2.27: 'Pop-Up' Event Related Potential sets. 0 on the x-axis is the point at which the Pop-Up stimulus was shown.

As can be seen in figure 2.27 (and will be explained further in Chapter 2.8 – *Participant Qualitative Interview*) the initial Pop-Ups (the first set in dark Blue) invoked a much higher amplitude ERP and in comparison to the final (seventh - Red). This suggests that initially the Pop-Ups invoked a greater response (cognitive demand) that over time with familiarity was reduced, a position that is supported in the time required to respond to the Pop-Up (as described in Chapter 2.5.2 *Interaction Metrics – Time to Answer (Pop-Up Stimulus).*

It was also of interest to understand how wrong answer notifications and correct answer notifications were experienced over repeated exposures. These are averaged into groups of 10% (i.e. 10% is an average of the first 10% of notifications across participants, 100% is an average of the last 10% of notifications). It is also important to recognize that participants differed in the number of correct : wrong answers across tests and so would not have an equal number of responses in this form of measurement. This would cause discrepancy in the data if calculating the averages as participants would naturally vary in their physiology in how the brain responds to stimulus. That is to say, responses to stimulus in EEG amplitude are participant relative. Consequently if, e.g. Participant 'A' had a far higher number of 'Wrong' notification stimulus and far higher amplitude than other participants that data would skew higher when it was solely their data. To counteract such effect the total number of stimulus measured for the 'Wrong' and 'Correct' notifications was limited per participant to the minimum number stimulus held by a (singular) participant in the group i.e. if P1 had the least total of 'Wrong' stimulus across all seven conditions (e.g. *x*) then both Wrong and Correct stimulus would be limited to *x* for all participants. The first 10% of stimulus (audio notifications) encountered are represented by the dark blue line, and the last set (90% onward) is represented by the brightest red line (stimulus groupings between are varied in colour from blue to red as a gradient).

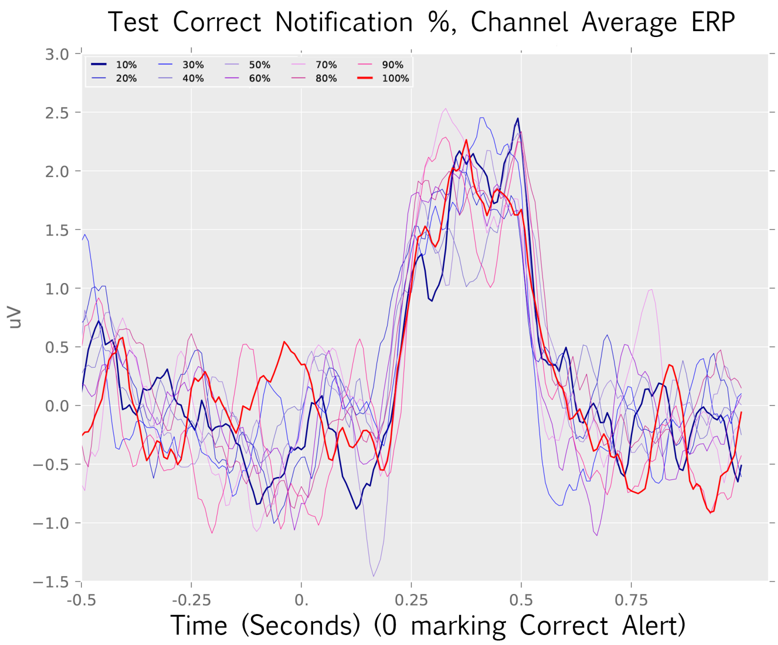

Figure 2.28: 'Correct Answer Alert' Event Related Potential sets. 0 on the x-axis is the point at which the Audio stimulus was sounded.

As can be seen in figure 2.28 (above) the Correct Answer Alerts, while still invoking an ERP held a reasonably consistent response throughout the entire data sets. This highlights little initial response and little change with familiarity.

Differing from the Correct Answer Alerts, the Wrong Answer Alerts (figure 2.29) varied across exposures. Initially there was a large ERP invoked from the auditory stimulus, however, with repeated exposures there was a reducing in the stimulus invoked ERP. This suggests that while initially there was a large cognitive demand and response to the alerts, with familiarity these became less influential upon the participants actions and experience.

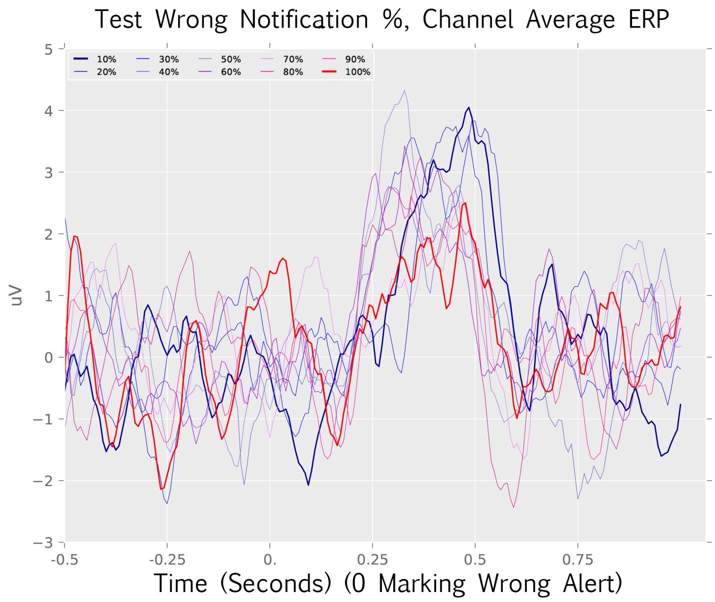

Figure 2.29: 'Wrong Answer Alert' Event Related Potential sets. 0 on the x-axis is the point at which the Audio stimulus was sounded.

2.6.5: Event Related Potential As Measurement in Mindful and Mindless States

It was found through analysis of event related potentials that the amplitude of P300 revealed not only differences in cognitive demands but additionally how these were altered over time with familiarity to the stimulus. The greater amplitude of P300 appeared in the Clock Face conditions upon their showing, and was additionally present during the initial Pop-Ups and Wrong alerts stimulus. However, as was shown, with repeated exposure the evoked reaction to the Pop-Ups and Wrong alerts stimulus (intended to raise attention and awareness) was reduced.

These findings indicate that to measure Mindful and Mindless reactions to specific stimulus one should consider P300 ERPs (and their alteration in amplitude) as indicators to the level of information processing held by an individual. The core of this proposition follows that of Donchin, Kramer, and Wickens, (1986), (Donchin and Coles, 1988), Jung et al. (1997), and Gray et al (2004); in highlighting P300 amplitude as providing an indication of mental loading and attentional resources.

Furthermore the proposition here holds that the measurement of ERP evoked by specific stimulus can additionally indicate events that invoke a shift in the functioning of the individual; realized as a revision of context in response to ones functioning in an environment or activity. Here this framed as a Mindful act whereby a revised mental schema of an action (or environment) is forced into effect and revealed following a specific causal stimulus as stated by Baars' *global workspace theory* (1993, 1996, 1997, 2003); invoking conscious and reflective-conscious access to previously sub-conscious processes as important events are 'broadcast' through the brain (Shanahan, 2010).

2.7: Mental State Changes Across Prolonged Periods Of Time

While it is useful to understand responses to specific events (through observable ERPs), it was also hoped to gain an understanding of the participants mental states as a progression over time in response engaging in the task (as opposed to reaction to a specific event). This was primarily approached through two methods. Firstly, mental states were evaluated as classified by Ewing, Fairclough and Gilleade (2016); consisting of analysis of Flow, Engagement, Boredom, and, Overload. Secondly analysis of the correlation between neural dynamical complexity and the level of consciousness (Mindful/Mindless balance) was performed, following Schartner et al.'s (2015) method for evaluating consciousness variation during induced anesthesia, and findings of Mölle et al (1996) evaluation of dynamic and convergent thinking.

2.7.1: Flow, Boredom, Engagement, Overload

The understanding of Flow states (Csikszentmihalyi, 1992) through EEG during interactions has previously been explored in a number of ways such as; in combination with galvanic skin response - measuring arousal (Kramer, 2016), in combination with pupillometry - understanding peoples immersion and pleasure with online social media (Mauri et al, 2011), and understanding video game player experience (Nacke, Stellmach, and Lindley, 2011). The work of Ewing, Fairclough and Gilleade (2016) explores not only the measurement of states of Flow, but additionally its position relatively in a broader range of mental states during interaction (engagement, overload, and boredom). Their work explores the use of EEG in the real time monitoring of these mental states during an interaction with an adaptive computer game i.e. an interaction that changes its difficulty depending on the broader spectrum of mental states (measured through EEG) of a user of technology. The basis of their position is to provide a framework for analysis of an adaptation of the Motivational Intensity Model (MIM) (Wright, 2008); figure 2.30. Their predictive model understands motivation and engagement with a task as reciprocal toward its difficulty. Ewing, Fairclough and Gilleade's (2016) core premise (as equally Csikszentmihalyi's (1992)), is that through a balance of effort and difficulty a range of differing mental states are activated (specifically of interest here is the immersive qualities that may be offered through such balance). During an interaction, if effort (analogous to skill level) and demand (analogous to challenge level) requirements are low a state of boredom is experienced, as both increase a state of engagement is invoked, this continues to 'Zone' (understood as a state of Flow). However, should demand become too great over the perceived effort (a skills deficit) a state of 'overload' exists, resulting in detachment from the task as can be seen in figure 2.30. This position supports the previously described findings of Acee et al (2010) who suggest that disinterest from interactions and task-oriented experiences of boredom may arise in both under- and over- challenging situations.

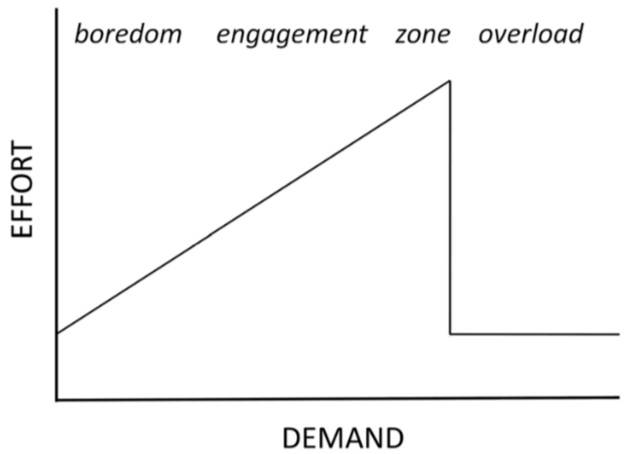

figure 2.30; (p2, Ewing, Fairclough and Gilleade, 2016): Adaptation of Wright (2008) MIM model of user engagement.

Ewing, Fairclough and Gilleade (2016) draw upon two classifiers in their measurement of the four states previously described. Firstly they draw upon frequency bandwidths, Alpha (7.5 – 13Hz) and Theta (4-7Hz) as measures of cortical activation mental effort, as measures of power in these frequency domains indicate manipulations in cognitive demand and motivational incentives. Secondly, from their findings it was shown that Frontal central (Fz) and Parietal (P4) regions were most sensitive to demands during an interaction in addition to being sites responding to incentives/rewards during interactions. In particular was Frontal Theta amplitude in relation to sustained attention and cognitive demands, yet also note that previously unreported was reduced Frontal Theta amplitude observed during periods of cognitive overloading (p7, Ewing, Fairclough and Gilleade, 2016). From this they propose the first classifier as Fz Theta amplitude. The second classifier was drawn from observations of changes in P4 Alpha (specifically upper 10-13Hz) wave amplitude that showed increases relative to interaction demands. From these two positions and bandwidths the four mental state classifiers of 'zone' (Flow), engagements, boredom, and overload can be calculated (Ewing, Fairclough and Gilleade, 2016). The way in which these classifiers indicate the specified states is highlighted in figure 2.31. The classifiers proposed by Ewing, Fairclough and Gilleade, (2016) are additionally supported by the work of Gevins et al (1997) who describe a frontal midline theta increase in magnitude with increased memory load;

and parietal-central, alpha signal decrease with increased working memory load, during verbal/spatial match/mismatch study.

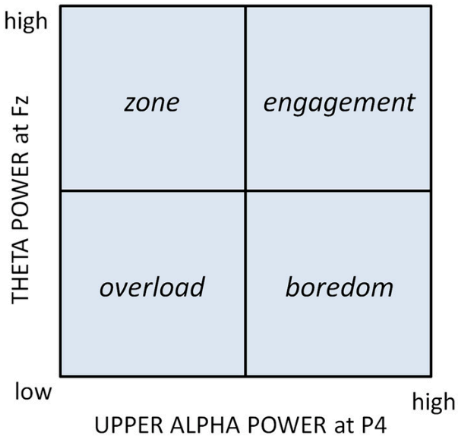

Figure 2.31; Two-dimensional representation of user state and their relation to Theta amplitude at Fz and upper Alpha amplitude at P4 (p8, Ewing, Fairclough and Gilleade, 2016)

Using the MNE Python package (Gramfort et. al., 2013; Gramfort et. al., 2014) raw data across the entire condition was processed. This firstly involved performing an FFT (Fast Fourier Transform) upon the data to obtain time/frequency amplitudes (though the mne.time_frequency. single_trial_power module that utilizes scipy.fftpack.fft[19]). Frequency information was windowed between the frequencies of interest per channel as previously described by Ewing, Fairclough and Gilleade (2016). Due to differences in participant physiology and frequency amplitude, relative power variables were transformed by $\log[\chi \div (1 - \chi)]$ to normalize the distribution of the data as per Gasser, Bacher, Mocks (1982), Knott et al (2001), Marosi et al (2001), and Yuvaraj et al (2014); which provided comparative amplitudes of frequencies. The mean of each channels frequency band were calculated and then subtracted from the corresponding data with values above the mean considered 'high' (time position represented by +1 in an array) and values below mean as 'low' (time position represented by 0. in an array). This was then used to calculate mental states as per Figure 2.31: Ewing, Fairclough and Gilleade (2016); e.g. P4 with a value of 1 and Fz with a value of 1 would indicate a state of engagement. Data was then averaged through a moving window of 2 seconds to provide clearer indication of sustained states.

The results of this analysis are discussed in Chapter 2.8.3.

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[19]https://docs.scipy.org/doc/scipy/reference/generated/scipy.fftpack.html

2.7.2: Dynamic Complexity And Degrees Of Conscious Awareness

In addition to measuring changes in mental states, analysis of the correlation between neural dynamical complexity and the level of consciousness (Mindful/Mindless balance) was also performed. This was following Schartner et al.'s (2015) method for evaluating differing states of consciousness during induced anaesthesia. Schartner et al (p1, 2015) highlight the growing body of literature that suggests neural theories of consciousness indicate a correlation between specific types of consciousness (e.g. sleep in comparison to waking alertness) and neural dynamical complexity. Dynamical complexity is understood as subsets of a system (the subsets of brain activity) being dynamically distinct (*differentiation*) yet additionally supporting *integration* across the whole system. And so, various conscious experiences are composed of a differentiation of subsets of brain activity though experienced through a coherent integrated whole, measureable as a degree of 'system wide' coherency. To measure complexity Schartner et al (2015) propose the computation of Lempel-Ziv complexity (Lempel and Ziv, 1976) upon EEG data, that provides an understanding of differentiation as diversity in EEG activity across both space and time, however they note (p2, 2015) that on spontaneous data (as with this study) such measurement reflects only differentiation and not the degree of integration. Lempel-Ziv complexity is used within a range of applications beyond analysis of biometric signal, such as compression algorithms, and can be most simplistically understood as an algorithm for counting the number of distinct (and recurring) patterns within a series of data; the higher the degree of repetition of patterns the lower the complexity of the data.

Following Schartner et al (2015)[20] the EEG data was transformed to a binary sequence with rows corresponding to channels of EEG data in observation, and columns of time points of the data in observation. The Lempel and Ziv compression algorithm (Lempel and Ziv, 1976; Schartner et al, 2015) obtains a dictionary of words from this data period, the words being recurring binary sequences as exemplified in figure 2.32, and then calculated across the matrix of data for their recurrence. Resulting from this, a high degree of randomness in EEG data would produce a higher number of 'words' in the dictionary set (a completely random dataset requiring more words to describe it than its length). Thus the Lempel Ziv compression calculation is proportional to the level of complexity within a data

[20] Code obtainable from: https://doi.org/10.1371/journal.pone.0133532.s002

matrix, returning a score between 0 (entirely repetitive), to 1 (highly complex).

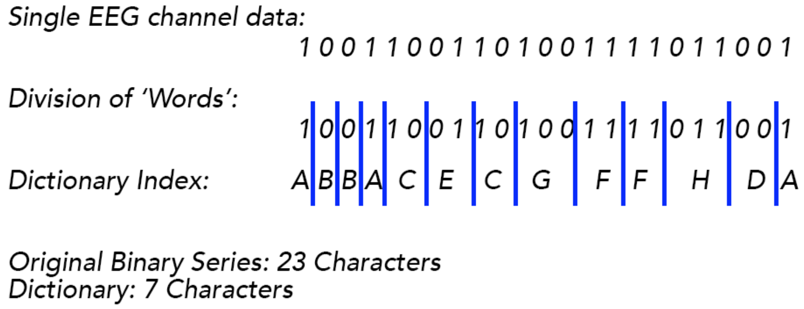

figure 2.32; Example of Lempel Ziv compression.

While Schartner et al (2015) use Lempel Ziv Complexity to differentiate between participants waking, mild, and heavy sedation others have proposed the measurement of complexity in different context. Klonowski, Olejarczyk, and Stepien (2002) propose the use of EEG complexity as a diagnostic tool for the assessment of patients in medical settings due to its robustness in measurement and the speed and simplicity of data outcome (i.e. one series) in comparison to raw EEG (multiple channels of subtle changes). While noting the difficulty in producing concrete meaning in such measures of EEG, Bhattacharya (2000) highlights the degree of complexity in EEG data can provide understandings of independent, parallel and functional processes of brain activity produced from differing states, actions and experiences; suggesting complexity measures might provide clues to parallel sub-conscious processes as described by Baars' (1993, 2003) and Shanahan (2010). More relatedly to the aims of this thesis is the work of Mölle et al (1996), who propose the measurement of EEG complexity in the understanding of processes during creative thinking. Mölle et al (1996) provide the distinction of divergent thinking as the general process underlying creative production, and convergent thinking as that which one experiences during analytical thought. They note how EEG activity complexity was higher across the central and posterior cortex during divergent thinking exercises, in comparison to periods of relaxation; and while complexity in the frontal cortex was comparable during divergent thinking and mental relaxation it was reduced during convergent thinking. Their results indicate that the processes underlying the novel ideation are observable in a strong increase in the EEG's complexity. However, the framing of divergent and convergent thinking posed by Mölle et al (1996) does not directly map to Mindful and Mindless framings. While novel ideation is a core outcome of a Mindful perspective or approach, it is additionally of an analytical framing. A Mindful thought process requires divergent thinking to see new perspectives and solutions, but additionally is not a blind creative process. Consequently Mindful thought processes additionally require an analytical approach in determining context and evaluation of available information. This is not to say that the findings of Mölle et al (1996) are not of use however, most prominent difference between divergent and convergent thinking in comparison relaxation was found to be in the parietal regions; providing a site of enquiry during complexity analysis (i.e. exposing both modalities of thinking as observable changes during interaction).

To understand changes in EEG complexity the measures were performed on 1 second (128 samples) of data per complexity data point. This provides an understanding of changes in complexity as the interaction with conditions occurs over time. To observe EEG complexity two methods in analysis were used. This was conducted following Schartner et al (2015) across three measurements, using the entire range of viable EEG channels across the: raw EEG data, frequency amplitude, and EEG phase coherency (see appendix 2.4); and a second following findings of Mölle et al (1996) observing Alpha wave (7.5 – 13Hz) complexity in the parietal region (across 10:20 positions P3,4, and z as 'Rear Complexity') and Theta wave (3.5 – 7Hz) complexity in the frontal region (across 10:20 positions F3,4, and z as 'Frontal Complexity'). The results of this analysis are discussed in Chapter 2.8.3.

2.7.3: Pupil and Eye Gaze

It has long been understood that there is a relationship between the eyes and mental states as a bidirectional relationship (Goldwater, 1972). Hess and Polt (1960) noted how the pupil diameter variations accompanied seeing emotionally toned or interesting stimulus such as sexual attraction and fear (increasing with arousal and decreasing with negative emotions). Kahneman and Beatty (1966) noted that the relationship between pupil diameter mental states moves beyond solely emotion and attraction and is additionally altered through demand upon working memory and cognitive loading (increasing proportionately with demands) (Kahneman, 1973). Similarly, and more recently, Pomplun and Sunkara (2003) note the use of pupil dilation in rapid and reliable indication of individuals cognitive workload during human computer interaction. Consequently the variation of the pupil size during and across conditions can provide indication to the cognitive loading and learning aspects of a participant. Since each condition remains at a relative difficulty, aspects of learning and reduction in cognitive loading (i.e the task becoming Mindless) present themselves in a reduction of pupil diameter, conversely, events that require additional effort, cognitive loading and awareness will report as increases.

In addition to pupil dilation is the observation of fixations and saccades. Fixations are classified as moments when the eye holds focus toward a specific area. Saccades are (broadly) classified as the movement between fixation points. Saccades direct the eyes toward areas of importance and considered most informative, where fixation occurs. Thus the observing of saccade and fixation events provides understanding of a persons attention toward a scene of vision. As noted by Rayner (1977), it is not only that these events occur or the order in which they occur that is of sole significance, but the duration they hold that might reveal affect of cognitive processes. Such position is observable in recent work understanding mind-wandering or Mindless reading (Reichle, Reineberg and Schooler, 2010; Uzzaman and Joordens, 2011; Schad, Nuthmann, and Engbert, 2012). These are typically defined as states whereby a person is reading a piece of text yet has little retention of information or the goal to which the activity is held; when attention is directed away from the external environment and cognitive processing is "*decoupled from perceptual information*"(Schad, Nuthmann, and Engbert, 2012). During this period individuals fail to notice the goal they originally held has been replaced by another activity or concern (Uzzaman and Joordens, 2011) and that "*none of what they have been "reading" has been processed in a meaningful manner*" (Reichle, Reineberg and Schooler, 2010). From each of these studies it was found that during mind-wandering events the duration of fixations increased. Similarly the study of eye movements has held recognition of its importance in understanding attentive and awareness processes (Hoffman and Subramaniam, 1995) and reflecting a number of psychological processes (Liversedge and Findley, 2000); with some claiming the study of eye movement offers a measure of mental activity independent of participant report (Bridgeman, 1992). Kumari et al (2017) held lens toward the understanding of smooth pursuit eye movements, where the eye follows a particular 'object' in a field of view; and anti-saccade movements, where a person intentionally prevents the eye from instinctual following toward an object. However, Kumari et al (2017) additionally sought to understand the effect of Mindfulness upon these eye-movements. Kumari et al (2017) assessed Mindfulness through analysis of Mindfulness trait through the previously described Five Facet Mindfulness Questionnaire (Baer et al., 2006; chapter 1.2.0); and through Mindfulness developed through training (meditation practice for a minimum of two years v's non-meditators) as 'cultivated Mindfulness' (Ivanovski and Malhi, 2007). While it was found that those who practiced meditation (cultivated Mindfulness) had superior smooth pursuit eye movement and anti-saccade control; there was little consistency in correlation in reporting of high trait Mindfulness (assessed through Five Facet Mindfulness Questionnaire) (p71, Kumari et al, 2017).

Fixation and saccade classifications were performed automatically through the Tobii Studio Professional v3.2 software[21] during eye data capture, (classifications derived from Olsson, 2007; Komogortsev et al. 2010) and formatted for analysis in Python (v2.7). Due to the nature of eye events being significant in periods of length, the durations of saccades and fixations were calculated as (multiple) individual events per test in each condition presented to participants. These were then calculated as a mean per test (i.e. mean number of samples of all fixations/saccades lengths per test). Test length was calculated in seconds and the mean fixation/saccade per second (as opposed to test) calculated. Due to fixations being (naturally) a magnitude longer than saccades these are divided by 10 to provide comparability to mean saccade length per second. Pupil dilation is reported with the subtraction of the total (per condition) mean.

The results of this analysis are discussed in Chapter 2.8.3.

[21] http://www.tobiipro.com/product-listing/tobii-pro-tx300/

2.8: Participant Qualitative Interview and Physiological Measurement Results and Analysis

As noted by Braun and Clarke (2006) "*Thematic analysis is a method for identifying, analysing, and reporting patterns (themes) within data.*". Theoretical thematic analysis was conducted upon participant interviews following Braun and Clarke (2006) at the sentence to paragraph level for semantic and latent meaning i.e. a top-down approach driven by the concepts informing the definitions of Section 1. This was drawn upon to provide further insight toward points of analysis and common themes, and so it was chosen to focus toward data that was of this particular analytic interest, specifically to descriptions related to the previously defined phenomena of question and to the interactions themselves. Consequently, data unrelated to the interaction tasks and phenomena of Mindfulness and Mindlessness (and their related understandings) were discarded; such as conversation between trials (e.g. asking if they require a refreshment or personal break, general conversation e.g. how their day had been) and informing the participant of the process (e.g. informing when calibration data would be performed). Given that participants might discuss aspects of analytic interest outside of interview (e.g. following calibration of equipment), whole study conversation was analysed. Analysis centred upon increasing/reducing cognitive loading and interaction strategies adopted, attention and awareness, thinking and knowing, experience of passage of time, moments of reflection, moments of automaticity, significant interaction events i.e. wrong answers, pop-ups, participant identified events. As recognised by Braun and Clarke (2006), for some excerpts of data many codes might exist. Some of the themes identified (**[bold and underlined]**) were latent in description e.g. P3, Int. 2, "*I saw blue [word] a couple of times [in different colours]* **[attention and awareness]**, *but then the next word is red, but I naturally hit blue* **[moment of automaticity]**, *when that happened I would notice...* **[moment of reflection, attention and awareness]**"; P4, Int. 2 "*when I didn't think about it… when I didn't try to think what I was doing, then I could do it.* **[thinking and knowing, interaction strategies adopted]**". Others described events in more explicit ways e.g. P5, Int. 7 "*That was harder when I zoned out.* **[moment of automaticity]**"; P6 Int. 3 "[…] *you're not thinking of all the bits you're doing you're just kind of doing it* **[thinking and knowing, moment of automaticity]**", P3, Int. 2 "*… I can feel my attention going away* **[attention and awareness]**".

Graphs of participants physiological metrics for conditions present the following information:

A. *Engagement* and *Boredom* (see chapter 2.7.1)

B. *Flow* and *Overload* (see chapter 2.7.1)
C. *Rear Complexity*: Alpha wave (7.5 – 13Hz) complexity of the parietal region (10:20 positions P3, 4, and z); and *Frontal Complexity*: Theta wave (3.5 – 7Hz) complexity across 10:20 positions F3, 4, and z. (see chapter 2.7.2)
D. *Frequency amplitude complexity*, and *EEG phase coherency* (See chapter 2.7.2) *complexity* (across all channels) over a 3 second period.
E. Raw EEG complexity mean variation (across 3 second period), and, raw EEG complexity mean standard deviation (across 3 second period). This measurement was produced following initial observations that complexity varied greatly in response to wrong answer alerts, hesitations, and pop-ups.
F. Mean Pupil Dilation (across 3 seconds), Mean Eye Saccades duration per second (across 5 seconds), Mean Eye Fixation duration per second (across 5 seconds) (divided by 10 to accommodate comparability to saccades), and Mean Eye Saccades duration per second minus mean Eye Fixation duration per second. This data is collated as a per-test measurement as opposed to continuous data (See chapter 2.7.3).

Each of the graphs additionally indicates tests where hesitations occurred (green vertical), wrong answer alerts (red vertical) and Pop-Ups (blue vertical).

2.8.1: Participant strategies to augment cognitive load to improve performance

Reducing Cognitive Load

During interview it became clear that some participants held strategies for improving performance. This was often in relation to reducing the cognitive loading of the condition to improve speed. For example, Participant 1 (Interview 2 - Spatial Stroop 1) reported they found it easier to rely upon peripheral vision as opposed to directly focusing on the information displayed:

> "If I looked at it I tend to follow the arrows, so if it pointed right even though it was up I'd press the right button, but if I looked off to one corner of the screen my peripheral vision knew where it was without paying attention to the arrows"
> (Participant 1, Interview 2 - Spatial Stroop 1)

Whereas previous framings of Mindlessness (e.g. Bodner and Langer, 2001) have suggested that such states occur with a trait of ignoring or obliviousness to additional, often contextual, information; here Participant 1 sought this capacity. While traditional concepts of Mindfulness and Mindlessness would hold this as a negative attribute it provided functionality whereby information would not cause additional questioning over meaning. Participant 3 also applied similar practice; during their first Linguistic Stroop condition Participant 3 was required to provide the colour of the word and not the word itself and so intentionally ignored the shape and size of the words to hold focus to the colour of the word alongside imagining coloured lines emanating from the words position to the position of the answers. During their Linguistic Stroop condition requiring the colour Participant 1 again chose to look off screen and rely upon their peripheral vision.

However, there was not only an intentional blocking of additional and unnecessary information but also of subjective evaluation and, as participants often described it, "thinking" upon the task at hand. Participant 4 noted during their second condition (Rotating Clock Face) that they were often confused over their actions and if it was correct or not (even though there are audible alerts informing so):

> *"[…]* I think a lot of the time I wasn't really sure if I was doing it right, and when I did think I was doing it right, that's when I got it wrong. Every time. I was like "oh yeah I know this one" *[makes button press gesture]*; and wrong, wrong, wrong.
> But, when I didn't think about it… when I didn't try to think what I was doing, then I could do it."
> (Participant 4, Interview 2 - Rotating Clock Face)

Several participants reported that the act of 'thinking' of what it was they were doing often provided more of a hindrance and such second questioning would lead to mistakes and wrong answers. Consequently many reported the desire to achieve automaticity, recognizing its value and capacity, such as Participant 6 (Interview 3 - Linguistic Stroop 1):

> "I think that's what I was going for, I was trying to get to a place where I was, ok this sounds bad… you know when you kind of driving and you're not thinking of all the bits you're doing you're just kind of doing it… I guess that's the aim, you're trying to get to a point where your hands, where you see the thing and do the thing."
> (Participant 6, Interview 3 - Linguistic Stroop 1)

Participant 7 (Interview 1, Linguistic Stroop 1) reported how they had achieved this state, notable as no longer requiring looking at the physical interface or potential answer positions and just knowing 'where to go'. They described how their "*hands knew where the buttons where I didn't have to check*" coupled with a pleasurable feeling that allowed them to "*forget everything*". Such descriptions are akin to that of Flow states (Csikszentmihalyi, 1992), often described as an optimal experience that incorporates the merging of action and awareness and pleasure.

The most commonly the reported strategy to reduce cognitive loading was employed during the two Clock Face conditions whereby participants would often resort to observing a sole 'hand' of the clock (e.g. the hour hand) and then choosing an answer based on the nearest time displayed in potential answers.

Increasing Cognitive Load

In contradiction to reducing cognitive load and information, a number of participants reported strategies to increase cognitive loading during some of the conditions to prevent wrong answers, predominantly during the two variations of Stroop conditions. This included mentally repeating aloud the words or colours of the words during the Linguistic Stroop, and mentally announcing the position or direction during the Spatial Stroop. One bilingual participant (Participant 3) reported how they had relied upon translating the information on screen into their native language to add a cognitive step and differentiate possible answers. Others remarked how they had kept a rhythm and focused toward maintaining this to keep them alert, such as Participant 8 tapping rhythm on the table supporting the interface to cover the 'off beat' between pressing the answer.

2.8.2: Recognition Of Mindlessness And Automatic Processes

For many participants there was a recognition or understanding as to the experience of Mindful and Mindless states, though described through different terms. While these were clearly described indirectly, when directly questioned in regard to these states the 'orientation' of these was often confused and far narrower than originally indicated. That is to say, while participants could report of phenomenological states akin to Mindfulness and Mindlessness when directly questioned they would over assume e.g. their state of awareness. Often when asking participants upon their attention or degree of held awareness they would respond they were fully attentive and aware, yet with further probing into aspects, such as if this was toward the broader environment, would often reveal that it was directly toward the interaction at hand with little or no external awareness (i.e. immersion toward the condition). Similarly, participants who's initial responses suggested they held a high degree of awareness would additionally report that they had little or lost sense of the passage of time when questioned further. However, participants could often provide indication as to where points of conscious awareness were experienced in contrast to sub-conscious operating; often at specific points such as wrong answer alerts or Pop-Ups or when they had experienced repetition of answers/stimulus and this changed (though all stimuli was randomly generated).

Participant 3 (Interview 2, Linguistic Stroop 2) clearly described their inability to prevent an automatic action. As described by Anderson (1992, Chapter 1.12.3) automatic actions become difficult to prevent or stop. While this is often described through long standing habitual behaviours, Participant 3's account additionally highlights short-term persistent automatic actions:

> *Interviewer:* Can you describe your attention?
> *Participant 3:* Mostly at the screen,
> *Interviewer:* And did your mind wonder?
> *Participant 3:* Yes, same words showed up multiple times in a row I just started to… I don't know, I can feel my attention going away. When the same word repeated 3 times…
> *Interviewer:* And what happened then, were you still…
> *Participant 3:* I stopped processing, and when there was a new word, I thought what do I do now?, do I match the colour or the word then that was when I made a mistake also.
> Interviewer: So, you were answering them in a row correctly?
> Participant 3: Yes
> *Interviewer:* And you knew you had to answer with the word?
> Participant 3: Yeah
> *Interviewer:* And the colours were changing?
> Participant 3: Uh-huh.
> *Interviewer:* But then the word changed, which you were already answering correctly...
> *Participant 3:* I saw blue *[word]* a couple of times *[in different colours]*, but then the next word is red, but I naturally hit blue, when that happened I would notice but its too late by then.
> (Participant 3, Interview 2, Linguistic Stroop 2)

While Participant 3's account provides a clear enactment of automaticity (and Mindlessness) their recollection of events additionally provides insight to how this is experienced. They were consciously aware of the interaction and its requirements, and so the interaction was not of Mindless totality, yet they were unable to prevent their actions and only aware as it occurred. The change and interruption caused them to question their actions and how to proceed, though they had successfully been performing the interaction. Participant 9 described similar experience as an inability to see the images in the same way, and when they had drifted into this state as it not being a hallucination but as a 'dream effect' (Interview 1 – Green X O, Red X O). They further described their immersion as similar to riding a bike whereby you don't pay attention in terms of 'how' (to ride a bike) until an event occurs and you 'suddenly wake up', that "*then you loose focus, and its not there, and you realize, but all these happen in a second*" (Participant 9, Interview 1 – Green X O, Red X O). While it is often described that Mindless actions are performed over broader actions and prolonged engagements, Participant 9 and Participant 3's (above) accounts suggest that Mindlessness additionally occurs in brevity of singular actions that are recognizable as moments of disruption to ongoing activities.

Others described a broader spectrum of experience than a clearly defined moment of Mindlessness. Participant 5 (Interview 7 – Linguistic Stroop 2) provided a description of a spectrum of conscious experience they held during one condition. They described being in a conscious awareness state following wrong answers, an automatic mode of answering (sub-conscious being 'in the zone'); in addition to a further (less functional) 'zoned out' state:

> *Participant 5:* That was harder when I zoned out. I was getting more correct when I was doing it more automatically.
> *Interviewer:* When were you aware you were doing this automatically?
> *Participant 5:* When I made an error, there was a couple of times I made an error and realized what I was doing.
> I was just in the zone, I wasn't conscious of doing it… I was just… I guess I was kind of just in that space of doing something…
> *Interviewer:* And when in that space if I asked you for the answer, would you be able to tell me?
> *Participant 5:* No, I don't think so, I was just in the, probably the most automatic then; and I really struggled to get myself back.
> So when I made an error, it was like breaking *[hand gestures chop],* but I was still going.
>
> (Participant 5, Interview 7 – Linguistic Stroop 2)

While it is difficult to clearly delineate the experienced states from their description it could be assumed that for Participant 5, acting 'automatically' is experienced as a conscious control of automatic actions (i.e. a sub-conscious action by intent, a degree of conscious awareness), whereas 'zoned out' might refer to the non-conscious control over the enactment of these actions (non-conscious).

While it was assumed during study design that wrong answers would provoke a more Mindful stance toward the interaction, i.e. breaking of automatic actions, many participants described wrong answers and mistakes (hesitations) as leading from

Mindful like thoughtful interactions. Participant 4 (Interview 1, Fixed Clock Face) described this with certainty that they could maintain a "rhythm" and the interaction would be successful, however, when they lost this "rhythm" and "thought about it" they failed.

2.8.3: Notable Conditions

Several of the conditions contained notable events that served as unintended points of enquiry and exemplar cases of critique. This included participants confusion when encountering Pop-Ups, dramatic changes in physiological data in response to wrong answers, participants reporting being more considerate of answers at known time points (i.e. encountering Pop-Up), and interruption to condition study from an external source. Notable conditions were selected through observation during the condition (i.e. interruptions, participant requesting instructions on how to proceed) and through response during qualitative interview.

Participant 1, 1st Condition (Green X O - Red X O):

When questioned if there were any moments in which they felt they had 'zoned out' participant 1 responded that they had experienced this "*from the beginning*" (Participant 1, interview 1). They reported that they were not aware of any thoughts or feelings other than to when the condition would end, and their experience or awareness of time was irrelevant, the audio being the only indicator of time passing. They additionally reported their awareness of wrong answer alerts slowing them down, and that "[…] *it was easier to slow down and get them right than to try and do it more quickly*" (Participant 1, interview 1). Participant 1's first condition presented an opportunity to understand Mindfulness and Mindlessness during interactions in an unexpected way. While the undertaking the condition the initial Pop-Up caused confusion over how to proceed. While they had confirmed they understood the instructions of how to respond to the Pop-Up prior to commencing the condition they required assistance when the event occurred (verbally asking how to proceed after several seconds):

> *Interviewer:* "So what happened when you saw the pop-up?"
> *P1:* "I looked for an option, but there wasn't an option"
> *Interviewer:* "When the pop-up of "re-try" appears you enter what the answer to the previous test was or what you think is the correct answer"
> *P1:* "but I'm not remembering them"
> Interviewer: "So you didn't remember the answers or the positions?"
> *P1:* "I'm just reacting, I'm not recording them, so when it comes to the retry screen it was just a random… I just hit something"

(Participant 1, interview 1)

The reaction to the initial Pop-Up can be seen in figure 2.33 (at approximately 205 seconds) (following page). In graph C of figure 2.33 it can be seen that the point at which the Pop-Up occurs there is a large decrease in frontal complexity in comparison to rear complexity. In graph D of figure 2.33 it can be observed that the phase coherency complexity has little response yet the Frequency Amplitude complexity is reduced. Following the Pop-Up presentation (at the point of Pop-Up answer at approximately 230 seconds), graph E of figure 2.33 shows a large variation in the mean standard deviation (across 3 seconds) of raw EEG complexity at the point where the answer was provided. In graph F of figure 2.33 it can be observed that following the initial Pop-Up there is an increase in mean pupil dilation, and following an initial fall (to the point where the answer was provided) an increase in the Mean Eye Saccades duration per second minus mean Eye Fixation duration per second.

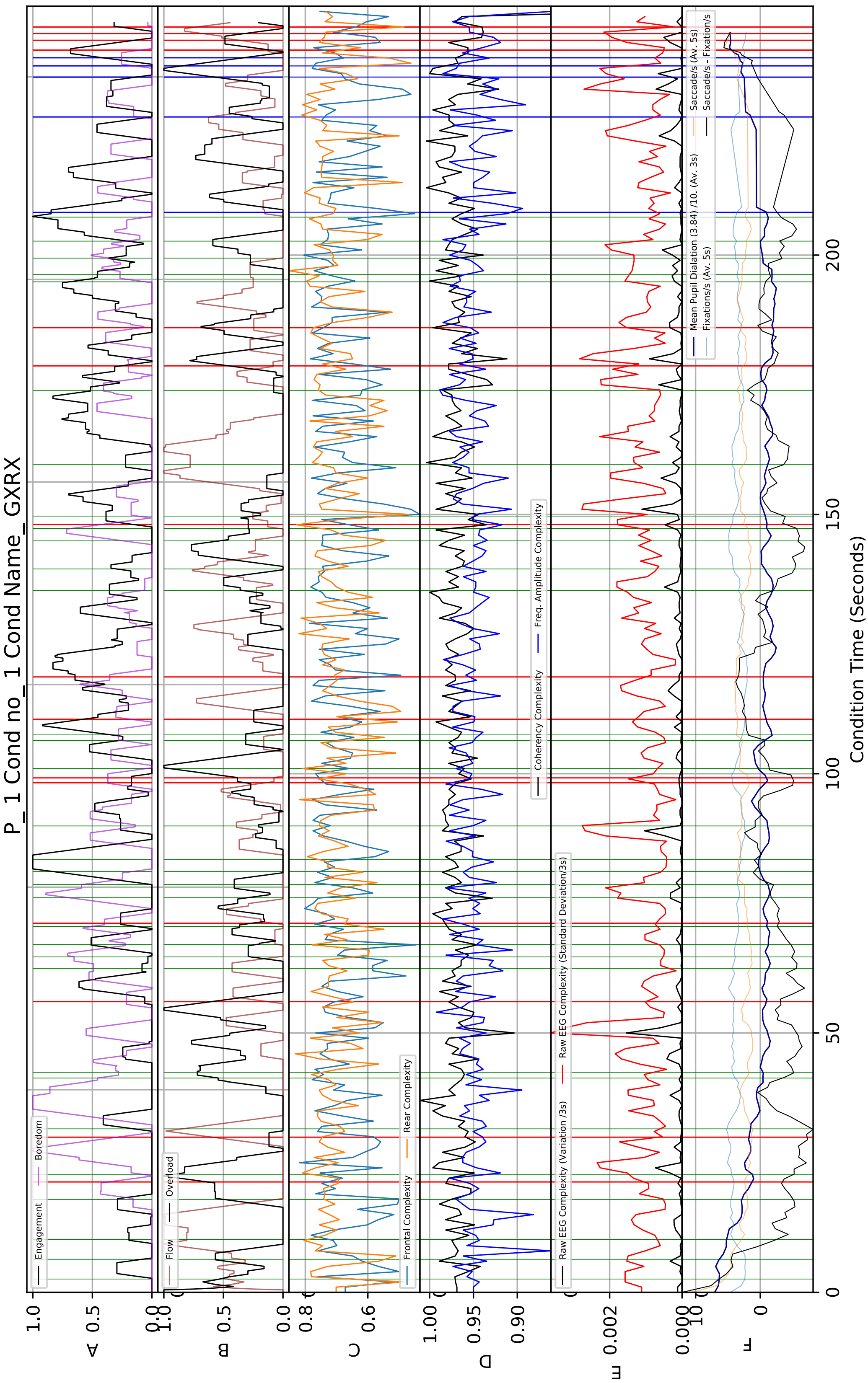

Figure 2.33; Physiological measurements: Participant 1, Condition 1 (Green X O - Red X O)

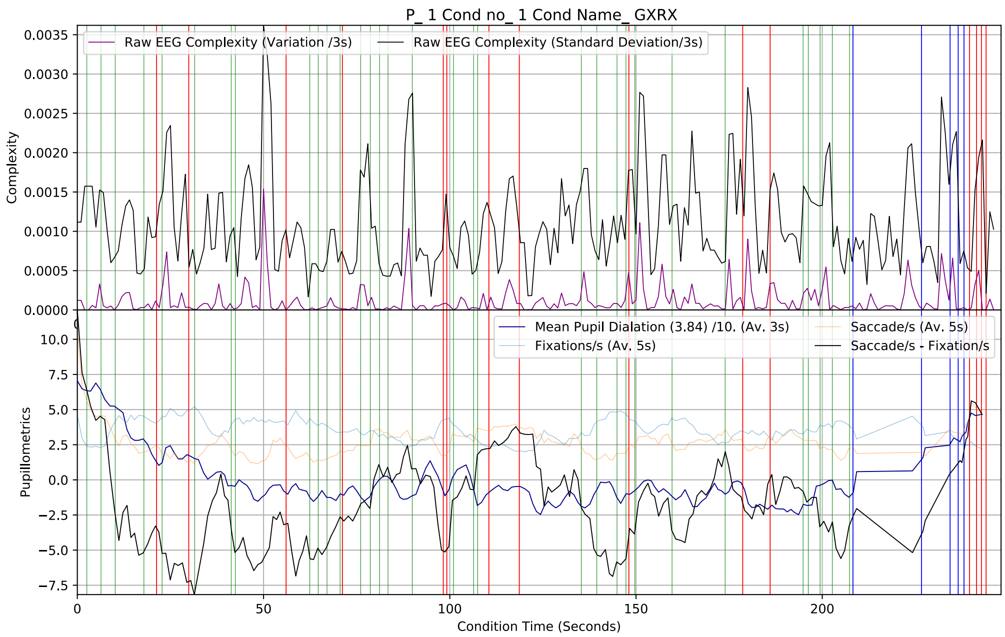

Figure 2.34: Raw EEG complexity (top) and Eye Data (bottom): Participant 1, Condition 1 (Green X O - Red X O). Hesitations (green vertical), Wrong answer alerts (red vertical), Pop-Ups (blue vertical).

From the pupil and gaze measurements it can be seen that participant 1's first condition initially required a high cognitive loading (relative to the entire condition) seen as large pupil dilation at the beginning of the condition (Figure 2.34, above). However, this quickly reduced (from 0-50 seconds) and plateaued until the end of the condition where the onset of Pop-Ups increased pupil dilation (understood as relational to cognitive loading, mental effort, and mental arousal). Similarly mean Eye Saccades duration per second minus mean Eye Fixation duration per second also followed this trend yet were more responsive to wrong answers (e.g. wrong answers at approximately 25 seconds, 100 seconds, 150 seconds, Figure 2.34, above). This suggests that following the wrong answer alerts and Pop-Up's there was an increase in the cognitive loading that is observable in these metrics. It is important to note that the tests themselves in this condition (as with the others) do not change in objective difficulty and so indicates that there was a learning process that required less mental effort yet subjectively increased with interruption that required a degree of conscious thought (e.g. correcting or reflecting upon actions and responses).

While the participant reported that they were 'zoned out' throughout the condition they additionally reported awareness that wrong answer alerts and mistakes (as hesitations) slowed them down, suggesting that the condition was not a period of Mindlessness totality but induced a Mindful (or closer to Mindful) experiences of contemplation of events and actions that interrupted the ongoing condition. As can be seen in (Figure 2.34, above) many increases in raw EEG standard deviation complexity occur around such events, some prior to the events and some in response. Yet this is not without exception, the largest increase in EEG complexity occurs at 50 seconds into the condition, though there is no wrong answer alert or hesitation to prompt such a response. At the same timeframe there is also an increase in the mean saccades per second (Figure 2.34, Pupillometrics). The increase of saccades in comparison to fixations was observed in the study data following wrong answer alerts and suggest an active search of the 'environment' or area of interaction. Thus such observation may indicate a subjectively motivated (as opposed to reactionary) reflective-/conscious awareness.

During interview upon this condition participant 1 was questioned on their experience of the passage of time to which they answered:

> "it wasn't relevant, I could hear the pings so I knew I was going faster, but there was a point about mid way through that I was making lots of mistakes so I slowed down" *[their answer times varied little]*
> "it was easier to slow down and get them right than to try and do it more quickly."

(Participant 1, interview 1)

This may relate to the period at 100 seconds where the participant answered incorrectly twice in a row, followed by several hesitations. It can be seen in Figure 2.34 (Pupillometrics) that prior to these wrong answers there is a decrease in both mean pupil dilation and saccades per second in comparison to fixations per second, both of which increase following the wrong answer.

Participant 4, 1st Condition (Fixed Clock Face):

Participant 4's first condition was the Fixed Clock Face. While this condition was not unusual in terms of external events or participant interview the physiological data captured during this condition provided a strong indication of areas investigation. During interview Participant 4 was questioned on how they felt the condition went. Participant 4 expressed their confusion and frustration during the condition regarding incorrect answers: "*Some of them I got wrong, I was sure I got them right. I found it confusing.*" (participant 4, interview 1). They expressed that they were aware that these errors slowed their completion of tests and that they were aware of the frustrations that arose following these mistakes. They additionally remarked in interview that when they thought about the process of how to answer the tests they would loose their rhythm and make errors. Similarly they expressed how the Pop-Ups were "quite a surprise" (participant 4, interview 1) that woke them up. As can be seen in Figure 2.35 pupillometrics (below), highlighted by blue ovals, these wrong answers though not holding impact toward the raw EEG complexity variation / deviation, dramatically increased the mean pupil dilation and mean Eye Saccades duration per second minus mean Eye Fixation duration per second.

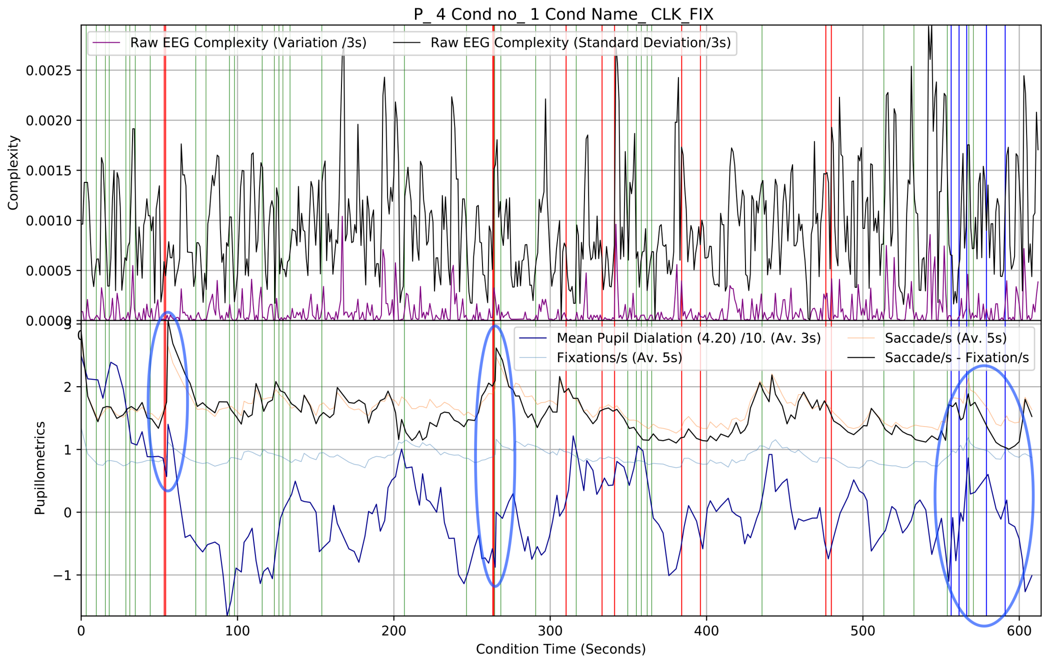

Figure 2.35: Raw EEG complexity (top) and Eye Data (bottom): Participant 4, Condition 1 (Fixed Clock Face). Hesitations (green vertical), Wrong answer alerts (red vertical), Pop-Ups (blue vertical). Blue ovals indicating wrong answer and Pop-Up effect upon mean Pupil Dilation and mean Eye Saccades duration per second minus mean Eye Fixation duration per second.

Participant 9, 5th Condition (2nd Spatial Stroop Condition):

As previously described (Chapter 2.5.2) participant 9 chose to intentionally take time to "think" upon their answer during the first Pop-Up stimulus, though it remained the same. Upon viewing the physiological metrics (see figure 2.37 on following page) for this time point it can be seen that there is a large reduction in the raw EEG complexity mean standard deviation (figure 2.37 graph E). This, however, is following a hesitation (that immediately preceded the Pop-Up), which in turn was following a period where there were no wrong answer alerts or hesitations. As such the participant may have been more Mindful toward the interaction due to the preceding hesitation and the Pop-Up invoked intentional "thinking" upon the answer resulting from a primed state. This potentially maintained a higher degree of complexity, thus reducing the complexity variation related to the Pop-Up. It can be observed in figure 2.36 (Below) that the raw EEG complexity is often, for this participant in this condition, erratic with a high degree of deviation prior to (and during periods of) hesitations or following wrong answer alerts. However, as can be see in figure 2.38 there are many instances where these fluctuations in the standard deviation of raw EEG complexity and changes in saccade-fixation per second correspond to events such as hesitations and wrong answer alerts (indicated by blue circles/ovals, in figure 2.38). Similarly there are many instances where raw EEG complexity changes alongside changes in saccade-fixation per second trends (indicated by red arrows, in figure 2.38).

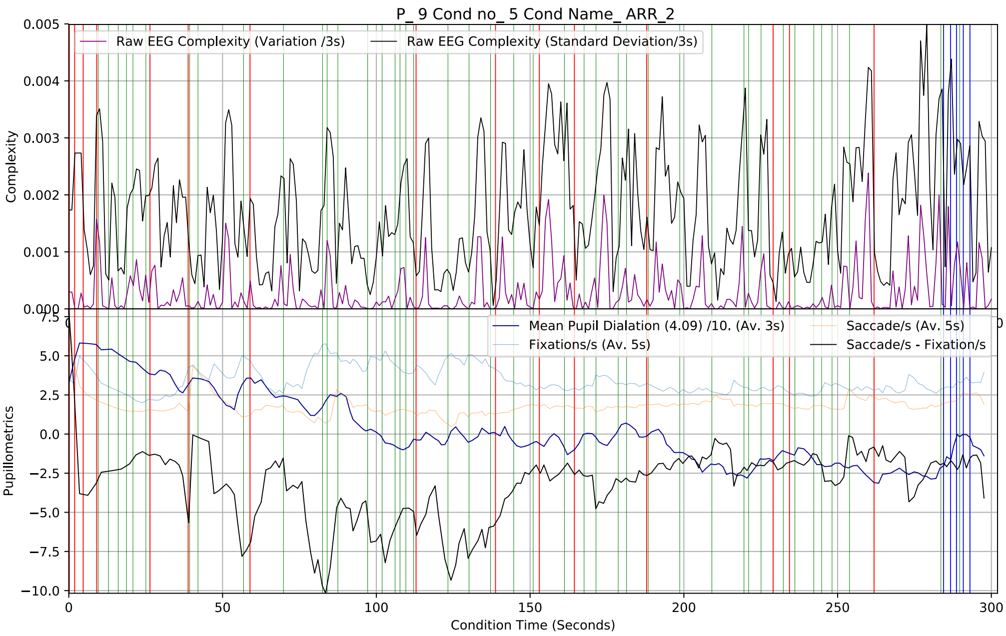

Figure 2.36: Raw EEG complexity (top) and Eye Data (bottom): Participant 9, Condition 5 (2nd Spatial Stroop). Hesitations (green vertical), Wrong answer alerts (red vertical), Pop-Ups (blue vertical).

<u>*Participant 10, 7th Condition (2nd Spatial Stroop):*</u>

Participant 10's final condition, similarly to participant 1, also presented an opportunity to understand Mindfulness and Mindlessness during interactions in an unanticipated way. This condition was interrupted midway due to an external party entering the room the study was held to converse with both myself (conducting the study) and the participant. When questioned on how this affected them the participant responded that they were "fresher" when they returned to the condition and that it gave them a welcomed rest. The decision was made to not repeat the condition, as this would influence any developed automaticity of the condition; and to keep the data for this period as it provides a point of analysis in comparison to the broader condition. The period of interruption is observable in figure 2.39

(following page) as a period between approximately 190 seconds to 330 seconds (notable as a continuous line in figure 2.39 graph F). The effect of the interruption on the participant was most noticeable at approximately 200 seconds into the condition where the participant was engaged in a conversation (correlating to the increase in variation and standard deviation). This is also reflected in a following period of sustained engagement (figure 2.39 graph A), and a drop in both frontal and parietal (rear) complexity followed by an increased parietal complexity in comparison to frontal complexity (figure 2.39 graph C). Similar metrics are observable when the condition testing resumed (indicated by a wrong answer), however, mean pupil dilation increases (figure 2.39 graph F) suggesting an increase in cognitive loading following condition resume. This may be accountable as the participants report on being 'fresher' upon the condition resume.

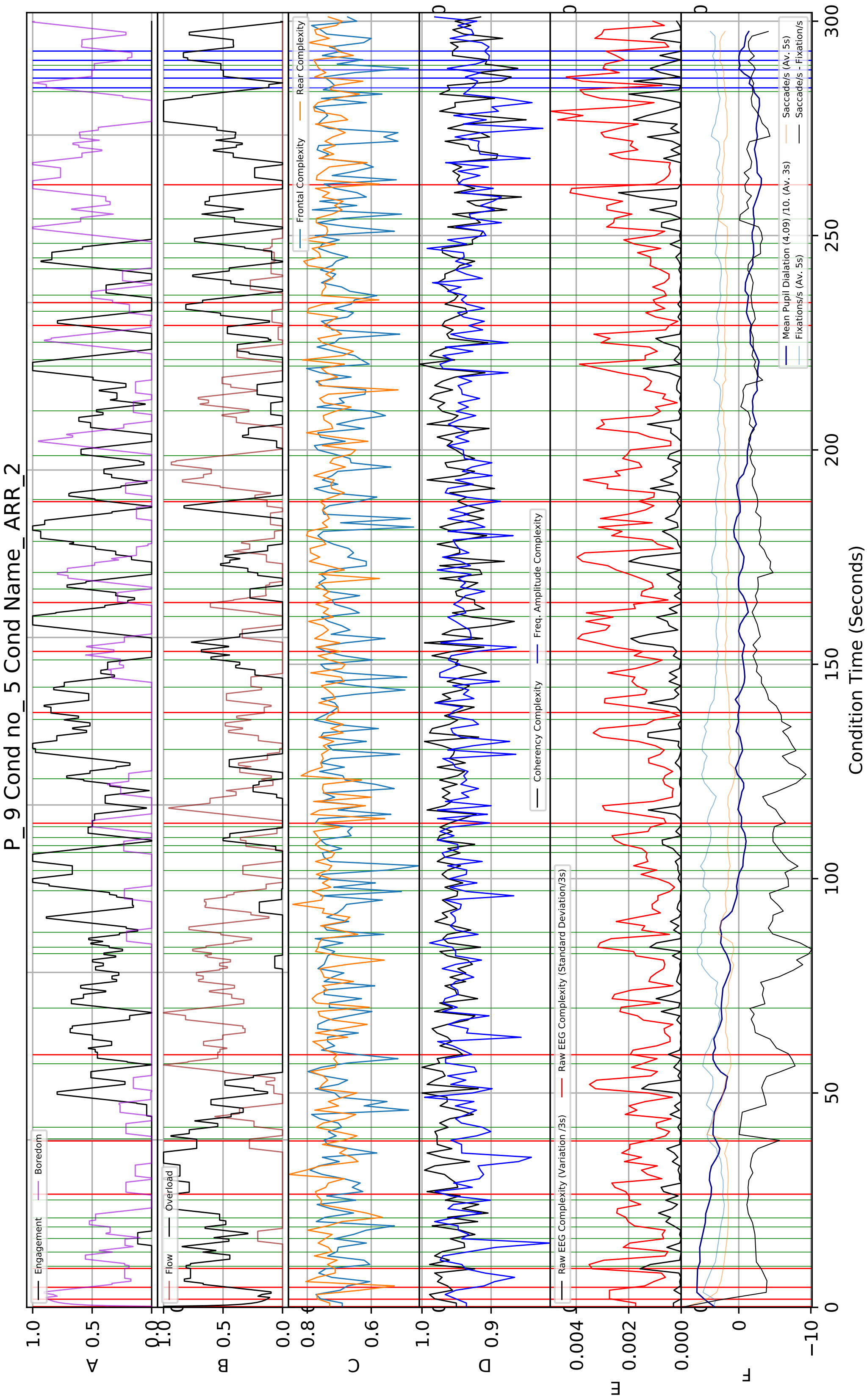

Figure 2.37: Physiological measurements: Participant 9, Condition 5 (2nd Spatial Stroop)

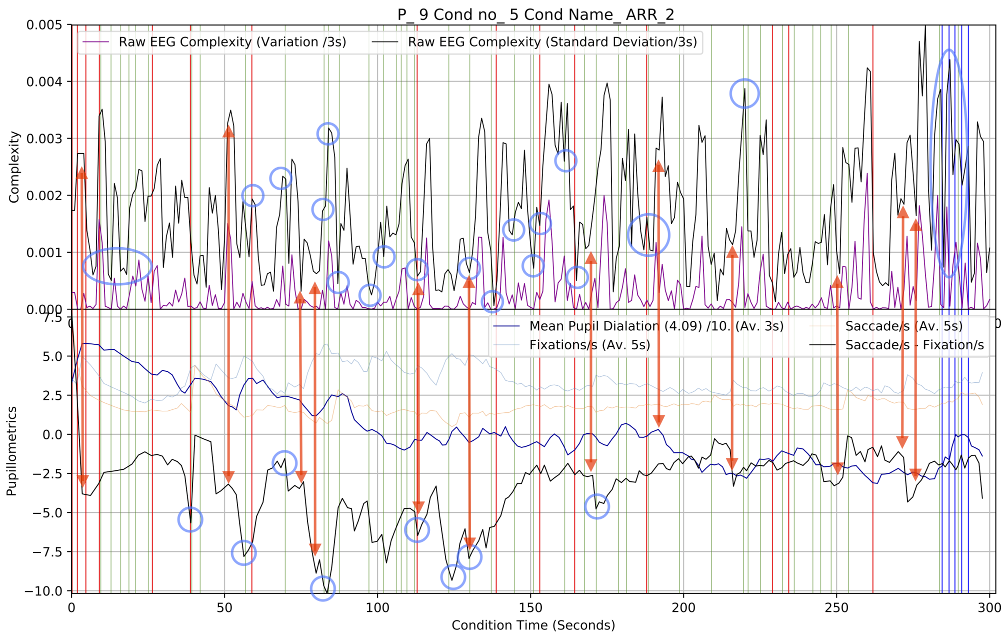

Figure 2.38; Raw EEG complexity (top) and Eye Data (bottom): Participant 9, Condition 5 (2nd Spatial Stroop). Hesitations (green vertical), Wrong answer alerts (red vertical), Pop-Ups (blue vertical). Fluctuations in the standard deviation of raw EEG complexity and changes in saccade-fixation per second corresponding to events such as hesitations and wrong answer alerts indicated by blue ovals. Fluctuations in the standard deviation of raw EEG complexity corresponding to changes in saccade-fixation per second indicated by red arrows.

It can be seen in Figure 2.40 (complexity) there is a large increase in raw EEG complexity variation / standard deviation at 200 seconds as previously described (highlighted by blue oval) followed by a second when the condition resumed. While the largest increase occurs at 200 seconds it should be noted that is nearly double the largest increase in raw EEG complexity variation / standard deviation of the comparable condition (i.e. the 1st spatial Stroop condition) (Figure 2.41). This dramatic change in variation suggests a relationship to the degree of interruption toward ongoing tasks. That is, wrong alerts and pop-ups are accommodated as part of the condition whereas in Participant 10, Condition 7 (2nd Spatial Stroop) the interruption of an external event caused a prevention of the task, yet also required a much more subjectively involving interaction (answering and responding in conversation). Similarly in Figure 2.41 it can be observed that the two largest 'spikes' in raw EEG complexity deviation are followed by large increases in mean pupil dilation (indicated by red arrows). This might be the change in complexity denoting a drawing forward of sub-conscious and Mindless cognitive processes toward conscious Mindful engagements.

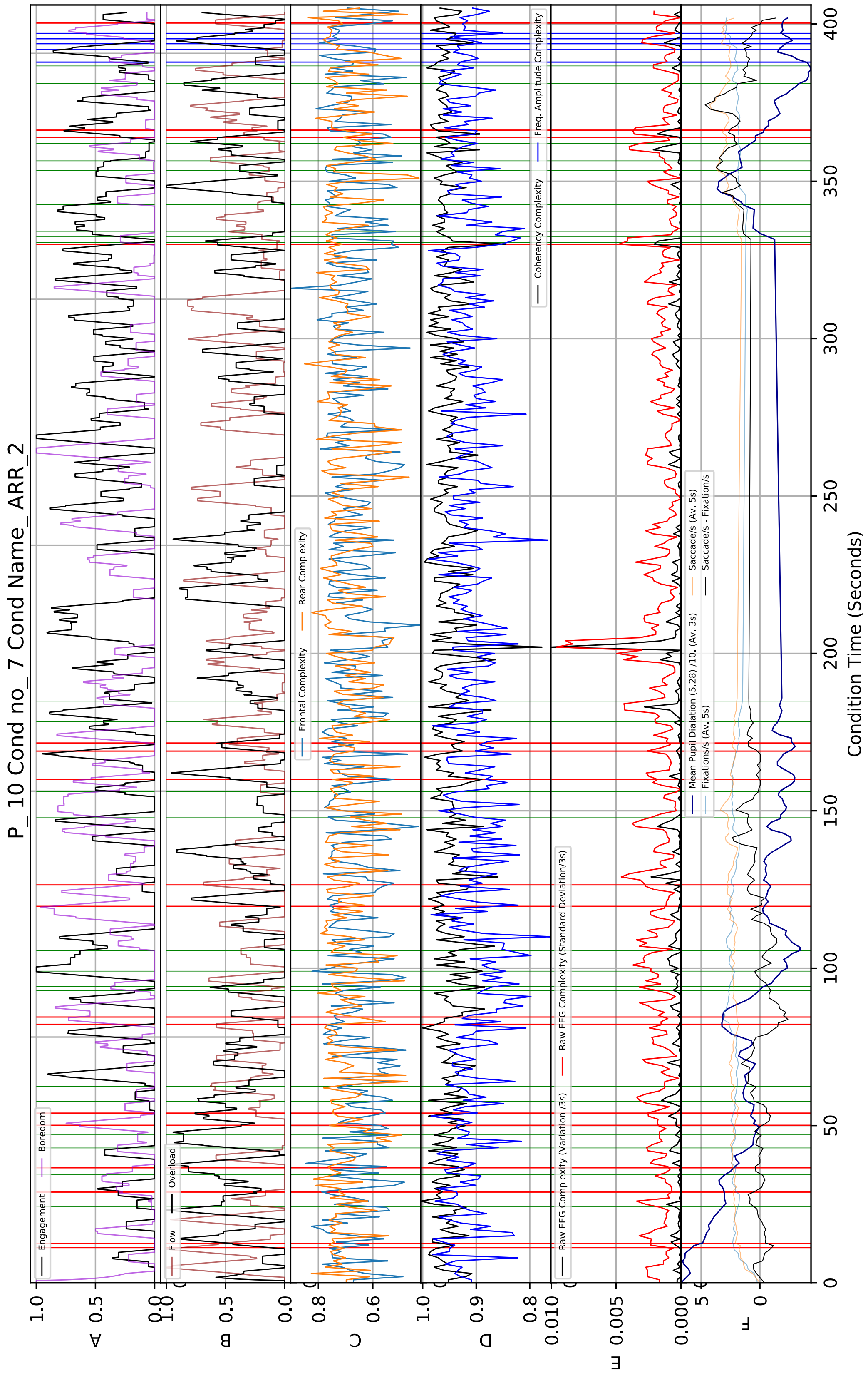

Figure 2.39: Physiological measurements: Participant 10, Condition 7 (2nd Spatial Stroop)

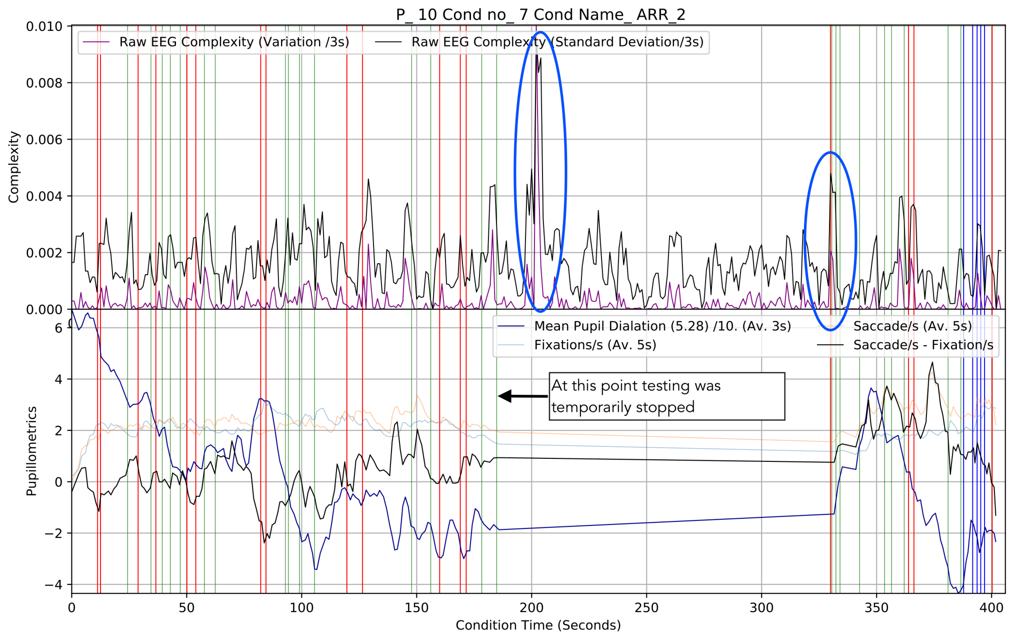

Figure 2.40; Raw EEG complexity (top) and Eye Data (bottom): Participant 10, Condition 7 (2nd Spatial Stroop). Hesitations (green vertical), Wrong answer alerts (red vertical), Pop-Ups (blue vertical). Fluctuations in the standard deviation of raw EEG complexity and changes in saccade-fixation per second corresponding to condition interruption indicated by blue ovals.

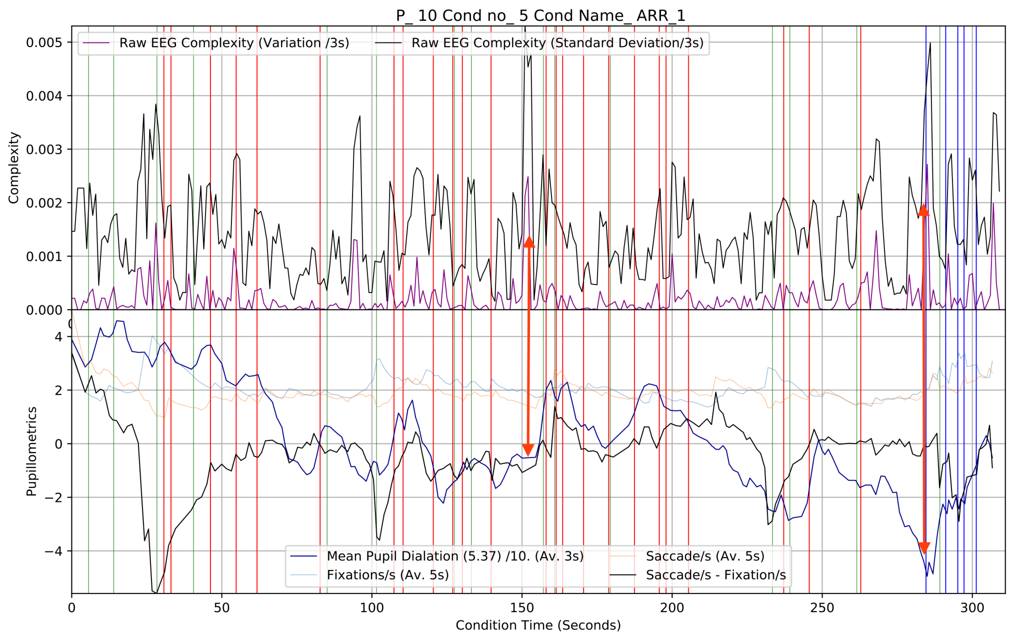

Figure 2.41: Raw EEG complexity (top) and Eye Data (bottom): Participant 10, Condition 5 (1st Spatial Stroop). Hesitations (green vertical), Wrong answer alerts (red vertical), Pop-Ups (blue vertical).

2.9.0 Section 2 Discussion and Conclusion

As previously described (Chapter 2.0.2- Limitations and Support) there are many complexities in understanding physiological metrics in relation toward felt experiences and actions. While there remain a number of uncertainties in that there are no definitive physiological indicators of Mindful or Mindless states the findings of the study revealed a number of insights to guide future work.

As will be discussed in the following (Chapter 2.9.1) there was a validation of the guiding statements derived from the findings of Section 1. Equally noteworthy was the support in the distinctions of conscious and cognitive states. Participants when in states that might be considered automatic (and Mindless) reported contradictory statements and a lack of knowledge of their actions. This however was often not described as a negative quality as they often held confidence that their actions were correct. Equally important is the finding that participants seek such states (often described as being in the 'zone') yet for some they recognised the danger of a further state of uncontrolled automaticity (a non-conscious state). Such findings highlight the need for a greater consideration in how and when Mindful and Mindless interactions might be sought. The simpler conditions facilitated Mindless interactions easily however, some participants took steps to increase their cognitive loading (perhaps to maintain the correct balance of Mindlessness); similarly 'short cuts' were adopted in the more difficult clock face conditions increasing their ease. Likewise the 'Pop-Up' breakdown that was introduced was quickly adopted into a Mindless response with the middle 'analysis' step removed and replaced with an action akin to 're-press the previous button'. Here 're-press the previous button' should not be confused with previous answer as the answer in itself was quickly forgotten and unavailable for recall upon 'Pop-Up'. The analytical steps in 'Pop-Ups' was also removed i.e. [if Pop-Up, review previous answer choice, then choose correct answer, then press/repress answer button] removed the analytical elements to streamline the process to become [if Pop-Up, repress button]. Such trade-off's in meaning and information for speed (i.e. employing a Mindless equipmental use) consequently loose the analytical and experiential steps and as such the potential for exploring novel affordances (as a Mindful tool).

2.9.1: Validation Of Guiding Statements

There were a number of guiding statements that informed the study design as previously described (Chapter 2.2.2 – Statements Informing Study Design):

With enough repetition a task will become automatic (sub-conscious).

It was observed that in many of the conditions participants reported experiences relatable to Mindlessness and automatic behaviours. As described in Chapter 2.8.1 and 2.8.2 participants explained these states in differing terms with confusion over their allocation of awareness and attention, often claiming to have maintained a high degree of awareness yet upon further enquiry this was revealed to be a high degree of immersion. Often participants would describe conditions performed in automaticity as additionally performed with little awareness of the passage of time, suggesting the entrance of Flow states (Csikszentmihalyi, 1992). Consequently, it can be held that with repetition of tests, these conditions hold capacity to become Mindless interactions (in varying degrees). While participants responses indicated an entrance to Flow this was less evident in EEG analysis and so it is suggested that Flow estimation is conducted through qualitative methods rather than objective quantitative methods (such as EEG).

A novel task will require concerted effort (conscious cognition), and so require more time (or incur more errors) than when the task is automatic.

Points of errors remained erratic throughout the condition across all conditions; i.e. there was not an observable reduction in wrong answers as specific conditions progressed. However, as highlighted in table 2.2 (chapter 2.5.3) with increasing the difficulty in condition and with requiring a reversal of test answer (e.g. providing the direction of an arrow in comparison to previously providing its spatial position), the average number of wrong answers did increase. The number of hesitations, however, did not follow such trend though did increase in comparable conditions (e.g. Linguistic Stroop 1 in comparison to Linguistic Stroop 2). It is observable that the conditions did accommodate a reduction in answer times from initial test (though to a far lesser degree for the Clock Face conditions) to a plateau. This varied across participants and conditions, the more difficult conditions typically taking longer for answer time to plateau (if at all). Many participants, during the two Clock Face conditions, chose to reject much of the information and focus toward a single hand and guess the closest time (e.g. choosing to read the hour hand and choose a time that appeared to be closest). This may have accounted for a plateau in answer times as it was often reported that this was not a strategy employed from the onset of the condition. Similarly observation of mean pupil dilation (a physiological metric in cognitive loading and arousal as described in chapter 2.7.3), while taking longer to plateau than answer times, also indicated a reduction in mental effort. However, mean pupil dilation additionally increased with response to initial wrong answers and Pop-Ups. Coinciding with testing times Pop-Ups additionally highlighted a decrease in response times with successive exposures.

Consistent stimulus-to-response mapping will better facilitate automatic responses.

A task with fewer 'individual parts' or steps of processing will better facilitate a transition toward automaticity.

During interview many participants reported a loss of the sensation of time across all conditions. This was particularly evident in the simpler of conditions where participants not only reported experiences that can be interpreted as Mindlessness and automatic (loss of the sensation of time, being on 'auto-pilot', merging of action and awareness, lack of conscious recollection of events and information) but additionally expressed effort and desire to achieve these states. However, for the more complex Clock Face conditions (aimed to impede automaticity) it was expressed that this was harder to achieve and was framed as a state of boredom due to its difficulty. As described in chapter 2.5.4, such states of boredom might induce experiences of mind wandering (and consequently Mindlessness), yet might not be experienced in similar ways to, as some participants professed, a more functional automaticity. Thus automaticity reported as 'being in the zone' and as effortless interactions may correspond to the statements above (Anderson, 1992; Langer, 1989; Koschmann, Kuutti, and Hickman, 1998); yet Mindlessness (from boredom) may also be facilitated in interactions that do not hold consistent stimulus-to-response and have a perceived difficulty and higher cognitive and conscious requirement.

Disruption to an automatic task will force the individual to adopt a more reflective or deliberative (i.e. Mindful) stance toward the task.

Automatic tasks will be less interfering with concurrent automatic tasks.

It was predicted that wrong answer alerts would invoke a disruption to the condition task and result in a reflective stance. As can be seen in figure 2.15 (Chapter 2.5.3) wrong answers increased the following answer time. Similarly, though not predicted, it can be seen that participant hesitations additionally increased the following test answers time in comparison to the preceding tests (the test with hesitation remaining the longest). This highlights the disruption to the on-going task caused by hesitations and wrong answer alerts, and may indicate additional cognitive resources in resolving previous / preventing further errors.

It was intended that Pop-Ups would create an interruption to the on-going condition task. This was observable in the answering times and was reported in participant interview. However, the effects were short lived as participants became accustomed to them.

2.9.2: Participant Questionnaire

The participant questionnaire (chapter 2.5.4) while useful in providing prompts for the qualitative questionnaire offered little variation over the conditions. While it provided opportunity for participants to expand upon answers few chose to do so. It did however provide participants opportunity to reflect upon the questions (where comments were made) and provided the qualitative interview with points of discussion and expansion. As can be seen in the final results of the participant questionnaires (Appendix 2.5 (Questionnaire Appendix 2.3), Figure 2.16 (Comparison of conditions) Chapter 2.5.4); there was little variation in responses across the conditions. It was revealed however, during further questioning in interview, that many participants held over estimations to the quality of their experience when initially questioned at a 'surface' level. This was illustrated e.g. when asking "can you describe your awareness?" with response of being fully aware, yet on further inquiry was revealed to be 'in the zone', or directed fully toward the task.

Future work might look refine and better tailor such survey toward specific conditions and explore where and how participants understood their attention and awareness and perceptions of passage of time. However, this would need to be supported through further qualitative interview and ensure that participant responses are of how they experienced and not how they assumed to have experienced.

Consequently, this form of analysis does not hold the utility expected and future researchers should be aware of its limitations.

2.9.3: Participant Interview

For many participants the experience of Mindlessness was prized during the interactions with these conditions. Many expressed desire toward 'being in the zone' in recognition of its speed, ease, and functionality. These sates were often described in similar ways to states of Flow (Csikszentmihalyi, 1992), yet (as described) such Flow states were not apparent in EEG data. For some, however, there was the opposite, enforcing additional cognitive tasks to prevent the automatic actions from making wrongful assumptions and answers. In this study the reasoning for wanting automaticity and being 'in the zone' were clearly in relationship to task simplicity and desire for fast completion. Though these were relatively simple tasks (aimed to facilitate automaticity), future work might widen and vary the degrees of creativity and reflection required. In doing so such work might gain broader understanding of how, when and why people apply strategies to accommodate Mindlessness in more general interactions and the effect of doing so.

Unexpected was the variation in description of Mindful and Mindless events and experiences reported by participants. While many initially reported a high degree of awareness it was only upon further questioning, and enquiry upon such awareness, that participants expanded upon their actual experience, often describing states of Flow or immersion. This was often assumed as being highly aware and attentive though critically was toward a single point (the interaction) lacking in awareness of events outside to this including the passage of time. In describing the drifts in degrees of attention Participant 3 (interview 2) described how "*I can feel my attention going away*". This statement is particularly interesting as it highlights a degree of awareness associated with shifts in attention and a lack of control that occur over substantial time frames. Conversely Participant 9 described their knowledge in the loss of awareness as occurring in much shorter periods; "*then you loose focus, and its not there, and you realize, but all these happen in a second*" (Interview 1). Future work might build upon these insights to understand their differences and how such awareness might be utilized to prevent moments of automaticity in future systems. Similarly participants also reported differing degrees of Mindlessness. This revealed four distinct states during interactions, a Mindful reflective state caused by errors and realization as meta-awareness/metacognition, one of awareness and consideration to the interaction, a controlled effortless interaction as automaticity understood to be a functional 'in the zone', and a less functional automaticity where interaction still occurs yet is uncontrolled and experienced as 'zoned out' and Mindless.

Consequently, participant interviews proved to be a vital part of a broader method in the analysis of Mindful and Mindless interactions, though future research should hold that such reporting occurs following specific events, holds inherent limitations (as described in Chapter 2.0.2) and so should be used to understand broader aspects of interaction as opposed to specific occurrences.

2.9.4: Physiological Measurement – EEG, Gaze and Pupilometry

While it was hoped that existing EEG measures of Mindful states would provide correlation and insight to the study data this was not found. This highlights the differences in the qualities of Mindfulness as it is perceived and described. Consequently this further highlights the need (and aims of this thesis) to explicitly describe and define what form of Mindfulness (and Mindlessness) is being drawn upon in study, analysis, and conclusions to prevent confusion and wrongful evaluation of states which are phenomenologically distinct.

Similarly, mental state classifications of Flow, Boredom, Engagement, and Overload (as described in chapter 2.7.1) held little response and correlation to interaction events (such as wrong answer alerts and Pop-Ups). This may be due to the time period and activity in which this was calculated. As was seen in Participant 10 Condition 7, engagement was sustained for a longer period that coincided with direct engagement with another person outside of the condition.

Future work would benefit from drawing upon a broader range of conditions for comparison, such as relaxation, immersion, cognitively challenging interactions etc.; from which a 'baseline' (per participant) might be drawn upon for comparison in further interactions of enquiry.

While there were some uncertainties in EEG analysis, as described above, there was additionally findings which highlight avenues of future work; particularly in P300 Event Related Potentials and EEG Dynamic Complexity and its variation. As highlighted in Chapter 2.6.3 P300 activations were found in response to all condition events that could be located accurately in time position (test show, wrong answers, Pop-Ups). The average amplitude of P300 ERP was observed to be nearly double for the two Clock Face conditions (approximately 4 μV) in comparison to the other conditions (approximately 2 – 2.5 μV). This highlights the additional cognitive resources required during the Clock Face conditions. Likewise it was observed that the Stroop based conditions (Linguistic and Spatial) lowered in P300 amplitude when the condition reversed (e.g. from indicating the word V's indicating the colour of font). This suggests that the following reversed condition required less cognitive resources. It is assumed that the reverse condition will initially require more cognitive effort (to overcome acquired automaticity) and this was reported by a few participants during interview. As previously described (Chapter 1.12.1) schema theory proposes that schemas can be applied to fit a required action or event as an automatic action (the application of previously knowledge) (Fischer, Itoh, and Inagaki, 2009). However, when no schema is triggered an effortful analysis of information of the environment/interaction is required mechanism until new *ad hoc* schemas are constructed. However, as noted by Chalmers (2003), Piaget (1962) states that schemas need not always be produced as new; schemas allow for the assimilation of new information into an existing schema. This faster and less effortful process justifies the reduction in cognitive load (and P300 ERP) in the reverse (in comparison to the initial comparable) Stoop conditions, as elements of interaction are retained yet the rule (e.g. provide an arrows direction) is adapted to support the new requirements (e.g. provide an arrows position).

Observations of P300 ERP were most apparent in the correct, wrong, and Pop-Up events (Chapter 2.6.4). It was observed that the correct alerts held little variation in amplitude over time (from the first 10% of correct alerts to the last 10% of correct alerts). Contrary to this wrong answer alerts showed a more broader change, the ERP moving firstly closer to the event (i.e. reducing in time) and then reducing in amplitude (from approximately 4 μV to approximately 2 μV). Likewise Pop-Up ERP's can also be observed to firstly closer to the event (i.e. reduce in time to peak) and then reducing in amplitude (from approximately 4 μV in the first conditions Pop-Up set to approximately 2 μV in the last conditions Pop-Up set). It should be noted however that there are substantially fewer observations of Pop-Ups to wrong and correct answer alerts. While all events still retained an ERP the change in amplitude follows participants responses that Pop-Ups became less surprising, and supports that wrong answers while initially causing interruption to the ongoing task became less meaningful as participants grew familiar (i.e. Mindless) to their occurrence. This provides indication that observation of ERP amplitude and peak amplitude time point within a time frame of 200 to 500 milliseconds following specific events can provide indication to event significance in a Mindful or Mindless context.

Raw EEG complexity mean variation and standard deviation (across 3 second period) additionally provides basis for further investigation in future work. While previously it was found that EEG complexity (over prolonged periods of time) would increase with more complex conscious states and reduce in less conscious states (e.g. anaesthesia (Schartner et. al., 2015)); it was observed that both increases and decreases of raw EEG complexity correlated with differing events. These alterations (and variation) in the complexity of brain activity suggest disruption to on-going mental processes. That is to say that simply being of high complexity does not conclusively indicate high mental activity. Low complexity may be representative of differing areas of the brain working synchronously yet in high frequency (e.g. a complex task performed globally); with high channel complexity but low comparative channel complexity. Yet this may equally be representative of independent brain regions working in low frequency (e.g. multiple simple tasks performed independently) low channel complexity and high comparative channel complexity. Thus the fluctuations toward lower raw EEG complexity might reveal actions whereby the brain engages in activating multiple regions (and processes) in harmony (as a global workspace proposed by Baars (1993, 1996, 1997)). Consequently the observation raw EEG complexity may be of the movement from sub-conscious activities to conscious events and so it is not the degree of complexity that is here understood to hold significance but the comparative variation in complexity.

While there were many instances where raw EEG complexity mean variation was seen to dramatically increase without apparent (comparative) cause there were many instances where increases followed specific events. The degree of these variations was also seen to be considerably higher in many instances, such as Participant 10's final condition where an interruption occurred and they were forced to engage in conversation (Chapter 2.8.3). It is possible that the un-associated changes in variation of raw EEG complexity mean variation could be the result of momentary loss and regain of conscious awareness over the interaction. As described by many in interview there was often moments of 'being in the zone' and then 'loosing it' that might not necessarily be from e.g. wrong answer, with some reporting such occurrences as preceding mistakes and wrong answers. Similarly, as described by Participant 9, these changes from (possibly) conscious to sub-/non-conscious experiences could occur in very short timeframes. Thus future work should utilize the measurement of variation in raw EEG complexity as a potential indicator to Mindful and Mindless events and changes.

In addition to EEG measurement providing avenues for future work data from gaze and pupilometry data also provided points that might be considered changes in and states of Mindfulness and Mindlessness. As previously described (Chapter 2.3.7) the relationship between the eyes and mental states has previously been stated as a bidirectional relationship (Goldwater, 1972). As with Kahneman and Beatty (1966), Kahneman (1973) and, Pomplun and Sunkara (2003); changes (i.e. increases) in pupil dilation were observed at events such as Pop-Ups, in addition to preceding and following wrong answer alerts and hesitations. As increases of pupil diameter have been previously associated with cognitive loading, these events reflect such changes and may provide indication to Mindful and Mindless interactions. As the conditions test themselves are randomized and of equal difficulty the reduction in diameter of pupil suggests a learning that requires fewer cognitive demands, i.e. the task becoming automatic. As many participants exhibited an increase in pupil dilation following events such as wrong answers, hesitations and Pop-Ups, and the difficulty of the condition did not alter; it suggest that the increase of cognitive demands is of a conscious demand, breaking the previous automatic action. This may be the alteration or questioning of mental schemas as a reflective conscious event drawing the interaction to the forefront of the global workspace and allowing the interaction to be experienced Mindfully.

In addition to pupil dilation, saccades and fixations additionally responded to errors and events during the conditions. The role of saccades and fixations has previously been linked to mind-wandering and automatic actions (Reichle, Reineberg and Schooler, 2010; Uzzaman and Joordens, 2011; Schad, Nuthmann, and Engbert, 2012); with the eyes movements recognized as meaningful in understanding a number of psychological processes (Liversedge and Findley, 2000) including attentive and awareness processes (Hoffman and Subramaniam, 1995), and its role in Mindfulness (Kumari et al, 2017). In this study it was found that Mean Eye Saccades duration per second minus mean Eye Fixation duration per second (divided by 10 to accommodate comparability to saccades) was altered by events such as hesitations, Pop-Ups, and wrong answers. The changes were occurred both preceding and following such events, following participants reporting during interview that their sudden awareness would cause a wrong answer, and highlighting the bidirectional relationship between what we see and our experience as noted by Goldwater (1972). This was not always true however and so future work might explore the relationship of pupil dilation and saccade/fixations duration per second in assessing Mindful and Mindless states in broader contexts and scenarios of interaction.

2.9.5: Limitations In Physiological Measurements

While the value of physiological measurements in understanding our being and behaviours is without question there are inherent difficulties that range beyond sensitivities of the equipment and concern experiential states (as previously described in Chapter 2.0.2). It cannot be expected that participants in study will hold mental states on demand, nor can it be expected that such states can be controlled. As noted by Anderson, Devulapalli and Stolz (p172, 1995) "*the concentration of a person can vary while the person is supposedly performing a simple mental task*". Consequently the classification accuracy of decoding mental states from physiological measures varies greatly, with even the best classifications of motor activities (e.g. imagined movement of left arm V's right) EEG activity occurring in differing hemispheres holding an accuracy of 70% (Anderson, Devulapalli and Stolz, 1995). Often such classification models are developed in carefully controlled and highly simplified situations and observing very short time frames (often under a second following stimulus), in comparison to what might be expected in practical applications (Haynes, 2011).

Such restriction of conditions would here be inappropriate given the context of Mindful and Mindless occurring over both short and long timeframes. As highlighted by Haynes (p524, 2011), the determining factor in whether conscious and unconscious "cognitive" states can be decoded is how distinct one state is from another. While it can be seen in the data (appendix 2.6) the physiological measurements are not consistently responsive to events, future work might hold focus to further understanding the role of these and refining such measurements. This might involve responsive measurements that probe participants immediately following such occurrences; e.g. should there be a large increase in raw EEG complexity variation the condition be halted and participant questioned. This would require extensively informing the participant of differences in attention and awareness to overcome initial presumptions found during this study (e.g. participants reporting high degrees of immersion (Mindless) as high levels of attention and awareness (Mindful)). Similarly future work might seek to establish differences though a broader range of conditions e.g. watching uninvolving media v's complex solution finding, such as those requiring a approach viewing objects as Tool's (Chapter 1.9.1) to overcome functional fixedness (Chapter 1.7.1); to extrapolate differences in mental states.

2.9.6: Future Work

As outlined above this exploratory study has provided a number of insights that can guide future work in the development in methods to detect Mindful and Mindless states.

The quantitative participant questionnaire proved ineffective in drawing clear distinctions between Mindful and Mindless states.

In contrast the qualitative interviews proved successful in gaining a broader understanding of participants experiences in relation to the conditions. This neurophenomenological methodology proved vital in understanding participant experiences that would not be possible without such line of inquiry. However, care must be taken to ensure that participants have the capacities to describe phenomenal states accurately, such as the distinction between immersion and awareness.

Successes were found in physiological metrics in four areas. Firstly ERP showed changes in time of peak amplitude and changes in degree of amplitude. While these occur within small timeframes (typically less than 500ms) such measurement might allow for the understanding of Mindful and Mindless responses to interaction events (i.e. from interface to user) such as security warning Pop-Ups or system notifications. Likewise variation in raw EEG complexity also indicated physiological changes in response to events and alongside gaze and pupil dilation changes. Further work is required to explore the variation in raw EEG complexity as a potential indicator to Mindful and Mindless events and changes. However, such work would benefit from a broader range of conditions for and incorporate participant feedback during the condition. Mean eye saccades duration per second minus mean eye fixation duration per second and mean pupil dilation also signposted response to events that invoked an interruption to the on-going activity. Future work might focus upon these physiological measurements and seek to apply them in 'real time', allowing participants to provide immediate responses to the phenomenal state. This would allow for better classification and understanding of these different mechanisms role in Mindful and Mindless states.

2.9.7: Evaluating The Success Of The Exploratory Study

At the start of this section it was highlighted that the aims were to lay groundwork for future work on methods of analysis for Mindful and Mindless interactions and not to produce a final method of analysis but to highlight potentially useful methods (that might be refined through future study). This has been described in the previous chapter (2.9.6) and so the study highlights success in this aim. Equally important is the "ruling out" of methods that are unsuitable (from those used in related fields and/or in the analysis of Mindfulness and Mindlessness in different contexts). This is reported in the chapter 2.6.1 where little correlation was found between EEG analysis (using existing methods) and participant feedback and interaction metrics. Lacking in utility was analysis of Flow, Boredom, Engagement, Overload; future work might explore changes in these states however it is suggested here that a far greater degree of refinement would be required.

It was described that a useful method of analysis will hold the capabilities of being easily integrated into interactive technologies (and their evaluation) and accessible by common place/commercial technologies (i.e. non-specialised medical equipment such as fMRI technologies). This has been demonstrated throughout the study.

It was highlighted that a useful method would provide indicators of specific moments of Mindful and/or Mindless interactions; and would work toward the future development of an unobtrusive and objective method/system for the analysis of Mindful and Mindless interactions with technologies. This was achieved and highlighted through chapter 2.9.6 on future work.

While a definitive method for the analysis of Mindfulness and Mindlessness during interaction with technology is not provided fertile groundwork for future methods to reach this aim are; explicitly, future work should hold lens toward a neurophenomenological methodology to draw upon qualitatively rich interview alongside EEG (specifically in terms of ERP and variation in raw EEG complexity) and mean eye saccades duration per second minus mean eye fixation duration per second, and mean pupil dilation.

SECTION THREE

Invoking Mindfulness And Mindlessness During Interaction

3.0: Human-Computer Interaction Design, Mindfulness And Mindlessness

> “[…] novices learn skills first by acquiring a set of decontextualized rules. The novices' mode of understanding is "theoretical." As they become more experienced, they become more attuned to situational specifics and their reasoning becomes more holistic. Previously solved problems are retained as resources for future problem solving. Eventually, a level of expertise is achieved in which problems are approached "intuitively" instead of "analytically." Expert problem solving, therefore, involves a more "primary" mode of understanding. However, when the expert encounters a novel problem, one for which a previously solved case is not available (or not recognizable), the expert may be required to adopt an "interpretive" approach to solving the problem, appealing to previously learned rules and reasoning from basic principles.”
> (p39, Koschmann, Kuutti, and Hickman, 1998)

As learned in the first section (Section 1) novices learn skills and this knowledge may become stored within a mental schema, a blueprint of action or knowledge learned, as a state of rules e.g. [*if • then do ⦿ and then* ***O***]. While during rule formation this action set may have been conscious they increasingly become enacted (and potentially adapted) sub-consciously with repeated exposures. This holds benefits of speed and freeing of (conscious) cognitive resources toward other objects of attentive awareness. This can be seen in the Mindless expert who performs multiple tasks with speed and without effortful attention. In this state a natural and primacy of understanding exists (often described as “intuitive”); the agent and equipment perform as one where the technology exists as an extension of the self. This process (when operational) becomes increasingly automatic over repeated exposure; as noted by Langer (1989) the steps involved become sub-conscious and inaccessible (without difficulty) to contemplation [• = ***O***]. Furthermore, it is also recognized that these actions may be invoked through events that suggest or appear to (yet do not) match the mapping existent mental schema, [◆ = ***O***]. To be noted • and ◆ though similar are not the same; though they appear to be similar enough that previous understandings *may* be wrongfully applied. A potentially crucial step [e.g. ⦿] is also removed from the process. Such steps may be contextual (and analytical) and required when the familiar context stimulus is not there, though now lost from conscious availability as the task becomes intuitive, automatic and Mindless (Koschmann, Kuutti, and Hickman, 1998).

This forces the (now) expert to adopt "…*previously learned rules and reasoning from basic principles*" (p39, Koschmann, Kuutti, and Hickman, 1998); ones that may not be appropriate/correct toward this novel problem (Schramm and Hu, 2014). The task (technology) has become functionally fixed as intermediary steps (and potential novel solutions) exist in a 'phenomenological invisibility'.

As will be highlighted in the following, interactive systems invoke this state of 'phenomenological invisibility' through:

- Easing cognitive loading by transferring familiarly through metaphor
- Invoking routine behaviours and fixed meaning
- Homogenization and repetition of interface and information provision
- Forcing users to adopt defensive behaviours from information intense environments and through surface level information consumption

And

- Immersion

This section addresses this dominance of 'phenomenological invisibility' within Human-Computer Interaction. This is here specifically understood as interactions without conscious consideration or reflection upon "*how*" they are performed i.e. as non-/sub-conscious interactions. This is achieved through critique upon the promotion of the *invisible computer* as optimal design in all circumstance; building upon existing notions that designers should attend to both the functional and non-functional properties of interactive systems to improve the experience and abilities of the user.

Primarily this section illustrates alternate framing and understanding of interaction design in terms of the previously defined *Mindfulness* and *Mindlessness*; and provides example of why such states may occur and how they may be countered through design. This is achieved through highlighting the interrelated nature of cognitive load, metaphor, intuition, efficiency and functionality, repetition and routine, and information provision, as motivating Mindless states through differing influence; and provide example of how these may be countered to foster Mindful interactions.

Through this understanding of such experiences with technologies (e.g. when a user is unaware of the presence of a technology or interface as distinct from themselves), it is highlighted both positive and negative qualities held by users of technologies when in these differing states. In doing so it is aimed to demonstrate how positioning interactions with technologies through such lens (of Mindful and Mindlessness) may draw better balance the understanding (and subsequently the design) of how technologies work *for* us, 'invisibly' and autonomously; and *with* us, exposing and encouraging opportunities for novel solutions and interactions.

3.1.0 How Things Become Mindless - The Vision Of Invisible Interactions And The Counter

> "The most profound technologies are those that disappear […] Such a disappearance is a fundamental consequence not of technology but of human psychology."
> (p94, Weiser, 1991)

Designing for 'Knowing' and 'Thinking'

Weiser's seminal article "*The computer for the 21st century*" (Weiser, 1991) presented a vision of the next generation of computing technologies disappearing into the "periphery" of our awareness (Weiser and Brown, 1997), and embedding themselves into "*…everyday life until they are indistinguishable from it*" (p94, Weiser, 1991). This disappearance, Weiser claims, is to free us "*…to focus beyond them on new goals*" (Weiser, 1991, p94). The disappearance occurs not as a visual property of the object but in a phenomenological awareness of the technology. That is to say a well-designed technology is considered to employ invisibility *of* and *in* operation (Weiser, 1994), it "*does not intrude on your consciousness; you focus on the task, not the tool*" (Weiser, 1994, p7) (see Chapter 1.9.1 on tool and Chapter 1.9.2 on equipment). As noted by Weiser (above) this is not a unique property of digital technologies but is a functional aspect of human existence as previously described in Chapters 1.6, 1.7 and 1.8.

This view of invisible computing was extended by Tolmie et.al. (2002) who proposed that computing technologies should become "*Unremarkable*". Unremarkable computing relates to technologies that become 'phenomenologically invisible' through integration into routine, providing a level of automation that the user assumes occurred through their actions; fundamentally the "*…ubiquitous computer leaves you feeling as though you did it yourself* " (p404, Tolmie et.al., 2002). Such positions strongly advocate the designing of technologies to be phenomenologically invisible, not just in design theory but in applied design practice (i.e. designing toward equipment –Chapter 1.9.2). As previously described (chapter's 1.6 to 1.12) such invisibility is incurred both in our approach to the technology and through our understanding as technologies become routinized in our activities. Resultantly such invisible and unremarkable technologies leave the user 'knowing' the interaction without need to 'think' how such interaction occurred.

Whilst the complete vision of ubiquitous computing may not be fully realised, many its concepts have been adopted throughout computing research and practice

(Abowd, 2012). The former dominance of the stationary desktop personal computer is no longer as clear as the number of smartphones and tablets in use now rivals. While these devices offer a broader range of input the majority of communication to the user occurs in the same modality, via a two dimensional Graphical User Interface (GUI) (Abowd, 2012), moving the desktop design traditions (developed for the workplace) into our hands and environments. These are, however, pervasive in our daily routines and social interactions; the effects of which warrants investigation into the influences that exist beyond the immediacy of the technologies design and intended use (Nathan et. al., 2006) to facilitate reconsideration to the broader impact of such design practices.

As noted, at present many of the ideas of ubiquitous computing are now implemented in most of computing research and practice (Abowd, 2012). Algorithms are being developed to replace the "mundane" actions of the user through automation (Rogers, 2006) by interpretation of routine and preference. Yet how designers should decide if, when and why such automation should occur receives far smaller attention; the ideals of designing computing for using without thinking still needing to be "*counter-balanced*" (Rogers, 2006).

Rogers (2006) proposes "*a new agenda for UbiComp*", one in which computing technology should be designed to "*…extend and engage people in their activities and pursuits.*" (p411, Rogers, 2006); arguing that rather than reducing the requirements of the user to "think" ubiquitous computing should consider further driving the abilities of human intellect and extend "*…their ability to learn, make decisions, reason, create, solve complex problems and generate innovative ideas*" (p411, Rogers, 2006). Such position echo's distinctions drawn by Shanahan (p42, 2010) who frames cognition as to "know" (reliant upon previous schemas); as opposed to "*cogitare, to think*" an active process such as a formation of new knowledge and mental schemas.

Likewise Wright, Wallace and McCarthy (2008) propose that though functional attributes of interactive systems are of high value, an understanding of the emotional and experiential values that people construct through interactions with technology should also be supported and designed for. Wright, Wallace and McCarthy's (2008) position highlights how HCI research is limited in its focus on making interactions between people and technology functionally efficient rather than attending to the subtle and on-going changes in emotions and experiences people might feel.

Such visions that highlight the need to reconsider the design and usage of computing technology are fundamental and syncretic to the aims of this thesis.

3.1.1 Designing for Transparency (Knowing) or Reflectivity (Thinking)

Much of HCI design may be considered as situated within cognitive models of understanding human-machine interactions (Bolter and Gromala, 2006); that is, the user in action independent of experience. To further this, the archetypal measurements of "User Experience" hold 3 qualities of focus in the evaluation and improvement of HCI systems:

1. Effectiveness (Can it perform the required task)
2. Efficiency (Steps/time/skills required)
3. Satisfaction (Fittingness of technology to achieve desired goals)

Whilst these qualities allow for a quantification of the performance of an interactive system they fail to consider the experience of the user.

Subsequently, attempts to analyse and further develop interactive systems based upon this paradigm retain a focus upon usability (effectiveness, efficiency, and user satisfaction) and performance of the system (speed) rather than the subjective experience (how the experience "felt") of the user (Dillon, 2002); a method of measurement that reinforces the "transparency" model of human computer interaction (as critiqued by Bolter and Gromala, 2006; and the work of *Wright and McCarthy, 2010; Wright, Wallace and McCarthy 2008*).

To further highlight the need of human computer interactions to support Mindfulness (and how those needs might currently be neglected); it is proposed that current design qualities, specifically the use of "metaphor" in suggesting particular affordance, are applied in such a way that they further encourage/facilitate *Mindlessness* and *Automaticity*.

This position is supported by Blackwell (2006), who suggests that even though metaphor is widely used in user interface design many have recognised the potential harmful effects of such design strategies (when applied as universal principles of design). Blackwell highlights several authors (including design guidelines from the dominant software development companies such as *Apple* and *Microsoft*) (p492, Blackwell, 2006) who reinforce the use of metaphor as a device to allow users to rapidly recognise "digital objects" (interactive elements of a user interface as a graphical representation of a function e.g. a "trash can" for discarding no longer required files). By use of these design principles designers are able to relate functions of the digital objects to "real-world" abilities of the physical counterpart the metaphor is developed from; and allow users to quickly familiarise with function. Furthermore, through the sharing of these design elements across applications users may apply knowledge across differing applications (through the commonality of design elements).

However, as noted by Blackwell (2006), through "enhancing" these digital objects by increasing the "realness" or "richness" of the pictorial representation beyond more abstract representations the ability of the user to recognise function did not increase. This suggests that the communication of affordance offered by the digital object and metaphor is not of perceptual affordance but of a conceptual affordance, the mapping of an existent mental schema (Chapter 1.12.1) of function (of a physical object) to the digital counterpart. Thus, such relationship between the digital object and its physical counter part suggest to the user that they both share the "affordances" (Chapter 1.8) of one another and the same mental schema.

As noted by Fischer, Itoh, and Inagak:

> "Schema theory postulates that perception, interpretation, specification and execution can be shortcut when prior schemas are triggered. Action is direct, automatic - we might here say intuitive - if each stage benefits from prior schemas. Conversely, when no schema is triggered, the user has to analyze the interface content. This effortful mechanism is necessary until new ad hoc schemas are constructed. It is consequently important that the "system image" or the interface that fails to trigger prior schemas, at least supports the construction or induction of new ones"
> (p36, Fischer, Itoh, and Inagaki, 2009)

Consequently, this mental schema does not need questioning on the difference between the digital and the physical since it is automatic; and so stand to reason that the previous rule set of the "applicable" mental schema is transferable and valid [*if* • *then do* ⊙ *and then* ***O***]. As previously described this may include a removal of contextual and analytical steps, which may prove problematic as they wont hold same properties (being differing digital and physical objects. Subsequently the digital object performs as a 'tool' (Chapter 1.9.1) of the physical, limiting the availability of affordances that might be offered or extended (in relation to the physical counterpart).

While the dominance of designing for the invisible computer is clear there have been previous works that seek to reframe and address this balance. Bolter and Gromala (2006) provide the explanation of interface design as falling into two principles; those that utilise "*Transparency*" (akin to 'equipment' Chapter 1.9.2) and those that utilise "*Reflectivity*" " (akin to 'tool' Chapter 1.9.1). Bolter and Gromala (2006) claim that designers of interactive systems attempt to create a "transparent" window that presents information of the workspace to the user without (or with minimal) interference and distortion. Interactive systems designed upon this paradigm are therefore considered flawed if the technology draws attention to itself or enters the users conscious consideration. Contradictory to this are designs that "reflect" the interactor, such as an aesthetical representation as seen in the majority of interactive digital art. This mirroring promotes the user to reflect on the interaction process and their relationship with the interface. Additionally through the use of aesthetically focused interaction states of play occur with user who experiments with the interface to explore new creative possibilities. This idea of bringing the interface and interaction to the centre of the dialogue between the user and the technology runs in opposition to how many ubiquitous computing technologies are designed as embedded and autonomous in the environment, invisible in their processes. Although Bolter and Gromala (2006) argue for mirroring of the users interaction they further support the notion that there should be a degree of exchange between transparency and reflectivity, which the interactive system should reflect the users action and presence yet should also provide a transparent window to information.

Consequently, it can be understood that systems developed upon a "transparency" model are reliant upon/encouraging Mindless (sub-/non-conscious and cognitive) actions. As such there is a removal of the contextual awareness (i.e. The Mindful awareness) of the information presented and may not facilitate the broader (and richer) abilities that are associated with reflective-/conscious actions. This may result in or encourage a premature cognitive commitment or "blindness" to the semantic variation (As described in chapters 1.7 and 1.12).

3.1.2 Enhancing Reflection Through Augmenting Cognitive Load

As will be highlighted through this section there are various modalities for designing Mindful interactions; specifically drawing upon differing forms of reflection through a number of modalities and design values.

While the previous (3.1.0) has discussed a design trope of reducing cognitive loading, Mindfulness (high in cognitive loading in comparison to Mindless interactions) may be encouraged through provoking and utilizing cognitive load. Niedderer (2014) proposes such position through example of "*Come a little bit closer*" (by Nina Farkache of Droog Design[22] (p. 57, Ramakers, 2002); Figure 3.1).

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[22]http://www.droog.com/project/come-little-bit-closer-bench-nina-farkache

Figure 3.1; "Come a little bit closer bench"[23] *by Nina Farkache of Droog Design*

'*Come a little bit closer*' is, defined by Niedderer a 'performative object' (Niedderer, 2007), a bench that has altered its performance as a bench. This is achieved through the placement of marbles under seating 'shells' that allow them to 'float' i.e. move freely across the width of the bench frame. As these seating shells are free moving the design allows for users to move the seating position to and from others sharing the bench; as Niedderer (2014) claims suggesting movement of not only a physical presence but closer and further on (conceptual) social levels. As noted by Niedderer (p347, 2014): "[…] *the design questions people's behavior in public places— which is to avoid strangers and to sit down at opposite ends of a public bench—by offering alternative actions*". In its alteration *'Come a little bit closer'* forces a questioning upon the premature cognitive commitment held of a bench in a public place (Niedderer, 2014); drawing attention to the additional affordance and questioning what a bench is 'commonly like' through adding additional choices – to slide closer or further, perhaps to engage in 'play'.

As Niedderer explains (p352, 2014); "*The aspect of choice is important because choice makes us Mindful*", and that with more choices being expected to increase reflection and so more Mindful through:

- Encouraging a greater sensitivity to the environment
- Encouraging openness to new information
- Creation of new categories for structuring our perception

[23] Image retrieved 16/09/2017 - http://www.designlaunches.com/wp-content/uploads/2013/01/come_closer_bench.jpg

And

- Enhancing awareness toward multiple perspectives of problem solving

(As stated by p3, Langer and Moldoveanu, 2000)

Niedderer goes on to state:

> "This suggests that Mindful design needs to offer the user choices. Adding more choices can be expected to increase reflection and thus Mindfulness,[…] "
> (p352, 2014)

This, however, is at odds with the statement of Anderson (1992) who described automatic (Mindless) processes as '*less slowed down by the number of alternatives*' (chapter 1.12.3). This suggests that the augmented bench (or other augmented object) is not perceived through the same understanding as other commonplace comparable (automatically / Mindlessly experienced) bench/objects; e.g. regular benches – perceived as 'equipments' (chapter 1.9.2) with sole, immediate, and apparent affordance of 'bench for sitting'.

Possibly such augmented objects are instead so ill-fitting to pre-existing mental schemas that they require a 'tool' (chapter 1.9.1) approach to apply previous (or combinations of) mental schema. And so *then* (when experienced as tool) reveal the additional choices afforded beyond the most immediate and apparent of 'bench for sitting'. Through this perspective it is not the *choices* offered by the augmentation of the bench but the *augmentation itself* that prompts Mindfulness, the choices offered (revealed through a tool – multiple affordances) being a result of a Mindful approach. As previously described, Niedderer explains (p352, 2014); "*The aspect of choice is important because choice makes us Mindful*". However, considering Anderson's (1992) understanding, this statement might better be explained as "the aspect of Mindfulness is important because *Mindfulness* reveals choice".

An analogy of this could be, for example: in my favorite coffee shop I order a flat-white each visit; they have multiple choices available but these are 'invisible' to my habit (automatic process) – I am Mindless to them. If however, I move beyond my habit (e.g. a new barista does not know how to make a flat-white – causing a augmentation of the process (a breakdown)), I become Mindful of the differing kinds of coffee – though the number of choices are the same as before (minus the flat-white) these are now phenomenologically present. Thus the augmentation (not the choices):

- Require multiple perspectives of problem solving to fit pre-existing knowledge
- Require creation of new categories for structuring our perception (i.e.

novel mental schemas)

- Require openness to new information to develop new schemas

And

- Require a greater sensitivity to the environment to contextualize schemas

And as a result of this process the availability of choices we understand as afforded by the augmentation. Though such differences may seem perhaps 'chicken-and-egg'; here discrepancy is important in justifying the provocation of Mindful experiences over simply offering additional choices (that may be Mindlessly invisible).

What is clear from the "*Come a little bit closer*" bench (Ramakers, 2002) is that there is an additional level of reflection required in understanding and approaching the bench. While (as previously described (3.0 and 3.1)) designers typically seek to provide a transparent window to information, and remove the 'middle steps' e.g. [*if* • *then do* ⊙ *and then* ***O***] to ease cognitive loading; here there is an intentional increase upon cognitive loading to cause reflection. With such design there is intentional breaking (through augmentation) of the intuitive and automatic approaches we hold to commonplace technologies, and in doing so a refusal to easily fit to existing mental schemas:

> "Conversely, when no schema is triggered, the user has to analyze the interface content. This effortful mechanism is necessary until new ad hoc schemas are constructed. It is consequently important that the "system image" or the interface that fails to trigger prior schemas, at least supports the construction or induction of new ones"
> (p36, Fischer, Itoh, and Inagaki, 2009)

Thus such design attributes can be seen to augment not solely the object (as it still remains a bench and holds affordance of sitting), but rather they are an alteration toward the efficiency of cognitive loading, forcing effortful interactions, interpretation, and reflection. In doing so performance as a metric of cognitive load (ease of use and intuitiveness) is reduced, however, performance as tool is increased (revealing novel affordances in the objects 'tool' state).

3.2. Intuition and Metaphor as design attributes of Mindless interaction

As previously described, designers seek to reduce concerted conscious awareness of an interfaces presence and functionality (i.e. 'thinking' about the interface) through being *Intuitive* (Naumann et. al., 2007). The ability to allow users to draw on previous knowledge to interact with new interfaces has prescribed the 'intuitiveness' of a software or interface as a desirable trait (Löffler et. al. 2013; Raskin, 1994), used as a measure in the analysis of "usability" (Naumann et. al., 2007; O'Brien, Rodgers & Frisk, 2008; Poole et. al., 2008; Raskin, 1994) and, as a device for marketing (O'Brien, Rodgers & Frisk, 2008; Raskin, 1994). Thus, improvements of interactive technologies seek to enhance the intuitiveness (and so the phenomenological invisibility) of interfaces and interactions. As previously described (Chapter 1.12.2) such intuitiveness is not 'intuitive' in the truest sense of the word, but developed from existing mental schemas as an act of automaticity in 'knowing' an interface or 'rule' of interaction.

Though intuition may appear as a positive attribute it presents problems when it is misused. Users may learn incorrect methods of interaction through their reliance upon and application of previous knowledge, and may fail to utilise many system features (O'Brien, Rodgers & Frisk, 2008). There is a lack of guidance for designers to correctly implement intuitiveness (Löffler et al, 2013), and if there is a novel experience to which there is no relational prior experience, the seemingly intuitive (to the designer) requires exposing (see Raskin, 1994 for example). Additional failures resulting from misguided intuition are exposed when viewing intuition developed from metaphors. As intuition is largely developed from pre-existing knowledge; designers of interactive systems often exploit this through the use of interface metaphors (Blackwell, 2006) (as previously described). This is evident when viewing the commonplace "desktop" model, applying metaphors gained from office workspaces (Bewly et. al., 1983). Metaphors have played a dominant role in HCI interface design since the earliest GUI's (Graphic User Interface) with software development companies suggesting that metaphors based upon "real-world" objects allow users to draw upon existing knowledge and quickly familiarise themselves with the functions of the interface (Blackwell, 2006).

Norman (p50, 2013) suggests that this mode of design may be understood as part of the three levels of information/interaction (and cognitive) processing - *Visceral*, *Behavioural* and *Reflective*.

Visceral processing involves an initial non-conscious assessment (e.g. a positive or negative valence) of the information provided from an object; it is rapid and entirely automatic (in that it is beyond conscious control) and being reflexive occurs without any context, as an affective property. Visceral is the most immediate of all the sensing and directs decision to what is good/bad, safe/dangerous etc. The visceral level of understanding informs the next level of information processing; behavioural.

Behavioural processing exists as learned (well practiced) skills and occurs largely as sub-conscious actions. Whilst a user may interact with a system and have an awareness of their actions (to an extent) the actions are carried out too quickly for conscious control (p51,Norman, 2013), the behavioural response is one that's is learned (through repetition) and repeated, that may be understood as an "experiential cognition" (Niedderer, 2007).

Reflective processing is least immediate level, in which conscious consideration and reflection on past experiences is drawn upon the object. Reflective processing can enhance or inhibit behavioral processing, but has no influence upon the automatic visceral reaction. Through reflective processing we are able to integrate previous experience with technologies into broader life experiences and associate meaning and value with the artifacts themselves.

A metaphor, when used in a GUI, is specifically chosen to convey a particular (single or set) of 'affordances' and suggest how that object may be used (Norman, 2013) (see chapter 1.8) and its significance. A designer utilising a metaphor will draw upon a user's expectations of the affordances of a non-digital object or quality to give clues to the digital counterpart's ability through invoking differing stages of processing as described above. For example, this may be the colour scheme or aesthetic elements to help direct visceral processing (e.g. warning signs in yellow and black diagonal stripes); invoking behavioural processing through highlighting affordances of a metaphor (e.g. a broken padlock suggesting caution to safety and security) and familiar traits to help direct the user in a suggested or desirable action (e.g. fig 3.2 below).

Figure 3.2; Broken padlock symbol suggestive of broken or flawed security. Colour use additionally familiar to that of typical warning or alert signs

Whilst interface metaphor is useful to provide users instantaneous knowledge of the functional potentials of a system it has been met with some resistance (Blackwell, 2006). The usage of metaphors, while beneficial for basic understanding, may influence the user's perceptions of the system's functionality negatively (Blair-Early and Zender, 2008) as they attribute abilities in a fixed "premature cognitive commitment" (Chanowitz and Langer, 1981). A premature cognitive commitment occurs from an initial exposure of information whereby the information is accepted uncritically. As previously described, Langer (1992) proposes that this state occurs when information (or objects) is perceived in such a way it appears as an absolute and requires little or no reason to critically examine further. When this assumption is made the person viewing the information fails to see "contextual dependencies" (Langer, 1992) that may alter the meaning of the information and "fixes" the meaning of what was originally assumed. This removes the ability to perceive the "semantic variability" and makes future reconsideration of their understanding unlikely (Chanowitz and Langer, 1981; Langer, 1989). While previous examples held focus toward non-digital objects in problem solving (chapter 1.7: Two-rings problem (McCaffrey, 2012) and Dunker's "Box" problem (Dunker, 1945; Anderson, 1992)); example of this in HCI may be a *save* icon/action whereby a novice user commits to the assumption this will safely store a file. Through repetitive use the *save* function replaces the original file (deleting it). Therefore the *save* function actually has the dual action of both saving and deleting, however due to the premature cognitive commitment, *save* fails to include "removal of previous version" in its perceived meaning, this is problematic as the original file (or previous versions), if looked for, has been replaced. The metaphor here is a representation of a number of functions yet understood as an absolute singular function – in its automatic use as an 'equipment' (Chapter 1.9.2) the analytical and contextual steps are lost in the more direct mental schema. These problems are further understood through framing within "functional fixedness" (Chapter 1.7.1; Adamson, 1952). More specifically, this may be seen as a user failing to find or account for the full functionality of a system through assumption derived from overt and common use metaphor to infer a specific function (without providing more broader contextualization of said function).

To summarize, designs that employ metaphor invoke a visceral reaction (of familiarity) and prompt a learned behavioural response (through association of affordances) that can be seen as being performed 'intuitively' (chapter 1.12.2), all mostly occurring as non-/sub-conscious process (i.e. prior to a reflective processing) with aim to direct the user in a suggested or desirable action (as described by Norman, 2013).

Yet perhaps more rarely, and advocated in this thesis, there are times when a designer might wish to invoke the reflective processing (Norman, 2013), allowing the user to contextualize the meaning and use of a technology in a broader, specific, or personal context than that of previously learned routines.

3.2.1 Enhancing Reflection Through Augmenting Utility

The design methods described above draw upon intuitiveness (and metaphor) as a utility and exploit this feature as a Mindless attribute of a system. Here utility is understood to be a function, a use toward a particular benefit – here specifically a conveyance of meaning and information. Though this is clearly a required attribute of any interface here it is suggested that this might be augmented to provide benefits (in the right circumstance). Designs to support Mindfulness might seek to open up utility through embracing interpretative qualities; encouraging reflection upon the wider affordance space and meanings offered through the interaction; and consequently the development of appropriate schemas of meaning contextualized to the present interaction.

Mind Pool[24] (Long and Vines, 2013), is a Brain-Computer Interface (BCI) artwork that provides real-time feedback to participants of brainwave activity. The work highlights how the use of multiple modalities of ambiguous feedback (Gaver, Beaver, and Benford, 2003) engaged users in reflective ways that is unsupported by quantitative information feedback. The aim of the system was to present EEG information ambiguously so as to encourage and support sustained interactions and Mindful-reflection by participants through relating the ambiguous feedback with their brain activity. Brain activity is sonically represented and physically represented via a magnetically reactive liquid (*ferro-fluid*) sitting in a pool in front of the participant (See Fig AA). Feedback is produced from 12 dominant brainwave frequencies of a participant wearing a BCI device and represented through ambiguous forms allowing participant's to associate information provided with their own experiential state.

Mind Pool utilizes EEG (Electroencephalography) as a source of control by revealing 12 dominant brainwave frequencies that alter parameters of information feedback. This frequency information is gathered from QEEG (appendix 2.4), whereby readings were taken between 1 and 48Hz and then further divided into six bandwidths of 8Hz (i.e. 0-8Hz, 8-16Hz and so on). The frequency with the highest amplitude within a bandwidth was used as the dominant frequency providing six dominant frequencies per hemisphere. It is these dominant frequencies that alter the

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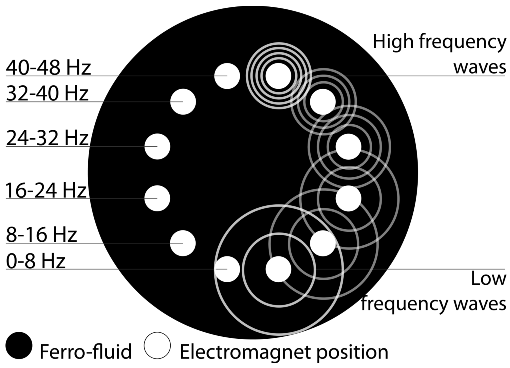
[24] Mind Pool Publication: Kiel Long and John Vines, 2013, Mind Pool: Encouraging Self-Reflection Through Ambiguous Bio-Feedback, ACM CHI doi:10.1145/2468356.2479588
*Previous iterations of Mind Pool were developed as part of a Master of the Arts Degree completed at University of Wales, Newport (2010). The system was subsequently redesigned with deployments in various art and conference exhibitions following this period.

parameters of the installation (such as pitch and timing of audio triggered, and control of physical feedback system). The final iteration of Mind Pool consisted of a large flat surface with a 'pool' of ferro-fluid at its center. 12 electromagnets below the pool produce ripples through alternating on/off cycles at a rate determined by the dominating frequency for that bandwidth. The electromagnets are arranged in a circle with lowest bandwidth closest to user and higher bandwidth furthest, and are split left and right according to the hemispheres (Figure 3.3). Audio is triggered in correlation to ripples produced and alters pitch according to dominant brainwave frequency. Participants sat at the installation (Figure 3.4) although were free to move around the environment.



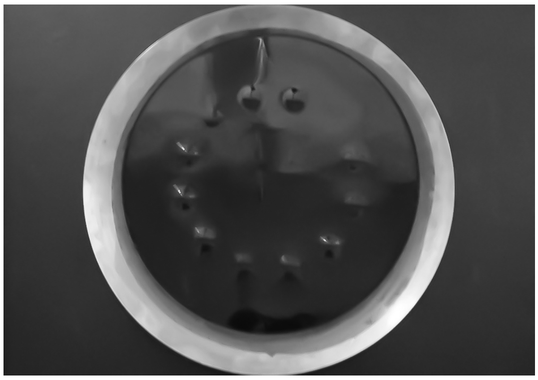


Figure 3.3; Mind Pool installation feedback system layout.

Figure 3.4; Participant using Mind Pool

The governing motivations behind the design of Mind Pool was the information provided to participants had to balance opportunities to interpret its meaning (i.e., its relationship to brain activity) with motivating sustained interaction. During development testing a number of feedback mechanisms were tested such as a 'physical' visual feedback system (a series of moving actuators) and graphical displays (graphs of the full spectrum of brain activity) alongside the audio feedback. There were stark contrasts in the ways in which testing participants reacted to these two forms of representation. When observing the graphical display, which was very information rich, testing participants would initially be highly engaged. Very quickly however testing participants would come to passively observe the information and there was very little impetus to explore how the information related to actual brain activity. Contrasting with this, the combination of 'physical' visual representation and sonic feedback led to less immediate engagement but supported exploratory interactions over more sustained periods of time. Equal frequency division was applied to avoid users of the installation applying any existing knowledge of brainwave pattern categorization and their associations (e.g. *"Alpha (8-13Hz) is relaxation"*), promoting self-derived correlations of mental states and experiences with feedback. This was particularly important as during the initial development testing many participants with some knowledge of EEG and brain activity would assume the interface feedback (i.e. when numeric/graphical) was dictating their states causing conflict between their experiential state and that 'told' to them from previous knowledge and information rich displays. Following these explorations the 'Pool' (previously described) and audio were designed to provide ambiguous (Gaver, Beaver, and Benford, 2003) level of feedback for participants. This allowed participants to observe activity for individual brain hemispheres and bandwidths; and, by viewing the center of the pool the waves of each bandwidth aggregated to produce a pattern of activity across the entire brain. It is important to note here that while the information feedback was ambiguous, it still remained 'true' and was an accurate reproduction of the data. However, the ambiguity of the feedback did not hold suggestion toward how to 'read' the system and encouraged reflection upon the subjective state and how this was correlated through the system changes.

The metaphors used in Mind Pool (Long and Vines, 2013) were intended to be interpretive and so would hold meaning subjectively. This required users of the system to find their own meaning in the data, relating alterations in the feedback with their own subjective experience. This was starkly different from the information rich feedback previously explored where values and bar charts, though familiar and easily read, suggested rises and falls as holding positive and negative meanings. Such use of metaphor and their interpretation affecting emotional reactions and perception has been widely discussed such as the work of Lakoff and Johnson (2008). Thus, it was clear that the form in which feedback is presented had noteworthy impact upon the quality of engagement with the interface. While one of the key aims of the work was to provide an ambiguous (Gaver, Beaver, and Benford, 2003) interface where participants could explore relationships between brain activity and feedback it is still important for participants to be able to 'see themselves' in the interface in order to provoke reflectivity (Bolter and Gromala 2006).

While more commonplace design tropes draw upon familiar objects as directions toward use and specific meaning (through metaphor), the utilization of ambiguity in

Mind Pool (Long and Vines, 2013) opened a space for users to interpret meaning of interface elements – the utility of the feedback. This was realized as the users own understandings, through a required contextualization that relates the present interaction to system feedback (as opposed to previous and/or ill-fitting schemas). In doing so such systems encourage a moving beyond *Visceral* and *Behavioural* (Norman, 2013) equipment (Chapter 1.9.2) understandings and promote a *Reflective* (Norman, 2013) engagement (inclusive of the visceral and behavioural understanding) with technologies as tools (Chapter 1.9.1) that may be considered as Mindful. Such experiences facilitate novel behavioural responses (as opposed to learned) that open users toward novel solutions and identifying personally meaningful interactions.

3.3: Mindlessness From Repetition - Disappearing Through Design - Disappearing Through Repetition and Homogenisation

Whilst intuition (previously described) draws upon previous experiences and knowledge to understand new experiences (and metaphors), phenomenological invisibility additionally occurs through well-learned actions (described in chapter 1.12). As previously described, Hollis-Walker and Colosimo (2011) frame Mindlessness as an "*unknowing of underlying processes in our subjective and objective worlds* […] *where a person goes into automatic pilot-mode during a complex, well-learned activity*". Likewise, Langer (1992) proposes "*that Mindlessness may result from a single exposure to information.*"; suggesting that Mindlessness states occur when information (e.g. technologies and interfaces) are presented and perceived in such a way they require little or no reason to critically examine further. In this state the person viewing the information fails to see "contextual dependencies" that may alter the meaning (and context) of the information; and assume the same meaning of a previously learned interaction through enacting a "premature cognitive commitment" (Chanowitz and Langer, 1981); as though performing a well-learned script.

Langer's (1992) position states that Mindfulness and Mindlessness are central to cognitive functioning; here this is understood in relations to working memory, and more specifically the limitation on the available amount of workable information/memory that humans can engage with during tasks. In learning, automaticity (through mental schemas) takes sequential steps required to perform an action and groups them as a singular whole. For example, to log into a computer the steps might involve: opening a laptop, waiting for the login screen to appear, entering a user name, entering a password, pressing the return key; however in the perceived conscious action the process is simply grouped within the mental schema of "log in" (perhaps the log in screen acting as a prompt to enter the automatic following steps). This is exemplified in Langer's (1989) statement that such steps, with repetition, eventually drop out of mind (conscious awareness); that anyone familiar to this "*…knows how learned tasks drop out of mind.*" (p20); how the "*…the individual parts of the task move out of our consciousness. Eventually, we come to assume that we <u>can</u> [original in italics] do the task although we no longer know <u>how</u> [original in italics] we do it.*" (p20, Langer, 1989). This is typically experienced when being required to enter a user name and password on a different device, the well learned (and automatic) routine is enacted before and without interruption (realization often occurring when the password or user is denied). Similarly (and in personal experience of switching between Apple OS X and Microsoft Windows) such difficulties occur when using differing operating systems; the match of how one functions in comparison to another, the aesthetics (typically a windowed display), suggest that the previous mental schemas will transfer (and they often do with minor amendments) – yet when reaching to "close" a window on the interface one will find that they are clicking on the wrong side of the windows frame (no affordances of the interface suggest the 'wrong' corner as holding any functions i.e. there are no 'buttons' placed there).

While this phenomena of 'disappearing'/'invisible' technologies occurs naturally from repeated exposures (Weiser, 1991) it has also been noted (Bolter and Gromala, 2006) that designers of more commonplace interactive systems (e.g. personal computers, smartphones) seek to utilize this phenomenological state under the guise of simplifying the experience of the user. This helps in allowing the user to transfer and apply previous learning's without need to re-learn all of the previously learned actions.

Such interfaces may be considered as seeking to provide a "transparent" (Bolter and Gromala, 2006) window that presents the information for the workspace to the user without (or with minimal) interference and distortion; the designer seeks to make the interface "disappear" and become a window to information. In doing so, the designer aims to reduce the cognitive load as the user will no longer hold consideration upon the accustomed interface tropes but see beyond to focus upon the goal of the interaction (as previously described by Weiser, (p94, 1991)). Interactive systems designed upon this paradigm could therefore be considered flawed if the interface draws attention to itself through the users conscious consideration. Consequently, such interfaces, derived from previously learned experiences, also limit opportunities for novel interactions and explorations as they encourage a reiteration of previous actions used to achieve goals.

> "With enough practice we can make many apparently difficult things disappear- my fingers know editing commands that my conscious mind has long forgotten. Good tools enhance invisibility." *(p7, Weiser, 1994)*

The effects (and exploitation) of automaticity can be seen in 'phishing' attempts where websites appeal to users visceral reactions and lack off reflective conscious awareness by displaying graphic elements, such as padlocks to invoke a sense of security and trust, and mimic official websites to extract personal data (passwords, financial information etc.) through users automatic (non-/sub-conscious) and behavioural actions (Dhamija, Tygar and Hearst, 2006).

3.3.1 Enhancing Reflection Through Augmenting Usability

While use of repetition in interaction design is beneficial as it quickens the learning process, it may also be altered to provoke Mindful states. Here this is exemplified through the augmentation of usability – specifically alterations to the familiar use of objects while maintaining core functionality.

The work of Niedderer (2007), focused within the field of design, explores "Mindful interaction" through the use of objects within social context. Although these objects are not digitally interactive they serve well as an example of how interactions can be designed for inducing Mindfulness.

Niedderer's "performative objects" consisted of "Social Cups" (figure 3.5 below) "…designed to actively explore the social interaction within which they are used, and to make the user aware of this interaction and reflect on it." (Niedderer, 2007, p3). These cups follow the design of a champagne flute glass however where usually a stem and base would normally be present (to allow the glass to stand freely) this is lacking in the Social Cups. This design requires at least 3 cups to group together (and be connected via suction pads attached to the cups) to allow the cups to stand freely without being held. These design choices were specifically implemented with aim that "[…] people are encouraged to explore their interactions when using the cups" (p3, Niedderer, 2007).

Figure 3.5; Niedderer's "Performative object" of "Social Cups" (p3, Niedderer, 2007)

Such 'Performative Objects' (Niedderer, 2007) are intently designed for Mindful engagements, as Niedderer states:

> "The concept of Mindfulness refers here to the attentiveness of the user towards the social consequences of actions performed with the object. *[…]* we can design artifacts that communicate and cause Mindfulness of others

in the context of social interaction by means of a modification of function *[…]*"
(p4, Niedderer, 2007).

By altering the usability the user of the object is forced to reflect on their engagement with the object, its meaning and how it is used within the context of the environment (by enforcing a social interaction). This can be seen as breaking the repetition of what a cup/glass is and how it is used, and forces the user of the cup to reflect upon the semantic variability; the cup is no longer solely a vessel for containing liquid but includes the dependency of social interaction (more explicitly a negotiation) to function as a cup would normally fully function. The 'cup' no longer functions as a cup equipment (Chapter 1.9.2), but calls itself into question as a 'tool' object (Chapter 1.9.1), maintaining the perhaps more explicitly recognized affordances of a cup (storing liquid for consumption), but with socio and functional affordances brought to the fore also.

Niedderer's cups (2007) highlight designing for usability in terms beyond traditional concepts of performance (as described by Dillon (2002)) through considering the broader experiential aspects and contexts of the user. Thus alterations in usability (here removing the phenomenologically invisible aspects of usability), even if considered damaging in more traditional metrics, may facilitate and provoke Mindful engagements, contextual awareness, and performance in understandings of peoples lived values and experience. In their design these 'cups' break traditional concepts and familiarity of what a cup *is* and how it may be used (its usability) while maintaining enough familiarity to be recognizable and usable as such (a cup).

3.4: Invisible And Everyware: Mindlessness As A Defensive Response To Information Intense Environments

As Weiser (1994) claims "good design", is considered to employ invisibility of and in operation. Likewise, this position is encouraged by (Tolmie et al., 2002) who propose that ubiquitous computing technologies become "Unremarkable" and "phenomenologically invisible" through integration into routine, providing a level of automation that the user assumes occurred through their own actions. In the view of Weiser (1994) and Tolmie et al. (2002) the "*…ubiquitous computer leaves you feeling as though you did it yourself.*" (p404, Tolmie et.al., 2002) and seeks to "*…embed computation within life not just in cups.*" (p404, Tolmie et.al al., 2002). This is highlighted through Greenfield's definition of ubiquitous computing as being "Everyware", a technology that is:

> "Ever more pervasive, ever harder to perceive, […] will appear in many different contexts and take a wide variety of forms, but will affect almost every one of us, whether we're aware of it or not."
> (Greenfield, 2006, p8).

These movements in the application of technologies (as "post-desktop") redefines the notion of ubiquitous as "being" in every location but towards becoming a part of everything, enveloping our interactions with commonplace (and potentially all) objects; a concept more commonly known as "*the internet of things*" (Atzori et al. 2010). Although the term internet of things may be defined in differing ways (Atzori et al. 2010), it may be classified as "*a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols* (NSFO, 2008). That is to say, the internet of things is a broad range of objects with embedded technology that facilitates the (often) bidirectional communication of information across the internet. This allows for a world where your fridge could know when your milk is low and order you more, your shoes might tell your doctor how far you have walked, or your newspaper automatically updates with latest news based on its urgency/importance and proximity; all of which would occur through unremarkable computing and as invisible.

Though such technologies hold utility and convenience there is risk that the degree of automation left unchecked might facilitate a level of Mindlessness and inability to understand and contextualise the interaction, particularly when breakdown occurs. For example, if there is a failure to deliver more milk one might not know an alternative source, misreporting shoe sensors might suggest poor level of activity and wrongful diagnosis, hacking a digital newspaper might misinform of events and sway political opinion. While such overt (Mindless) trust in technologies commanding actions over reflective (Mindful) questioning may appear counter to common sense and plausible actions there have been many accounts of such experiences. Carr (p45, 2015) notes (among other examples) how such complacent trust in technologies resulted in the death of 228 crew and passengers aboard Air France flight AF447, Rio de Janeiro to Paris June 1st, 2009. The official cause of the crash is reported as a high altitude stall; however, a faulty airspeed reading caused by ice on airspeed sensors first caused the interference of the autopilot to correct; following this a disengaging of the autopilot and pilot error (multiple and drastic over corrections following incorrect display commands) caused the crash. Resulting from alerts and warnings (form the initial faulty readings) the co-pilot forced the plane into a steep accent, drastically reducing the speed. This attempted climb, dictated by the aircrafts information display, persisted until the crash; the readings provided to them being a mixture of inaccurate and missing information resulting in confusion on how to react. It has been claimed that this poor information feedback provided by the aircraft encouraged the pilots to "slavishly" follow incorrect commands (to pull up) rather than questioning validity or following suggested procedures ignoring unreliable speed indications (Dubois, 2012). The accident report (BEA Report, 2012) on the incident stated:

> "In the first minute after the autopilot disconnection, the failure of the attempt to understand the situation and the disruption of crew cooperation had a multiplying effect, inducing total loss of cognitive control of the situation.
> […]
> the crew never understood they were in a stall situation and therefore never undertook any recovery manoeuvres."
> " (p3, BEA Report, 2012).

With digital technology becoming increasingly pervasive accounts of the negative impacts are increasingly reported on. Experiences of "Technological Addictions" (Griffiths, 1996) are commonplace, existing since the beginnings of the internet becoming publicly available (but with reports of similar experiences dating back to the advent of mass produced books) as reported by Shenk (1997). Shenk, within the first decade following the launch of the worldwide-web (i.e. internet becoming publicly available), had comprised a book detailing various accounts of persons experiencing an uncontrollable desire for, (and subsequently the inability to manage) the increasing amounts of information that could be provided through this new medium (the internet). The resultant from persons acting in the way Shenk reported is commonly referred to as "Information Overload". Information overload is defined by Eppler and Mengis (2004) as a situation whereby too much information is presented or available to a person resulting in the person being unable to recognize, understand or handle the amount of information; the person becomes highly selective of information (ignoring large amounts of additional information), holds difficulty in identifying relationships within the information and broader perspective and requires more time to make an accurate decision (Eppler and Mengis, 2004). Thus, when information available exceeds our capacities to process it we ignore large amounts of the information and hold focus to a selective amount while failing to recognize the broader context, details, and relationships within the information – i.e. we approach the data from a Mindless perspective.

Shenk (1997) quotes Dr. Theodore Gross (p36, Shenk, 1997) on these new technologies and information overload as correlating to persons developing a form of Attention Deficit Disorder (ADD); whereby usually ADD is (assumed to be) genetically inherited, this "*"condition" develops as a* […] *culturally induced attention deficit disorder*" (Shenk, 1997, p36). In combination with this condition, now widely recognized yet defined in many ways, it is often described that these dense bursts of information overload and interaction with technology are sought after (by the user or consumer of information) similar to states of drug addiction; for example "Information anxiety", a state of anxiety/stress induced from a lack of information accessibility (Wurman et al, 2001); and, "Infobesity" (Bawden and Robinson, 2009) a situation of "personal information overload" that is similar to "feasting on fast food". A natural response occurs to these states of information overload defined by Hallowell (2005) as acquiring an "Attention Deficit Trait" (ADT);

> "ADT isn't an illness or character defect. It's our brains' natural response to exploding demands on our time and attention. As data increasingly floods our brains, we lose our ability to solve problems and handle the unknown. Creativity shrivels; mistakes multiply. Some sufferers eventually melt down."
> (p55, Hallowell, 2005)

These qualities of unremarkable and invisible computing, technological addiction and attention deficit trait may be understood as invoking states of, or, the body/mind exhibiting Mindlessness:

> "… Mindlessness, which we denote as the relative absence of Mindfulness, can be defensively motivated, as when an individual refuses to acknowledge or attend to a thought, emotion, motive, or object of perception. These forms of consciousness thus serve as concrete counterpoints to Mindful presence and the attention to current experience within and without oneself that such presence entails."
> (p823, Brown and Ryan, 2003)

Evidence of the type of behaviour, as a defensively induced/responsive state, can be seen through the example of "Display Blindness" (Müller et al, 2009; Huang et al., 2008). Display blindness is an action that individuals exhibit when confronted with seemingly unimportant/unnecessary or non-personally relevant information displays in information intensive environments. When in environments that provide stimulus that is too excessive for an inhabitant, the inhabitant becomes unable to "recognize, understand or handle" the information, and, as a result "*He/she becomes highly selective and ignores large amounts of information,*" (p2, Müller et al, 2009). As such, multiple exposures of this kind encourage a habitual (automatic / Mindless) behaviour where by the commonplace modalities of "irrelevant" information (e.g. public displays as discussed by Müller et al, (2009); or Burke et al. (2005) "banner blindness" from internet banners/popups) are unconsciously ignored. That is to say, the user/inhabitant sub-consciously (automatically – Mindlessly without reflection) chooses what information to regard as important and what information to disregard based upon previous experiences of similar exposure. Consequently this choice is made regardless of the content of the information presented in the current exposure (i.e. it is decontextualized). The user acts upon a premature cognitive commitment and fails to recognise the semantic variability e.g. of an operating system/browser 'pop-up' security warning as opposed to an advertisement.

This position of information overload and "homogenisation" being inter-related is recognize by Bawden and Robinson (2009):

> "This diversity of provision, however, is typically delivered through a limited number of interfaces: most usually a web browser, whether on a computer screen, a mobile device, an e-book reader or some other device. The result is a 'homogenisation' of the information, with the look and feel of different resources of the print age – a text book, a newspaper, a hand-written diary entry, a photo-copy of a journal article, a printout of a data file, etc. – being largely lost. It is this 'homogenised diversity' of information communication which lies at the root of the problems discussed here, as much as the expanded volumes of information which are available."

(Bawden & Robinson, 2009, p181)

3.4.1 Enhancing Reflection Through Augmenting Efficacy

Currently within HCI research there is growing support in movements that aim to encourage users of technologies to reconsider/reflect and readdress how they engage with technology that is often demanding, "invisible" and time centric.

The "Slow Technology" movement (Hallnäs and Redström, 2001) "*…is about exposing technology in a way that encourages people to reflect and think about it.*" (p169, Hallnäs and Redström, 2001) and arose in response to computers that are increasingly integrated into commonplace experiences (such as ubiquitous computing technologies). The movement promotes a reconsideration in the design values of information technology that were previously designed to make people more efficient in a specific task; yet, now have greater demands that encompass a broad spectrum of activities (such as assistive, social and entertainment) and are "*…more or less continuously present as part of a designed environment*" (p162, Hallnäs and Redström, 2001). Thus, the goals of slow technology may be seen to counteract states that may be explained through Anderson's (1992) "Acquired Automaticity" and provide "*reflection and moments of mental rest rather than efficiency in performance*" (p161, Hallnäs and Redström, 2001); a position highly sympathetic to the action of Mindfulness.

In a similar vein to the slow technology movement is growing interest within the HCI research community that considers the felt experience of the user as central motivations of action and design. Such concepts support the position that interactive experiences focusing on functionality (understood in quantifiable metrics of evaluation) only activate limited capacities of the experience of the user. Exemplar position supporting such views can be found in *experience-centered design* (Wright, Wallace and McCarthy, 2008; Wright and McCarthy, 2010; Hassenzahl 2011); that proposes while functional attributes of interactive systems are of great importance, these should be supported through an understanding of the emotional values that people construct through interactions with other people and technology. Wright, Wallace and McCarthy; (2008) propose three central tenants of experience–centered design:

- User as an individual with emotions, thoughts etc. is the focus for design.
- Design process is seen as continually evaluating the experience of the user.
- Design process is a dialogical ontology in which self, others, and technology are constructed as multiple centers of value.

McCarthy and Wright's argument highlights how HCI research is limited in its focus on making interactions between people and technology experientially efficient rather than attending to the subtle and ongoing changes in emotions and experience people might feel.

Grosse-Hering et al. (p3431, 2013) directly relate Slow Technology to Mindfulness, noting how "*Slow Design principles can be used to create more 'Mindful' interactions that stimulate positive user involvement*". They go on to state that such slow design does not specifically mean slowing interactions (with regards to time taken) but opening up interactions to promote 'slowness' on aspects of interaction that may be more meaningful for users. While it is recognized that such principles of design are yet to be realized in the broader arena of mass-produced objects (Grosse-Hering et al., 2013); there are a number of bespoke explorations of these ideals. In particular notoriety to the Slow technology movement is the catalogue of work by William Odom such as:

'Photo Box' (Odom et al. 2014)

Photo Box is a 'domestic technology' device that prints 4 or 5 randomly selected images from the 'users' online photographic archive at random time points through a month. The aims of the technology was to support experiences of anticipation and re-visitation of the past events and moments of importance (given the significance to take a picture and store it online). In use the technology initially caused frustration yet during the course of the deployment (14 months) the photos produced facilitated reflections on previous life events and renewed interest in personal online image repositories, and was accepted as a 'domestic technology' and produce a broader reflection on technologies in the home. In its slow (and random) release the technology facilitates anticipation and reflection upon what will be produced; and consequently from what – facilitating a Mindful reflection upon the amount and kinds of 'things' we store digitally, sometimes without intent to view again.

Olly (Odom[25], On-going)

The on-going work *Olly* is a slow technology in the form of a tangible music player linked with the users music streaming service. Several times per week the Olly will allow the user to play songs from the their past. When a song is ready to play the Olly rotates a circular wooden disc, with the speed determined by the period of time from when the song was selected (i.e. the further in the past the slower the speed of rotation). The disc turns for 20 rotations at which point the song is 'abandoned'. To play a song users must tangibly rotate the wooden disc, speeding up the rotation.

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[25] http://willodom.com/portfolio/portfolio/olly-design-field-study/ - retrieved 25/05/17

Through this interaction it can be imagined that users are presented chance opportunities to engage with the technology and reveal opportunistic reminiscence of their past.

Slow Game (Odom[26], On-going)

Slow game is a project drawn upon the practice of playing Chess across distances remotely, communicating moves through postal correspondence. Slow game maintains this 'slowness' through a tangible digital artefact based on the 'classic' video (and mobile) game 'Snake', that allows for a single move a day. With such a low resolution of interaction it is hope the project will challenge understandings and experiences of memory, observation and patience.

Fenestra (Uriu and Odom, 2016)

Fenestra consists of a digital photo-frame mirror and candle, when active the technology displays images of departed loved ones. When lighting the candle the Fenestra is activated, linked to the changes in the flame of the candle altering how images are displayed and cycled through, though it is only by gazing directly into the mirror the images are revealed to the user.

Through these interactions are facilitated rituals of memorialization that might alter how we engage with digital media and memories of those who have past.

While these works vary in their forms and interactions they hold a unique set of properties that embody the philosophy of 'slow technology'. These are realized through invoking moments that encourage anticipation, chance, patience, and ritualization; and challenge the immediacy facilitated by more commonplace interactions with digital technologies. Thus the changes to the performance of the technologies that challenge commonplace values (speed and efficiency) open opportunities for reflection on the content of the media and interaction. Furthermore such technologies break the homogenization of the ways in which we consume and engage with digital media and facilitate rituals around objects.

[26]http://willodom.com/portfolio/portfolio/slow-game/ - retrieved 25/05/17

3.5: Framing Mindfulness Within Existing Human-Computer Interaction And Design – Designing Beyond Functionality And Immersion

It is evident that the definitions of Mindfulness include a central commonality, i.e. a particular form of awareness. This awareness however is not to be confused as solely attention (or as a singular properties) as noted by Westen (1996) who suggests that sensory experience can be in "awareness" (present in consciousness and experienced) without being the focus of "attention"; attention being a directed conscious awareness towards a limited range of experience. A position further explained through awareness as "*…monitoring the inner and outer environment…*" and attention as "*a process of focusing conscious awareness, providing heightened sensitivity to a limited range of experience*", yet it is noted that these processes are intertwined where attention draws out elements of interest from awareness (p822, Brown and Ryan, 2003).

While it may initially seem that with attention being focused awareness it is therefore more Mindful, it may be also be enacted Mindlessly. Such Mindless yet focused states can be likened to high levels of immersion that, while holding the focused attention of the immersed, remove the broader awareness required for a situated contextualization. This is exemplified through the concept of "Flow" (Csíkszentmihályi, 1990). It has been has argued at length that certain activities allow people to enter a state of flow where there is a balance between effort and ease in a particular task, a concept that suggests an "optimal experience" when this occurs. The concept of Flow has been applied to many differing fields and practices including human-computer interaction. This theory has, in its components of flow, six factors that may be considered as Mindfulness and Mindlessness. During the experience of flow a person will experience:

- Intense and focused concentration on the present moment (considered Mindful)
- Merging of action and awareness (considered Mindless)
- A loss of reflective self-conscious (considered Mindless)
- A sense of control/action over a task or activity (considered Mindful)
- A loss/alteration in the subjective experience of time (e.g. 1 "real" hour may "feel" as 5 minutes) (considered Mindless)
- Autotelic/intrinsic reward from the task/activity (neither Mindful or Mindless)

A Flow state holds several characteristics, notably here the focus of attention becomes limited to specific task whereby external stimulus (to the task) are ignored. This is additionally accompanied by a loss of reflective self-conscious and a distortion in the subjective experience of time, highlighting the de-contextualization of the task and the restricted range in awareness. Additionally highlighted by Csíkszentmihályi (1990), as one of the most distinctive features of Flow, is the merging of action and awareness. When a person's attention is completely absorbed within a task (when in a state of Flow) the "*activity becomes spontaneous, almost automatic; they stop being aware of themselves as separate from the actions they are performing*." (p53, Csíkszentmihályi, 1990), therefore it is understood here as the interaction being phenomenologically invisible (i.e. Mindless).

Norman also discusses a similar quality as "experiential cognition", a sub-conscious "expertise" (p23, Norman, 1993). However Norman states that when (and if) decision-making is required a "Reflective" cognition or processing is required that although slower, allows following "chains of reasoning" forward and/or backward (when decisions prove unsuccessful), by inferring upon temporarily stored knowledge. This reflective cognition is the *Reflective* level of processing that is beyond the visceral and behavioural levels of processing (previously discussed) and is, as Norman states, the "*home of conscious cognition*" (p53, Norman, 2013). The reflective level is where conscious decision making occurs, whilst it is slow in comparison to sub-conscious and non-conscious actions, it is the highly analytical process. Whilst Norman (2013) suggests that all three processing levels (*visceral*, *behavioral* and *reflective*) are required for Flow (the reflective processing level is the analysis of "results" in comparison to "expectations") I infer this (in the context of Flow) as being a low-level analytical reflection and still captivated in the singular task (as opposed to a broader level of reflection facilitated by truly Mindful states). Dane (2011) supports this position through differentiating Flow and Mindfulness in terms of the breadth of attention, Flow being narrow and Mindfulness being relatively wide. When in a Mindful state individuals are "attuned" to a large number of internal and external phenomena, a state where individuals can consciously attend to increased number of stimulus within the environment (Dane, 2011). As Langer and Moldoveanu (2000) describe, it is the process of drawing novel distinctions situated in the present rather than reliance upon previously drawn distinctions and categories. This leads towards a greater sensitivity to one's environment, openness to new information, the creation of new categories for structuring perception, and, an enhanced awareness of multiple perspectives in problem solving (Langer and Moldoveanu, 2000).

3.5.1 Enhancing Reflection Through Augmenting Immersion

While many designers often seek to facilitate experiences of 'Flow' (Csíkszentmihályi, 1990) - given its reward and engaging properties in addition to 'good design practice' guides that promote practices that reduce "friction" of interactive systems[27]; there are those who argue for designing in opportunities to counter these moments through 'Design Frictions' (Cox et al., 2016). Design frictions can be understood (here) as purposeful interruptions to an interaction through a slowing or breaking of the process. This differs from slow technology (previously described) by being an element of interactions (typically a purposeful difficulty introduced) as opposed to a purposeful technology; however, design frictions carry much of the same principles. Cox et al. (2016) state that design frictions can disrupt "Mindless" and automatic interactions and promote moments of reflection and "Mindful" interactions. They (Cox et al., 2016) propose the introduction of "*Microboundaries*", small moments of friction or obstacles that encourage a change in cognitive strategy through an interruption and prevent users from "*rushing from one context to the next*" and slow us down before acting. Through this, they suggest that these moments might provide brief opportunities for moments of reflection.

Thus Microboundaries and design frictions can be understood as devices toward the interruption of immersive engagements (such as those that facilitate experiences of Flow) and breaking of chains in interactions. In doing so mincroboundaries and design frictions can be understood as Mindful design qualities.

[27] https://thenextweb.com/dd/2015/03/08/how-to-reduce-friction-with-good-design/#.tnw_5nregzdy - retrieved 26-05-2017

3.6.0 Section 3 Discussion and Conclusion

As previously described, designers of commonplace interactive systems typically seek to employ "transparency" (Bolter and Gromala, 2006), a 'phenomenologically invisible' interface to information. In contradiction to this are designs that "reflect" (Bolter and Gromala, 2006) or mirror the user (such as an aesthetic representation as seen in the majority of interactive digital art). This quality can be seen as bringing the interface and interaction to the center of the dialogue between the user and aims of the interaction; and so encouraging reflection upon the relationship of self with the interface and technology, framed here as a Mindful interaction. Whilst these design qualities (reflection and transparency) may appear at conflict within interaction design requirements; as highlighted, the significance of the "non-functional" (Poole et al., 2008) attributes of technologies is increasingly apparent in recognition that computational technologies are no longer solely in the workplace; and as such design practices developed for the workplace may risk quality of life when applied outside of those spaces (Sengers et al, 2005). A position supporting the argument that interactive experiences focusing on functionality (performance, utility, and usability) (Poole et al., 2008) only activate limited capacities of the experience of the user (framed here as Mindless).

In this section (3) it is proposed that while the designing of Mindless engagements of systems holds benefit there are additional opportunities to design for moments of reflection and Mindfulness. Therefor a number of design qualities present in Mindless and Mindful engagements with technologies can be put forward.

3.6.1 Designing For Mindlessness

Mindlessness is defined as an intuitive understanding that exists in *non-conscious* processes, with failure to account for contextual dependencies through premature cognitive commitments; where information and technologies hold a functional fixedness viewed as absolute through *equipmental-fixedness*.

During interaction, Mindlessness is without conscious deliberation through *sub-conscious* automaticity, developed from a cognitive fixation upon previous well-learned solutions. Such actions are performed before, faster than or without concerted conscious awareness in phenomenological invisibility; resulting in the inability to develop novel solutions and the application of technology through *equipmental-transparency*.

Commonalities of Systems Supporting Mindless Interactions and Equipment:

The implementation of what are here considered 'Mindless' equipment of interaction are often employed as measures to reduce cognitive loading and ease of use. While the term Mindless is often a negative connotation, here (in this thesis) it is understood to be of a neither inherently positive or negative nature. Mindlessness is clearly a valuable quality in our daily lives and interactions facilitating speed and intuition of how we interact and navigate a multitude of complex systems. Mindless equipment's allow for users to quickly achieve known goals and interactions, missing out process steps between intent and completion (as they require little or no consideration toward the 'how' to achieve this). Mindless equipment allow for 'expert-like' operation where users experience low cognitive loading and so can multitask if required, as highlighted by Langer (1989). Such equipment perform complex actions but allow the user to feel though they did it themselves (Tolmie et al.; 2002) through e.g. automation. Equipment of interaction typically prize; effectiveness in performing a specific task, efficiency through a low number of steps, time and skill required to perform an action, and, speed; all with aims to improve user satisfaction. Consequently, such equipment encourage flow like experiences, allowing for immersion and prolonged interactions and in doing so allow for a 'shutting out' of events outside of the interaction. Additionally Mindless equipment might be seen to encourage repetition and routine of actions and in their communication of elements of action and features (Rogers, 2006), drawing upon familiar symbols, layout, and steps of process (Blackwell, 2006). Through these processes Mindless interactive systems can be understood to provide efficient transparent windows to information (Bolter and Gromala, 2004).

A resulting trade-off of these systems of efficiency is a difficulty to inhibit actions once initiated and a dependency upon the information provided (i.e. failure to question if the information is accurate or optimal). Similarly, difficulties in recalling or altering (or preventing) the "middle steps" of a process are also a result of drawing upon automatic processes. Mindless systems might also invoke wrong mental schemas if they are too similar to existing schemas. Consequently contextualization of the interaction is lost as processes are executed as though performing a well-learned script; whereby equipment's are functionally fixed in their capabilities and so lack novel problem solving or exploration of novel features. In their use of algorithms and automation (such as recommender systems and performing background processes), Mindless interactions additionally result in an unknowing of the underlying architecture of our interactions with technologies; and so mystify how these might be changed or replaced if required. Ultimately, through repetition and decontextualization of the aspects of interaction, and disregarding new information from the interaction, the potential for novel and creative solutions is contracted.

Designing Mindless Interactions:

To design for Mindlessness equipment's should facilitate technologies to hide the "middle steps" through increasing automation, and reducing the "friction" between steps involved. Technologies should remain 'unremarkable', predicable and 'invisible', and commonplace, as not to draw attention to the interface. Equipment should facilitate intuition though use of common metaphors (homogenization). These metaphors should be unambiguous and singular in their meaning and function. Interactions should not facilitate or require contextual dependencies. In doing so the equipment interface should draw upon 'known' knowledge (as opposed to requiring 'thinking' (contemplation) and interpretation). This should be achieved through drawing upon and invoking visceral and behavioural knowledge processing and routine. Likewise, equipment should direct use and present information in a way that subtly directs action toward desired goal. Mindless interactive systems should also limit the affordances offered and encourage selectivity of information (i.e. a low number of choices and information sources).

3.6.2 Designing For Mindfulness

Mindfulness, is defined as a state of broad *reflective-conscious* awareness upon the present context and content of information and stimulus. Information and technologies are explored and combined through concerted deliberation in novel categorisations of distinctions and action potentials as an *abstract-tool*. During interaction Mindfulness is slow yet analytical whilst being receptive to change, whereby constituting elements are *consciously* present through use and application of a *fluidic-tool*.

Commonalities of Systems Supporting Mindful Interactions and Tools:

While, understandably, in this thesis there is support for designing Mindful tools this is not to be held as true in all circumstance. Mindful tools are slow in their nature and as such should not be enforced or encouraged when technologies are time sensitive or hold little need for critical and creative engagements e.g. emergency shutdown systems. The core commonality of tools that support Mindful interactions is a focus toward facilitating prolonged or moments of reflection. That is to say, Mindful tools encourage 'thinking' (i.e. increase cognitive load) over reliance upon previously gained knowledge; they require and encourage the user to learn, make decisions, reason, and create to solve complex problems, generate innovative ideas, and provide moments for contemplation upon information exchanges. Mindful technologies are often unfamiliar and bespoke, and are outside of 'work' environments and so hold different values; specifically holding user experience at the centre of design choices above more traditional concepts of performance and functionality. With this Mindfulness supporting technologies encourage openness to multiple perspectives and new information (i.e. the viewing of information as novel) and discourage ignoring or selective attention to specific elements. In doing so Mindful tools encourage contextualization to the present. Mindful tools also reject homogenization of information and interaction methods and so encourage creativity in their approach, understanding and outcomes. Mindful technologies additionally incorporate the philosophy and ideas of Slow Technology, with effortful, fractioned, and slow interactions providing opportunities of reflection over efficiency; alongside inhibiting states of Flow that might be initially frustrating (Odom et al. 2014) as they interrupt the commonplace 'on-demand' interactions with technologies.

Mindful tools, however, are not suitable to interactions that require low cognitive load or those that are time sensitive. They are additionally problematic in their interpretation given they encourage reflection and realization of multiple affordances, and so may facilitate multiple (valid) perspectives, meaning, and usages. Similarly, given their (often) novelty, Mindful interfaces may take considerably longer for users to understand and learn in comparison to those designed around familiar design tropes.

Designing Mindful Interactions:

As previously described, designing for Mindful tools requires valuing a different set of ideals over more traditional performance metrics as suggested by Dillon (2002). They should hold contextualization to the present and in doing so recognize or adapt to on-going and subtle changes in a users experience and needs. This requires a moving beyond repetition of previous 'known' design tropes (that carry with them their own inherent meaning), or altering the interaction so that it incorporates a new meaning derived from the production of new schemas. It should be noted that such design implementation will additionally increase cognitive loading through the requirement of 'thinking' (and so time to perform an action or task), though this in turn can open the technology toward a 'tool' like state. In this tool state, there is openness toward multiple affordances and values, realized as novel choices, interpretations, and information (contextualized to the present interaction and goals); revealing novel answers or multiple perspectives to problem solving. Thus Mindful tools should additionally be designed to accommodate multiple affordances and encourage change through reflective processing, limiting visceral and behavioural learned responses.

Where there is need to balance functionality (in traditional performance metrics) with Mindful and reflective moments breakdowns such as design frictions and microboundaries can be incorporated. However, it is encouraged to make these 'remarkable' and unique perhaps highlighting moments of background automation, and explicitly contextualizing 'pop-up' and banners to prevent habitual 'blindness' as described by Burke et al. (2005), Huang et al., (2008). However, commonly Mindful tools might be considered entirely new modalities of interaction, holding common features and functionality, but presented in radically different and augmented forms that force the development of new mental schemas. To encourage this, Mindful tools should be designed in ways that highlight their novelty and difference as bespoke performative tools. These might seek to encourage ritual and provoke ceremony over accessibility to encourage significance and meaning of interaction. Similarly, designs might encourage interactions take place over protracted periods of time and require periods of memory, observation and patience. In the sacrifice of functionality there is opportunity to enhance utility through the application of ambiguity, allowing multiple modes of interpretation and meaning. Similarly, through augmenting interactions through designing for anticipation and the unplanned opportunities for chance interactions that require engagement, *on-chance* as opposed to *on-demand* are facilitated that break routines and provide opportunities to see oneself within new connections. Thus Mindful tools should additionally invite and provoke openness to change and 'un-control'.

SECTION FOUR

Overview Of Thesis Findings And Contributions

4.0: Conclusion

For a large part this thesis has predominantly sought to address the concerns raised in the position of Brown and Cordon (p59, 2009) regarding Mindfulness (and Mindlessness) to prevent similar failings as those found in clinical applications of Mindfulness (as described in chapters 1.1 to 1.3). As stated they, Brown and Cordon (2009), highlight "*a phenomenon can be studied only if it can be properly defined and measured*". This was addressed through the broader research question of how Mindfulness and Mindlessness might be understood, measured and invoked in relation to Human-Computer Interactions.

Understanding Mindfulness and Mindlessness

Firstly it is important to understand that applying previous definitions and framings of Mindfulness toward human-computer interactions is problematic in that there is often confusion in describing exactly what form or 'parts' of Mindfulness are being discussed. For many previous framings the concept of Mindfulness carries with it a spiritual and/or emotional aspect that is part of a persons broader disposition. Consequently such positions hold values that might be considered inappropriate in their application or use in evaluation (particularly when applied directly from Mindfulness based cognitive therapy). As such positions additionally often portray Mindfulness as a personality disposition, due to their intended application, they fail to account for transient periods and experiences of Mindfulness and Mindlessness. However, as described by participants reporting on their experiences (Chapter 2.8) moments of automaticity (Mindlessly performing a task while holding little subjectively experienced 'consciousness') and moments of Mindfulness like qualities (such as meta awareness – evaluating ones mental state) were often fast in their transitions.

- Mindful and Mindless states are not trait like but state like moving and changing rapidly in response to demands of actions, environmental stimulus, and subjective direction.

The defining of Mindfulness and Mindlessness has been approached from a pragmatic stance that sought to position the understandings through a number of associated fields and paradigms. The aims of this were threefold, firstly to provide a unified interaction oriented understanding (avoiding the pitfalls described above), to allow for the future alteration and refinement of the concepts, and finally to allow for the further enquiry into the phenomena through research methods developed and transferable from well-established related domains.

Broadly this understanding holds two central perspectives guided by a neurophenomenological approach; one philosophically informed concerning subjective experience (conscious experience) and a second informed through cognitive science concerning biological and cognitive findings. Consequently Mindfulness is understood to be of a conscious state while Mindlessness is understood to function as a cognitive property.

- Mindfulness and Mindlessness are understood (and defined) to be conscious and cognitive processes (respectively).

Philosophical understandings highlighted familiar technologies incorporated into our actions and behaviours as moving toward a phenomenological invisibility, experienced as an extension of the self without contemplation upon (additional/alternate) meaning or use. As such states exist outside of conscious experience and driven by previous use they are here considered as a cognitive process and consequently as Mindless. Contrary to this are technologies that prevent 'normal' functioning, drawn into the forefront of consciousness through contemplation on meaning and use. In such a state novel applications (and affordances) are revealed. As such states involve a reflective-conscious process in exploring the affordances offered they are here considered Mindful.

- Mindful technologies are present at the forefront of conscious experience, available to be theorized upon, and so reveal the multiple (and potential) affordances offered.
- Mindless technologies draw upon previous and familiar actions and mask novel affordances from conscious consideration.
- Interruption to the normal functioning of a technology can call it into question and facilitate Mindful contemplation.
- Affordances are not a fixed property of a technology and agent but fluid and reciprocal to an agents Mindful or Mindless approach.

It was highlighted that actions with enough repetition become streamlined, where once separate steps amalgamate into a singular mental schema. The discounted steps however might involve analytical or contextually differing processes required or meaningful to novel contextual encounters of the familiar technology. Such schemas are subsequently (sub-/non-consciously) enacted when encountering the stimulus that relates to them (perception directed action). While the above concerns technologies that have a repetitive or habitual use it was also highlighted that when encountering events or technologies that are *familiar* to previous encounters (i.e. not the same be understood to be the same) the corresponding mental schema may be enacted without modification. This allows for rapid understanding and engagements with environments or technologies without requiring extensive contemplation upon how.

- Mindless engagements occur with repetitive use of technologies.
- Mindless engagements with technologies remove intermediary steps that might provide contextual information or required analytical steps.
- Familiar technologies invoke Mindless intuitive engagements if similar mental schemas exist. These might however be inappropriate for the context in which they are enacted.

In a similar light, it was additionally highlighted that due to streamlining of mental schemas Mindless states were cognitively light and facilitate rapid responses. This was observable through the study data presented in Section 2, where wrong answers provoked reflection upon the following test which was subsequently longer to answer, the accommodation of Pop-Up responses becoming faster with subsequent repetition, etc.. Likewise participants during this study reported an effortless ease and speed when operating in states of Mindlessness – where they 'knew' what to do. Contrary to this were moments where participants described needing to take time and 'think'.

- Mindless engagements are cognitively light and fast in action.
- Mindless engagements are difficult to prevent once initiated and will be enacted till completion or interruption.
- Mindful engagements are effortful and slow.
- Mindful engagements facilitate drawing forth sub-conscious processes into the front of conscious and reflective-conscious experience.

In addition to the above understandings this thesis contributes:

A lexicon for describing conscious states in the context of Mindful and Mindless framings (Chapter 1.5.2)

- Reflective-Conscious
- Conscious
- Sub-Conscious
- Non-Conscious

Definitions of technologies affordance availability in the context of Mindful and Mindless approaches (Chapter 1.9)

- Tool
- Equipment

Definitions of technologies affordance availability inclusive of the broader experiential state of the agent operating the technology in the context of Mindful and Mindless approaches (Chapter 1.10)

- Abstract-tool
- Fluidic-tool
- Equipmental-fixedness
- Equipmental- transparency

And most significantly the overarching defining of **Mindfulness** and **Mindlessness** during interactions with technologies (Chapter 1.3)

Measuring Mindfulness and Mindlessness

As previously highlighted a phenomenon can be studied only if it can be properly defined and measured. Through the previously described contributions a definition of Mindfulness and Mindlessness was developed (Section 1). Building upon this Section 2 aimed to provide an initial framework with which to measure such states. This was inherently exploratory as an initial body of work to pave way for future investigations (highlighted in Chapter 2.9.6) in hopes it might build upon and further refine such measurements. While there remain challenges in such refinement in that there are no "definitive" physiological indicators of Mindful or Mindless states this is not unexpected in the application and understanding of physiological measurements (as highlighted in Chapter 2.0.2). This is not to say that this contribution is without value, it was evident that through the application of a neurophenomenological methodology insights were gained that might otherwise be overlooked.

- Accounting for an agent's subjective experience alongside physiological responses (through a neurophenomenological methodology) is vital in the understanding, measurement, and justification of Mindful and Mindless states.

Persons interacting with technology were able to report, through careful questioning, on their conscious (Mindful) experience *and* moments where there was sub-conscious processes (Mindlessness) through their lack of awareness. Furthermore many understood and valued Mindless processing for its cognitive ease and speed, often viewing interruptions to simple tasks (such as 'Pop-Ups') as distracting and negative, an interruption to being 'in the zone'. While such optimal Mindless operations (for simple repetitive tasks) were often desired, some recognized the danger of a further state of uncontrolled automaticity (possibly a non-conscious state of action) introducing additional cognitive steps and processes to prevent such states.

- With moving beyond surface level responses upon attention and awareness people are able to respond upon a spectrum of varying levels and qualities of consciousness, awareness, and attention.
- Mindless states in simple repetitive actions can be desired and functional. Interruptions (breakdowns to normal functioning) of Mindless states (when in optimal conditions) are negative in felt experience.
- Balance between Mindfulness and Mindlessness is not only related to which of the states is invoked but the degree to which each is allowed to extend.

However, once Mindless states were achieved there were several properties that highlight potential negatives of Mindlessness; lack of sense of time, lack of recall in processes (unknowing of actions taken), lack of knowledge to external events (outside of immediate interaction). Participants assumed they were holding awareness though were immersed in the interaction (as Mindless activity). This was highlighted with 'Pop-Ups' which initially prompted reflection toward the previous answer though quickly became '*re-press the previous button*', however with 'Pop-Ups' becoming enacted as Mindlessly the previous answer was sub-conscious and consequently unavailable for recall. The analytical steps in 'Pop-Ups' was removed i.e. *if Pop-Up, review previous answer choice, choose correct answer, and then press/repress answer button* became *Pop-Up ' repress ' button*.

- Mindless activities lack: contextual awareness, information external to immediate interaction, sense of passage of time, conscious awareness, recall of interactive information (choices made, information presented etc.).
- Immersion may be considered Mindlessness interaction.
- Simple action/response prompts (e.g. Pop-Ups) that previously forced reflection/conscious awareness quickly became Mindless.
- Mindless responses removed contextualizing information.

In addition to the above findings and those reported in Chapter 2.9 four measures are also provided in contribution to the development of systems to measure physiological indications of Mindful and Mindless states:

- Through EEG recordings P300 ERP amplitude as a cross channel average was seen to be correlational to invoked Mindful (and noteworthy) events (Chapter 2.6.2 – 2.6.5 and Chapter 2.9.4). This supports that conscious and Mindful actions draw upon (and orientate) larger cognitive resources of the brain (as described in Chapter 1.11 and Chapter 1.12) than sub-/non-conscious actions.

- Raw EEG dynamic complexity mean variation and standard deviation (across 3 second period) was seen to follow invoked Mindful (and meaningful) events (Chapter 2.7.2, 2.8.3, and Chapter 2.9.4). This supports that conscious and Mindful actions disrupt / alter previous brain activity (of Mindless actions) and might reveal a reorienting of a global unified activity or drawing upon / activation of multiple regions of cognition (as described in Chapter 1.11 and Chapter 1.12). Consequently it is not the degree of complexity that is understood to hold significance but the comparative variation in complexity.
- Increases of pupil diameter are associated with cognitive loading (Chapter 2.7.3) and such changes may provide indication to Mindful and Mindless interactions and events (when viewed comparatively across ongoing activities). This measure highlights Mindful activities as more cognitively demanding (as described in Chapter 2.8.3 and Chapter 2.9.4).
- Eye movements are recognized as substantial in understanding a number of psychological processes including attentive and awareness processes and here as Mindful and Mindless state changes. It was found that Mean Eye Saccades duration per second - mean Eye Fixation duration per second (divided by 10 to accommodate comparability to saccades) increased with events that could be considered to invoke Mindful states of interaction. This highlights Mindful states as actively seeking multiple sources of information from the environment (here the interface of interaction).

Invoking and Designing Mindfulness and Mindlessness

While the above has demonstrated the thesis contributions in defining and measuring Mindfulness and Mindlessness Section 3 aimed to provide better understanding of how and where such states are understood and designed for in the wider field HCI design. Here findings are summarised with design considerations applicable to the designing of technologies to encourage Mindful and Mindless interactions.

Primarily Mindful interactions can be understood to encourage and hold reflectivity (of the user and interaction context), novel and exploratory thinking, and experientially focused interactions as a central tenet (Chapter 3.1.1). Mindless interactions can be understood to prize efficiency, effectiveness, and windows to information as core attributes; encouraging 'calm' and 'unremarkable' interactions that exist in the periphery of the users awareness and 'thinking *for* us' (Chapter 3.1.0).

- Mindful technologies should be designed to think *with* us and encourage us to *think* (Consciously – Chapter 1.11.2). They should account for slow interactions.
- Mindless technologies should be designed to think *for* us and allow us to *know* (Cognitively – Chapter 1.11.2). They should encourage fast interactions.

As highlighted, users of technologies learn skills and this knowledge becomes stored within a mental schema, a blueprint of action or knowledge learned as a set of rules. While during rule formation an action set may have been conscious it will increasingly become enacted (and potentially adapted) sub-consciously with repeated reenactments. Such application of mental schemas allows for rapid use of technologies and additionally facilitates 'intuition' the application of previous knowledge to similar situations (Chapter 1.12.2). The application of intuition facilitates rapid learning, however, care must be taken to ensure that contextual and analytical steps, if offered or required, are highlighted as novel from previous schemas. Similarly it was highlighted presentation of familiar technologies can limit their novel use (Chapter 1.7) and are less receptive to novel or alternate options (Chapter 1.12.3).

- Mindful designs should highlight differences, options and novelty, expanding cognitive loading and questioning upon the technology (Chapter 3.1.2); invoking a *tool* state of technology. In doing so, Mindful technologies reveal affordances in their questioning.
- Mindful technologies should be designed to encourage the user to 'see' themselves and the relationship they hold within a technology.
- Mindful designs should seek to limit automation or highlight its presence and function (Chapter 3.1.0).
- Mindless designs should draw upon previous schemas where possible through familiar design and interaction elements. They should seek to encourage transparent windows to information without question upon the interface elements (Chapter 3.1.1).
- Mindless interactions are less altered by options and difficult to inhibit once initiated. Such interactions exist as nested behaviors (Chapter 1.12.4) and run to completion if left uninterrupted. Consequently Mindless designs should not stray from mental schemas or offer options without imposing a 'breakdown' of familiar functioning. It should be noted breakdowns in themselves become resolved

Mindlessly if left unchanged (e.g. the responding toward 'Pop-Ups' (described in Section 2) becoming habitualised and automatic). Similarly, Mindless interactions should be designed to minimize interruptions to normal functioning's.

As highlighted in Chapter 3.1.2 Mindful interactions can be facilitated by increasing and augmenting cognitive loading; through breaking existing mental schema and forcing the user to 'think'. Similar practice was reported by some participants during the study reported in Chapter 2.8.1 in finding the right balance or preventing Mindless interactions.

- Mindful designs augment and increase cognitive loading through the prevention of enacting mental schemas

It was described in Chapter 3.2.1 that Mindless systems invoke intuitive interactions and guide the users understanding through the use of metaphor, invoking visceral and behavioural modes of interaction. The use of metaphor allows users to quickly apply the understandings of alternate mental schemas to the present interaction, through may not actually hold the original technologies functionalities. It is therefore critical that designers acknowledge that the use of metaphor should hold true to the object/technology they draw upon. This might be through explicitly stating or notifying where, when and how differences arise.

- Mindless designs should draw upon metaphor to invoke visceral and behavioral actions and understandings. However, these must hold true to the metaphor, else risk misunderstandings and interpretations. The use of metaphor will draw upon previous understandings and so current context may be lost.

In Chapter 3.2.1 it was highlighted that the augmentation of utility (through ambiguity) encouraged users of a technology to reflect on its meanings. While the example provided drew upon metaphor it was intentionally abstract, forcing interpretation. Ambiguity does not equate to fuzzy or inconsistent information, but rather an availability of interpretation. In the application of ambiguity an interpretation of the interaction is encouraged and so the invoking of a *tool* state and multiple affordances revealed.

- Mindful designs augment utility by interpretation through the use of ambiguity

As described above and more extensively in Chapter 3.3 the homogenisation of technology encourages a Mindless approach. Similar technologies invoke similar behaviours and actions, for good or ill (such as information displays holding common design elements for ease of reading, and phishing websites replicating login pages to invoke previous actions).

- Mindless designs follow homogenization of information, interface, and interaction.

While homogenisation affords rapid and familiar usability this can be augmented as highlighted in Chapter 3.3.1. Through the alteration of commonplace usability, such as removal of elements that support normal functioning, reflection occurs that can call for a re-contextualisation of the technology. Such technologies operate in the same 'fundamental' ways though their broader usability is novel.

- Mindful designs can promote novelty and contemplation over familiarity and usability

As highlighted in Chapter 3.4, there is an increasing pervasiveness of technology as automated 'everyware'. While such technologies lessen work and mundane tasks they additionally pose risk of increasing an unknowning of how, where, and when technologies perform processes for us. Such unknowning however poses potential risk in its failings as persons are unable to reconsider what and how the technology performed. Similarly dependence on automated systems that *think for* us creates difficulties should they fail to account for a contextual dependency or fail in reportability.

- Automated systems encourage Mindless interactions. Measures should be included to facilitate reflection (user thinking) upon failure and contemplation upon potential erroneous information.

As previously described, homogenisation facilitates a Mindless approach to technologies, this is additionally problematic in information intense environments. When encountering environments that hold vast amounts of information a defensively motivated Mindlessness state may be produced to allow the inhabitant to better consume information in manageable amounts (reduction of critical information consumption toward a Mindless accepting, surface level understanding, or, selectively ignoring large amounts of information). During such states the experiencer (inhabitant) of the environment views information sources as homogenised and as previous encounters. Such states are problematic during human-computer interactions as information events such as 'Pop-Ups' are quickly viewed as similar to previous exposures (i.e. regardless of information or criticality). This was observed during the study reported in Section 2, where 'Pop-Up' warnings quickly became viewed as irrelevant and no-longer read or observed as a prompt to action.

- Information intensive environments encourage defensively motivated Mindless interactions where large amounts of information are discarded to enable consumption. Familiar events are viewed uncritically regardless of meaning as information becomes homogenized.

In countering homogenisation and information intensity is Slow Technology (Chapter 3.4.1), a movement to encourage interactions with technologies that support rest and reflection over more commonplace values in efficacy. Slow Technologies share the ideals of experience centred design through consideration of users felt experience (as a central tenet), the self, others, and technology, are held as equally valuable and intrinsic to the design process. Slow Technologies encourage 'slow' interactions that are less 'on demand' than commonplace engagements (e.g. the twitter app continually updating with newest information) and move toward an unfolding over protracted periods of time and chance interactions. Similarly Slow Technologies encourage ritualization of interactions, drawing upon multiple stipulations to formulate a unique experience and remove homogenized interactions and information exchange; as highlighted by *Fenestra* (Uriu and Odom, 2016).

- Mindful designs are slow and unfolding, they encourage reflection and rest over speed and efficiency.
- Mindful interactions are designed to encourage and facilitate experience centric interactions.

It was additionally highlighted that immersive states of *Flow* are considered Mindless interactions (Chapter 3.5.1). While a common misconception that flow states are Mindful states (given the attentive process of immersion) or optimal, here the counter is proposed. As reported by participants during study (Section 2), there was a loss of the passage of time, a lack of awareness of external (to interaction) events, and a merging of action and (sub-conscious) awareness. Participants often reported these sates as 'being in the zone', in this thesis understood to be an optimal Mindless functioning. It was described that interactions can incorporate design frictions and microboundaries to slow otherwise rapid Mindless interactions. While such interventions can be viewed as strategies toward the interruption of immersive engagements (such as Flow) and breaking of chains in interactions here they might facilitate the balance of Mindlessness (and Mindfulness) that participants sought to achieve during the study (Chapter 2.8.1). As such, such design considerations might better facilitate the desired degree of Mindlessness; maintaining a Mindless functionality without a Mindless totality. The modalities of measurements presented in Section 2 might be incorporated into systems and automatically introduce design frictions to prevent undesirable degrees of

Mindlessness.

- Mindless technologies should consider the degree to which Mindlessness is desired and facilitate optimal levels through the inclusion of adaptive design frictions and microboundaries.
- While understanding the balance of Mindful and Mindless systems of interactions is important, the degree of these states must also be considered and designed for

Final Reflection

While this work is positioned within HCI design research it should also be recognised that the understandings hold value in a number of fields and so future work should seek to incorporate these as a multi-disciplinary effort to strengthen the understandings. Where typically areas such as neuroscience attempt to understand singular functions of an organisms 'parts' and processes, here a view was held not to understand Mindfulness or Mindlessness as singular specific biological functions (in isolation) but as intrinsically interrelated acts of an agent, a spectrum of subjectivity and being. The neurophenomenological approach of marrying the two differing practices of 'science' and 'philosophy', an act some might view in same light as mixing ice-cream and sand, provides fertile ground by justifying and confirming philosophical understandings while simultaneously providing a 'knowledge crutch' while empirical methods are developed. The work presented in this thesis is by no means a closed book; and it is hoped that it will serve as an early chapter for future work. In summation the overarching question of this thesis, "*How might Mindfulness and Mindlessness might be understood, measured and invoked in relation to Human-Computer Interactions?*"; has been addressed as an initial basis from which further work can build upon. Section one has addressed how Mindfulness and Mindlessness can be understood and provides operational definitions and lexicon for understanding the facets of Mindfulness and Mindlessness as they relate to human-computer interaction. Section two has addressed how Mindfulness and Mindlessness can be measured and provided fertile ground from which to build and incorporate systems for the automatic detection of such phenomena during interaction with technologies. Section three has provided insight to how Mindfulness and Mindlessness can be invoked, with example from which to further understanding of how one might design interactions with digital technologies to provoke these qualities. However, much work is still needed in refining and maturing these understandings as a distinct sub-field within human-computer interaction research. This is to be expected given the position of the work as an initial grounding for such research to build upon. Specifically future work should focus effort to the measurement of these phenomena under a number of settings and scenarios. The suggested next steps for future work would be to incorporate the physiological measures into a real time system, perhaps alerting users as they drift between Mindful and Mindless states or prompting for reporting of validity of measures. Such findings and refinement of such system would then allow for the evaluation of systems Mindful and Mindless invoking qualities. In doing so future interactive systems can be developed that fully apply and adapt to Mindful and Mindless states to enhance our interactions with technology. More significantly such work would greatly improve our understanding of who, what, and where *we* are.

5.0: Appendix

Appendix 1.1: Mindful Attention And Awareness Scale Questionnaire

The MAAS study was developed with specific focus to examine empirical links between Mindfulness and well-being and focuses upon the presence or absence of attention to awareness of present moment (as opposed to more traditional concepts from Buddhist practice that emphasise behaviours such as empathy, gratitude and acceptance to emotional/psychological valence).

Brown and Ryan (2003) state that allowing automatic / habitual thought processes can be non-beneficial and facilitate unwanted responses; and that persons having a greater awareness of their actions, environment etc. (i.e. "Mindful") are better able to control these actions with benefits to their cognitive and emotional well-being. While finding grounding in more Western (and scientific) conceptualisations of Mindfulness, Brown and Ryan note: "*The present definition emphasizes an open, undivided observation of what is occurring both internally and externally rather than a particular cognitive approach to external stimuli.*" (p823, Brown and Ryan, 2003). The agree / disagree items presented in the Mindful attention and awareness scale questionnaire can be found below:

- I could be experiencing some emotion and not be conscious of it until some time later.
- I break or spill things because of carelessness, not paying attention, or thinking of something else.
- I find it difficult to stay focused on what's happening in the present.
- I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.
- I tend not to notice feelings of physical tension or discomfort until they really grab my attention.
- I forget a person's name almost as soon as I've been told it for the first time.
- It seems I am "running on automatic," without much awareness of what I'm doing.
- I rush through activities without being really attentive to them.
- I get so focused on the goal I want to achieve that I lose touch with what I'm doing right now to get there.
- I do jobs or tasks automatically, without being aware of what I'm doing.

- I find myself listening to someone with one ear, doing something else at the same time.
- I drive places on "automatic pilot" and then wonder why I went there.
- I find myself preoccupied with the future or the past.
- I find myself doing things without paying attention.
- I snack without being aware that I'm eating.

(Brown and Ryan, 2003)

Appendix 1.2: Toronto Mindfulness Scale Questionnaire

Mindfulness is framed by Lau et al. in the Toronto Mindfulness scale as:

> "(a) the intentional self-regulation of attention to facilitate greater awareness of bodily sensations, thoughts, and emotions;
> and
> (b) a specific quality of attention characterized by endeavoring to connect with each object in one's awareness (e.g., each bodily sensation, thought, or emotion) with curiosity, acceptance, and openness to experience. Such a state involves an active process of relating openly with one's current experience by allowing current thoughts, feelings, and sensations"
> (p1447, Lau et al., 2006)

The Toronto Mindfulness Scale test states that the interest of the questionnaire is directed towards what the participant "just experienced" (contextualised to the present) and is divided into two categories; "curiosity" (questions 3, 5, 6, 10, 12, 13), and "decentring" (questions 1, 2, 4, 7, 8, 9, 11). The questions presented during the test are:

- I experienced myself as separate from my changing thoughts and feelings.
- I was more concerned with being open to my experiences than controlling or changing them.
- I was curious about what I might learn about myself by taking notice of how I react to certain thoughts, feelings or sensations.
- I experienced my thoughts more as events in my mind than as a necessarily accurate reflection of the way things 'really' are.
- I was curious to see what my mind was up to from moment to moment.
- I was curious about each of the thoughts and feelings that I was having.

- I was receptive to observing unpleasant thoughts and feelings without interfering with them.
- I was more invested in just watching my experiences as they arose, than in figuring out what they could mean.
- I approached each experience by trying to accept it, no matter whether it was pleasant or unpleasant.
- I remained curious about the nature of each experience as it arose.
- I was aware of my thoughts and feelings without over-identifying with them.
- I was curious about my reactions to things.
- I was curious about what I might learn about myself by just taking notice of what my attention gets drawn to.

(Lau et al., 2006)

Appendix 1.3: State Mindfulness Scale Questionnaire

Tanay and Bernstein frame Mindfulness through an integration of both Buddhist philosophy and contemporary psychological definitions of Mindfulness. In recognition of the limited number of measurements of Mindfulness as a temporary state Tanay and Bernstein (2013) seek to apply such measures towards specific task and context dependent understandings. This is achieved through understanding Mindfulness on the first level as "*focused on the nature of events or aspects of one's experience in the present moment of which one is mindful*" (p1287); and a second level focusing upon Mindfulness "*… as a meta-cognitive state (i.e., "how" a person attends)*" consisting of five qualities; awareness, perceptual sensitivity to stimuli, deliberate attention to the present moment, intimacy or closeness to one's subjective experience, and curiosity (p1287). Points of measurement in the State Mindfulness Scale (including omissions that "*lacked evidence of univocality or theoretically interpretable multivocality*" (p1289, Tanay and Bernstein, 2013)) can be found below:

- I was aware of different emotions that arose in me.
- I tried to pay attention to pleasant and unpleasant sensations.
- I found some of my experiences interesting.
- I noticed many small details of my experience.
- I felt aware of what was happening inside of me.
- Omission: "I noticed various sounds [e.g., sounds in the room, sound of my own breathing]"

- I noticed pleasant and unpleasant emotions.
- I actively explored my experience in the moment.
- I clearly physically felt what was going on in my body.
- I changed my body posture and paid attention to the physical process of moving.
- Omission: "I noticed a thought that came into my mind and then that it passed"
- I felt that I was experiencing the present moment fully.
- I noticed pleasant and unpleasant thoughts.
- I noticed emotions come and go.
- I noticed various sensations caused by my surroundings (e.g., heat, coolness, the wind on my face).
- I noticed physical sensations come and go.
- I had moments when I felt alert and aware.
- I felt closely connected to the present moment.
- I noticed thoughts come and go.
- I felt in contact with my body.
- I was aware of what was going on in my mind.
- It was interesting to see the patterns of my thinking.
- I noticed some pleasant and unpleasant physical sensations.

(Tanay and Bernstein, 2013)

Appendix 1.4: Langer Mindfulness/Mindlessness scale

Bodner and Langer (2001) construct validation of the Mindfulness/Mindlessness Scale though several theoretically associated constructs.

Openness to experience: a part of the "Big Five" personality dimensions (Digman,1990), is cited as a correlation toward Mindfulness. Those who exhibit a willingness to be open to experience are more likely to novelly engage with the surrounding environment. It is further hypothesised that: "*individuals with high levels of openness to experience have a greater degree of tolerance for the unfamiliar; in fact, such individuals seek out and explore the unfamiliar*" (p2, Bodner and Langer, 2001). That is, a Mindful individual will be open to and seek unfamiliar and novel experiences.

Capacity to entertain multiple perspectives: is highlighted as a concurrent construct; that is, the capacity to view/understand the "world" form another's/multiple perspectives corresponds to Bodner and Langers understanding of Mindfulness:

> "Mindfulness too involves an awareness that any event or fact can be understood from multiple perspectives. In fact, one might anticipate that the propensity to be mindful and a capacity to entertain multiple perspectives to correlate strongly as entertaining multiple perspectives is a key component of mindfulness (Langer, 1997)"
> (p2, Bodner and Langer, 2001)

Need for cognition: (Cohen, Stotland and Wolfe, 1955), the degree to which an individual enjoys and engages in thinking (Bodner and Langer, 2001), is suggested as a component of Mindfulness. Cohen, Stotland and Wolfe (1955) define the need for cognition as:

> "… a need to structure relevant situations in meaningful, integrated ways. It is a need to understand and make reasonable the experiential world. "Meaningfulness" and "integration" are individually defined in that they vary with the person's past experience and capacity for such integration. For any given individual different situations will be differentially important for the arousal and satisfaction of the need. In addition, any given situation will have differential importance for the arousal and satisfaction of the cognition need."
> (p291, Cohen, Stotland and Wolfe, 1955)

That is to say, individuals who possess a high need for cognition will actively seek to apply cognitive processing in order to fully understand the underlying structure of a situation or experience (i.e. Mindfully seek further information and understanding); in opposition to this would be individual with a low need for cognition who may choose to accept (uncritically) experiences or information without further inquiry.

Need for simple structure and need for cognitive closure: as Bodner and Langer (2001) additionally state:

> "In a complex environment, individuals use a variety of cognitive tools to minimize the competition for precious cognitive resources. One such tool is a reliance on cognitive structures (e.g., prototypes, schemas, scripts) to organize experience."
> (p3, Bodner and Langer, 2001)

Quoting Neuberg and Newsom (p.114, 1993)[28], Bodner and Langer (2001)

---

[28] "people meaningfully differ in the extent to which they are dispositionally motivated to cognitively structure their worlds in simple, unambiguous ways"

highlight that a Mindful state requires "complex and dynamic" cognitive structures that are receptive to change through multiple interpretations of a given situation, thus retain and facilitate ambiguity. Likewise, Bodner and Langer (p3, 2001) state that individuals who seek to achieve cognitive closure display decisiveness and close-mindedness and are motivated to quickly attend and resolve uncertainties and desire predictability, order and structure over the discomfort caused by ambiguity; whereas contrary to this "*mindfulness is antithetical to the need for structure and the need for closure*".

Thinking styles and *general cognitive ability* are additionally factored into the construct validation of Mindfulness/Mindless Scale. Bodner and Langer (2001) state that a Mindful person should exhibit a "legislative-liberal" thinking style:

> "When mindful, individuals are aware of the existence and limitations of currently used rules and procedures. They are also aware that other rules and procedures are possible and can generate these new rules and procedures. Though mindful individuals can implement their plans consistent with existing rules and procedures, this takes place after the mindful consideration and construction of alternative procedures."
>
> (p3, Bodner and Langer, 2001)

The "general cognitive ability" or intelligence is framed as "*a constellation of thinking abilities designed to cope with environmental complexity*" (p3, Bodner and Langer, 2001). Such abilities include memory, reasoning and recognition; the combination these "*lower-level cognitive and perceptual systems*" (p3, Bodner and Langer, 2001) with intelligence being the higher level abstraction of such abilities. Bodner and Langer (2001) suggest that such "cognitive systems" are additionally important in facilitating Mindfulness, e.g. The ability to generate and maintain multiple interpretations of a situation requires the "*existence of a fluent associative memory system*" (p3, Bodner and Langer, 2001). Such perspectives are discussed at greater length in chapter 1.12. The Mindfulness/Mindlessness scale questioning is presented with the factoring as defined by Haigh et al. (2010) (test order number prior to statement):

Mindfulness/Mindlessness Scale (MMS)
Factor 1 (Mindfulness):
14 : I try to think of new ways of doing things.
18 : I find it easy to create new and effective ideas.
3 : I am always open to new ways of doing things.
13 : I am very curious.
10 : I am very creative.
20 : I like to figure out how things work.

17 : I like to be challenged intellectually.
1 : I like to investigate things.
4 : I "get involved" in almost everything I do.
12 : I attend to the "big picture."
16 : I have an open mind about everything, even things that challenge my core beliefs

Factor 2 (Mindlessness):

15 : I am rarely aware of changes.
19 : I am rarely alert to new developments.
8 : I seldom notice what other people are up to.
9 : I avoid thought provoking conversations.
21 : I am not an original thinker.

Items that do not load on either factor:

2 : I generate few novel ideas.
5 : I do not actively seek to learn new things.
6 : I make many novel contributions.
7 : I stay with the old tried and true ways of doing things.
11 : I can behave in many different ways for a given situation.

(Haigh et al., 2010)

Appendix 1.5 Codification Of Mindfulness And Mindlessness From Pre-Existing Definitions And Framings

The construct of Mindfulness in the previously discussed framings that may be applied within the intended scope of the research and applicable to human-computer interaction was coded as: 1 = Directed / controlled attention and / or awareness; 2 = Presence of "mind" (i.e. Conscious awareness of experience); 3 = Habit / repetition / automatic behaviour; 4 = Contextualisation to present moment; 5 = Openness to novelty; and, 6 = Cognitive state.

Eastern/Buddhist construct: A presence of mind [2]; Reflection upon moment-to-moment experience [2, 4]; Consciousness orientated toward present reality [2, 4]; Directed attention [1]; Open and self-guided awareness [1, 5].

Clinical application and measurement as trait like (Eastern): Observation of sensory experience [2]; Controlled attention and awareness [1, 6]; Attentive to present experience [2, 4]; Directed focus [1].

Clinical application and measurement as state like (Eastern) (* Indicates Mindlessness): Focused awareness toward inner and outer environment (as attention) [1]; Attentive to present reality [2, 3, 4]; * Carelessness / distraction [1]; Goal oriented [3, 4]; * Failure to retain recent information [4]; * Automatic behaviour and processing of information [1, 2, 3, 4]; Bodily awareness [2]; Awareness of thoughts [1]; Openness to experience [2, 5]; Reflection upon experience [1, 2, 4].

Western understanding and measurement as state-like (* Indicates Mindlessness):

Mental behaviour [6]; State-like experience (variable) [4, 6]; Meta-cognitive / self-reflective state [6]; Concerted/ deliberate awareness to present [1, 2, 4]; Self-regulated attention toward immediate experience [1, 2, 4]; Interest in experience [5]; Context dependant [3, 4]; Object/task oriented [3, 4]; Relational to present stimulus [2, 4]; Attention to bodily experience [2]; Awareness of surrounding [1, 2, 4]; Attention to detail [1]; Alertness [6]; * Automaticity [1, 3, 4, 5]; * Rigid understanding [4, 5]; Active discovery of novel distinctions [1, 4, 5]; Awareness to alternate meanings [1, 4, 5]; * Repetitive behaviour [3, 4, 5]; * Behaviours without conscious control/awareness [1, 2, 3, 4]; Tolerance of unfamiliar [5]; Arousal and satisfaction of cognition [5, 6]; Complex/dynamic cognitive structures (mental models) [6]; Generating new rules and procedures [3, 4, 5]; Higher functioning memory, reasoning and recognition [1, 3, 6]; Novelty in action [3, 5]; Novelty in thought [3, 5, 6]; Creative/ease of ideation [5]; Open to new modes of action [5]; Investigatory [5]; Aware of bigger picture (contextualization of understanding) [1, 4, 5]; * Lack of change awareness [1, 2, 3, 4]; * Lack of awareness of surroundings [1, 2, 4].

Appendix 2.1: Participant Information Sheet and Consent Form

Dear participant,

Thank you for participating in the study "Influence of feedback modalities upon Mindfulness"; which is part of an ongoing PhD research project in Lancaster University.

This study is concerned with how differing designs/forms of feedback modalities with digital technology: -

- Support mindfulness during interaction
- Allow a deeper understanding of information/feedback
- Encourage longer duration interactions

with the aim to improve interactions with technology through better design.

Study	Influence of feedback modalities upon Mindfulness
Key terms:	**Mindfulness**: Mindfulness in this study is described as a state of awareness where one is actively conscious of (paying attention to) thoughts, feelings, bodily sensations and the surrounding environment. This is the opposite of Mindlessness where one is "on auto-pilot" or "zoning out", for example when travelling a familiar route and arriving at the destination with no recollection/awareness of the journey. The testing will use EEG as an input. **EEG**: EEG measures fluctuations in electronic charge produced by normal brain functioning by the placement of electrodes across the scalp *(these do not pierce the skin and do not cause pain/discomfort)*. ***EEG cannot detect individual thoughts or any personal information***.
What will happen and when	Participants will be expected to attend a 2 hour session (approximate) The session will consist of 7 differing forms of interaction followed by a short questionnaire/survey. At the end of the final session an informal Q&A will be held (optional).
Privacy and confidentiality	All your information will be treated with confidentiality. At any point in the research you have the right to withdraw from the study; this will not affect your relationship with any of the organisations/persons connected to the study. Should you withdraw within 2 weeks following the study your data will be destroyed; however after this period data will remain in the study.
Data handling and processing	If you partake in the study the principal investigator will create a transcript of your interview and testing, collect questionnaire feedback, capture video recording of testing, measure and record EEG data and eye-tracking data. Data may be recorded on a password-protected and encrypted mobile device. For subsequent analysis, data will be stored on an encrypted password-protected PC and will be accessible only to the principal investigator and his supervisors. You have the right to request any data from your

	participation in the study at any time. Data will be stored in ways to make sure your identity can't be inferred. Data (and/or a summary of data) will be stored up to and including December 2015 unless otherwise requested.
Use of your data	The principal investigator may use your survey/questionnaire/feedback, data collected from eye-tracking and EEG, and/or data collected from video analysis in academic publishing (e.g. PhD thesis) and reports (e.g. journal articles, presentations) that concern this study. Any such public document/presentation will never state/show your identity, but use pseudonyms instead. From testing/questionnaires, quotes will only be snippets of the entirety. Any audio recordings/video recordings of testing will be deleted once the study is complete. All other data will be preserved for long-term access and will be anonymised for this purpose.
Project funding	The principal investigator is funded via the Digital Economy Program of the EPSRC (Engineering and physical sciences research council of the UK).
Contact details	**Principal investigator**: Kiel Long, PhD Candidate, HighWire Centre for Doctoral Training, Lancaster University. e-mail: : kslong@highwire-dtc.co.uk // 07530 003185 If you wish to contact an independent person for concerns or complaints please contact: Dr Paul Coulton e-mail: p.coulton@lancaster.ac.uk The LICA Building, Lancaster University, Bailrigg, Lancaster, LA1 4YW *Or alternatively* Dr Jason Alexander; e-mail: j.alexander@lancaster.ac.uk Office C18, InfoLab21, Lancaster University, Bailrigg, Lancaster, LA1 4WA

CONSENT FORM:

Influence of feedback modalities upon Mindfulness

Name of Researcher: Kiel Long, HighWire DTC, Lancaster University

Participant Identification Number: ____________

Please initial box

3. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.
4. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.
5. I understand that any information collected from/given by me may be used in future reports, articles or presentations by the research team.
6. I understand that my name will not appear in any reports, articles or presentations.
7. I agree to take part in the above study.

______________________ ______________ _________

Name of Participant Signature Date

______________________ ______________ _________

Name of Researcher Signature Date

When completed, please return to the researcher conducting the study. One copy will be given to the participant and the original to be kept in the file of the research team at Lancaster University.

Appendix 2.2: Condition Presentation Ordering

The following table A2.2 provides the condition presentation per participant (A through G). Comparative conditions were intentionally clustered with aims to provoke automatic responses in the following test (e.g. Condition 2 Stroop influencing condition 3 Stroop), and subsequent effort to inhibit the recently acquired automaticity. GXRX denotes Condition 1; STR denotes an adapted Stroop word test (Condition 2 and 3) (WRD – participants providing the written word, COL - participants providing the colour of text); ARR denotes an adapted Stroop Arrow test (Condition 4 and 5) (POS – participants providing the position of arrow, DIR - participants providing the direction of arrow); CLK denotes a clock face based condition test (Condition 6 and 7) (FIX – Condition of a fixed clock face, ROT - Condition of a rotating clock face).

Participant No.	Condition A	Condition B	Condition C	Condition D
1	GXRX	ARR.DIR	ARR.POS	CLK.FIX
3	STR.COL	STR.WRD	CLK.FIX	CLK.ROT
4	CLK.FIX	CLK.ROT	GXRX	STR.COL
5	GXRX	ARR.POS	ARR.DIR	CLK.ROT
6	ARR.POS	ARR.DIR	STR.WRD	STR.COL
7	STR.WRD	STR.COL	CLK.ROT	CLK.FIX
8	CLK.ROT	CLK.FIX	GXRX	STR.WRD
9	GXRX	ARR.DIR	CLK.ROT	STR.COL
10	STR.WRD	CLK.FIX	STR.COL	CLK.ROT
11	STR.COL	STR.WRD	CLK.FIX	CLK.ROT
12	ARR.DIR	ARR.POS	STR.COL	STR.WRD

Participant No.	Condition E	Condition F	Condition G
1	CLK.ROT	STR.COL	STR.WRD
3	ARR.DIR	ARR.POS	GXRX
4	STR.WRD	ARR.DIR	ARR.POS
5	CLK.FIX	STR.WRD	STR.COL
6	GXRX	CLK.ROT	CLK.FIX
7	ARR.POS	ARR.DIR	GXRX
8	STR.COL	ARR.POS	ARR.DIR
9	ARR.POS	CLK.FIX	STR.WRD
10	ARR.POS	GXRX	ARR.DIR
11	ARR.DIR	ARR.POS	GXRX
12	GXRX	CLK.FIX	CLK.ROT

Table A2.2: Condition presentation ordering

Appendix 2.3: Participant Questionnaire

1. I was intentionally aware of my thoughts and feelings.

Agree completely Disagree completely

☐ ☐ ☐ ☐ ☐

……………………………………………………………………………………………
…………………………………………………………………………………………

2. My mind wondered off and I was easily distracted.

Agree completely Disagree completely

☐ ☐ ☐ ☐ ☐

……………………………………………………………………………………………
…………………………………………………………………………………………

3. I knew the correct answer and made my choice quickly without needing to think too much.

Agree completely Disagree completely

☐ ☐ ☐ ☐ ☐

……………………………………………………………………………………………
……………………………………………………………………………………………

4. I paid attention to the environment around me.

Agree completely Disagree completely

☐ ☐ ☐ ☐ ☐

……………………………………………………………………………………………
……………………………………………………………………………………………

5. I was completely absorbed in the display/audio; so that all my attention was focused on it.

Agree completely Disagree completely

☐ ☐ ☐ ☐ ☐

……………………………………………………………………………………………
……………………………………………………………………………………………

6. I found myself watching/listening to the display/audio but thinking of something else at the same time.

Agree completely Disagree completely

☐ ☐ ☐ ☐ ☐

……………………………………………………………………………………………
……………………………………………………………………………………………

ADDITIONAL COMMENTS:

……………………………………………………………………………………………
……………………………………………………………………………………………
…………………………………………………………………………

Appendix 2.4: Brain Activity, EEG and QEEG

The structure of the human brain is formed by an estimated 100 billion neurons 'connected' together via synapses (of which it is estimated of 100 quadrillion) to form clusters of densely connected areas known as lobes that specialize in differing functions e.g. the occipital lobe at the rear of the human brain is considered to be vital in visual processing. To form these clusters the neurons are connected in a complex mesh that extends to interconnect the differing lobes and form a network across (and of) the brain allowing differing specialized lobes/areas communication. Neurons can vary in length from less than a millimetre to over a meter (such as the motor neurons required to activate leg and foot muscles). Communication between neurons is produced by the passing of electrical charge across the body (along the axon to the axon terminals) (see figure A.2.1) to 'connected' neurons via synapse (though considered as connected, synapse do not always physically connect but exchange electrical and chemical stimulus). To receive stimulus a neuron will receive a charge (from another connected neuron) via its dendrites.

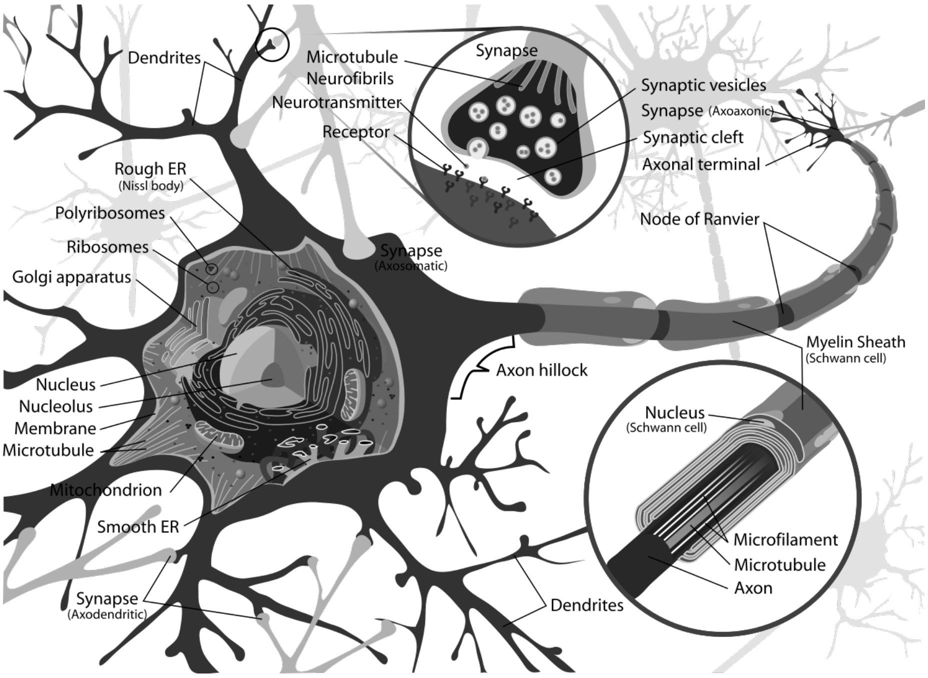


Figure A.2.1: diagram of a typical neuron[29].

It should be noted that neural pathways and synapses are able to change from

[29]https://upload.wikimedia.org/wikipedia/commons/thumb/a/a9/Complete_neuron_cell_diagram_en.svg/1280px-Complete_neuron_cell_diagram_en.svg.png

events such as brain injury, environment, changes in behavior, and (of importance to the research), from neural processes such as repeated or lack of firing. This process is known as "*neuroplasticity*" and is a "rewiring" of the brain in response to learning, memory, and to make processes more efficient (as described in Chapters 1.11 and 1.12.; Baars, 1993 and 1997; Århem and Liljenström, 1997). Neurons can allow and propagate information across connected neurons as 'excitatory', and may also prevent or slow communication as 'inhibitory' depending on stimulus received.

To prevent a chaotic pattern of communication the neurons of the brain (or clusters of neurons) "fire" (neurons discharge electric in communication) in rhythmic cycles of varying speeds (measured in Hertz- Hz, as cycles per second). It is important to note that EEG cannot detect singular neurons activity however, when firing in larger groups an electromagnetic field produced is large enough that it may be detected by the placement of electrodes on the scalp. Through measuring the amplitude (measured in micro-Volts, μV) of the electrical signal measured, EEG is able to give an indication to the amount of 'information processing' occurring in areas of the brain (e.g. a high amplitude indicating a large group of neurons discharging in synchronicity). An example of brainwave patterns and their associated mental states can be seen in figure A.2.2

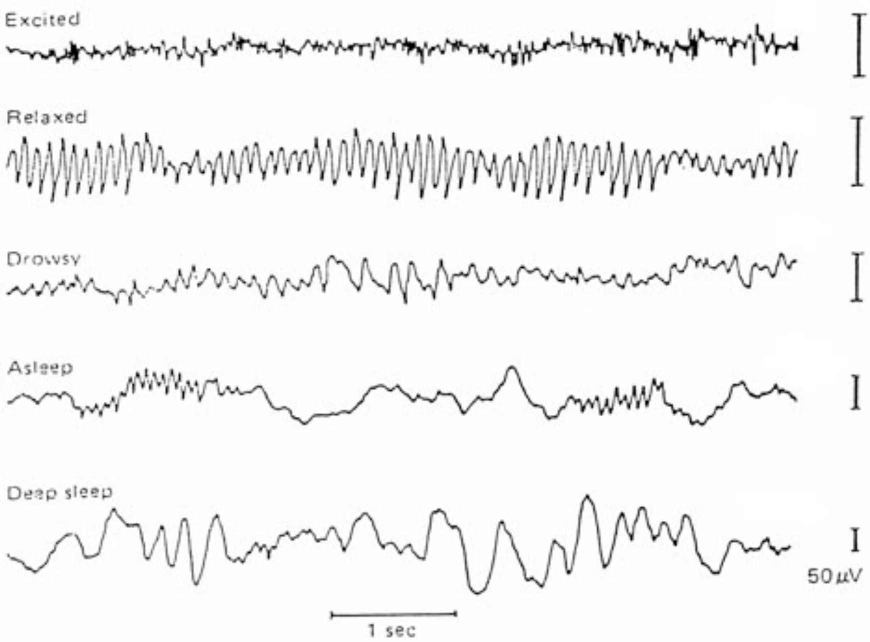


Figure A.2.2, EEG wave patterns in differing states[30]

[30] Electroencephalogram. (n.d.) *Miller-Keane Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health, Seventh Edition*. (2003). Retrieved May 17 2017 from http://medical-dictionary.thefreedictionary.com/electroencephalogram

It should be noted however that EEG does not have an advanced level of locational accuracy as the electrodes are placed away from the brain and the electromagnetic waves are partially deflected by the skull; however, reliable results are still obtained through the use of multiple electrodes (to compare signals) and through the mapping of the head known as the 10/20 system (see figure A.2.3) to measure and determine areas of interest. EEG does however provide near instantaneous readings over time (unlike more detailed recording procedures such as fMRI – functional magnetic resonance imaging) and so is a powerful tool in the analysis of brain activity when performing tasks – or as here, during specific interactions.

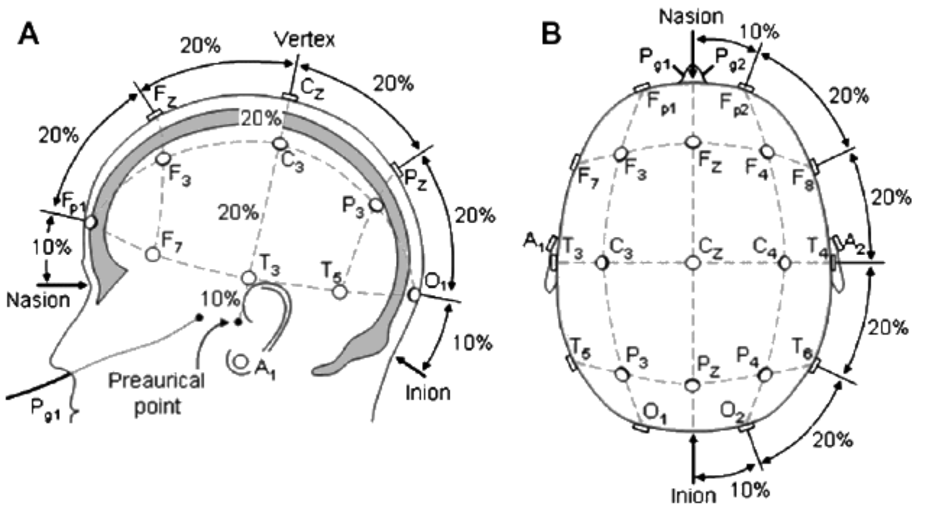
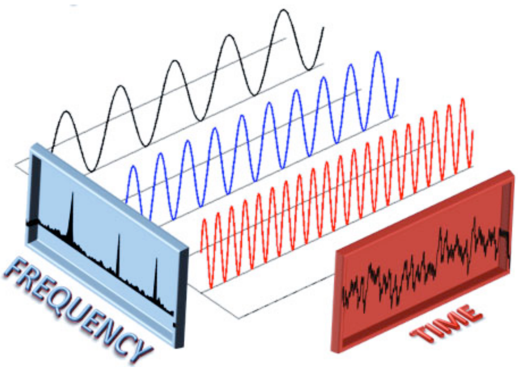


Figure A.2.3[31], 10/20 mapping across the human skull. Letters denote lobes Fp F, T, C, P and O relating to frontal polar, frontal, temporal, central (though not a lobe C denotes the central position), parietal, and occipital lobes, respectively. Even numbers indicate the right hemisphere and odd the left, while z indicates the central (zero) midline.

Quantitative EEG (QEEG) is the transform of "raw" EEG data (as in figure A.2.2) into a numerical representation through a Fast Furrier Transform (FFT) to extract the frequency and amplitude of neuronal group firing, and allow for easier classification and observation of EEG recordings. QEEG measures the frequency (Hz) of oscillations (as many frequencies occur simultaneously) to give an indication of the speed of information processing e.g. a high brainwave frequency (e.g. >30Hz)

[31] Adaptation of: Klem, G. H., Lüders, H. O., Jasper, H. H., & Elger, C. (1999). The ten-twenty electrode system of the International Federation. *Guidelines of the International Federation of Clinical Physiology*, 52(3), 3-6.

indicates fast information processing (e.g. alertness) and lower frequency (e.g. 10Hz) indicates a lower workload (e.g. relaxation). Fig. d below provides a pictorial representation of this.



(figure A.2.4[32], FFT example. A raw EEG signal is exemplified as in the red box, by performing an FFT the frequency bandwidths (ranges in Hz's) of the recording are extracted and can then be represented as in the blue box (showing the frequency and its amplitude). This process aids in the classification and analysis of brain activity.

In addition to understandings gained through brainwave frequency analysis, QEEG allows for understandings of phase coherence between EEG frequency waveforms.

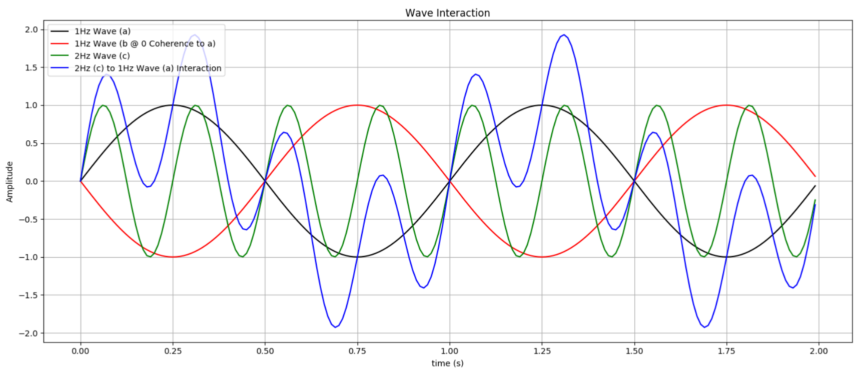


Figure A.2.5: Example of waveforms and phase

A waveform consists of both positive and negative amplitude that occur as an oscillation (a single positive (peaks) and negative (troughs) movement of the wave)

[32] https://groups.csail.mit.edu/netmit/sFFT/algorithm.html

(see: figure A.2.5); with the number of oscillations equal to the frequency of the wave (e.g. one oscillation per second equalling 1Hz). This is exemplified in figure A.2.5, where wave *a* (black) shows a 1Hz waveform, and *c* (green) shows a 2Hz waveform. Fourier transform is used to calculate frequency information as an angle, the waves position in oscillation relative to 0 degrees. Phase coherence is a measurement between two oscillations at specific time points as an understanding of the difference between them e.g. in figure A.2.5 wave *b* has zero coherence to wave *a* though both waves present the same amplitude and frequency. That is to say, while wave *a* and wave *b* in figure A.2.5 hold identical properties outside of consideration of their phase (i.e. high correlation), they are opposites in their phase (zero coherency). The understanding of phase is particularly import when understanding two waveforms as their phase influences their amplitude (increasing or reducing); as exemplified in the blue waveform in figure A.2.5 showing the interaction between wave *a* (1Hz) and wave *b* (2Hz). It has previously been identified that EEG phase coherency provides broader understandings of the functional connectivity of areas in the brain and indication to cognitive processes and hindrance (Marosi et al, 1997; Martin-Loeches et al, 2001; Kislova and Rusalova, 2009); and that alterations in phase (high and low phase coherency shifts) provide insight to the dynamic properties of brain functions (Thatcher, 2012). As previously described, within the brain neurons propagate information to connected neurons as 'excitatory', and may also prevent or slow communication as 'inhibitory'. The measurement of phase coherency reveals the synchronized neural oscillations, whereby areas of the brain with a high coherency are understood to be facilitating information flow (Fries, 2005) and facilitate multiple brain regions to interact in events such as sensory awareness (Engel and Singer, 2001), yet can be inhibitory (low phase coherence) and prevent activation and communication. Similarly, changes to EEG phase coherency have additionally been linked responses to error (Cavanagh, Cohen, and Allen, 2009), suggesting a re-ordering of brain processes to work in synchrony for re-evaluation of acts and behaviours.

Thus, through QEEG we are provided three metrics to understand brain activity. Firstly, we can understand brain regions activity in relation to their amplitude, revealing the degree of activity. Secondly, we can understand brain activity in terms of its frequency of activity, providing insight to information processing. Thirdly, we can understand brain activity in associative terms (between two or more sites) through understanding their phase coherency, revealing communication and cooperation between differing areas.

Appendix 2.5: Quantitative Questionnaire Data

As previously described following each condition participants were asked to complete a brief questionnaire (See Chapter 2.5.4). Answers were given through a six point Likert-type scale (from "Agree completely" to "Disagree completely"), and had option to provide comment following each statement. Scoring ranged from 1 =Agree Completely, to 6 = Disagree Completely.

Questions:

G. I was intentionally aware of my thoughts and feelings. Lower scores indicate Mindfulness
H. My mind wondered off and I was easily distracted. Higher scores indicate Mindfulness
I. I knew the correct answer and made my choice quickly without needing to think too much. Higher scores indicate Mindfulness
J. I paid attention to the environment around me. Lower scores indicate Mindfulness
K. I was completely absorbed in the display/audio; so that all my attention was focused on it. Higher scores indicate Mindfulness
L. I found myself watching/listening to the display/audio but thinking of something else at the same time. Higher scores indicate Mindfulness

<u>Condition 1 (Green X O - Red X O)</u>

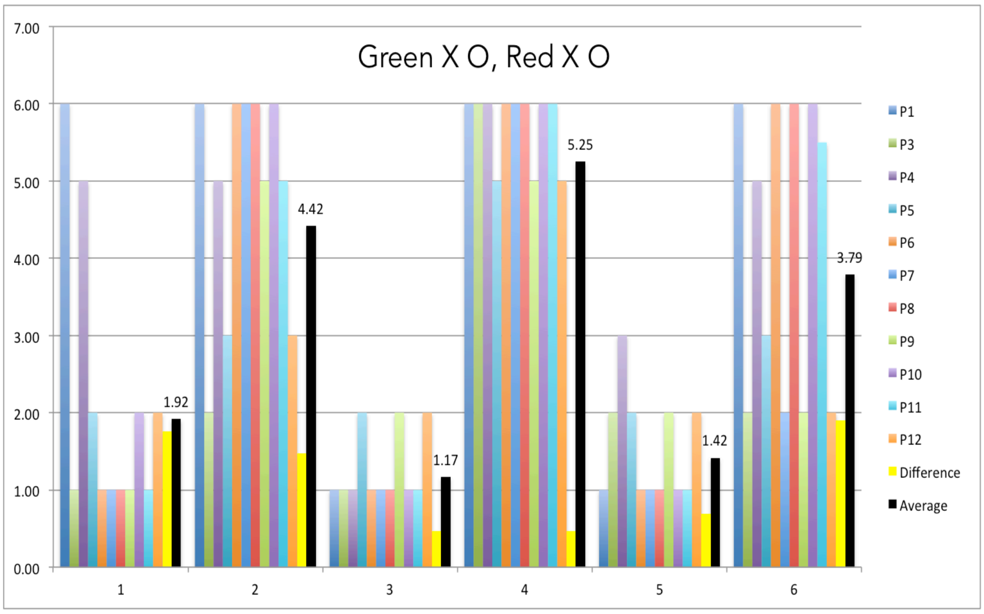


Figure A.2.6: GXRX quanatative questionaire feedback results

Condition 2 and 3 (Stroop (Word) and Reversed Stroop (Colour))

As the two linguistic Stroop tests were conducted in a mixed order across participants these are presented in the 'First' Stoop presented and 'Second' Stroop presented.

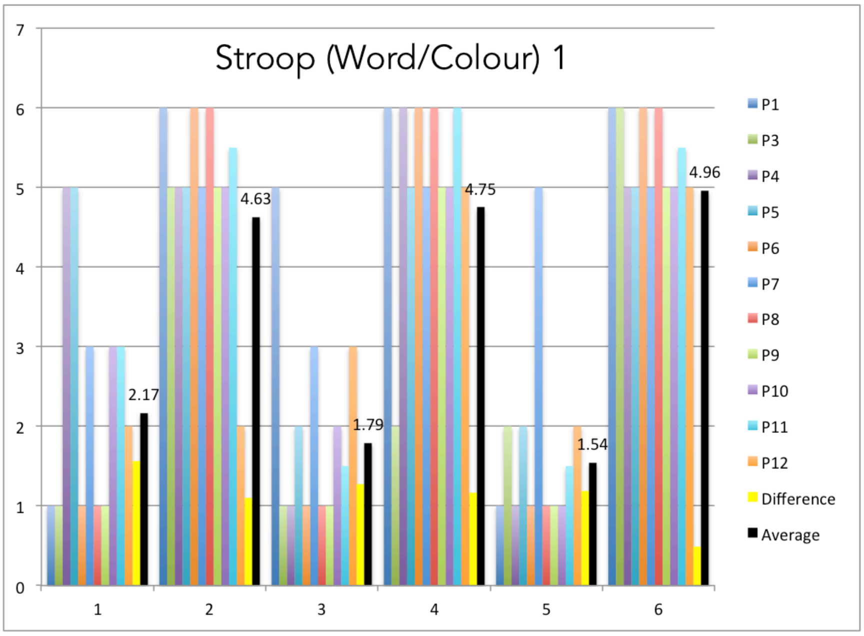


Figure A.2.7: Linguistic Stroop 1 quanatative questionaire feedback results

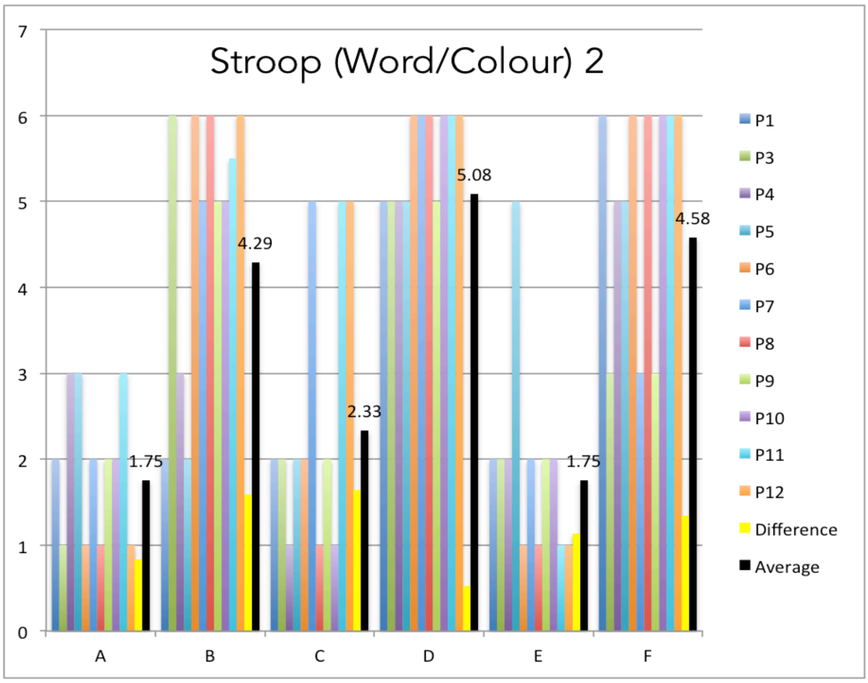


Figure A.2.8: Linguistic Stroop 2 quanatative questionaire feedback results

Condition 4 and 5 (Stroop Arrow (Direction) and Reversed Stroop Arrow (Position))

As with the linguistic based Stroop, the two symbolic based Stroop tests were conducted in a mixed order across participants these are presented in the 'First' Stoop presented and 'Second' Stroop presented.

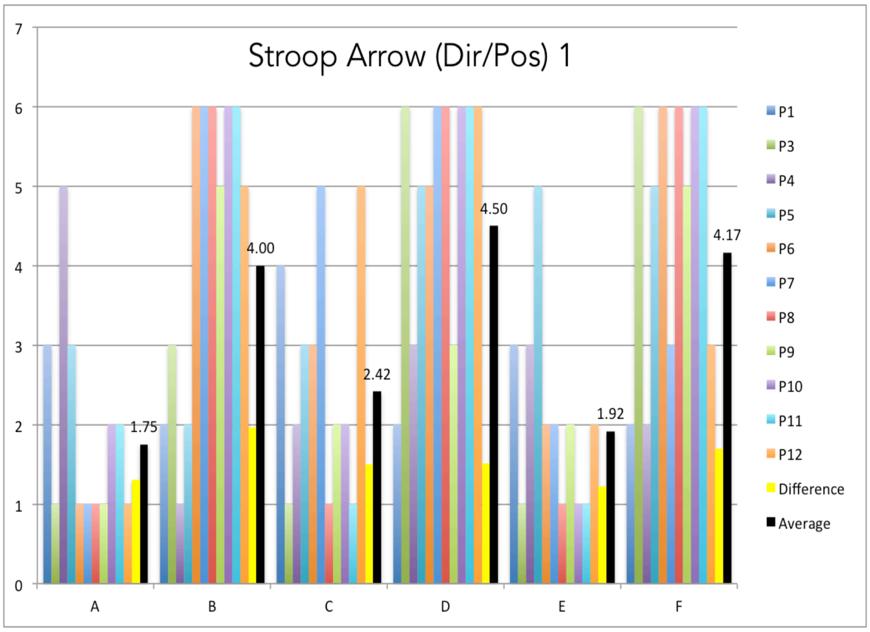


Figure A.2.9: Spatial Stroop 1 quanatative questionaire feedback results

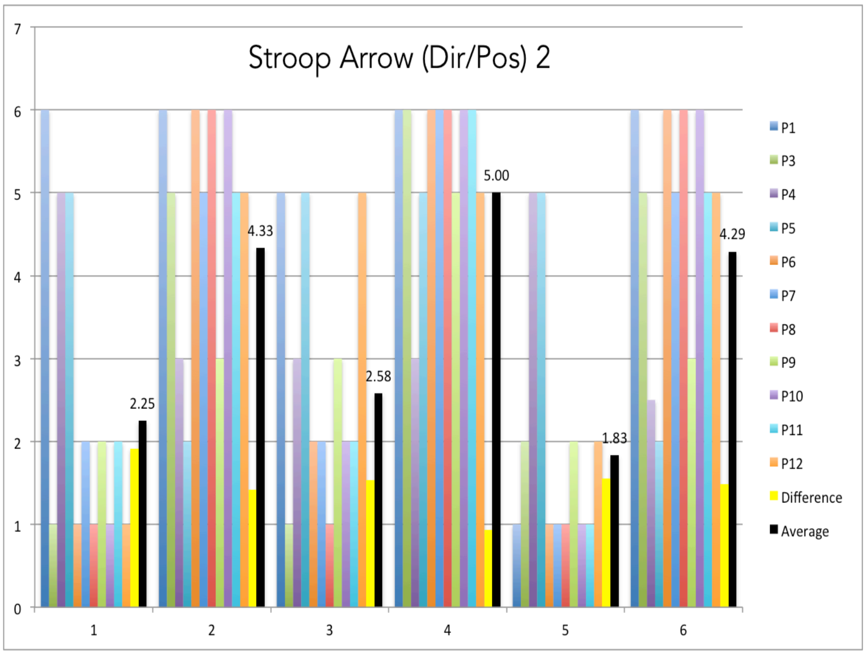


Figure A.2.10: Spatial Stroop 2 quanatative questionaire feedback results

Condition 6 & 7 (Fixed Clock Face and Rotating Clock Face):

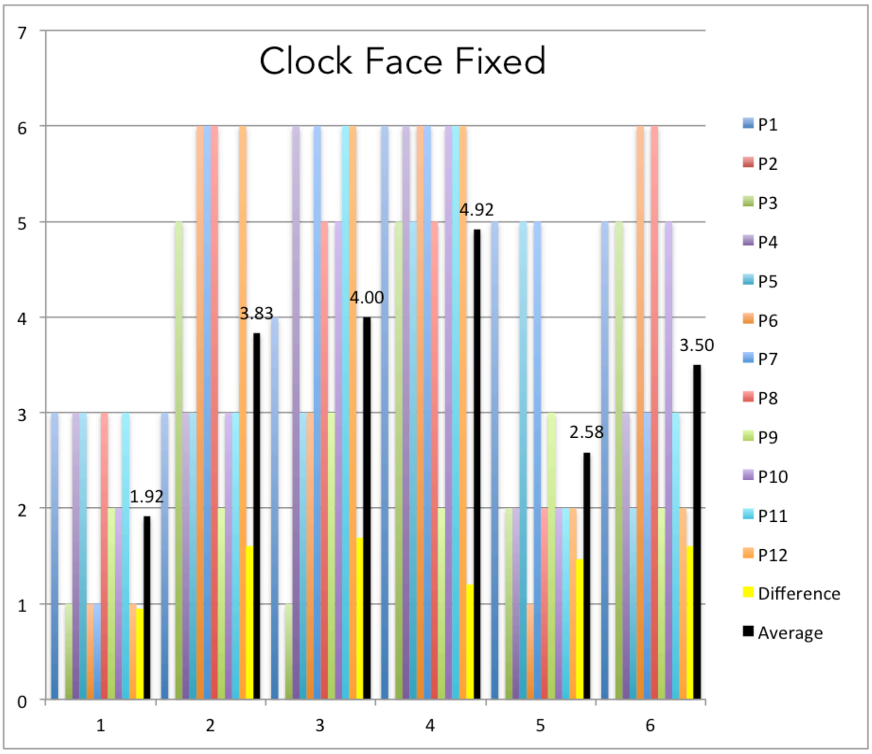


Figure A.2.11: Clock Face Fixed quanatative questionaire feedback results

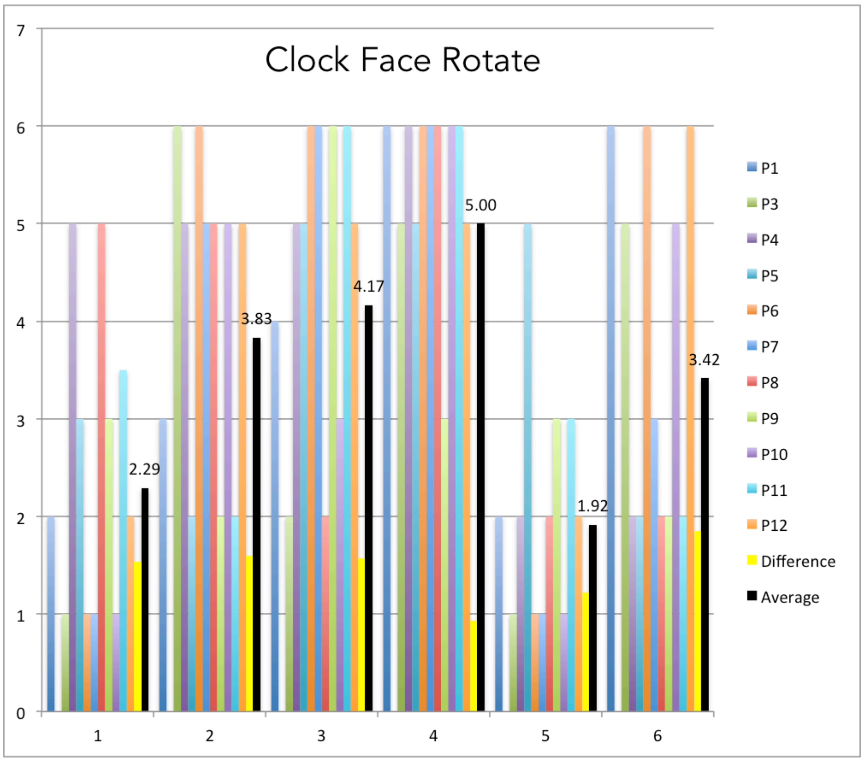


Figure A.2.12: Clock Face Rotate quanatative questionaire feedback results

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