DIVERGENT CRITICALITY – A MECHANISM OF NEURAL FUNCTION FOR PERCEPTION AND LEARNING

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ABSTRACT

The natural world presents opportunities to all organisms as they compete for the biological-value afforded to them through their ecological engagement. This presents two fundamental requirements for perceiving such opportunities: to be able to recognise value and learning how to access new value. Though many theoretical accounts of how we might achieve such selectionist ends have been explored – how ‘perception’ and ‘learning’ resonate with life’s challenges and opportunities, to date, no explanation has yet been able to naturalise such perception adequately in the Universal laws that govern our existence – not only for explaining the human experience of the world, but in exploring the true nature of our perception.

This thesis explores our perceptions of engaging with the world and seeks to explain how the demands of our experiences resonate with the efficient functioning of our brain. It proposes, that in a world of challenge and opportunity, rather than the efficient functioning of our neural resources, it is, instead, the optimising of ‘learning’ that is selected for, as an evolutionary priority.

Building on existing literature in the fields of Phenomenology, Free Energy and Neuroscience, this thesis considers perception and learning as synonymous with the cognitive constructs of an ‘attention’ tuned for learning optimisation, and explores the processes of learning in neural function. It addresses the philosophical issues of how an individual’s perception of subjective experiences, might provide some empirical objectivity in proposing a ‘Tolerance’ hypothesis. This is a relative definition able to coordinate a ‘perception of experience’ in terms of an learning-function, grounded in free-energy theory (the laws of physics) and the ecological dynamics of a spontaneous or ‘self- organising’ mechanism – Divergent Criticality.

The methodology incorporated three studies: Pilot, Developmental and Exploratory. Over the three studies, Divergent Criticality was tested by developing a functional Affordance measure to address the Research Question – are perceptions as affective-cognitions made aware as reflecting the agential mediation of a self-regulating, optimal learning mechanism?

Perception questionnaires of Situational Interest and Self-concept were used in Study One and Study Two to investigate their suitability in addressing the Research Question. Here, Factor Analysis and Structural Equation Modelling assessed the validity and reliability of these measures, developing robust questionnaires and a research design for testing Divergent Criticality.

In Study Three, the Divergent Criticality hypothesis was found to be significant, supporting that a Divergent Criticality mechanism is in operation: When individuals are engaging with dynamic ecological challenges, perception is affective in accordance with Tolerance Optimisation, demonstrating that a Divergent Criticality mechanism is driving individuals to the limits of their Effectivity – an optimal learning state which is fundamental to life and naturalised in Universal laws.

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NOTE:

All diagrams and figures are the graphical representations of the author unless otherwise cited.

All tables are derived from SPSS and AMOS (IBM_{24}) unless otherwise cited.

All pathway diagrams are derived from AMOS (IBM_{24}) unless otherwise cited.

PREFACE

"All living things seek to perpetuate themselves into the future"

(Cave, 2012, p2)

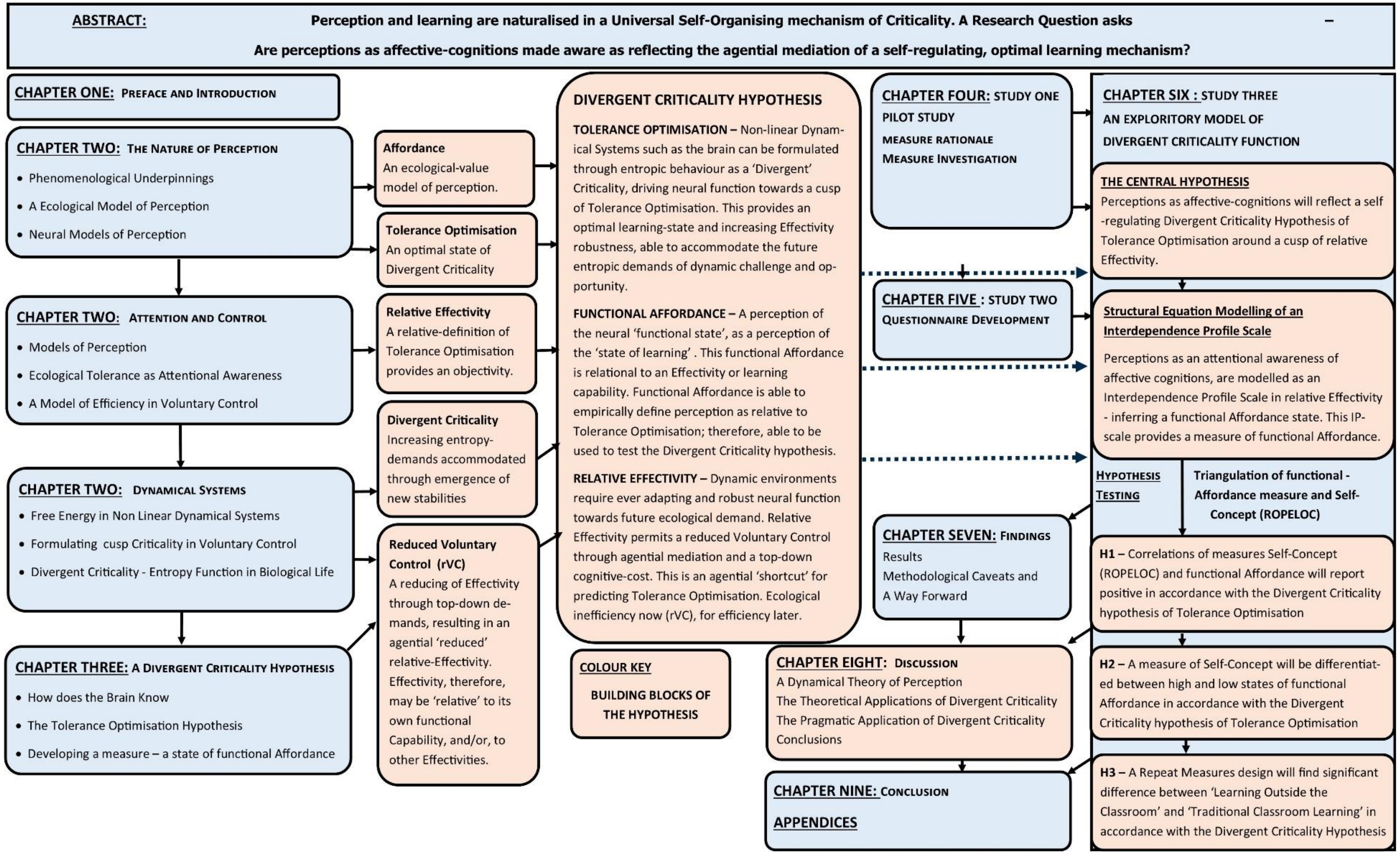
The Divergent Criticality hypothesis defines agential control within a phase of neural function: the efficiency of the individual towards engaging with the opportunities and threats the world affords. A Divergent Criticality 'optimisation' describes an agential affective mechanism – the regulation of entropy in neural-pathways, setting neural-function around an optimal state of ecological tolerance. Divergent Criticality driving Tolerance Optimisation provides a self-regulating, learning mechanism to adapt to a dynamic, ever changing world. Perception, here, is considered as awareness of entropic-efficiency in the neural network; an awareness of a state of learning as the 'relative' state of function. This enables the goal-oriented mediation of agential 'effect' on affective cognitions and behaviours for Tolerance Optimisation.

Rather than an optimisation of functional efficiency, an ecological 'Tolerance' provides a selectionist learning proposition for continued biological-life, driven, towards always inuring against an uncertain future. This is an evolutionary prerogative for dynamic environments, where surprise and challenge are affective, and adaptive cognitions and behaviours for possible future ecological demands can be naturalised as a Tolerance Optimisation in 'Non-linear Dynamical Systems' Theory. As such, perception becomes testable as a relative neural-function – an agential 'Effectivity' that is able to coordinate perceptions as 'states', relative to Tolerance Optimisation.

As a theory formulated in Phenomenology and Dynamical Theory, Divergent Criticality provides the functional mechanism for 'how the brain knows' how efficiently it is learning: a self-organising regulating mechanism from the fundamental principles of entropy. The Divergent Criticality hypothesis is able to naturalise cognition and behaviour in neural function, providing better explanations for the cognitions and behaviours observed as agency and awareness in ecological engagement – a 'perception for and of action' (Noë, 2008).

Thesis Overview

DIVERGENT CRITICALITY: A Mechanism of Neural Function for Perception and Learning



1 CHAPTER ONE – Introduction

We are not separate from the world we inhabit, we are shaped and grounded by our ecological experiences and our functional competence towards those experiences. The central hypothesis of this study is that of affective cognitions self-regulating around a Tolerance-Optimisation, explaining how perception and learning function towards optimising agential capabilities to engage, tolerate and thrive in relation to life's opportunities and challenges.

The findings of this study offer a fundamental mechanism for such a selectionist proposition. Rather than cognitions, affective towards efficiency and 'present' biological-value[1], we see a drive towards the limits of agential capability and a 'future' biological-value. This is an evolutionary prerogative that sees adaption and learning as an essential factor in tolerating a dynamic world of surprise and novelty, one regulated by affective behaviours towards Tolerance Optimisation. What emerges is a perception of the state of neural functioning in terms of biological-value (Figure 1, below). This is a 'model of perception' for ecological engagement, one which can be parameterised by an agential Effectivity[2] and ecological-tolerance, and able to be mapped as an efficiency function. Divergent Criticality now drives a functional Affordance towards a Tolerance Optimisation.

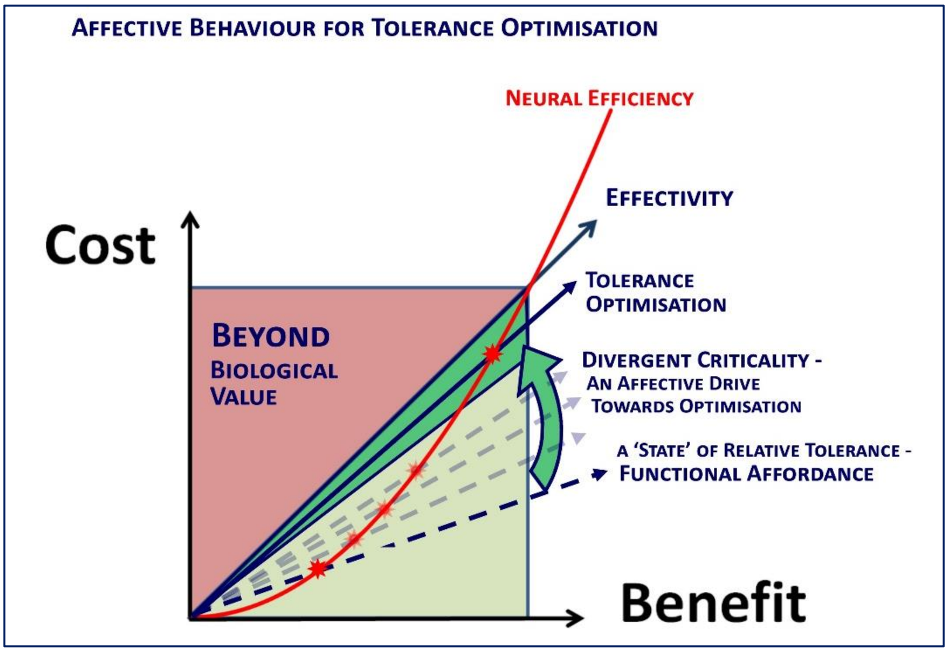


Figure 1 – Tolerance Optimisation set Within a Biological Value Model

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[1] As selectionist any theory must acknowledge biological-value as a fundamental end-point.

[2] Affordance and Effectivity as functioning in perception models of ecological engagement (Gibson, 1966, 1977).

1.1 The Divergent Criticality Hypothesis

The Divergent Criticality hypothesis is one of self-regulation around a 'relative' Tolerance Optimisation through cognitions and behaviours affective towards a maximal state of Tolerance Optimisation. Effectivity is seen here as an agential capability allowing a 'relative' definition of Tolerance in terms of cognitive function and a perception of that neural state of functioning.

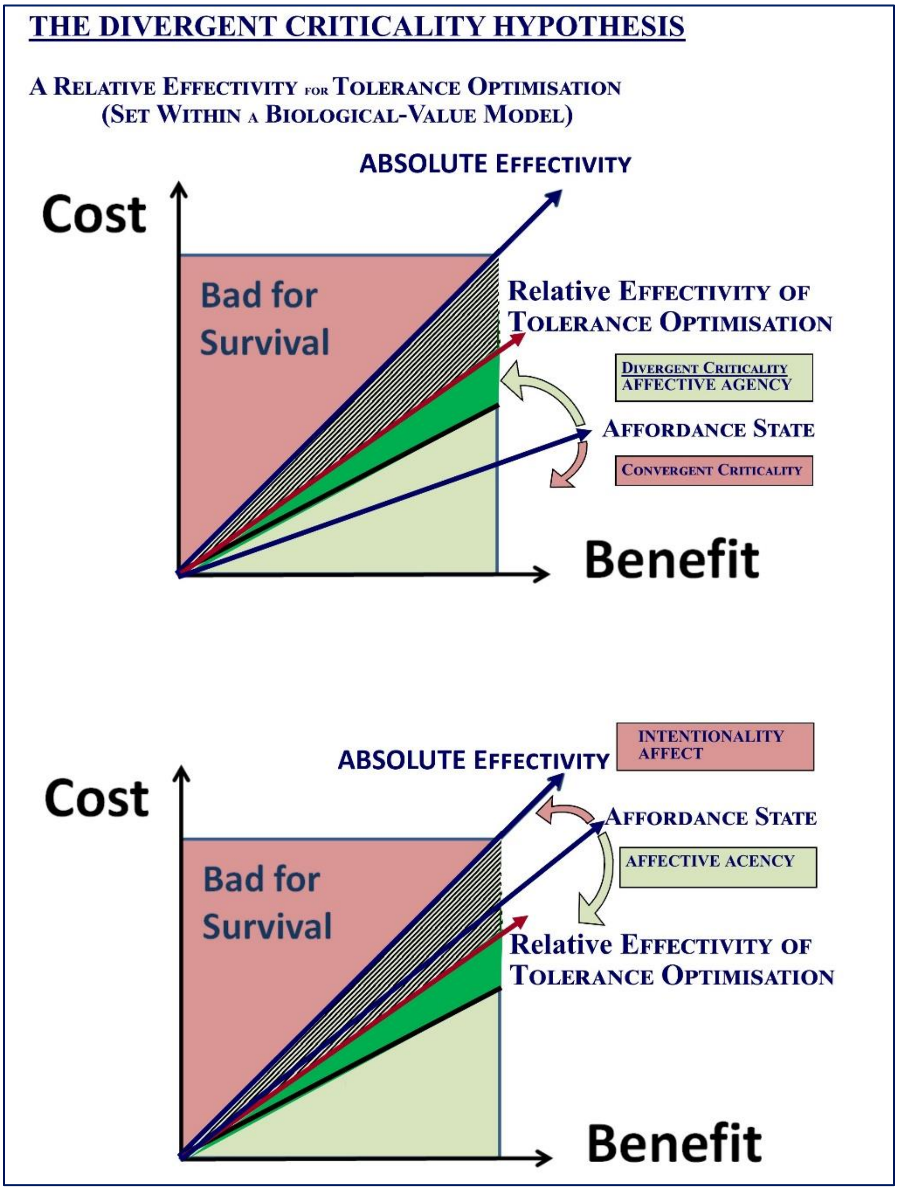

Figure 2 – The Divergent Criticality Hypothesis

In providing a coordinating definition for a relative Effectivity, Tolerance, what emerges is how perception, as an agent-environment autonomy, functions and is adaptive towards dynamic agency and ecological determinants. As such, perceptions, as an 'awareness' of ecological Effectivity, are mediated through ecological demand and made conscious as an agential awareness - a functional Affordance.

As a relative definition, the Divergent Criticality hypothesis of Tolerance Optimisation may be empirically tested through agential-awareness. Accordingly, a 'perception' measure as a measure of functional Affordance was derived to infer a 'state' of Tolerance function. This Tolerance state, as a 'state of functional Affordance', was able to be sampled from learning-domains considered to offer different ecological-demand[3]. Such differentiated function was then able to be triangulated against a self-concept measure of affective cognitive-function and used to test the Divergent Criticality hypothesis.

1.2 The Research Question

Perceptions as affective-cognitions are made aware and will reflect the agential mediation of a self-regulating, optimal learning mechanism – A Divergent Criticality Hypothesis

The central theme of this study is that of agential-regulated cognitions around a cusp-Criticality of Tolerance Optimisation. Ecological function is hypothesised to be mediated by agential perceptions as Affordances for biological-value made consciously 'aware' as affective-cognitions.

Firstly, Structural Equation Modelling was able to provide an Interdependence Profile, able to model an inductive 'state of functional Affordance'. In accordance with a Tolerance Optimisation of relative Effectivity, this state of functional Affordance is able to be differentiated in relation to ecological demand and tested in accordance with the Divergent Criticality hypothesis:

H1 – Correlations of measures Self-Concept (ROPELOC) and functional Affordance, will report in accordance with agential-mediation of Tolerance Optimisation

H2 – A measure of Self-Concept will be differentiated between high and low states of functional Affordance in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation

In the recognition of issues with homogeneity, a repeat measures research design was applied:

H3: A repeat measures design will find significant difference between 'Learning Outside the Classroom' and 'Traditional Classroom Learning' in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation.

[3] The sampling criteria of 'domain-grouping' provided perception measures reflecting ecological demand as functional Affordances (of social and situational cognitive-determinants).

1.3 What this study offers: The Functional Imperative

In presenting Divergent Criticality as an ‘underlying mechanism’ with which to explain cognitive function, this study provides not only an agential-regulated ‘perception’ model of Tolerance Optimisation as a ‘selectionist’ function, but also naturalises[4] such function in a ‘mechanism’ for ecological engagement. For Divergent Criticality to stand up to scrutiny in philosophical and scientific explanations, it must address Chemero’s requirements:

“the success or failure of the future (scientific) phenomenology depends upon its ability to show how higher-order experiences emerge from naturalistically conceived self-organisation” (Kaufer & Chemero, 2015, p217)

This is explored in this study through an interdisciplinary approach across Phenomenology, Neuro-psychology and Dynamical Systems Theory. It proposes that through the fundamental principles of Self Organising ‘Criticality’, our behaviour(s) are able to be shown as driven to the edge of function by Divergent Criticality and a maximal proposition for ‘entropy’ production. A proposition of Tolerance Optimisation is formulated in Complexity Theory as a selectionist prerogative for dynamic biological function – life.

A ‘functional’ grounding of theory in first principles, is set within the laws of physics and has driven this research. What emerges is a complex landscape of agency and functionality, simple in its Universality, but able to accommodate the philosophical and empirical complexity we observe. This is a fundamental mechanism of function that would account for a brain ‘perceiving’ and ‘learning’. Perception, it seems, reflects not only an efficiency (tolerance) towards engaging with the world, but involves an agential prerogative that can be grounded or naturalised in such engagement. Ecological tolerance then, is mediated by agential cognitions and becomes parameterised as a ‘relative’ function – ‘relative Effectivity’ as a Tolerance Optimisation with which to define a state of functional Affordance.

1.4 Adding to the Body of Knowledge

The overarching function of Divergent Criticality is one of a relative Effectivity or Tolerance Optimisation, and thus it proposes that all biological life must display Divergent Criticality (increasing entropy) within a self-organising and self-regulating system in order to tolerate ‘surprise’ and optimise biological-value. A selectionist prerogative operating at the cusp of functional tolerance

[4] Naturalises – set theory in terms of universal laws (of physics).

sees perception as an agential appraisal of ecological tolerance, and therefore, observable as able to reflect and awareness of a state of functional Affordance.

This study adds to the literature in Ecological Psychology and Dynamical Systems Theory. It explores a functional imperative of exploring perception as a mechanism of neural efficiency in relation to evolutionary theory. In presenting Divergent Criticality as a fundamental mechanism for neural function in perception and learning, this study makes the following contributions to the literature in Non-linear Dynamical System theory, Phenomenology and Neuro-Psychology:

Non-linear Dynamical Systems Theory

1) **Divergent Criticality:** There is a fundamental requirement in living things to counter dissipative entropy[5]. This study proposes an increasing entropy-production within neural-function and suggests, Divergent Criticality as a fundamental requirement for life.
2) **Tolerance Optimisation:** Divergent Criticality is formulated as entropy behaviour at cusp-Criticality. In defining 'maximal-entropy' as a parameter of phase-stability, Divergent Criticality 'drives' agential affective-behaviour towards Tolerance Optimisation as a cusp of Criticality function[6]. Such a maximal 'entropic' proposition sees neural-adaptations emerge as learning, a selectionist prerogative for dynamic functioning.

Neuro-Psychology

3) **An Interdependence Profile** was developed to model perception in ecological and agential function, a composite of cognitive processes able to infer a state of neural function as a state of function Affordance in agential awareness. An inductive Interdependence Profile is able to parse cognitions into top-down and bottom-up attentional processes, as cognitive processes of relative neural function this presents – a state of functional Affordance.

Phenomenology and Ecological Psychology

4) **Relative Effectivity** proposes an agential definition of neural efficiency with which to coordinate a model of 'relative' tolerance. The formulation of agency in terms of Voluntary Control[7] results in a 'reduced' capacity in Criticality function, providing an agential-

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[5] Autopoietic **–** living things that seek to perpetuate themselves into the future.

[6] Divergent Criticality will be seen to be self-regulating around cusp-Criticality.

[7] Voluntary control as consciously controlled cognitive behaviour, in comparison to autonomic (automatic) 'involuntary' regulation (of the body).

determined 'functional' landscape of Divergent Criticality. Relative Effectivity is an agential proposition of capability and tolerance, as such, a perception of relative Effectivity is able to be defined as a relative tolerance reflecting the functioning of agency and intentionality.

1.5 Guidance from Literature

Previous approaches in explaining neural-function might be considered as providing 'descriptions of behaviour' rather than coordinating 'definitions of function'. This is an important distinction as neural function demands 'functional' definitions in order to explain and 'generalise' cognition and behaviour. The defining of perception within an objective measure has been a fundamental issue in philosophical and scientific enquiry. Perception as subjective, presents a myriad of objectivity issues, not only what a 'perception' is, but 'how' we perceive and 'what' we perceive. This demands a coordinating definition that must accommodate agential subjectivity.

In their exploration of perception through an ecologically embodied approach to perception, Varela, Thompson and Rosch (1991) gave perception a broad scientific basis in their explanations through philosophy, neuroscience and cognitive psychology. This has been reappraised by Chemero (2013) in the need for cognitive scientists to take phenomenology seriously and the need to provide a naturalised 'Universal' approach to perception through a radically Embodied Cognitive Science.

In proposing a selectionist hypothesis, this thesis embraces this need for a wider, holistic application of phenomenology (Cisek & Kalaska, 2010; Lende & Downey, 2012). If cognitive complexity arises from a fundamental mechanism of Divergent Criticality, this requires not just adequate subjective description, but an objective 'definition' to be robust. An ontological proposition for perception as it pertains to the agential-environment experience.

Neural science sets perception in terms of 'cognitive-processes', the neural attending to ecological determinants is increasingly drawn towards a cognitive approach, one of agential processes aligned to a 'drive to survive', a future or goal-oriented perception. What unfolds is a paradigm for defining perception through ecological experience, a capability in neural functioning able to align experience with agential Effectivity – consciousness as a 'mind-body' prerogative, or more prosaically 'problem' (Thompson, 2007, p6). This is not an attempt to answer Chalmers (1995) 'Hard Problem' of what makes 'a consciousness', but in an awareness of subjective perception, consciousness is entwined in an agential and phenomenological richness and aligned to a dynamic ecological function.

It is in the selectionist axiom of an 'ecological function', that any theory for explaining perception must be made congruent with both an agential subjectivity, but also an objective Universality (of biological-value): Our subjective descriptions, if to be empirical, must concur and be made 'actual' through some form of objective definition in relation to biological-value. Only when such a coordinating definition has been parameterised, will it be possible to naturalise and explore perception. The exploration of Divergent Criticality addresses such prerogatives, first through the literature review, and then by developing the Divergent Criticality hypothesis from first principles.

In a cross-discipline enquiry, three main epistemological areas of knowledge form the basis of an inductive literature review: Phenomenology, Neuroscience and Complexity Theory. These areas of knowledge are explored towards their application in addressing the requirements for defining 'a perception'. The literature review evaluates these in order to differentiate the key elements from historically, diverse bodies of knowledge, but draws together the interdisciplinary principles from each, in order to develop the Divergent Criticality hypothesis. This was necessary, as Divergent Criticality must not only be theoretically robust within contemporary neuroscience, but in order to adequately account for a perception 'that reports on itself', must be able to account for phenomenological descriptions of ecological function.

1.5.1 The Phenomenology of Agency and Intentionality

From its philosophical underpinnings, Phenomenology is explored and an ecological tolerance hypothesis for perception, developed. In developing such a coordinating measure (i.e. a Tolerance Hypothesis), perception should be able to be relatively compared against different states of neural function towards ecological engagement.

1.5.2 Cognitive processes of Attention and Control

An interdependence profile is then induced from the literature on attentional processes. What emerges is that ecological tolerance is able to be inferred from a composite of attentional processing (i.e. sensory bottom-up and agential top-down).

1.5.3 Dynamical Theory and Self-Organising Criticality

In order to naturalise such a definition of 'ecological tolerance as perception', Self-Organising Criticality is set within a free-energy function, and perception, when formulated in terms of neural efficiency, provides an entropic optimisation that is able to infer neural functioning through the formulation of efficiency as ecological Tolerance – a Tolerance Optimisation in neural networks.

1.6 Developing the Divergent Criticality Hypothesis

Life systems require a flow of entropy in order for dissipation processes to maintain Self-Organising autopoietic[8] function. The proposed Divergent Criticality hypothesis is predicated on a necessity for a flow of 'increasing' entropy as fundamental for temporal stability in autopoietic processes.

Biological life in dynamic flux maintains a 'temporal stability' through the self-organising of entropy dissipation, functioning at the edge of an efficiency or stability-phase of entropy 'Criticality', a Tolerance Optimisation affective through what can be seen as "temporal agency" (Bandura, 2001, p3), one required to self-regulate at this functional cusp as a Tolerance Optimisation relative to agential mediation – a relative Effectivity.

It is in utilising relative Effectivity that agential-regulation of affective-behaviour (Panksepp, 1998) become selected for and that agential function resonates with entropic complexity. Both as mechanistic and agential, the Divergent Criticality hypothesis reconciles the seemingly separate 'Kantian' principles of "antinomy of teleological judgement" (Kant, 1987, p70, in Thompson, 2007) in a definition of relative tolerance as an 'agential mechanism'. The more dynamic the environment, the more complex the agential processes that emerge, with greater complexity and agency towards affective and adaptive cognitions as perceptions and learning reflecting Divergent Criticality.

1.7 Methodology

In proposing Divergent Criticality as a neural 'mechanism', a nomothetic approach might have been considered the most accessible method to explore this hypothesis and indeed, to some extent this provides the statistical power in the study. However, there is the danger of making 'observations of behaviour' and not addressing the philosophical and theoretical imperative of 'observations of function' for perception, as discussed.

Therefore, a phenomenological methodology was developed to coordinate an element of functional objectivity from conscious subjectivity. With perception reporting on perception, we are required to explore the philosophical foundations of enquiry as much as the theoretical hypothesis, thus, the functional imperative demands that a hypothesis and methodology for Divergent Criticality is derived from philosophical and scientific 'first principles'. By integrating the three areas of scientific

[8] Autopoietic –self-organisation for continued biological life (Maturana & Varela, 1972; Thompson, 2007).

knowledge, Divergent Criticality aims to naturalise neural function and address Chemero's postulation for an ecological perception that:

"it must be shown that the affordance-ability self-organizing, autonomous system and the autopoietic nervous system jointly constitute a higher order self-organizing, autonomous system" (p268, 2008).

The Divergent Criticality hypothesis was tested using self-report questionnaires which were designed to capture perception as awareness of attentional (processes), through Situational Interest and Self-Concept reports of life-effectiveness. These measures were adapted and validated over three studies: Study One – Measure Investigation; Study Two – Questionnaire Development; and Study Three –Explorative study of Divergent Criticality Function. The methodology was a quantitative analysis of data collected from environments thought to offer differentiation of Divergent Criticality function in different learning environments.

Study One (n=127), explores the possibility of an antagonistic mediator as an affective behaviour and its application to attention measures. Challenge is seen as antagonistic and an affective behavioural cognition for self-regulation towards life-effectiveness.

Study Two (n=281), is used to adapt the questionnaires, what emerges is a requirement to report perceptions of Challenge as an antagonistic cognition, and attention to ecological control (a value proposition).

Study Three (n= 870), an exploratory study sampled over 24 different learning-domains and across age bandings reflecting key stages in education. This study used Structural Equation Modelling to develop an Interdependence Profile (IP), allowing an IP-scale to infer a 'state of functional Affordance'. Underpinned by contemporary literature on perception, attention and free-energy, the Divergent Criticality hypothesis was tested using the IP-scale against a self-concept (affective cognition) measure.

As a new theory, significance was found supporting the research question and hypothesis, in both model building and associated triangulation tests. As exploratory, the developing research design provided robustness and validity in testing the Divergent Criticality hypothesis.
Future considerations are discussed in Findings and Conclusions.

2 CHAPTER TWO – Literature Review

Section 1: A Feeling of Perception

"the need for new research and for exponents of event perception to identify a theoretical motivation, within ecological theory, for why events should be perceived" *(Stoffregen, 2000b, p93)*

What is the nature of perception, what is it to know or 'feel' a perception and why do we perceive? From a selectionist perspective there must be a biological-value in knowing of our existence.

To explore perception we are not only exploring our experience of the world, but also reflecting on the reality of what we are perceiving (is what we perceive real?). Though this philosophical question is beyond the scope of this thesis, this study explores current literature to investigate a perception founded in the phenomenological and scientific traditions of empiricism, with the aim of setting perception within an objective-frame, i.e. enabling observation and measurement.

In order to explain our subjective expressions (as they ever must be subjective), we look to our experiences to offer some objective or 'coordinating definition' that might be interrogated. What emerges is, that it is not in a perception of reality that we are able find such objectivity, but in the experience of perceiving itself.

Perception set within a phenomenological tradition is one of empiricism, but also one skewed by subjective observation. Any theory of perception must be able to incorporate the exponents of a phenomenological explanation, but with the need to recognise and align our subjective experiences against an objective framework.

This section explores the philosophical transition from a 'rationalism': looking for 'reasons' for perception (e.g. Descartes), through to a 'relativism' of experience; providing an inferred objectivity to perception (e.g., Husserl, 1913; Kant, 1781). We find that such relativist 'transcendental' and 'existential' explanations fall short with their 'necessity for an inherent '*a priori* of *knowing'.* Such issues have been more recently termed a 'framing problem' (machine learning, McCarthy & Hayes, 1969); highlighting a major question in cognitive research – where does the *a priori* knowledge for knowing, come from?

Such a 'void of knowing' needs filling in order to avoid the criticisms of idealism.

From the observation of the perception 'as' ecological engagement, emerges the promise of an empiricism through experience (e.g., Heidegger, 1927; Merleau-Ponty, 1945). Though still a phenomenological observation, in explaining experience there is an attempt to define an objectivity through the 'experiencing a perception'.

What emerges from the literature is an ecological construct, one grounding perception in evolutionary principles and requiring robust theoretical explanation to support such an 'ecological perspective'. One such explanation, that of 'Affordance', is proposed and developed in this study as not only a model of ecological engagement (Gibson, 1966, 1977), but as a model that is able to reflect the possible cognitive functioning of perception as ecological engagement.

In critiquing the current phenomenological literature, ecological-tolerance is presented as a 'relative' definition from the subjective experience of 'being'. A proactive, agential proposition. In particular, it is how we tolerate and adapt to ecological feature-change through an agential capability (Chemero, Klein & Cordeiro, 2003), a proposition that sets tolerance in a functional Affordance model.

Functional Affordance embodies an individual's perception 'in' their experience of the world, an animal-environment prerogative of relational autonomy, one that now can be objectively and be theoretical grounded through a 'Tolerance hypothesis' and modelled in a functional Affordance for ecological engagement.

This first section proposes a Tolerance hypothesis and sets this with a new model of ecological value, that of 'functional Affordance'.

2.1 The Nature of Perception

This chapter explores an epistemology of perception: do we even know what we are trying to observe? A phenomenological perspective explores the shift from a philosophical rationalism, to the problem of identifying a coordinating definition[9] for a model of perception.

Much of the enquiry into perception tries to make meaning of our experiences, subjective perspectives through the lens of an individual's perception of life being lived. Though such perception, naturally, feels credible, it is only ever a phenomena of individual construction. Such a

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[9] 'Coordinating definition' is a term taken from the Philosophy of Space and Time (Reichenbach, 1937/2012): It provides a relative definition whatever the subjective experience, allowing a subjective-relativism to be defined, and objectively coordinated (measured against other 'relative' observations).

subjectivity, it might be suggested, is only valid for observation if it is evaluated in conjunction with some objective-reality with which to set the individual's experience.

In asking such questions, the contradictions within perception are exposed: our 'awareness' of experience, or the 'actuality' of experience. How are we to determine what is subjective and what is actual and how do we decide which definitions offer validation to our experiences, and therefore might be observed?

In trying to frame our experience with an objective-reality, we need to not only explore the processes of our cognitions and behaviours, but also accommodate the phenomenological experience in constructing a functional approach to exploring perception.

2.2 Defining Perception

Rene Descartes (1596 – 1650) would not only shape ways of exploring our 'place' in the world, but would also help frame the philosophical questions of our existence. However, his scientific-reductionism and the theology of the day presented a dilemma: if we are to have free-will and the (religious) necessity of self-determinism, consciousness couldn't be subject to such scientific-determinism. This subjectivism has echoed throughout enquiry ever since the scientific renaissance and Descartes solution to separate the mind and the physical in a Dualism (1641) that has framed dilemmas for defining an objective determination and plagued scientific enquiry into the nature of perception and consciousness.

This philosophical challenge was addressed by Immanuel Kant (1724 – 1804). Kant attempted to reconcile the deterministic dilemmas of subjectivity in a way that Dualism had failed. Whereas Descartes dismissed objectivity of a 'self' as independent from nature, a proposition open to what would become, a critique of Idealism[10] (Berkeley, 1709), Kant acknowledged the need for some objective perspective for perception and consciousness. He defined such objectivity through a 'transcendental' relationship, reconciling idealism – 'the truth as it appears', with an external 'the

[10] The Reverend G. Berkeley (1709) developed a philosophy of subjective 'Idealism' in, what was a religious counter-argument toward the scientific enlightenment. Berkeley asked, if we are to base our reality on the observation of 'qualia' as an objective empiricism, given that our perceptions are transcendental, who in such reductionism is the last observer to offer objective-validity to observation if not God? Berkeley proposed that our observations are idealised rather than realised. Idealism sought to expose materialism's reductionist dilemma by re-introducing a religious dualism – all observation eventually lead to an ideal of God's choosing.

thing in itself' *(Ding en sich, Kant, 1781).* In effect, we create a subjective perception of reality, accessible through our internal '*a priori*' knowledge, though we will never truly know the reality we experience until it becomes 'known to us' as a perception – a transcendental idealism (Kant, 1781; Kaufer & Chemero, 2015; Wulf, 2015).

In such transcendentalism there remains a reductionism open to critique: Where do such internal representations come from and how do they align with a reality? How can any idealism ever be considered a coordinating definition for objective knowledge?

Nevertheless, the critical exploration of both subjectivity and objectivity evident in Kant's '*Critique of Pure Reason'* (1781) lead to new methodologies for exploring perception as a scientific phenomenon. This was a new empiricism that, though subject to the critiques of reductionism, was one that recognised a defining objectivity in not only 'the thing' in itself, but also of the experience 'with' the thing. Kant had introduced a spatial and temporal definition for subjective 'objects of cognition', and in doing so, framed epistemological questions of enquiry into the nature of knowledge and how perception might be defined: an ontology of 'being-in' nature (Kaufer & Chemero, 2015). Transcendentalism would inspire the 'absolute' reduction of subjectivity from experience, Husserl (1913) and the 'existentialism' of Heidegger (1927), both fundamental in describing the nature of reality through the subjective experience – Phenomenology.

2.2.1 The Phenomenological Approach

Hursserl's (1913) phenomenological exploration gave prominence to 'perception' as a temporal-journey from one state (a percept) to another. Unlike Kant and Descartes, Husserl attempted to dispel idealism through a 'phenomenological-reductionism', an approach to observation, focused on the essence of the percept rather than any subjective knowledge of the perceiver. However, this still necessitated an *a priori* 'bracketing': that of a reality inferred through 'intentionality' and of an objectivity 'of' experience rather than 'from' the experience.

Husserl's Phenomenology set perception and consciousness within an ontology that acknowledged that the 'essence' of the experience went beyond what is subjectively presented, but within such experienced subjectivity, a hidden 'realism' might be gleaned by careful exploration of the subjective experience. Husserl introduced 'intentionality' to perception in that, though reality might never be subjectively known, it could show itself through an experience when 'intentionally-defined'.

Husserl's contribution was a recognition of the underlying 'features' of a perception, rather than a perception of objects in and of themselves. This freed subjectivity from the passivity of an internal reflection –*"Cogito ergo sum" I think therefore I am (Descartes, 1644)* – to an objectivity of 'agency' able to be inferred through an ecological interaction. Reality through experience rather than properties or knowledge awaiting observation:

“a shift of the focus from the object of experience to the structures that constitute the act in which that object can be experienced” (Kaufer & Chemero, 2015, p35).

One defining aspect of Husserl’s Phenomenology was the importance of ‘enduring’ flow of time in the construction of a conscious moment: Husserl sees perception as a ‘unity’ within a flow of precepts’; the past, realised in a now, but directed towards an agential future. Husserl took perception from the Kantian-idealism of a reductive epistemology (now widely discredited, see logical relativism, Reichenbach, 1937/2012, pp31-37), and introduced perception as a ‘flow’ of temporal existence. Perception, as moments in time, able to be defined through the stability of such percept-features, projected across time:

“*the unity of the temporal flow in which we experience objects is precisely the unity of the subjective consciousness of the experience of those objectives.” (Kaufer & Chemero, 2015, p46).*

Replacing transcendentalism with intentionality, however, is still open to reductionism: Though Husserl’s ‘intentionality in experience’ acknowledges the individual as an agent of anticipation in a temporal flow of perception, at some point in the idealism of reductionism, such *a priori* ‘brackets’ will need to be removed, and a ‘knowing’ – grounded.

Husserl is criticised by Heidegger (1927) and Merleau-Ponty (1945), for not developing this ontological (animal in environment) imperative further. A perception of such temporal structures should relate phenomenology to the ‘dynamic’ experience. This is a perception in existence and action as an existential phenomenology, one allowing the ‘brackets’ around intentionality to be removed. Through Existentialism, Heidegger (1927) brought an ontology of ‘time’ and ‘being’ to phenomenology, one of ‘ecological engagement’ embracing Husserl’s intentionality as ‘goal-orientation’ conferring a – ‘perception for action’ (Noë, 2008).

2.3 Affordance: an Ecological Perception for Action

By approaching perception as a phenomenology from action, we conceive perception as a dynamic-resonance of environment and of ‘being’. This offers a relational approach to perception as a dynamic-engagement in Gibson’s Affordance model for perception (1966, 1977). Gibson’s ‘ecological’ model defines perception through an individual’s capability towards ecological functioning (here parametrised through biological-value, see, Figure 3, p18). It is in what the environment ‘affords’ or presents to the ability(s) of the organism, that determines a perception of the biological-value in engaging with that Affordance – an ecological psychology proposition for Affordance.

Gibson saw Affordance as an organism-environment relationship for an 'optimal' biological condition, an 'implicit knowledge' informed through engagement with the environment, a theory influenced by Gestalt[11] perceptions: value-orientated perspectives from 'experiencing' the available information (see, Koffka, 1935).

"Each perceptual system orients itself in appropriate ways for the pickup of environmental information, and depends on the orienting system of the whole body. ..... they serve to explore the information" (Gibson, 1966, p58)

However, such 'implicit' knowledge implies not only an *a priori* idealism, but also a behaviourist approach to perception and is criticised as a disconnect between cognitive processes and behaviour (see, Fodor & Pylyshyn, 1981). In an attempt to address this 'behaviourist' label, Shaw, Turvey & Mace (1982) provided a relational platform for constraining Affordance perceptions within an agential[12] capability to engage with the environment. A perception of agent and environment is one accessible through the agential effectiveness towards what is presented. This is a 'state' of perceptual Affordance encompassed within an 'Effectivity' of capability (Shaw *et al.*, 1982). Though this dispels behaviourism somewhat, however, in not addressing the transcendental and existential *'a priori'* dilemma, Affordance still needs to answer the reductionist critique of where such capability(s) come from.

2.3.1 Affordances: Properties or Features of Perception

We might look to understand better, what an Affordance is through representing Affordance as an ecological perception.

Turvey (1992) proposes that Affordances are unproblematic properties of perception, existing as independent, dispositional, properties made actual by the pairing of environment with agential-knowledge (past-knowledge applied to a situational state of the now). Here perception is seen as a constructivist proposition:

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[11] Gestalt explorations of 'form and function' in an experience oriented perception, were a view running in conjunction with Husserl's temporal-features of experience – engagement-ontologies to defining perception.

[12] Rather than organism, animal or individual; 'agent' is used here as a proactive term for all organism-initiated ecological engagement. It will be theorised that all biological life can be considered 'agential' in some behavioural form of the expression.

"dispositions never fail to be actualised when conjoined with suitable circumstances" (Turvey, 1992, p178)

This viewpoint has been criticised by Chemero (2003) as invoking the '*a priori'* dilemma. The properties of such a perception would not only have to accommodate a multitude of agential-dispositions to actualise environmental-properties, but would need to select from an infinity of possible pairing-relationships. Such a proposition for a functional perception gets lost in this complexity of experience rather than emerging as 'readily available' from it (Heidegger, 1927).

Perception must be efficient to fulfil the ecological requirements of a selectionist proposition. Chemero (2001) therefore provides a viable argument to answer this 'property-inefficiency', one based on the 'feature placement' of Strawson (1959); here Chemero sees Affordances not as static properties, or dispositions of the environment and agent, but as 'temporal-features' that are dependent 'on' the environment and the agent. This is a relational-perception of the agent 'in' the environment and perception, a dynamic-construct of feature and agent as the agent moves through or experiences its actions. Though still dependent on the agent-environment autonomy of Affordance (Gibson's situational-imperative and individual-context), perception is emergent as an independent feature or temporal 'state' rather than any dispositional-property.

However, such emergent 'features' rather than dispositional properties have been argued by Stoffregen (2000b) to present a philosophical problem: If Affordance is feature-emergent, how can such ephemeral features be perceived as an 'event'? Would not such 'features' evaporate outside of perception, not able to be fixed or set in actuality?

Chemero (2003) sought to dismiss this:

"It is a small step from this to a rather silly global idealism, in which the world disappears whenever I close my eyes" (Pg193)

However, it is not enough to dismiss such an existential paradox; the very subjectivity of our observations (to be dependent on an observer to become), leaves room for Idealism and implies that reality might not be available within observation. If Affordance is to be considered an 'unproblematic-feature', one that may be used to ground our perceptions in reality rather than any 'Grand Illusion' (Noë, Pessoa & Thompson, 2000), then Stoffregen's criticism must be adequately answered rather than dismissed.

2.3.2 Perception as Affordance Features awaiting Engagement

Stoffregen proposes that although Affordances are relationally actualised between ‘environment and agent’, they should be considered as relational-opportunities, rather than relational-features. This is a view of Affordances as un-actualised, available to be actualised as *“opportunities for action”* (Stoffregen, 2003, p124). Affordance(s) exist now as opportunities independent from observation, removing the idealism by being ‘accessible’ through action.

Chemero (2003) attempts to reconcile the idealism of ‘features’ and dismiss the reductionism in ‘opportunities for action’ (how does the agent recognise these opportunities?), by suggesting a temporal-element to Stoffregen’s opportunities. Affordance ‘becomes’ through dynamic interaction a state(s) of feature-change. In this way, they may be considered as existing ‘independent of observation’ and as opportunities ‘from’ action.

“Events as changes in the layout of Affordances” (Chemero, 2000, p37)

By introducing the concept of feature-change, perception becomes a temporal-state actualised by changes in Affordance and a perception dependent on the Effectivity (capability) of the agent towards these features.

“Effectivities are properties of animals that allow them to make use of affordances” (Chemero, 2003, p184)

Though Affordances may be actualised by changes in the feature-landscape, it is in how these changes affect the agential functioning that determines how such Affordances are perceived. Events, as ‘opportunities for action’, must be set within the capability of the individual as an Effectivity towards feature-change. Perception as the dynamic ‘state’ of an individual’s capability.

A model of perception is now presented through such a functional capability as a biological-value model of Affordance – a perception of dynamic Effectivity towards feature-change in ecological engagement.

2.4 Introducing a Biological-value Model of Affordance

Ecological function may be defined within the concept of ecological or biological-value, (Figure 3, below). It is in the behavioural functioning towards biological-value that our perceptions may be evolutionally ‘grounded’ through cognitive processes for the regulation and stability of biological-value across time. It is in this adherence towards optimal biological-value that behaviour and cognition for life-regulation is seen as affective (Damasio, 2010; Panksepp & Biven, 2012; Pessoa, 2013).

An ‘ecological’ perception should reflect biological-value if it is to be considered evolutionary.

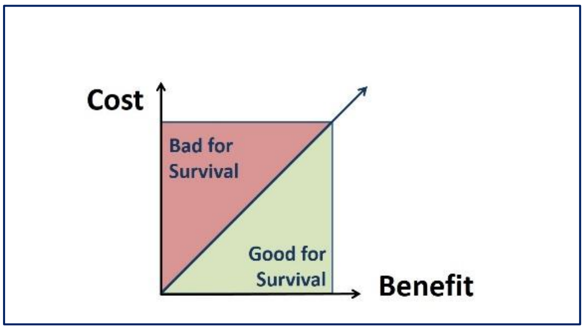

Figure 3 – The Cost/Benefit Parameters of Biological-value

Perception may therefore, be aligned with affective cognitions of ‘approach’ (accentuating life-benefits) and ‘avoid’ (limiting life-costs). These are evolutionary responses to the opportunities and threats afforded through our engagement with the world and such a value-bias provides the template on which a behaviourally affective proposition for perception may be founded.

For Affordance to be considered as a perceptual model, it is important that we align biological-value with phenomenological experience. Such a model must not only represent the individual’s dynamic-relationship with the world it pertains to represent, but be able to functionally operationalise ‘perception’ in accordance with affective behaviours for biological-value.

2.4.1 From Relative to Relational Affordance

An environment may offer different individuals and organisms, differing Affordance opportunities and therefore different perceptual experiences. We might, therefore, first consider Affordance from a ‘relative’ perspective, defined within a phenotype-capability for interaction. Here, species proclivities, rather than the agent’s capabilities define the Affordance perception.

Such blunt differentiation is ill-defined and implies an ‘implicit’ or innate species knowledge, criticised by Fodor and Pylyshyn (1981). Affordance therefore, might be better approached in respect of the individual’s capability within a phenotype (Figure 4, over), this is an Effectivity (Shaw *et al.*, 1982); Affordance made relational within an individual’s capability (Chemero, 2003; Stoffregen, 2003; Turvey, 1992). However, it should be remembered that though relational Affordance defines function within Effectivity, an Effectivity in itself may still be relatively considered against the Effectivity(s) of other(s).

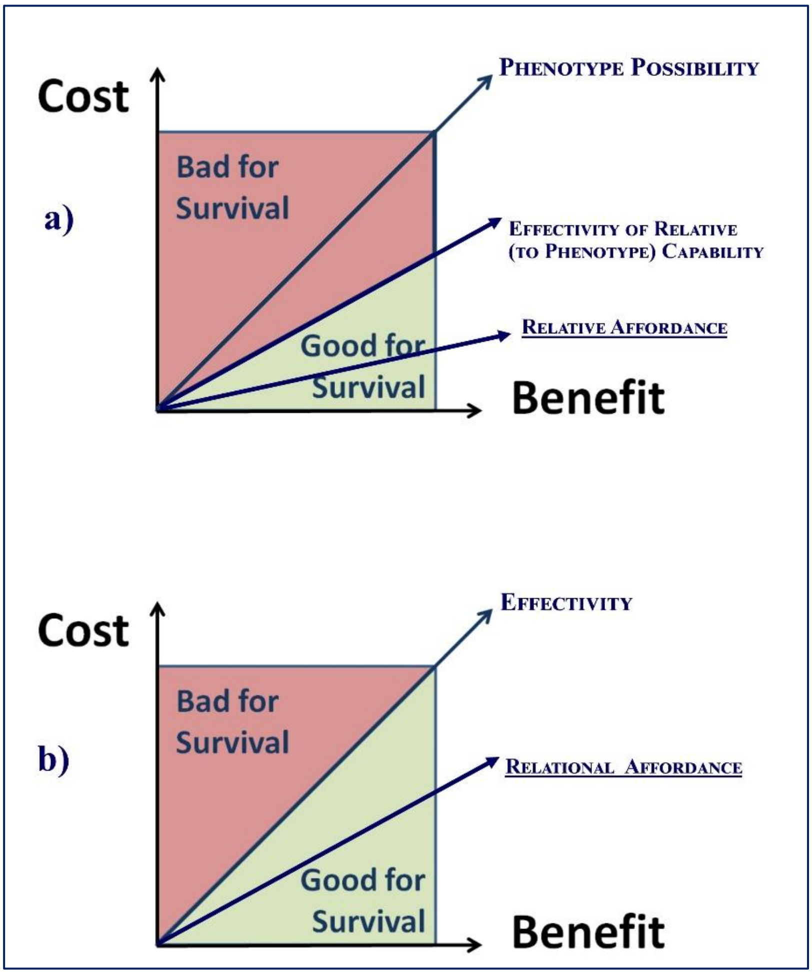

Figure 4 – a) A Relative Affordance b) Relational Affordance set within An Individual's Effectivity

2.4.2 A Relational Affordance

Effectivity, then, offers different individuals different Affordance perceptions dependent on their capabilities[13]. Effectivity allows a 'knowing' and a 'not knowing' as propositions of an Affordance perception within the concept of a capability reflecting biological-value (see, Figure 5, p21)

However, by describing Effectivity as a capability-basis for Affordance, does not answer where such 'capability' comes from. We are again thrown into the dilemma of the need for the prerequisites of such 'knowing'. How such a knowing-function might be accommodated in an Affordance model of perception without necessitating an '*a priori* bracketing' is addressed in the next section.

[13] Affordances offer differing opportunities to differing individuals. For example, the way a human might perceive the opportunities afforded by a chair, the "opportunities for action" (Stoffregen, 2003, p124) of; sitting, standing-on, etc. – an Elephant might perceive in a vastly different way - for the Elephant, a chair provides very few (if any) Affordance opportunities.

2.5 An Ecological Tolerance Hypothesis

By developing Affordance as a perception model of feature-change, the functioning of perception towards biological-value might be described through a state or moment set between past and future, a state of 'knowing', a state of functional Affordance.

Functional Affordance, therefore, is a dynamic proposition, best considered in a flow from one feature to the next, moments or 'percepts' captured, relative to a state of biological-value in ecological functioning.

It is in such functioning of perception towards an experience that a suitable definition may be sought. One that enables an objectivity in determining what an Affordance perception is.

This section explores perception as a state of functioning in experience (as proposed by Husserl) . By considering the control parameters of functioning relational to biological-value, perception is investigated in terms of the agent's functioning in relation to their capabilities.

This section seeks define such dynamic-functioning and to hypothesis what a perception might be, perceiving. In doing so, it hopes to provide a coordinating definition for an objective measure of what a perception might be – that of a 'functional tolerance' to biological-value in feature-change.

2.5.1 Functional Affordance: A Model of Ecological Efficiency

Ecological control is the requirement to constrain the feature-change presented to, or engaged-in, by the agent. A biological 'value' description allows perception to be described in terms of control parameters in its functioning towards ecological engagement.

How then is perception parameterised in terms of the functioning of Affordance and Effectivity?

When viewed through the perspective of a capability towards feature-change (Effectivity), perception as an Affordance may be seen to reflect the agent's capability to constrain the 'degrees of freedom'[14] presented through engagement with the environment (Bernstein, 1967).

A perception then, might now be considered in terms of 'efficiency' towards maintaining biological-value in the face of such feature-change – the functional efficiency in an Affordance.

[14] Bernstein defined musculoskeletal movement complexity in terms of 'Degrees of Freedom', a concept that expressed the parameters (feature-change) needing constraint or control in efficient functioning. The greater the capability to constrain the DoF, the more efficiency and therefore more ecologically robust the agent is.

Affordance is now explored, through an expression of functional efficiency towards ecological engagement. An Affordance model is proposed (Figure 5, below), displaying a trajectory[15] of possible functional states of efficiency – states of functional Affordance. Perception as a functional Affordance, then, is able to be represented as an Effectivity (of efficient functioning) towards an Affordance event in term of biological-value.

2.5.2 The Control of Affordance

Successful ecological-engagement requires, then, that the Degrees of Freedom presented by an Affordance event (feature-change), are controlled within an individual's Effectivity. Effectivity becomes a boundary or 'phase-parameter' of efficient-function in biological-value. Perception here, then, is represented by the ecological demands in constraining feature-change as a state of Affordance relational to an Effectivity capability.

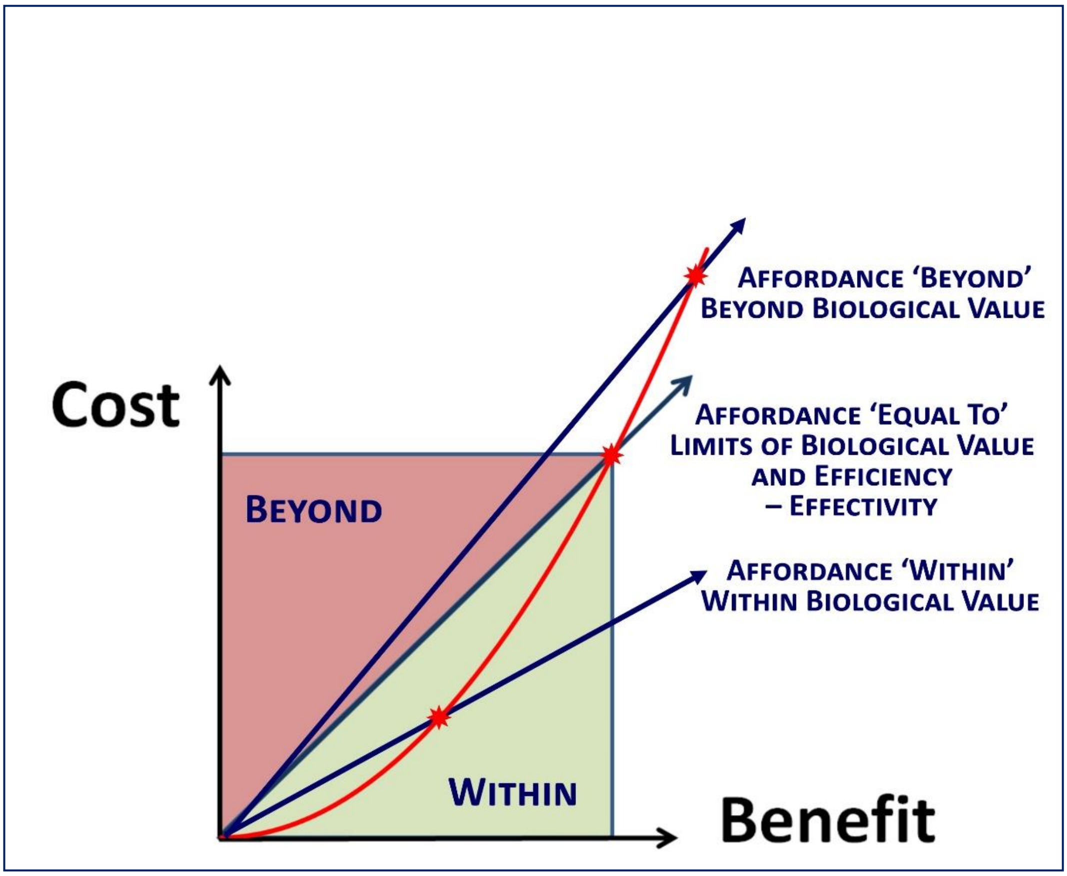

Figure 5 – States of functional Affordance: A Trajectory of Efficiency in relation to Biological-value.

[15] This is a trajectory of divergence from the known, and will be formulated in (3.4 – Formulating Divergent Criticality within an Efficiency Model of Function, p99).

This is a functional Affordance state parameterised by biological-value in the Effectivity of the agent (see, Box 1, below).

Box 1 – Functional Affordance as an Efficiency State of Effectivity

Ecological-value requires that –

1) ***Benefit ≥ Cost***

An Equivalence statement in terms of Affordance may be written as –

Effectivity to Control Degrees of Freedom for Ecological Value is greater or equal (≥) to the Affordance Event itself:

2) ***Effectivity ≥ Affordance***

Therefore, a Ratio for Affordance/Effectivity for the functioning within Ecological Value may be written as:

3) $$1 \geq \frac{Affordance}{Effectivity}$$

Using the control parameter of biological-value, an individual's state of perceptual functioning may be expressed in terms of the ratio between the Affordance presented and the individual's capability (Effectivity). To represent a state within Effectivity and therefore within Biological-value (a viable selectionist proposition), requires this ratio to be equal to or be less than one (see, Figure 6, below).

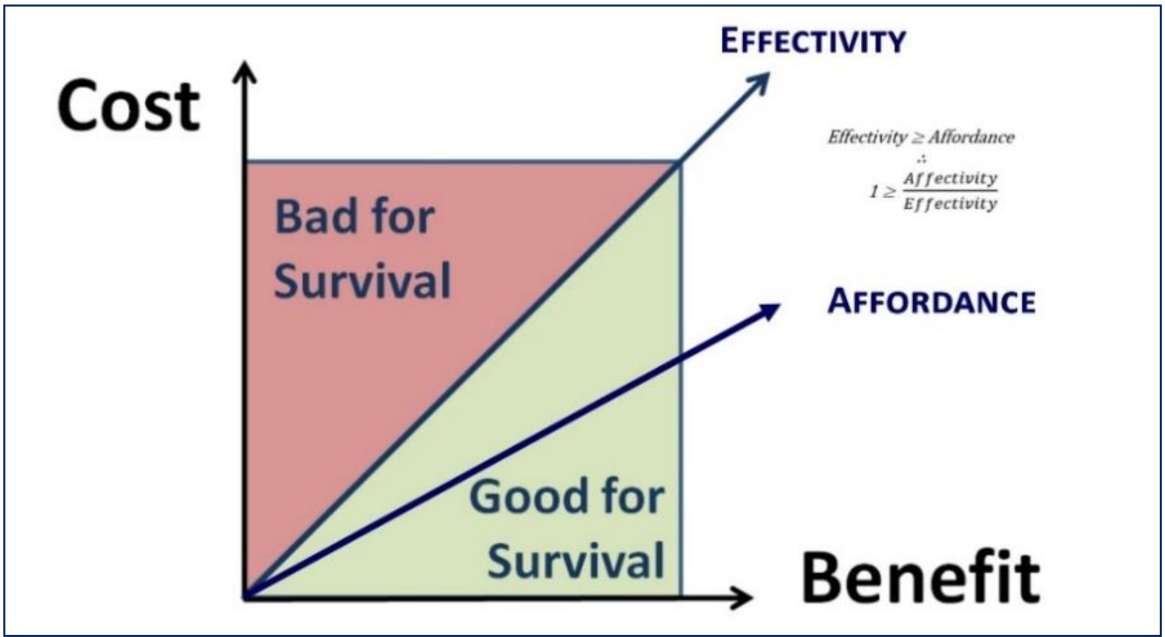

Figure 6 – Control Parameters of Effectivity and Affordance within Biological-value

In terms of function towards biological-value, an Affordance represents a state that may be formalised in efficiency terms[16] – An Affordance quantified by the state of function within the individual's capability (Effectivity) towards ecological demand (see, Box 2, below).

Box 2 – Ecological Efficiency in terms of Effectivity

From a statement of Affordance as a Ratio within parametrised by Effectivity:

1)
$$1 \geq \frac{Affordance}{Effectivity}$$

An absolute (maximal) capability allows an Affordance event to be considered in terms of an efficiency function:

2)
$$Efficiency = 1 - \frac{Ecological\ Demand}{Absolute\ of\ Capability}$$
(adapted Efficiency, Carnot, 1824b)

Therefore functional-Affordance may be expressed through an ecological efficiency function:

3)
$$Efficiency = 1 - \frac{Affordance}{Effectivity}$$

We might also represent Affordance as an Effectivity state, a coefficient of a functional tolerance:

4)
$$Coefficient\ of\ Tolerance = \frac{1}{\left(\frac{Affordance}{Effectivity} - 1\right)}$$
(Adapted from, Atkins, 2007, pg75)

2.5.3 From a fixed Dispositional Function to Generative Adaptability

An 'efficiency in Effectivity' now allows us to consider perception through a functional-efficiency towards ecological engagement, however, this is still a dispositional 'capacity'. That is to say that it still requires an Effectivity of prior-knowing in order to engage with the world. As such, Affectivity here is an *a priori* 'definite' or fixed capability proposition of a dispositional representation (Figure 7, below).

[16] This is possible as Effectivity is able to be considered as an 'absolute' of functional 'phase' for biological-value. Such an 'absolute of phase', allows an Affordance state to be expressed as an efficiency state within Effectivity and to be represented as a ratio of the Affordance and Effectivity parameters.

Dispositional representation[17], though able to support simplistic models of function (to perceive and to react), falls short when extrapolated to a dynamic engagement. Changing environments require representational models able to assimilate and 'represent' this divergence from the known. The components of a dispositional-perception of a known 'capacity' are 'heavy' they need lots of representational schemas or neural 'mini-models', invoking the reductionist dilemmas of a multitude of Effectivity(s) necessary for an Affordance to be actualised (Clark, 2015).

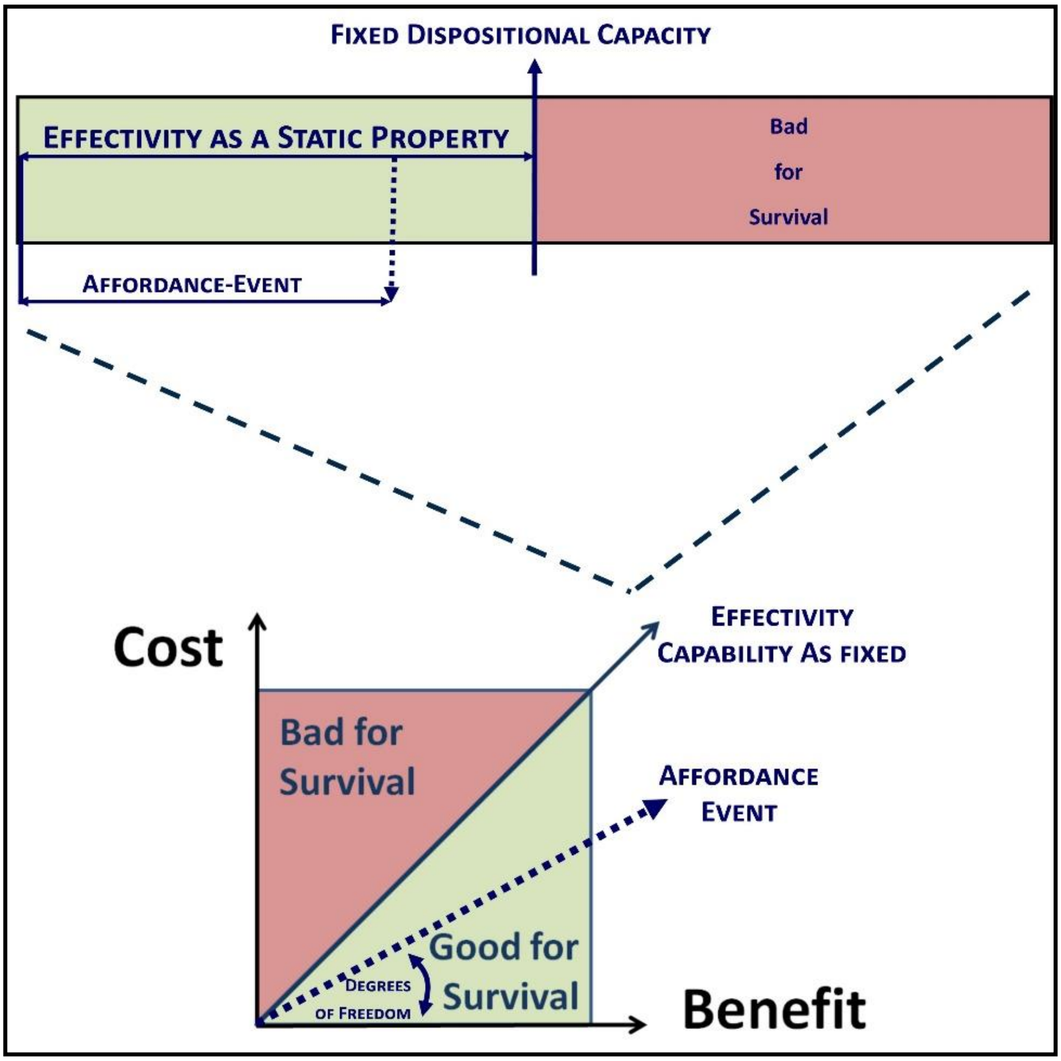

Figure 7 – A Dispositional Model

[17] Models of perception might be thought of as representational, an inner representation of what is 'sensory' experienced. As such, models might be labelled dependent on their functioning: dispositional fixed or generatively flexible.

Dispositional function could never confer the magnitude of resources needed to accommodate such representations for a perception as;

"the delicate opportunistic dance of brain, body and world……… a story about efficient, self-organising routes to adaptive success" (Clark, 2015, p244).

Through suggesting 'self-organising states' of 'efficiency', Clark recognises the necessity for a frugality or efficiency in perceptual functioning as a selectionist prerogative (2013, p22); and if there is efficiency, there exists also 'inefficiency'.

Any representational proposition would need to tolerate such inefficiency, but also provide 'self-organise routes to adaptive success', in order to embrace inefficiency for a selectionist Affordance model.

Disposition, then, does not adequately account for such selective adaptation. A functional Affordance model needs to accommodate the concept of a perception of efficiency in functioning towards biological-value through the modelling of tolerance and adaption.

2.6 Tolerance and Generative Models of Control

A state of Tolerance might now be proposed as an efficiency definition towards future feature-change: the availability of 'degrees of tolerance' from one state (now) toward a future state: the 'further' dynamic change the system is able to tolerate. Rather than a dispositional definition of Effectivity towards Affordance. This is perception as a state of tolerance to an Affordance within functional parameters of Effectivity.

"Affordances define the degrees of freedom available to the actor within the task" (Van Orden, Kloos & Wallot, 2011, p656)

Tolerance demands that we move from a static dispositional perspective to one of dynamic (future oriented) 'generative' representation (Clark, 2013; Damasio, 2010). Real life is chaotic and complex, so no matter how accurate our representations of the world there will always be difference, the unexpected. Any generative representation, therefore, should be considered as a probabilistic internal state that can never be wholly represented or known, but may, in terms of efficiency (in respect towards biological-value functioning), be represented as a 'functional' tolerance to such surprise[18], and may be parameterised within a functional Affordance model (see, Figure 9, p27).

Perception, as functional Affordance, is better represented through acknowledging the divergence or difference between the expected (generative) and what is subsequently experienced (sensed), the divergence or surprise 'afforded' as a statement of the tolerance functioning of the system.

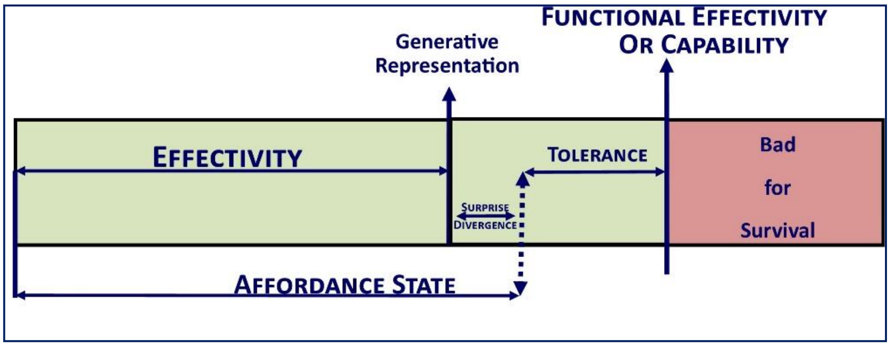

Figure 8 – Ecological Capability and Tolerance

Perception, as representing feature-change, might therefore be better viewed as a tolerance-state of functioning. This sees a functional Affordance inferred through its tolerance to 'feature change' (Franchak & Adolph, 2014). Affordances may now be viewed as probabilistic states in relation to their Effectivity providing an Effectivity-tolerance state to feature-change or 'surprise'. We now can re-formulate perception as an functional capability or Affordance state of Effectivity tolerance (see, Figure 8, above). Such a capability or Effectivity-tolerance enables perception to be considered through Husserl's hidden reality in ecological engagement, a perception 'from' not 'of' experience.

Effectivity-tolerance is now able to be define perception through tolerance towards an ecological 'surprise' a functional Affordance state. Such a definition provides Affordance with a relative definition: as the surprise-state is set within an absolute of relational capability (see, Figure 9, below).

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[18] Surprise here denotes the uncontrolled Degrees of Freedom, the new, the different; a proposition impossible in a dispositional model. In Universal terms, 'surprise' refers to entropy production (see, Defining a Steady-State of function Within a Maximum Phase of Entropy, p75).

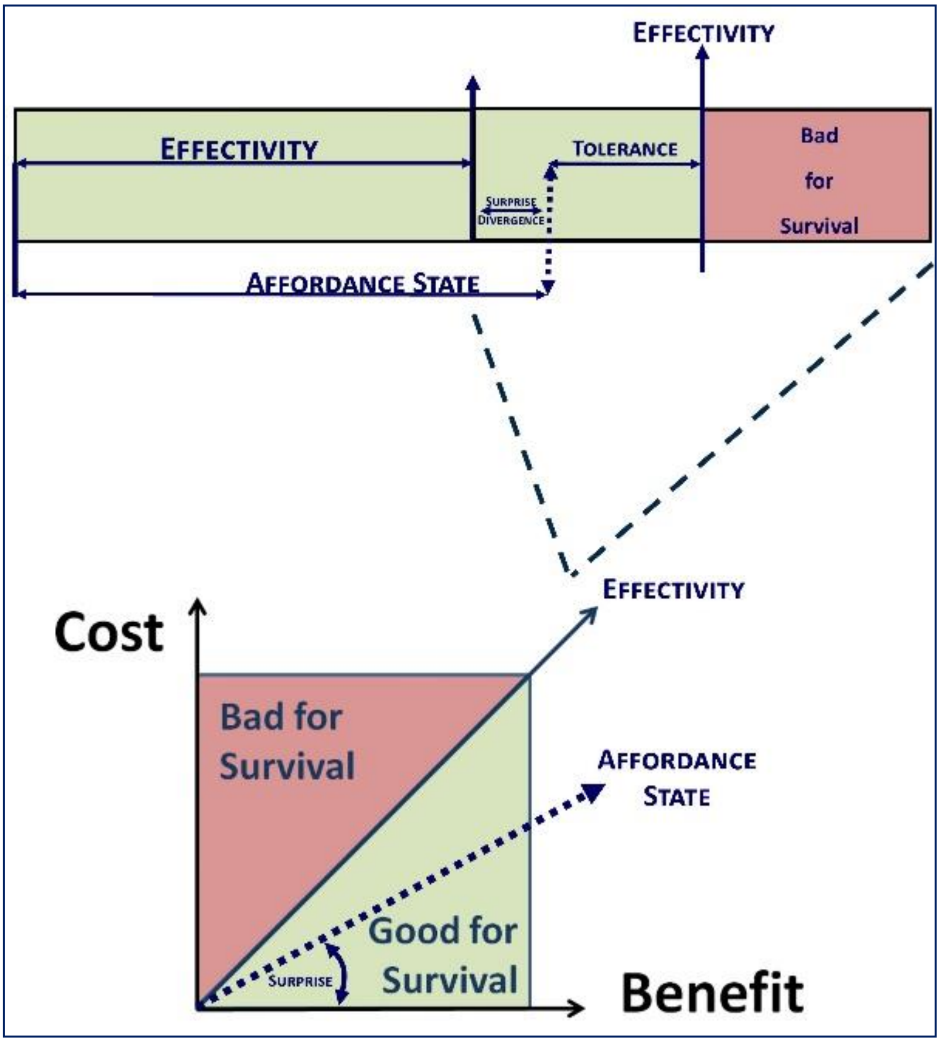
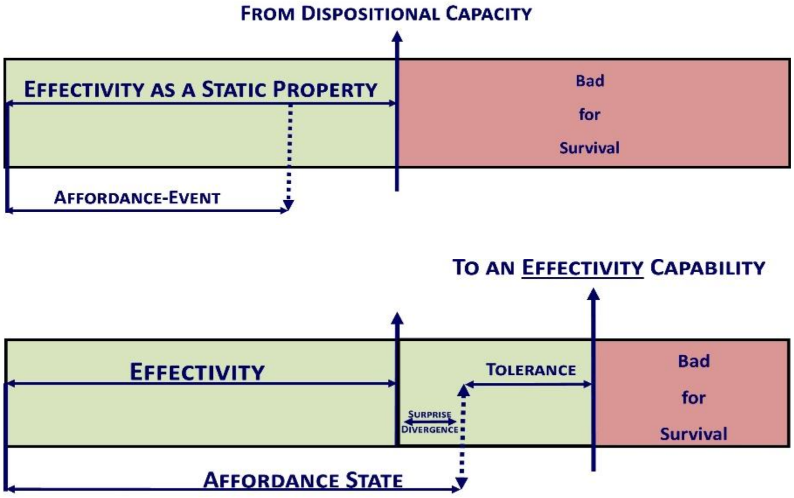


Figure 9 – Generative Tolerance: a functional Affordance

The control parameters of functional Affordance are now set in 'relative' terms and are revisited in our biological-value model (see, , below). Effectivity-tolerance is able, then, to represent not only a state of functional Affordance, but as a dynamic flow of feature-change, tolerance offers a definition to the functioning of the agential capabilities to such Affordance flow (as would be required for a perception of feature-change from experience). Such tolerance can be represented as an efficiency function, this enables an efficiency definition for a state Affordance as a state of perception: a defining quality of a functional Affordance, where the greater the tolerance the greater the functional efficiency towards an Affordance;

Tolerance as an 'Efficiency in function' $(\varepsilon) = 1 - \frac{Surprise}{Effectivity}$ (see, Box 2, p23)



From (Box 1, pg 22) from a dispositional proposition we require for Ecological-value: Benefit ≥ Cost

$$1 \geq \frac{Affordance}{Effectivity}$$ *Affordance (Demand) Does not exceed Effectivity (Capability)*

From (Box 2, pg 23) we derive a state of Affordance as a 'state of efficiency' in function towards Ecological-value:

$$\text{Affordance } \textbf{State} = 1 - \frac{Affordance}{Effectivity}$$

This allows an equivalence-statement of efficiency towards Ecological-value in terms of ***Tolerance****:*

$$\frac{Affordance}{Effectivity} \equiv \frac{Affordance\ Surprise}{Effectivity\ Capability}$$

$$1 \geq \frac{Surprise}{Effectivity}$$

Therefore Affordance as an efficiency in function ≡ $(\varepsilon) = 1 - \frac{Surprise}{Effectivity}$

Box 3 - A functional Affordance State as a State of Tolerance function

Affordance encompassed in such a state of Effectivity-tolerance, allows a dynamic formulation for feature-change (Chemero, 2000; Chemero *et al.*, 2003). This is an important distinction: tolerance may now be considered in relation to ecological engagement as reflecting the agential capability to tolerate feature-change – a selectionist proposition.

This state of perception as tolerance, is still 'relational' to individual capability (therefore subjectively experienced), but now framed within a definition of 'Effectivity tolerance' to feature-change, is able to be regarded as 'relative'. As such, tolerance provides the possibility of differentiation between 'relative' definitions: Individuals with greater 'relative' tolerance towards an Affordance will be able to better tolerate the surprise than those with relatively, less tolerance. They will be more efficient in surviving similar Affordance event(s)[19] than those with lesser 'relative' Effectivity-tolerance. Tolerance therefore, allows a selectionist proposition for perception (see, Figure 10, below) – as was ever the intention of Gibson's ecological psychology (Van Orden *et al.*, 2011, p658). Functional Affordance as a Tolerance proposition now provides a coordinating definition for perception, it can therefore be used to define different perception states.

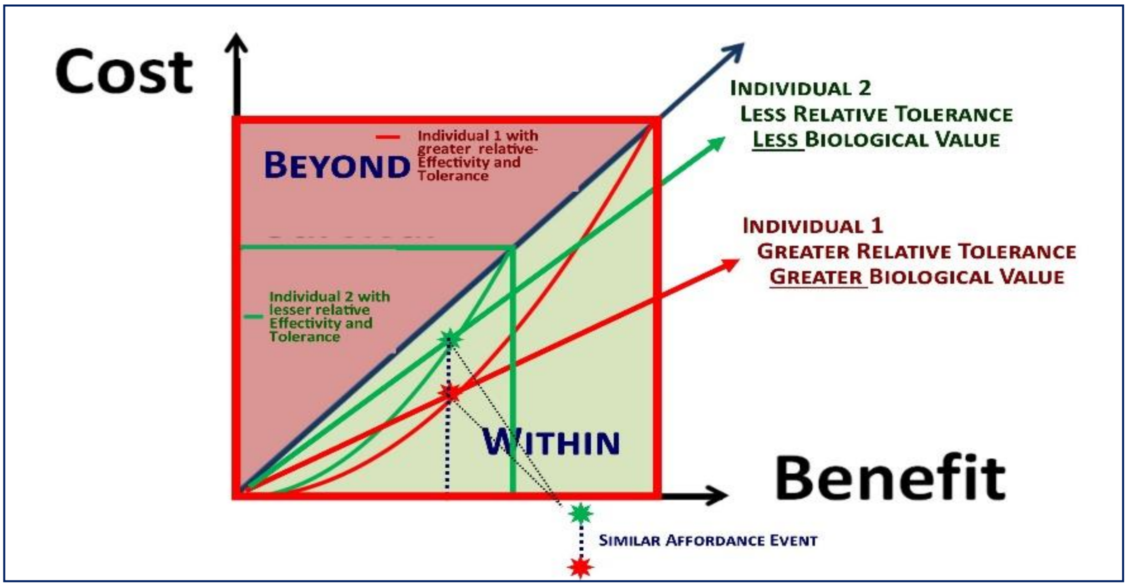


Figure 10 – Relative Trajectories of Effectivity-Tolerance

In being 'of' experience, functional Affordance as a model of perception would seem to address Husserl's (1913) phenomenological 'intentionality', whilst accommodating Heidegger (1927) and Merleau-Ponty's (1945) existential engagement prerogative towards biological-value: a perception from action that is readily available to the individual.

[19] Similar Affordance events, here, reflects that two Affordance (perceptions) will never be the same as they are from unique relational Effectivities (subjectivity). However, it is in the Effectivity-tolerance towards feature-change (as a perception), that we conceive of a relative quality of 'function' in defining perception.

2.6.1 The *a priori* Dilemma

However, Effectivity-tolerance is still a proposition that requires 'some' *a priori* knowledge in order to define an Effectivity 'capability'. If functional Affordance is not to fall prey to the recurrent critiques in reductionism, two important prerequisites should be addressed:

1) What is the *a priori* bases for Effectivity and therefore an Effectivity Tolerance – How do we know?

2) How do we assimilate the new?

2.7 How Do We Know?

In addressing 'What is the *a priori* bases for Effectivity', we might look to our evolutionary heritage, a lineage that takes us from simple affective behaviour (almost dispositional in its limited tolerance), towards the complexity and flexibility in behaviour through cognitive processes for a dynamic tolerance and engaging with the new. Such processes for a perception might then be ethologically grounded as 'affective processes for life-regulation'. This suggests perceptions evolved from ecological determinants, an Effectivity of 'evolved' capabilities and learnt cognitions for engagement with the environment (Shapiro, 2010; Thompson, 2007; Varela *et al.*, 1991). Such an evolved proposition may then align perception with cognitive-emotional behaviour (a biophile of positive-approach and biophilic avoid affect; Ulrich, 1993). This is a perception of innate drives for biological-value, situated in a cognitive-emotional landscape of life-regulation in ecological engagement.

Affective behaviour (Panksepp, 1998; Panksepp, 2005) provides a basis to such cognitive regulation, one that may be traced back to the very beginnings of life. An inherent or 'innate' behavioural platform on which to build further cognitive processes. As such, affective drives for experience or engagement with the world may be seen across species (e.g., a SEEKING, FEAR, RAGE, LUST,CARE, GRIEF & PLAY ,Panksepp, 1998), an ecological management evident even in non-cortical biological-value[20] (Yanai, Kenyon, Butler, Macklem & Kelly, 1996). Though not advocating any neural correlates or simplistic-analogy that incorporates consciousness or intentionality, such a 'seemingly' affective-

[20] The chemo-kinesis of simple replication in single-cell organisms, becomes a seemingly, agential, 'chemo-taxis' of the many, possibly displaying an early form of agential behaviour. Such agential-capability defines not only situated opportunity, but also the possibility of accessing future biological-value in response to contextual affective behaviour.

behaviour towards biological-value may suggest the foundations of such agency towards biological-value (Feinberg & Mallatt, 2016).

Life-maintenance may be traced from primordial first principles, through to the evolution of more complex function and affective behaviour. The proteins necessary for inter-cellular communication reside in virtually all organisms from the single-cell domains of bacteria and archaea, to multi-cellular organism neuronal-signalling. That such neuro-transmitters (dopamine, serotonin, cortisol, noradrenaline, etc.) are seen to propagate through the evolutionary lineage (Freestone & Lyte, 2008), speaks of not a limitation in adaptive possibilities, but of an 'efficiency and robustness in function'. Similar efficiency of function is found to be replicated through the structures of neural signalling, for example, the neural development found within vertebrates (Deacon, 1990; Krubitzer & Kaas, 2005). Rather than evolutionary adaptations in neural-structure being viewed as selected for in their increasing complexity, it is the functional efficiency that is seen to be conserved. The proliferation of 'architectural' adaptations are therefore better realised as differentiation of existing-structure for supporting efficiency – function over structure (Karmiloff-Smith, 2012).

Affective behaviour as evolutionary grounded, provides an *a priori* platform on which further cortical adaptation may be constructed (Damasio, 2010) and affective behaviour may be seen to be facilitated or regulated through cognitive-emotional constructs of agential drive towards biological-value (Wright & Panksepp, 2012). Such an agential relationship is emergent through an ecological context (Chemero, 2008; Ulrich, 1993), as an autonomy between the environment and the capability of the agent to tolerate and adapt behaviour for functional-value. This requires that we not only accommodate the efficient function of the individual in any Affordance model, but if selectionist, account for how the unknown in ecological engagement, becomes known – how do we adapt.

2.7.1 How do we Adapt – Assimilating the New

Such a functional efficiency and adaptive flexibility has been highlighted as necessary in cognitive function for an embodied Affordance of intentional behaviour (Chemero, 2008; Damasio, 2010; Karmiloff-Smith, 2012; Merker, 2007; Thompson, 2007). The adaption to able to constrain and assimilate the new and a cognitive flexibility that might be considered as an imperative to any functional model of perception: This is necessary to accommodate dynamic change. How then is the new and the novel be assimilated? What informs the neural system of its ignorance? How can unknowns become known and we learn to adapt to them?

Hatfield (1988), outlined a possible approach for tackling such issues by proposing an alternative approach from symbolic representation. The processing of new information through a 'complexity' approach and the spontaneous 'emergence' (from Self-Organisation) in Hebbian (1949, 2002) neural networks or schemas.

Chemero admonishes the lack of such Self-Organising in theory in his critique;

"Indeed, none of the extant views of affordances of which I am aware make it the case that animal-environment systems are self-organizing, autonomous systems." (p264, Chemero, 2008).

Though much has changed since then in Self-Organisation, with Dynamical Theory providing fresh theoretical models and landscapes in Evolutionary and Cognitive Science traditions with which to explore perception and ecological learning (Chemero, 2013; Chialvo, 2010):

"The ecological approach has been maintaining all along that movement and action functionality is fundamental in the greater scheme of the entirety of the human capacities…… For the purposes of the present paper movement is understood not merely as the efficient displacement of a limb from point A to point B, but as action—the real-time control of movement that is intentional with respect to a perceived affordance in the environment." (Dotov, 2014, p795)

A relative Effectivity-tolerance, provides for Gibson's autonomous animal-environment prerogative, whilst also allowing complexity theory to answer the dynamic imperative of a self-generating perception of being in the world – a self-organising and assimilation of the new into the agent-environment perception:

"………… a conception of affordances according to which the affordances of the animal-environment system are dynamic relationships between animals and their environments." (p265, Chemero, 2008)

This 'emergence' of internal stability toward external experience is one that answers Idealism in its abandonment of a dispositional *a priori* representation. A non-symbolic approach, through action , is still able to support a generative-representation model for the processes of perception (Gregory, 1972) by aligning the unknown with the known through an 'efficiency to biological-value functioning' in neural networks. Our cognitions might be better considered through a functional efficiency processes, rather than dispositional or modular capabilities (Karmiloff-Smith, 2012).

2.8 An Evolutionary Hypothesis

In simplistic terms, we might hypothesise that adaptations in cognition and behaviour that facilitate a change from less-tolerant to more-tolerance (relative expressions of efficiency in agent-environment autonomy), will be of biological-value and evolutionary retained (Chemero, 2013; Chialvo, 2010). Therefore, Effectivity-tolerance towards surprise if able to be shown as an 'adaptive' capability, sees the individual 'efficiently integrate' dynamic states of tolerance functioning. Here, it is in the agential robustness towards surprise in dynamic environments, that tolerance is prioritised as a selectionist proposition. Chemero (2003) would be wary of the term selectionist in Affordance in its agential-implication for what, from an evolutionary perspective, is not the 'hard' ecological barometer of life and death. However, as a tolerance proposition, functional Affordance takes the agent-animal autonomy to a relative function, one that could be considered as selectionist.

It is in the functional priority of constraining unknown degrees of freedom in dynamic environments, that agential directed behaviour for greater efficiency in Effectivity-tolerance, that a 'Tolerance' hypothesis emerges: – that affective behaviour will drive the agential-environmental autonomy towards an Affordance state 'for' maximum future tolerance through self-organisation. This is a tolerance (and therefore Effectivity) optimisation function that will be formulated (see, '3.1 – Developing a Divergent Criticality Hypothesis, p88).

2.9 Section Summary: A Feeling of Perception

An Affordance of agency requires a 'forward' directed or predictive model to neural- function. An agency towards the ecological demands of future 'projected' goals.

Tolerance allows such a 'predictive processes' (Clark, 2013) as a current Affordance state extrapolated forward to an 'expected' or generated future-state. If perception is to be considered an ecological proposition, it must be able to differentiate the 'best possible' future functioning in a model of 'predictive-processing' (Clark, 2015).

In order to investigate the proposition of agential perception as a perception of ecological tolerance or efficiency, explanations are needed of why such perceptions not only infer a tolerance in ecological engagement, but provide for affective cognitions and behaviours to accommodate the functionality of agency engaging in a changing world.

What is perception, how does it work and why do we have it? The history of research into perception has dealt primarily with the subjective appraisal of 'abstract thoughts' in order to explain the functioning of this cognitive process. This might be expected, we are our own perceptual experiment of seemingly coherent thought. However, such is subjective-abstraction and a phenomenological projection of a 'feeling of knowing', with a subjectivity of only – what is accessible to us. Though such subjective-bias should not be dismissed (as it is from the cognitive processes at work in constructing such our awareness), this 'feeling of knowing' is not reality. As a definition on which to base enquiry, reality then, is a 'will-o-the-wisp', and it is necessary to find some other definition with which to coordinate perception as an agential awareness able to be naturalised.

This section has explored such a coordinating definition. It has looked at what a perception might be in terms of the phenomenological literature – the nature and philosophy of perception; and has been aligned to a necessity for embodied functioning and biological-value for life in dynamic environments. In acknowledging this dynamic prerogative (of flux and change), a definition of 'tolerance to ecological demands' has been philosophically derived: If we are able to deconstruct perception objectively as an 'awareness of cognitive processes' towards what biological-value an ecological engagement 'affords' an agent (Affordance – a Phenomenological ontology), then it may be possible to measure and test perception to gain a better understanding of how a perception as an 'awareness as Affordance' comes to be.

It is evident that such cognitive awareness must come from functioning of neural-processes in relation to ecological demands. Perception, here, was aligned with biological-value through an ecological 'Tolerance' definition, the agent's capability of Effectivity towards a dynamic world of ecological demand. Tolerance, in defining a 'feeling of knowing', is a 'state' of neural-function, and can be considered in relation to an agential Effectivity in accessing biological-value. Tolerance when coordinated objectively, provides a perception measure of neural function towards biological-value. In doing so, Ecological Tolerance answers Stoffregen's (2000b) requirement for why Affordance as 'events' should be perceived: an Affordance as a 'state of Tolerance' becomes a perception of agential capabilities toward accessing biological-value – a functional Affordance.

It is now necessary to consider the neural processes that make such a functional Affordance salient; importantly, the agential or autopoietic imperative of cognition and behaviour for biological-value. In order to investigate such value processes, perception as a Tolerance, needs to be aligned with the necessity of engaging in a changing 'dynamic' world – the attending and controlling of neural-function for engaging in the now, and predicting an uncertain dynamic future.

In the next chapter, the neuro-scientific literature is explored in relation to how Tolerance as a neural efficiency proposition, might become an awareness. This approaches agential capability in relation to the cognitive functioning of attentional-processes – The Attention and Control of Agential Effectivity.

Section 2: Attention and Control

2.10 An Awareness of Affordance

One might approach a future that you ‘anticipate’ can utilise your existing abilities with less restraint than a future you anticipate as ‘beyond’ your capabilities. This agency speaks of a cognisant awareness, what Noë (2009) describes as an *Accessibility*. Such an agency is found in our phenomenological experiences; our emotions, cognitions and behaviours oriented towards a an expectation – an ‘accessibility’ of our capabilities towards being-in the world (Heidegger, 1927; Merleau-Ponty, 1945; Varela *et al.*, 1991).

Whereas Effectivity has been regarded as predominately a process from environmental or ‘bottom-up’ sensory information, an ‘agency’ and ‘being in’ the world, suggests internal ‘top-down’ processes that co-opt and define the sensory process of life-regulation (Damasio & Carvalho, 2013). Such internal ‘top-down’ and external ‘bottom-up’ cognitive processes are a composites of attending in a duel-processing model towards life-regulation; sometimes harmonious, sometimes discordant. Clark has referred to this as ‘predictive processing’ (Clark, 2015).

Rather than Affordance as a perception of simplistic animal-environment autonomy, perception becomes attention to the processes of Noë’s accessibility, agency, an agent-environment autonomy for a predicted future.

In developing functional Affordance as a ‘conscious’ model of ecological function (as any perception model must be), it must not only represent simplistic function through sensory management, but also be able to accommodate top-down agential processes. If not able to define a consciousness, functional Affordance must at least provide an adequate explanation for why and how an ‘awareness of attention’ as a cognitive processes for perception, might become ecologically selected for.

This is the fundamental requirement in ecological science, that if theoretical models of perception are to be considered functional, then they must be naturalised[21];

“it must be shown that the affordance-ability self-organizing, autonomous system and the autopoietic nervous system jointly constitute a higher order self-organizing, autonomous system” (Chemero, 2008, p268).

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[21] Naturalised, theory set with Universality (i.e. perception coupled with the laws of nature).

2.10.1 The Dilemma of Non-Symbolic Representation

In rejecting pre-specified networks of symbolic representation in favour of a naturalised 'ethological' approach to perception (one of animal-agential embodied sense and sense-making), then meaning must still be built on 'some' foundation (Glenberg, Havas, Becker & Rinck, 2005). Glenburn et al. argue that consciousness can't come from 'meaningless' symbolisms that are just collected or experienced. If not pre-specified, then meaning must be grounded somewhere.

Though this hints again at a causal platform, we should avoid labelling specification or grounding as causal, but consider it as function in terms of its application rather than any neural-modality (Karmiloff-Smith, 2009). It may be possible, however, to consider some behavioural pre-specification for cognition (we are born able to breath, along with other traits of our genetic heritage); we then build on these traits through experience. This is a neuro-constructivism in brain function (Plunkett, Karmiloff-Smith, Bates, Elman & Johnson, 2006; Spencer, Blumberg, McMurray, Robinson, Samuelson & Tomblin, 2009). One that offers a way forward beyond the necessity for any dispositional (and as we have discussed, philosophically dis-functional) representation in cognitive processes.

This requires consideration of the brain's organisation not of one of fixed modularity, but one of a dynamic, adaptable holism (Anderson, 2016; Karmiloff-Smith, 2009). A neural-network that responds within the constraints of its genetic heritage but is able to adapt to the situated demand with a contextual intent – the internal shaping the perception. This reappraisal of a functional flexibility holds the promise of an amalgam between symbolic-representation (Spelke & Kinzler, 2007) and dynamic-complexity (Bates, Elman, Johnson, Karmiloff-Smith, Parisi & Plunkett, 1998).

By naturalising cognitive function through ecological engagement, we pursue an ethological perspective for *"continuous sensorimotor interaction between an organism and its environment"* (Cisek & Kalaska, 2010, pg270), requiring a 'functionality' to perception, one that 'grounds' symbolic-representation in a landscape of agent-environment autonomy.

2.10.2 Modelling Agent-Environment Autonomy in Cognitive Processes

One such area of research in the mid-twentieth century that has seemed to offer an autonomy to the modelling of action and behaviour, was the adopting of 'symbolic' computerisation, as a model for neural representational (Marr, 1982; Turing, 1936; Von Neumann, 1945).

"It is worth mentioning, that the neurons of the higher animals are definitely elements in the above sense" (Von Neumann, 1945).

Such an 'abstract' processing through a computational 'model-based' approach seemed to provide an alternative cognitive determinism displacing the dominant psychology of behaviourism (for example, Skinner, 1953). However, such mechanisms of symbolic input, memory and output, provide only a rigid-model; Though cognitive science 'seemingly' promised a way into the cognitive 'black box'[22] of behaviourism, it is limited by the necessity of *a priori* dispositional representations.

Such a 'model-based' approach, might then be considered within an alternative 'model-free' approach (free in terms of set or 'fixed' symbolic or dispositional-representations). Here, trial and error mechanisms (mistake contingent feedback), are action-driven through value derived inputs (see, Anderson, 2016; Dayan & Daw, 2008; Gläscher, Daw, Dayan & O'Doherty, 2010). This provides a 'generative' representation of ecological-value through action-control, one offering an alternative to the reductionism of cognitive science by aligning cognitive function with a value-driven behaviour. This is a dynamic 'Self-Organising' of function in ecological engagement (this will be explored in depth in 2.26 – Free Energy and Entropy: The Physics of Biological Function, p65);

"time-dependent kinematics and dynamics of ecological engagement" (Warren, 2006, p359).

2.11 Ecological Control as a Functional Affordance

Such free-modelling as functional towards neural processes necessitates 'situated' ecological cues to be accommodated in an internal representation, and a control of agential action towards ecological value. This is a 'forward projection' in representation, a 'predictive-processing' (Clark, 2013).

Functional Affordance offers such a generative proposition in its Effectivity, but might be considered as limited or heavy in its 'capability' requirements (in representing sensory information towards modelling future states). However, when considered through Self-Organisation Theory, Effectivity as a generative-model is 'lightened' through only being required to represent model-free sensory information within an immediate sphere of reference: *"the world is its own best model"* (Brooks, 1991, p15).

[22] The Black Box criticism: The inability of behaviourism to account for cognitive processes has long been used as a criticism in its lack of internal (cognitive) methodologies. Though the disposition of cognitive science has been largely discredited, Behaviourism in its ethological focus is now finding validity in observations of behavioural-coupling with cognitive function in dynamical systems (Chemero, 2009; Cisek & Kalaska, 2010; Clark, 2013; Friston, Daunizeau, Kilner & Kiebel, 2010; Kelso, 1995).

What emerges is a 'finitude of function' from the multitude of possibility (Cisek, 2007). This is a representation of agential expectation, an expectation frugally weighted on past experience and continually compared against the sensory feedback of 'acting out' that expectation;

"learning of complex coordination dynamics is achieved by maximizing the amount of predictive information present in sensorimotor loops" (Clark, 2013, p12)

There must be[23] a divergence, a difference, between the generative expectation and the sensory experience; therefore, a generative free-model is an error contingent model (contingent on biological-value). It is in the effectiveness of both tolerating and adapting to such 'freedom' that 'divergence' and 'biological-value' come to define a generative model-free approach to perception functioning.

This parallel processing of generative and sensory representation drives dynamic, value-contingent actions as affective behavioural responses in order to reduce the 'divergence' state between *a priori* generative and sensory models, the dynamic redefining or emergence of adaptive function via the dynamic flow of information in a cognitive-landscape. This is an ongoing, iterative process, a dynamic self-generation of a perceptual generative 'now' contextual on an expectation (the past) towards a *posterior* future;

"This generative model is decomposed into a likelihood (the probability of sensory data, given their causes) and a prior (the a priori probability of those causes). Perception then becomes the process of inverting the likelihood model (mapping from causes to sensations) to access the posterior probability of the causes, given sensory data (mapping from sensations to causes)" (p129, Friston, 2010).

Expectation as affective behaviour from agential and situational motivations. An agency biased on cognitive capability (Effectivity) to ecological interaction (an Affordance-event).

Cisek and Kalaska (2010, p275), further support Effectivity through a "pragmatic representation" of ecological engagement: the need for a system of ecological value to respond to the dynamic flow of experience within the efficiency[24] of a model-free approach. This approach, combining Effectivity in a soft-assembly of resonant ecological interaction, avoids a 'too heavy' a representational model reliance through a 'flow' of cognitive function and Self-Organisation (Gläscher *et al.*, 2010; Kello &

[23] No prediction of future events will be perfect, either due to the agential paucity or the infinite vagaries of dynamic interactions.

[24] A 'cognitive efficiency' was first commented on by Hughlings Jackson (1884).

Van Orden, 2009). This suggests a perspective of an embodied, ecological cognition, where both model 'emotionally-biased' and model-free systems are seen in an action-synergy towards dynamic environments:

"adaptive behaviour does not consist in coordinated movement per se but in goal- directed action that is tailored to the environment. Hence, a few control variables must be left free to vary, which may be regulated by perceptual information. Thus, an action is some function of the current state of the action system together with informational variables, according to a law of control" (Warren, 2006, p366)

This is a composite constructivism grounded on *a priori* cognitions (an Effectivity of innate-behaviours and learnt-experience); cognitions that are projected towards a possible future and then tested through ecological engagement – a predictive-processing model of model-based tolerance and adaptive model-free function, in a dynamic world of action choices (Cisek & Kalaska, 2010; Clark, 2015).

Such an iterative representation in its parallel-processing of sensory and contextual information, compensates for both the dispositional-fallibilities of fixed models or schemas, and the knowledge-paucity of free-models, by accommodating dynamic function through a 'tolerance' towards ecological engagement. This presents a self-referencing and self-generating model, one grounded on sensory engagement but contingent on contextual agency: This is a generative end-point (Won & Hogan, 1995), an outcome-expectation of cognitive function for optimising (dynamic) biological-value. One that might be considered through a selectionist model that demands an ecological-tolerance prerogative to expectation-divergence.

2.11.1 Complex Behaviour in Dynamical Systems

Such free-modelling presents a cognition contingent on value through dynamic engagement, a value represented through tolerance to divergence or surprise; a probabilistic future for biological systems and the necessity of maintaining of a biological-value homeostasis within such dynamical demands (Bak, 1997; Dayan & Daw, 2008; Friston, 2010; McCune, 2006; Northoff & Hayes, 2011; Prigogine, 1996). Here probability approximations from complexity theory permit a parallel-processing in the representation of a divergence between the expected and the encountered. This probabilistic 'state' is a cognitive-function has been explored through the qualitative coupling of behaviour for cognition, in dynamical theory (Iberall, 1970; Kello & Van Orden, 2009; Kelso, 1995; Zanone, Kostrubiec, Albaret J & Temprado J, 2010).

Such descriptions of neural network function[25], allows us to consider the validity of generative optimisation models: They represent a function of work or energy minimisation and an 'optimisation' propensity towards functional equilibrium (to reduce the divergence signal through affective behaviour). This action and representation cycle self-references on itself to minimise divergence and is congruent with the 2nd Law of thermodynamics; a dissipation of dynamic variability towards an equilibrium of stability as an invariant end-point. However, in dynamic environments, new variance or surprise does not allow such linear function, a static stability cannot be the desired end-point for affective behaviour. What is required for divergence is ever more divergence as a dynamic actuality (see, 2.35.3 – Divergent Criticality: Functional in Entropic Tolerance, p81), this demands a tolerance-capability 'optimisation' as the desired end-point or selectionist outcome[26]. Affective behaviour might be better explored through a 'Tolerance Optimisation' function in dynamic environments, for the maintenance of biological stability across time.

2.11.2 Efficiency in function as a measure of Tolerance

Generative models, by allowing dynamic stability to 'emerge' through cognitive processes associated with complexity theory, is an approach that allows a real-time interactive coordination-dynamics, deemed as 'informationally' dominant (Haken, Kelso & Bunz, 1985; Kelso, 1995). This representational perspective is one supporting a cognitive-landscape as an agential-environment interaction. However, there is still a disconnect between such agential 'autopoiesis'[27] and a mechanism that is able to objectively regarded as a naturalistic process, an ethological and intentionality requirement (Chemero, 2008). We, therefore, look to the lack of naturalistic

[25] Complexity and Dynamical System theory, are manifestations of the functioning of free-energy principles, in particular the 2nd law of thermodynamics and non-linear, far from (classical) equilibrium functioning. This branch of physics is more often referred to in the pejorative term, Non-linear Dynamical Systems theory.

[26] A selectionist end-point is the function or behaviour that evolutionary principles will select (adaptations) for. This see selectionist principles sometime select less than obvious agential behaviours: see 'The Selfish Gene' (Dawkins, 2006), and Game Theory (Maynard Smith, 1982), e.g. Altruism and empathy, and maybe now – 'tolerance optimisation' with is not an efficient proposition of the now, but an insuring of future surprise in a dynamic world.

[27] Autopoiesis refers to the unique self-organising individuality of biological physicality over physical form – an agency towards stability in existence (Thompson, 2007; Varela & Maturana, 1972; Varela *et al.*, 1991).

grounding, criticisms to dynamical theory that have not yet been adequately addressed (Chemero, 2013; Chialvo, 2010). Can these direct a possible way forward to address these Universality issues?

Non-linear Dynamical Systems (NDS) theory suggests an efficiency in optimisation by providing 'frugality in function', but is open to the criticism of being one-dimensional as *"mirroring the medium rather than expressing the mechanism" (Warren, 2006, p361)*. This misses accounting for the 'agential-imperative' of a composite function and a "communication frugality" (Clark, 2013, p22). By addressing this lack of a suitable definition between differing states of agential-perception (phenomenology) and function, we should again address the agent-environment 'outcome-delivery' of biological-value for a truly 'dynamic' functional proposition. Tolerance again acts as the functional end-point, a 'mechanism over the medium' and one that is able to accommodate 'less than optimal' function inherent in any subjective agency (the top-down 'intentionality' within all dynamic models).

Ecological optimisation, then, in a composite model of neural function for biological-value, might be better addressed through its 'functional tolerance' in acknowledging the agential-inefficiency towards a generative divergence model. Tolerance towards inefficiency becomes relational to the functional capabilities of the agent as a tolerance parametrised within the agential capability or Effectivity. Importantly this as a functional-definition rather than a feature-definition, therefore transcends the perceptual-subjectivity by providing a contextual measure of functional efficiency to situated ecological demands. A relative state of efficiency in function – one able to be compared 'relatively' to other functional efficiencies and therefore, provide coordinative definition.

Regardless of the composite of function (agential or situated) Effectivity-tolerance provides such a coordinating-definition of an 'efficiency in function'. This is compositely-encapsulated however, as a state of 'relative' Effectivity that is dependent on the interplay in dominance between agential and situated interdependence: The state of a Effectivity becomes 'relative' as an outcome-state that will be able to be objectively-defined functionally through this relative outcome.

If we recognise that a selectionist paradigm sees agential-environment autonomy reflecting the environments they are situated in (i.e. niche-defined), therefore, a perception of relative Effectivity may also be considered as dynamically-defined: Environments of greater dynamic demand, will require greater tolerance functionality. This sees agential perception orientated towards Tolerance Optimisation, a selectionist proposition.

2.11.3 Mechanisms of Control: Affective Behaviour for Ecological Tolerance

It is possible to propose a Tolerance Optimisation hypothesis and trace niche-defined affective behaviour(s) from the first cellular proto-types of chemico kenestics and chemico-taxis, to complex affective-behaviours for life-regulation, reaction and a perception of agency have manifested themselves (Damasio & Carvalho, 2013; Feinberg & Mallatt, 2016; Panksepp & Biven, 2012): It is in the propensity for action as value-oriented, that a predictive hypothesis may be exprapolated to an affective-behavioural 'drive' moderated by ecological engagement and mediated by agential goal-orientation (Damasio, 2010; Panksepp, 1998, 2003; Thompson, 2007). In defining such a drive, we address the paucity in aligning agent and environment within a functional mechanism for perception, Warren's call for *" … a law of control" (2006, p366).*

When considering dynamic environments, the parameters of such an affective drive will still need to operate within ecological value, but a Tolerance Optimisation outcome takes the system to the edge of efficiency function, as, in Non-linear Dynamical Systems, it is at this 'state of function' that greatest 'future' tolerane in produced in the increase in Complexity and Criticality.The Tolernace hypothesis is one for future 'dynamic' ecological robustness. The agent-environment at the edge of control rather than the comfort of control (see, 3.7 – Affective Behaviour for a Divergent Criticality Hypothesis, p107).

We might reasonably question to what extent agential-mediation is in effect in such affective-behaviour? Such questions are to be explored in the 'nature' of the construct of cognitive-processes towards tolerance: Perception emerges as an 'affective' agential perogative congruent with affective drives and behaviour, an agential perception of ecological functioning. This suggests a perceptual-awareness from such cognitive-processes predicated on agency and encounter (Berridge & Kringelbach, 2013; Cisek & Kalaska, 2010; Clark, 2013; Craig, 2014; Damasio & Carvalho, 2013; Niv, Daw, Joel & Dayan, 2007; Northoff & Hayes, 2011; Pessoa, 2013; Schroeder, Wilson, Radman, Scharfman & Lakatos, 2010; Van Orden *et al.*, 2011; Wilson, Laidlaw, Butler, Hofmann & Bowman, 2006; Zahm, Parsley, Schwartz & Cheng, 2013).

A seemingly simple 'value-contingent' mechanism that 'drives' perception function to the 'edge of control' (Tolerance hypothesis), may now be aligned with more complex neural-moderation and mediation as 'intentional' (Bandura, 2001; Merleau-Ponty, 1945; Ryan & Grant, 2009; Walker, Brooks & Holden-Dye, 1996). Damasio (2010, p92) describes perception through affective-cognitions as "action programmes encoded by emotion".

Perceptions, might then be considered, emotionally-constructed cognitive processes that 'become' as a phenomena, but are a subjectively-constructed percept of a state of affective-functioning. Perceptions 'become' states of tolerance in function defined through agential goals and neural efficiency in approaching those goals.

2.12 Tolerance as a Neural Efficiency

The dynamic prerogative for a cognitive functioning of parallel-processing, demands an amalgam between environment, agency and an innate 'drive' for ecological engagement. This innate drive assists somewhat in framing Chemero's and Warren's call for a functional or naturalistic 'mechanism' of Affordance and therefore, perception. Such a mechanism should be grounded (on biological-value) and phenomenologically moderated as a cognitive-emotional process (Chemero, 2008; Damasio & Carvalho, 2013; Panksepp, 1998; Panksepp & Biven, 2012; Warren, 2006).

Functional Affordance in defining a Tolerance hypothesis provides a situated, affective perception, biased by agential mediation[28].

2.13 Generative Models of Representation

Generative models immerse the agent in ecological interaction, allowing for the emergence of regularities in cognition and behaviour, a complementary synergy of "stability and flexibility" for perception (Warren, 2006, p358).

Phenomenological or 'higher-order generative processes' are the evolution of ever more complex-cognitive-processes or 'perceptions' towards life-regulation. This is reflected in ever more dynamic ecologies through ever more complex composite processes. Such processes and perceptions that may be considered 'grounded' in affective-behaviour (life-regulatory drives) and made emotional-cognisant in a value-orientated agency and action (Damasio & Carvalho, 2013). Perception then, becomes defined by affective-behavioural 'programmes' or drives for action, regulated by cognitive-emotional agency in relation to ecological-value.

Such a selectionist proposition would see affective cognitions that optimised not only for the present, but be able to anticipate and optimise future situations. Such anticipation sees agency as a 'top-down' drive, an agency that amalgamates 'bottom-up' situated with contextually-generated cognitive processes towards a tolerance optimum.

[28] For example, the cognitive experience of Disgust, an innate affective-behaviour associated with ecological value (such as the mouth-closing effect to sour or stringent foods that would have posed a biological-cost or threat – poisoned or 'off' food): These affective cognitions may be experientially mediated as is observed in cultural-learning bias. e.g., Some cultures give great value (pleasure) to some food-stuffs (rotten fish / fermented lactic proteins [cheese]), whilst other cultures are disgusted to the point of vomiting (see, Curtis, Aunger & Rabie, 2004).

How such a ‘generative’ composite of bottom-up and top-down cognitions is attended-to requires the following questions be answered: how and what does ‘attention’ find salient and how does the brain model this information? An attending and attention of cognitive processes for a perception.

Knudsen (2007), approaches such attentional prerogatives through resource-biasing along situational and contextual pathways:

1) Bottom-Up stimulus; situational information-cues from and of ecological-engagement.

2) Top-Down cognitions; contextual-information ‘generated’ by our own neural apparatus.

These notions are now explored further in order to operationalise a mechanism of function for a perception of ecological tolerance.

2.14 Cognitive Processes of Attention

From a broad ethological perspective, Panksepp (1998) and Pessoa (2013) consider that cognitions are fundamentally emotional-constructs from an affective-behavioural base. Panksepp and Biven (2012) extrapolate further: in that the foundations of such affective-behavioural cognitions are ‘innate’ life-regulatory drives for engaging with the environment[29], action motivations that become emotionally affective as cognitions (Damasio & Carvalho, 2013). Therefore an attention for engagement and action-control would see emotionally adapted cognitions contextually acted out within a situated ecological landscape.

“action programme and the respective feeling are often referred to by the same name, although they are distinct phenomena. Thus ‘fear’ can refer to either an emotion [the set of programmed physiological actions triggered by a fear-inducing stimulus] or a feeling [the conscious experience of fear]” (Damasio & Carvalho, 2013, p144).

Attention, then, as an agential emotional-construct of action and control is grounded by a bottom-up actuality of being in a situated landscape of experience. Therefore attention might be described through action-control as an ‘informed’ agency: That is to say, bottom-up attention mediated by top-down agency becomes an informed, generated – action goal.

[29] Evolutionary affective behaviours such as; seeking, playing, lustful reproduction, nurturing, fear, anger, etc.

2.14.1 A Parallel Processing of Information

This resource-biasing through a bottom-up sensory approach to perception, is one that resonates with Panksepp (2003) in its ethological bases, but also accommodates the functional duality in being sensory 'and' action orientated (Hickok, 2014). This is an informational-perspective to perception: 'informed' attentional processes as a composite construct of attention, an ecological-cognition from the environmental 'information' transponded through sensory apparatus[30], then integrated within an internally generated affective-emotional model (Clark, 2013; Craig, 2014).

Much research had viewed attention as a cause and effect paradigm, where neurons were viewed as either sensory-responsive (causal) or motor-active (effect), a cognitive entrainment to action as a perception (Hickok, 2014). Such linearity has been challenged through the need for cognitive (parallel) processes in a perception function to accommodate both situated and contextual neural-information (Cisek & Kalaska, 2010; Gallese, Fadiga, Fogassi & Rizzolatti, 1996; Gold & Shadlen, 2007; Schall, 2004). In advocating the increasing recognition of the role of action 'selection' in information processing, control theories for perception should be reappraised and "viewed from an ethological perceptive" (Cisek & Kalaska, 2010, pg16) if to be considered, truly ecological.

It would seem that two worlds are brought together through the engagement of the individual with the environment: an internal agential-representation 'grounded' in sensory information for the best Biological-Value. These parallel processes generate an affective cognitive perception as a generative representation. Here attentional-bias within such a composite is defined by the resonance between the internal representations and external information (engagement informed). Ecological resource-biasing requires a generative-attention to be value oriented in accordance with biological-value; therefore engagement behaviour becomes 'affective' as emotionally-constructed cognitions of bottom-up and top-down processing (Damasio & Carvalho, 2013; Panksepp & Biven, 2012; Pessoa, 2013). Agential mediation through goal-oriented agency provides for a 'controlling' moderation of Affective behaviour towards optimal Biological-Value.

2.14.2 Attending to a World of Ecological Information

When perception as Affordance is viewed through feature-change (Chemero *et al.*, 2003), this directs us towards neural-processes for information becoming functional through attentional bias

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[30] Transponders as relating to sensory information receivers (of information as electro-chemical signals). These manifestations of energy (e.g. pressure for hearing and touch; light-waves for vision; chemical-potentials for smell and taste, etc.) are turned into the electro-chemical language of the brain.

towards that feature-change. We might then ask, how is that information represented through our sensory and neural systems, and how do we resonate, control, and agent-ally inform, cognitive processes in view of this information complexity?

Contingent in this exposition, is that, in defining the processes for accessing biological-value becomes action-biased and may be explored through an attention-directed approach to such action-bias. Perception from the 'Tolerance' proposition we have outlined in (2.6 – Tolerance and Generative Models of Control, p25), is a perception of the information through feature-change (divergence) accessible to the individual (Chemero, 2003; Gibson, 1977; Noë, 2004; Stoffregen, 2000a). Affordance then might be conceived as an perception of ecological engagement from the information available 'and' the agential capability towards accessing that information. An autopoiesis of relational-embodiment of the individual 'in' its perceived world, not one 'of' perceiving its world (Merleau-Ponty, 1945).

2.15 Self-Organisation in Neural Networks – Information is King

Sensory stimuli for such a bottom-up 'informing' of attentional processes might be better considered in terms of its information-signature rather than any symbolic representation of the world. This is a bottom-up 'signature' that is a composite of the cognitively-represented (known) and the unknown (surprise). Information is afforded a primacy over any modal representation in the context its functionality (Anderson, 2016; Karmiloff-Smith, 2009) and such a primacy is evident in observations of functionality over modality, where efficiency in action and cognition is orientated to the information available or accessible (Anderson, 2016; Bach-Y-Rita, Collins, Saunders, White & Scadden, 1969; Held & Hein, 1963; Hubel & Wiesel, 2005; Sur, Angelucci & Sharma, 1999; Uttal, 2011).

Perception and phenomenological research is pursuing such a 'grounded information' approach in neural-functions through a radical enactivism approach to perception, movement and cognition (see, Kello & Van Orden, 2009; Kelso, 1995; Macklem, 2008; Thompson, 2007; Van Orden *et al.*, 2011; Wallot & Van Orden, 2011; Zanone & Kostmbiec, 2004). Increasingly, perception and behaviour is being found to be influenced by a primacy of the information-accuracy. Attention as a cognition embodied for 'information', allows the consideration of neural function through such information theory, the functioning of perception as the efficiency of the information to function. In cognitive processes for perception it seems – 'information' is king.

This study looks at cognitions and behaviours in terms of such 'neural-function' towards information over representational-symbolism or modality (Karmiloff-Smith, 2009). This is a function of neural-efficiency towards ecological information, requiring that we question previous 'cognitive science' as symbolic processes and therefore, cannot fundamentally represent the complexity in function needed for an ecological perspective of biological-value for perception[31].

In this study, Self-Organisation is explored as a self-informed 'fundamental mechanism' of information function for biological-value. This is seen agential behaviour and cognition where Self-Organising criticality drives ecological engagement and will be hypothesised to provide a mechanism for a Tolerance hypothesis for perception.

2.16 Representing the Information

The essence of an ecological perception is one of function and control in relation to the ecological determinants. This is achieved through an information 'stability' concept in non-symbolic representation, information that the brain uses to decipher, predict and resonant in its sensory engagement with the world.

Though we reject the linear processing of information, we are still able to employ the conceptual schemas and 'arcs' of Hebbian networks (1949), but these should be conceived as whole brain representations of flowing functionality (Anderson, 2016). This sees a 'perception' as attention, through the representation of bottom-up sensory information informing an agential capability to feature-change, through top-down mediation and moderation. Though such an 'information' approach implies a mechanistic processes, an approach that should be cautioned against as 'quasi-computational' by Cisek and Kalaska (2010), it is in the considering of a Self-Organising resonance between agential goals and information-function that an 'attentional-mechanism' allows a

[31] The dominance of this computational approach may have obscured more fundamental mechanisms for cognition and behaviour by tying to constrain informational divergence rather than tolerance it. Uttal (2011) similarly appraises much of our current brain research as an over-reliance on positivistic approaches to scientific inquiry, how are we to be able to determine network-input with network-output in such network of biological complexity[31] (Burton, 2008; Stein, 2013). The computational specificity of Cognitive Science that hoped to validate cognitions as causal effective, provides only causal-description be it of ever of more refinement and reduction

theoretical-space for a perception of agency and intentionality. A perception embodied for information:

"patterns of activity, and cognition as a process in which a network of connections settles into a particular state depending on the input it has received and the connection weightings it has" (Shapiro, 2010, p47)

2.16.1 Information, Accuracy and Agency

Affordance as feature-change (an Affordance event or surprise) may be electrochemically represented as an information signature, and it is the 'quality' of knowing, (our capability in representing that information), where we might conceive of an 'accuracy' in neural function towards biological-value. This is our neural-efficiency towards representing the information accurately, a neural-efficiency that creates a 'stability' or equilibrium point, 'constructed' through a composite of bottom-up and top-down information (or more accurately self-emerges, see, 2.33.2 – Local Criticality in Self-Organising Dynamical Systems, p77). This representation is then given salience through the accuracy of situational adherence to that stability-point, a mistake-contingent divergence in the flow of situational information.

A functional-efficiency towards biological-value is a representation of the accuracy in this conveyance of the external (situated) information to the internal-generated representation. This allows an agential (capability) measure of accuracy towards an Affordance event as an agent-environment perception, an autonomous proposition.

In describing perception through informed agency as information-stability, the equilibrium point may be considered an agential end-point (Won & Hogan, 1995). Perception as attentional-stability (or more accurately, the divergence from stability-equilibrium) comes to represent the perturbation from that agential 'end-point'. In considering attentional processes defined through 'agency-accuracy', we can consider a perception of attention with regards to a 'tolerance' to such divergence from that agency end-point. Generative agential 'stabilities' become predictive agency end-point goals, and engagement informs the accuracy of such generative-representations, a perception through the divergence of internal representation and external actuality.

Rather the symbolic-representation of the information, this definition allows a neural efficiency function 'making' a perception rather than any 'taking' a perception from the world. Perception becomes a process of feature-change information represented in terms of the quality of its agential information capability. Efficiency in cognitive-function towards feature-change is seen as a moment of percept-stability in the flow of information, an 'episodic' moment as a state of functional Affordance.

This amalgam of a 'sensed' and 'agential' perception construct, 'tolerated' in its accuracy of representing the information flow (a mistake contingent model), will form the bases of a neural-efficiency towards resonating with the information for biological-value. Indeed it will set the foundations for perception as an attentional construct as a state of Effectivity-tolerance to the ecological information engaged with;

"Each perceptual system orients itself in appropriate ways for the pick-up of environmental information, and depends on the orienting system of the whole body ………. they serve to explore the information" (Gibson, 1966, p58)

Effectivity-tolerance implies a relationship between ecological information and neural-representation that can never be, perfectly resonant. There will always be the different. Any information-signature therefore will be distorted by 'noise' and is at best, a 'probable' representation.

This probabilistic quality of representation relies on; the degrees of capability in our situative Effectivity and agential context. Noë (2009) refers to this as an 'Accessibility'. However, as a composite construct, this is still encapsulated in the Effectivity or cognitive-capability of the individual's 'available' neural-stabilities[32] to constrain the degrees of freedom presented in any feature-change.

As Effectivity defines neural tolerance as a state of cognitive-efficiency toward life-effectiveness, Tolerance comes to represent the functional 'attending' to situated sensory and contextual agential information in order to utilise biological-value. A functional Affordance then, is the resonate-relationship between our Effectivity-capabilities and the dynamic demands of ecological engagement – the informational environments of; the situation, the social and the self.

[32] Perceptibility might be considered as one description of the 'agential' end points (top-down goal oriented) of neural stability. These become better defined in the concept of relative Effectivities to reflect the agential inhibition on Effectivity. As a perception, is able to be modelled in a reduced Voluntary Control (Control and the Agency of Voluntary Control, p62).

2.16.2 Perception an Attending to Ecological Tolerance

A perception as a temporal information-state, then, is a 'moment' in neural processing as perception 'flows' through and an ecology of feature-change in a flow of cognition precepts: temporal states of efficiency-functioning defined through Efficiency-tolerance.

Our senses, rather than internalising a reflection of an external world, are better conceived as 'transponders' detecting ecological information, that is then attended and cognitively-constructed into goal-oriented action for ecological engagement. This is a perception of tolerating ecological engagement and agential mediation whilst maintaining biological-value.

2.17 Perception as an Attentional Awareness State

Attention, then, as a neuro-psychological description may be considered a cognitive-construct of competing neural resources. This is a biased 'attending' of top-down and bottom-up cognitive processes towards to 'salient' information (Cisek & Kalaska, 2010; Clark, 2013; Milner & Goodale, 1995). This differentiation of 'attending' and 'attention' hints at the biases that might affect such attending and salience, the cognitive-resource processes towards a perception of ecological tolerance.

By considering an ecological tolerance directs us towards exploring the construct of 'attention' through naturalistic and ethologically value propositions (Cisek & Kalaska, 2010) and to adopting an agential approach to neural processing (Chemero, 2009). Such a competitive, agential and as we shall see, hierarchical, composite of attention processes has been widely documented across many affective domains: e.g. physical performance (Eysenck, Derakshan, Santos & Calvo, 2007; Miyake & Friedman, 2012; Wilson, 2008); neural function (Lavie, Hirst, De Fockert & Viding, 2004) (Baddeley & Hitch, 1974; Posner & Boies, 1971); social interaction (Graziano, 2013); motivation and interest (Chen, Darst & Pangrazi, 2001a; Deci, 1992); learning (Illeris, 2003b; Knudsen, 2007). What seems ubiquitous across such diverse reporting is that attentional-bias is both ecologically-situative and relationally-contextual (Cisek & Kalaska, 2010; Franchak & Adolph, 2014; Schroeder *et al.*, 2010).

2.17.1 Attention Models of Composite Construct and Control

Hardy and Fazey (1987) presented such a composite of cognitive and physiological demand through attentional processes as affective on behaviour (performance). This was formulated as an alternative to the historical 'Inverted U hypothesis' (Yerks & Dobson, 1908), of cognitive habit forming learning and physiological demand (electric shock)[33].

However, since its initial psychological-physiological application, attempting to incorporate cognitive top-down demand into physiological performance, Hardy, Beattie and Woodman (2007) have encountered a richer and more complex landscape of cognitive-physiological interaction and confounding function (see Discussion, 8.4.3 – Divergent Criticality: Contributions to Cusp Catastrophe Theory, p229).Though the attentional constructs in the Hardy and Fazey (1987) Catastrophe model takes account of interdependent cognitive constructs (the influence of either top-down or bottom-up cognitive processes), this model might be critiqued as a static landscape, one that does not adequately account for the dynamic effects of these attentional biases on cognitive resources (Cohen, Pargman & Tenenbaum, 2003; Tenenbaum & Becker, 2005). That is to say, that though the catastrophe model (below, Figure 11) 'seems' to accommodate attentional demands and agential mediations (in an anxiety construct), this is done in fixed landscape of situated 'physiological arousal' and contextual 'cognitive anxiety' – the 'performance surface' is seen as static). As we shall see, in Self-Organisation, a more dynamic 'landscape of function' needs to be considered, one that reflects the double edged sword of agential cognitions on function: the reducing of attentional resources for bottom-up surprise, but also, top-down demand on attentional resources changing the profile of the functional catastrophe performance-surface.

However, the recognition of performance (surface) parameters in Catastrophe models (Thom & Fowler, 1975; Zeeman, 1976), does allow us to consider parameters as efficient functioning in action from attentional processes of cognition (e.g., Figure 11, below). A perception for efficient attention and control.

[33] It should be noted that these experiments were conducted on rodents. With the application of Divergent Criticality in a Tolerance hypothesis we are able to offer an ethological perspective to these results that aligns the inconsistencies that inspired the catastrophe model of attentional behaviours.

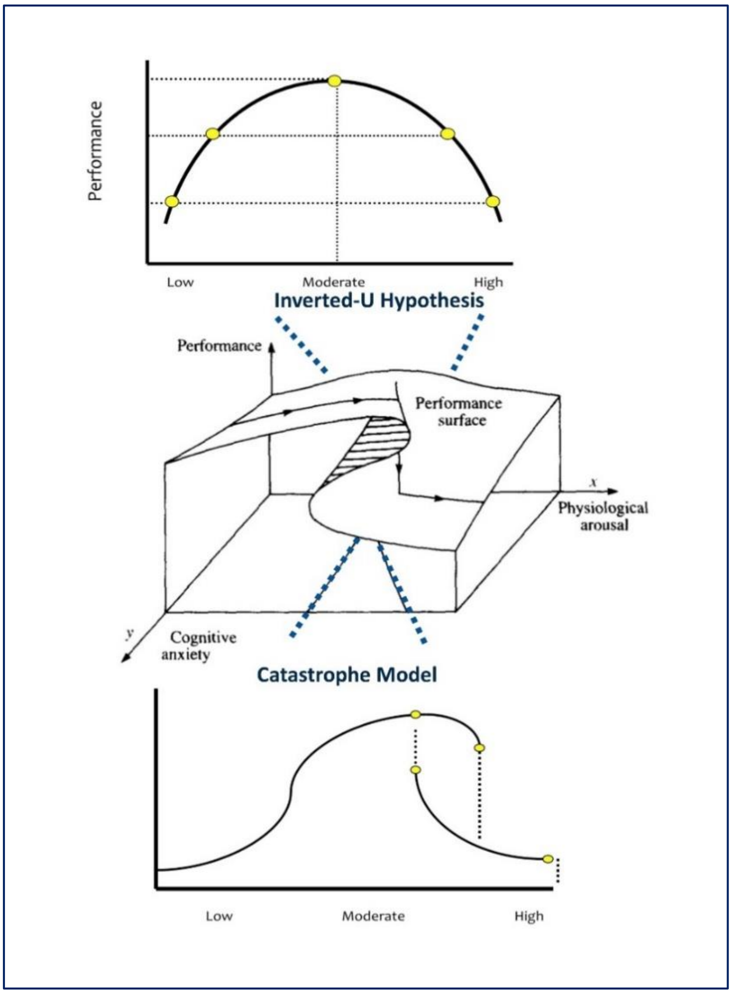

Figure 11 – From Inverted U Model (Yerks & Dobson, 1908) to the Catastrophe Model adapted from (Zeeman, 1976)

2.17.2 Attention and Control

As an agential construct for ecological engagement, attention has been described as the action-control of seeking of stability through intentional 'end-effect' actions (Merton, 1972; Rothwell, 2012). An agential control that has been described as a Voluntary Control by Van Orden *et al.* (2011) One necessitating action or action-control to achieve that 'end-effect'.

Such action-control has seen a re-application of Motor Theory, a theory originated from research in language perception (Galantucci, Fowler & Turvey, 2006; Liberman, Cooper, Shankweiler & Studdert-Kennedy, 1967). Motor Theory as a perception for the 'control' of action, is a perception theory of sense and action to engage and facilitate biological-value in a world of opportunities and threats.

It views cognitive-processes as a complex synergy of control variables and recognises the interplay of both internally generated variables and ecologically entrained variables for action to be constructed in the maintenance of a cognitive 'efficiency in action'. In defining thresholds of efficient-function in these interrelated variables, an 'Equilibrium Point' (Feldman, 1986, 2011), is a stability 'controlled-for' in an equilibrium of information processing (this will be explored as a entropy steady-state in, 2.30 – Neural Functioning in the Free Energy of Phase: Entropy Principles, p69). This is a theory where each variable is influenced and affective on all others through competitive biasing. A stability end-point (a finitude of function from the multitude of possibility) is produced from the internal and external information available in a Voluntary Control.

Such self-organisation toward an intentional end-point is a 'soft-assembly' of neural function for behaviour[34] (Kello & Van Orden, 2009). This highlights the perspective of function over form: No set 'schema' or 'arc' could account for such end-point stability across so many possible Degrees of Freedom. However, a 'generated' and iteration of self-organising representation, can, assemble body-environment information and attempt to reduce sensory divergence from the perception – intentionality, in the enactment of that end-point. The agency defines the equilibrium-stability or efficiency in function, as much as the Affordance demands on Effectivity. This is the self-organisation in agency as a neural-capability towards ecological demand.

Accordingly, an attentional-model, is a self-organising model of action-control that needs to address the core issues of such an end-point stability – what variable(s) become salient and selected for efficient control, between the situational demands and agential context (Posner & Boies, 1971).

2.18 Competitive Resources for Action Selection:

Neuroscientists (Chialvo, 2010; Cisek, 2007; Clark, 2013; Friston, 2010), outline this composite demand on neural resources in a functional action model of attention. This is the recognition of not only contextual (top-down) and situated (bottom-up) cognitive pathways, but also of the interdependence of these pathways working in parallel. Such interdependence becomes agential through what has been described as the 'Executive' functioning of attentional processes (Baddeley, 2007; Eysenck *et al.*, 2007; Miyake & Friedman, 2012). It speaks of a cognitive resource-biasing in a model of attentional function, as a competitive process for cognitive resources that requires an attending to the most salient cognitions for most efficient end-point (outcome) delivery. These are

[34] End-point or goal soft-assembly can be graphically demonstrated in the completion of a personal signature (Strawson, 1959): Whether on paper or on a wall, essentially the same signature is created in the face of the many 'different' degrees of freedom available through differing body-environment variables as a stability end-point in intentional action

processes of frugality and optimisation in neural function and a tolerance towards the cognitive demands made on attention. It is this ecological 'Tolerance', that defines effective neural-function for biological-value and allows us to consider 'attention' and 'biological-value' as constructs of an efficiency-biased perception (Clark, 2015).

2.19 Affective Bottom-Up and Top-Down Cognitions

Action-selection might then be considered as an affective-cognitive accommodating the parallel, situational and contextual pathways (bottom-up and top-down), for an attention of composite-complexity. If selection pressures favour increasingly agential contextual-complexity, then increasingly complex contextual constructs of agential cognition would be selected for; If the environment demands situational interest, then bottom-up cognitions would become dominant.

Importantly here we can surmise, that increasingly dynamic environments would select for greater tolerance via greater anticipation and intentionality towards future oriented goals (stability end-point) for biological-value. We see here intentionality increasingly becoming a dynamic driver of ecological tolerance in increasingly dynamic environments. One extreme example of this composite selection is the behaviour of a Sea Squirt (Llinas, 1989). Here a neuronal network is present in sea-squirt lave, as they search for an environment that optimises their biological Effectivity. When such an 'ideal' niche has been found, the sea squirt stops moving, buries its head in the sand and then ingests its own brain as it no longer requires such a complex contextual response to access optimum biological-value. This highlights several ecological determinants on cognition processes: a) the importance of neuronal-networks for a composite of agential (parallel) processing – a perception of agential action; b) It illustrates the biological-cost such a complex function – agential function is inefficient to biological-value as top-down cognitions are expensive: there must be an overall (goal oriented) benefit and therefore; c) Dynamic environments 'demands' agency in goal-oriented cognitive constructs to present better future biological-value via a greater ecological tolerance.

What should be noted from a any theory for action selection, is that attention is represented as an affective-cognition from external information: We imbibe information into our own emotional attending. This should not be confused with an 'awareness' of attention, indeed, as such, this is an introspective attending to that might be viewed as a non-conscious processing of information. This is still a generative approach as the individual 'brings' their relational context (an agency of past for future to the situated 'now'). However, if we are to use perceptions the test out Tolerance hypothesis, we need to answer Stroffengen's 'why' question: why such introspective attention(s) should become known as a perception. Maybe by asking 'how' affective cognitions and behaviours become known to us as awareness of attention – perceptions, might allow for perceptions to be inferred as attentional processes made cognisant.

2.20 Attending to Attention: Motor Theory as Awareness

It is in the information application of Motor Theory, that how such attention information may become an awareness of attention, a perception of attending to attentional processes (Hickok, 2014).

To be able to attend to an 'other's' proxy experiences, an internally represent from attention to external (bottom-up) information, is efficient for an action perception as 'information at a distance'. This is the observation and representation of another's Affordance state from sensory information-cues observed of that 'other's' functional state of ecological tolerance. Cues such as facial features, warning calls etc. Importantly this is highly valuable information, information that has already been attention-distilled by the 'others' cognitive processes. This is an end-point cognitive-emotion cue without agential engagement and its ecological cost (maybe knowing about a tiger before experiencing a tiger!). As an intentionality of cognitive-value from predictive processing, such extra-perception represents a selectionist saving and therefore tolerance frugality in Ecological Cost.

This is not mimicry or empathy, but an attending to ecological-information from the attentional or functional state of another. Nothing more than the vicarious use of another's attentional-behaviour, just as the many extra-perceptual information-gathering (ecological) opportunities. Another information 'source' to be agent-utilised such as heat, cold, food, etc. The observer 'internalises' the information from another's attention-state for an affective emotional-cognition of their own.

The informational ecological-landscape, now not only encompasses the physical environment (be in inanimate or biological), but allows a societal environment of information to emerge. This has been conceptualised in Social Cognitive Theory as a societal agency (Bandura, 1986; Bandura, 2001)

Such awareness as experienced through the 'extra' perception of Affordance-states seems ubiquitous; from the entrainment behaviours across the species, warning signals and calls spanning many species; to more nuanced emotional-cognitions passed between individuals. Ethnological research is seen to support such agential attention to affective-state(s) of others, and is observed in societal behaviours seen across species that utilize not only the attention of 'other', but many other 'societal' functions of information (for example, Emery & Clayton, 2004; Gómez, 2005; Graziano & Kastner, 2011). This has the advantage of inculcating the costly processing-product of another's ecological experiences, into your own intra-perceptive feelings. Attention at a distance, feelings for free. This is a neurally efficient proposition in agential anticipation and therefore, one of selectionist value that seems to support an attentional 'bias' towards attending to attention (Anderson, 2003; Clark, 2013; Craig, 2014; Graziano, 2013; Hickok, 2014).

Rizzolatti and Gallese (1996) in their action-control research found that neurons considered as 'sensing-only' were also seen to fire as motor-neurons, a seeming duality in modality of neuronal function. Though a 'mirroring' hypothesis of empathy and altruism is often cited as the purpose of such duality in neuronal function (mirror theory – monkey see, monkey do), many of the assumptions and assertions that have been made as to the veracity of such mirroring as a shared-awareness have been found wanting. There seems little direct evidence of such a mirror hypothesis as an effective or causal functioning (see, Hickok, 2009; Kilner & Lemon, 2013).

Rizzolatti's (et al.) neuronal-duality, fits more comfortably into a 'motor' theory interpretation. Hickok (2014) has appraised the 'duality' seen in neuronal functioning as processes best viewed from an ecological information perspective: an 'Awareness of other' becomes merely a representational information source for agent's own ecological function (not for the 'other' as in an empathetic cognition). Hickok views such awareness as; treating another's attentional state as, just one more ecological information source for your own survival, rather than any empathetic 'awareness' as in mirror-theory.

It can be conjectured that it is the 'information' in such encounters that is observer-affective: You may attend to your own ecological needs through an attention process oriented towards another's emotional functioning. Awareness of 'other' becomes 'one's own' affective emotional cognitions, projected. Again a functional Affordance of individual-environment autonomy.

As attentional-information (attending to the informational cues from another), has the attentional effect of the projection of one's own attentional-state onto the source. This notion is one of perception as a phenomenological perspective (Merleau-Ponty, 1945) and such self-anthropological conceit was poetically focused in Nagel's (1974) "What Is It Like to Be a Bat": Even though these are sensory expositions towards an others agential projections, Nagel succinctly expressed the uniqueness and primacy of the individual's own agential cognitions towards any appraisal of other's state of cognitive function: You do not 'mirror' another's emotions, you can never truly know them, you merely project your own attentional-state and associated emotion, towards them.

Sensory and motor neurons Hickok (2014) suggests, fulfil a duality of function in 'sensory' information processing and 'action' affective-behaviours. This is an important distinction, it moves 'perception' towards cognitive-processes that elicit an awareness through affective processes. Here sensory-information from bottom-up information-cues (of other) becomes attentional biased and internalised as an agential (observer) emotional cognitions, an amalgam of sensory and action processing for a cognition-emotional 'affective' behaviour. Affective behaviour that biases a best behavioural outcome by the accuracy of constructing and representing others emotions as self-agency; stolen emotions able to advance one's own biological-value. Perception as an awareness was ever a truly selfish selectionist-behaviour (Dawkins, 2006). Such an information-approach then is able to account for the many iterated affective-behavioural adaptations associated with models of societal and evolutionary theory (e.g., see game theory, Maynard Smith, 1974).

2.21 Awareness of Attention – Affective Emotional Cognitions

One of the biggest issues in a Phenomenology is that of how a consciousness or a perception is made subjectively aware. Here we address not the 'hard' problem of how consciousness 'comes to be', [Chalmers' (1995) 'a consciousness of self'], but in proposing a possible efficiency-model for awareness, we seek to provide a mechanism for such awareness to 'be'. Not an attempt to unravel the complexity of self-consciousness, more so the exploration of a theoretical and conceptual 'space' for a 'perception' as an 'awareness', to become.

How attentional resource bias might result in awareness can be considered through information theory: By treating all attention-states as information-states, an 'attention of other' becomes an information-cue providing the agent with a richer ecological information source of biological-value (an agential emotional state built on another's ecologically-distilled information). This has selectionist worth, favouring attending to the outcomes of other's attentional states, and appropriating a cognitive-emotional state of your own (i.e. projecting or externalising your emotion to the other).

However, though the 'attending' to other's attentional-states might allow us to consider attention processes as cognitions made feeling or aware, this externalisation merely shifts the problem of 'why' any attention states might be known from the intra-perceptual to the extra-perceptual, as Noë puts it (2009, p9) " the machinery of mind is extended", but still does not answer why perceptions become known to the agent.

We might take this hypothesis of projection-similarity further, however, through a societal-similarity hypothesis (Bandura, 2001; Graziano, 2013; Graziano & Kastner, 2011). Such a projection-hypothesis is at its most acute and accurate when the projections of 'our' attentional-state are in relation to an organism of close (species or behaviour) similarity. The accuracy of the attentional projection will correlate 'better' between species-similarity. The more accurate your representation of the world, including your projection of other's attentional-states, the greater the biological-value conferred.

What differentiates this accuracy in societal approaches to attending to others, in biological-value, is the accuracy of recursive feedback 'between' one or more organisms of a similar species. This allows a resonance of observation and feeling to be more accurately perceived.

2.21.1 'Attention of Attention' becomes 'Awareness of Attention'

Societal adaptations for biological-value are seen across many species from 'sub-sociality' solitary animals that may only share limited communication (say information for procreation), to highly advanced 'eusocial' groups such as ants and colony bees (Nowak, Tarnita & Wilson, 2010; Smelser & Baltes, 2001). Quintessential to societal associations is the operation of a recursive feedback process between the individuals. Such bi-directional feedback presents many biological-value opportunities for societal organisms in complex (dynamic) environments. Attention, informed by similar 'others' provides information for efficient engagement with the environment. Societal information therefore has a selectionist bias – we pay more attention to the 'similar', in the recognition of a more biologically resonant information source. Such a proposition is seen in entrainment behaviour.

Graziano (2013) suggests that a similarity of phenotype allows iterative feedback to become resonant in real-time, thus allowing emotional cognitions (the cascading neural processes for responding to the biological-value) from another to be 'affectively-graduated' by one's own behaviour.

Again, no causal inference is offered here, merely the selectionist-space for attending 'to other' to be considered as one's own cognitive-emotional state. As affective cognitions are graduated in a 'similarity of action', projected emotion presents an opportunity for social perceptions to become graduated to affective behaviour (if they do that, I feel this; therefore, when I do that, I feel this also). An awareness of the affective cognitions of another, can becomes an awareness of self-affective cognitions[35]. It may be that we had social awareness before perception (Graziano, 2013).

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[35] Note: This is not proposing a self-awareness hypothesis; only, that the complementarity of action-control and emotional regulation (for affective behaviour), there exists the selectionist bias 'of' why a perception of self, no matter how and why it might become, can be used to infer attentional processes for biological-value as an 'awareness' of those cognitive processes towards biological-value functioning – Perception as an awareness of attention.

By hypothesising that extra-perceptual attention of other's emotional states, as they are projections of the agent's own attentional processes, may be extrapolated to representing the agent's own neural-function. Such awareness becomes graduated, allowing for neural-process to be conceived, through behavioural engagement, as 'operant-discriminative' cognitive processes (Bandura, 2001; Linden, 2003; Pavlov, 1927; Skinner, 1938; Thompson, 2009).

In dynamic environments, societal communication can confer greater evolutionary robustness, allowing for greater operant-conditioning through efficiency in ecological engagement. This relationship between agential awareness and functional efficiency, promotes a known perception through agency towards ecological control and goal-oriented agency.

Awareness, as a societal construct, allows a perception to be considered as drawing on the same agential control processes as attention, and therefore of control. This societal imperative of an awareness of agential control can be observed across anthropocentric evolution (Dawkins, 2006; Dunbar, 1998; Dunbar, 2003; Harari, 2011; Maynard Smith, 1974, 1982).

Graziano (2013, p132) dispels the necessity for any causal determination to this proposition. Whether it be socially founded or self-founded in some respects, does not matter. Therefore no 'cart and/or horse' hypothesis is needed for societal attentional processes of attention being made, aware. All that is necessary is the selectionist understanding, that as a functional construct, awareness of attention as a 'perception' has biological-value: An agential perception permits greater 'agency' toward goal oriented 'societal' outcome behaviours or agential end-point. In a dynamic world, the greater the perceptual ability to tolerate future surprise, the greater the biological-value.

When now approaching Stroffengen's 'why we perceive at all', an ecological prerogative necessitates that we acknowledge our animal condition: a bald, weak, social ape in an ever challenging world. To evolve an agential perception confers greater biological worth for the individual from the many. Whether from social agency or some other agential-selectionist adaptations, agential perception confers greater ecological worth, so is selected for. The primary life-regulation of ecological attending evolves to an agential perception for ecological efficiency.

2.21.2 Perception as Attentional Functioning and Tolerance Awareness

Cognitive-emotional affective behaviour is functionally associative on attentional processes, therefore, as perception reports on attention, so perception reports on function. We may now define attentional processes through an awareness of perception: perceptions of affective cognition representing the neural functioning for biological-value. Perception is an awareness of the neural processes of engagement: the state of efficiency and tolerance – an agential awareness as ecological learning. Perception is learning and learning – perception (whether it be the direct inculcation of the engaged new, or the iterated re-formulation of the internal known).

What is important is that perception is seen as attentional operant as an affective-cognitive-process: a cognitive awareness reflecting ecological functioning towards biological-value. Perception, then, is seen as both contextually agential but, importantly, situationally affective in its reflecting a state functional tolerance. Our perceptions, feelings and phenomenological appraisal will reflect our state of ecological efficiency in biological-value functioning. Our perceptions are not only of the 'surprise' divergence afforded by the environment(s), but also of our 'agential-demands', a divergence of a reduced accessibility to bottom-up cognitive resources from top-down cognitive demand.

2.22 Control and the Agency of Voluntary Control

It has been suggested by Van Orden et al. (2011), that a relative Effectivity (via a 'reduced' Voluntary Control, see below, p61) might be considered as indicative of an 'agency' evident as cognitive function, a contextual volition of the individual towards the environment rather than of the environment, affective on the organism. Whereas Bandura (2001) would have it that agency is a temporal extension of a consciousness: an agency operating through differing expressions, from functional (motivational) to phenomenal (intentionality and volition). Though expressed as social cognitions in his 'Social Cognitive Theory' (Bandura, 1986; Bandura, 1999), agency is seen as life-regulating information to drive a cognition of "emergent interactive agency" (Bandura, 2001, p4).

As such a cognitive-construct, agential perception infers a 'reduced' Voluntary Control [reduced efficiency in function has been termed "reduced Voluntary Control" in Van Orden *et al.* (2011, p658)]. This is a top-down drain on attentional resources (there is a cost when top-down processes become ever more dominant in a composite of bottom-up and top-down attentional-cognitions, 'reducing' the efficiency of in neural-function. In societal evolution (as discussed above), such 'top down' processes or 'awareness of attention', confers greater evolutionary solutions through agential intentionality towards greater future biological-value.

This neural efficiency function is able to be formulated through the Voluntary Control of Motor theory and applied to an Affordance tolerance model. As a perception of attentional biases (top-down and bottom-up), Voluntary Control can be thought of as ranging from the most stable, an automation or 'habituation' of attentional processes (Thompson, 2009), through to the least stable and functionally-effective, i.e. requiring greatest cognitive-attention to function. Such efficiency is a divergence from ‘accuracy prediction’ and allows a continuum of functional efficiency, as an attention state towards the ecological demand moderated by the contextualisation of agential goals.

This enables the conception of perception as efficiency in a Voluntary Control model, and can graphically represented as a state of Voluntary Control in terms of tolerance (see, Figure 12, below).

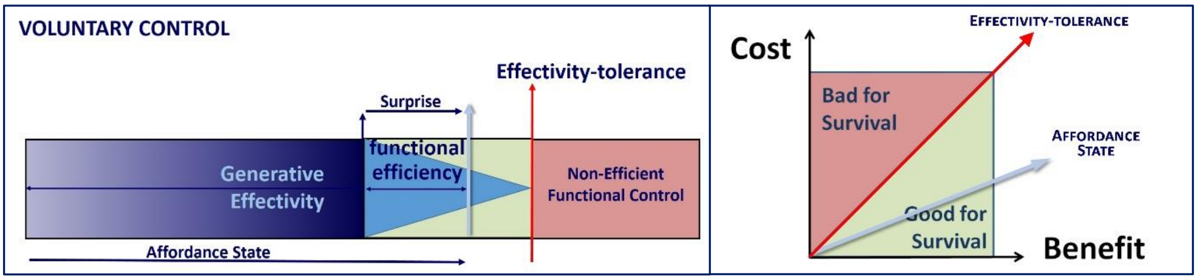

Figure 12 – Tolerance represented in Voluntary Control

This allows the interdependence of top-down and bottom-up process of attention in terms of efficiency, to be explored, in a revised model of ‘reduced’ Voluntary Control.

2.23 Reduced Voluntary Control

When attentional interdependence changes its processing biases from bottom-up ‘reactive’ to ever more top-down ‘predictive’ processing (Clark, 2015; Damasio & Carvalho, 2013), suggests an agential-perception and moves Voluntary Control from one of bottom-up dominance towards an ever more complex-composite of top-down processes.

Such agency in a Voluntary Control ‘acts on’ rather than ‘acts out’ events: A moderation of Effectivity through ever more resources being spent on a top-down agential cognitions. Such agency must be paid-for and therefore, has a functional cost. This produces a ‘reduced’ Effectivity-tolerance and

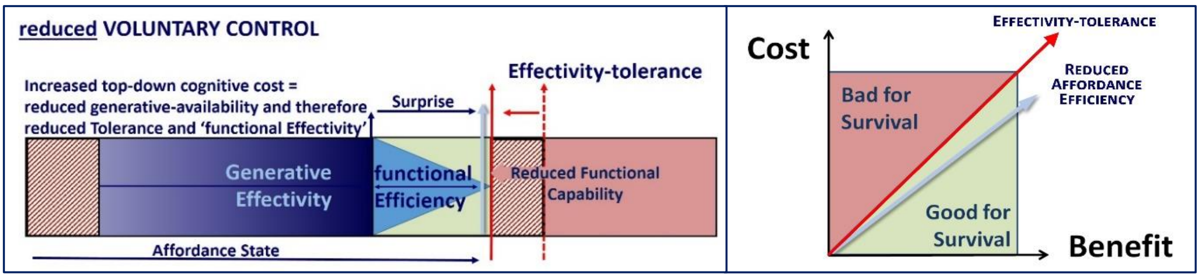

Figure 13 – Reduced Voluntary Control

In functional terms, top-down cognitions restrict Effectivity-tolerance as they demand a cognitive effort and therefore a cost. This therefore reduces the efficiency in function towards ecological management and a 'relatively' lesser Effectivity-function results. This is relative in comparison to the absolute Effectivity of the individual – you do not lose your neural capabilities, but you will exhibit a perception of tolerance as a reduced Effectivity, i.e. attentional processes and functional Effectivity will reflect the reduced Voluntary Control as an inefficiency in function more typical of novice functioning (relatively – reduced Effectivity, see, Figure 14, below).

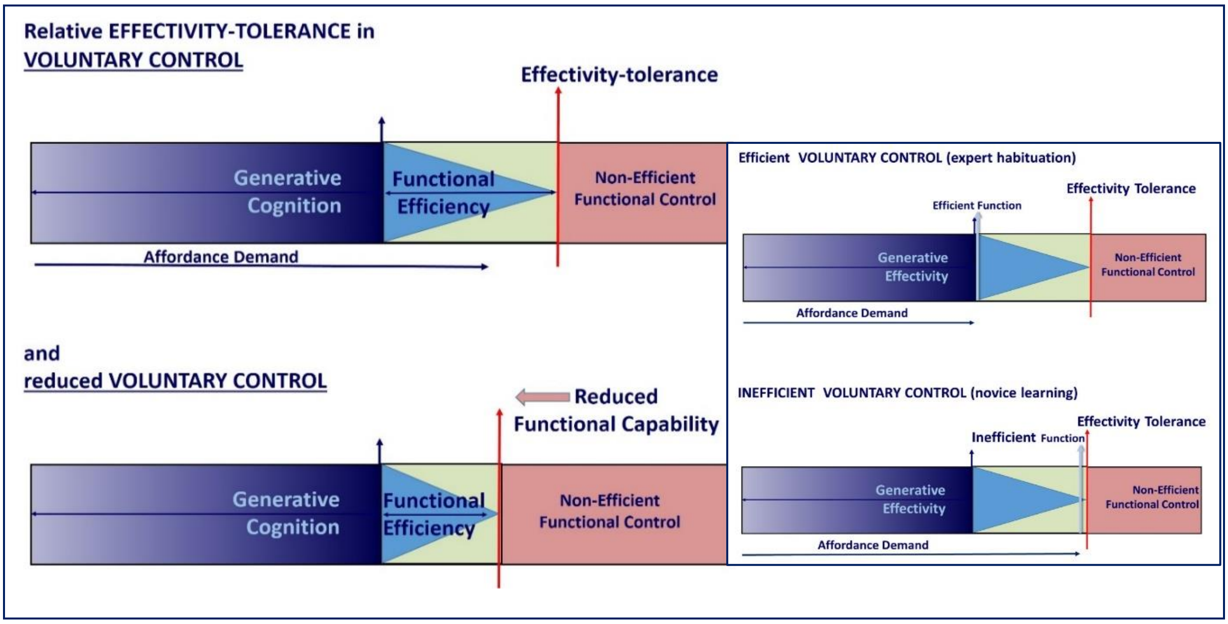

Figure 14 –reduced Relative Effectivity reduced Voluntary Control

Reduced Voluntary Control as an attentional model for a perception for action, resonates with many attentional-biased approaches to attentional states. The top-down neural functioning affecting ecological-control of an Affordance via a reduced functional performance (Eysenck & Calvo, 1992; Eysenck *et al.*, 2007; Friston *et al.*, 2010; Hardy & Parfitt, 1991; Miyake, Friedman, Emerson, Witzki, Howerter & Wager, 2000).

2.23.1 Reduced Voluntary Control in Working Memory

Voluntary Control has been formulated into a cognitive efficiency approach in neural function, one that has attempted to match behaviour and perception in neural modulation[36] [e.g. the functioning of a 'Working Memory' Baddeley (2007); Baddeley and Hitch (1974)].

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[36] Though we might be cautious of this modularity over functionality, this is explored in the discussion of Divergent Criticality as a possible functional approach to working memory (see, Discussion 8.6.6 – Agential Capabilities and Control in Cognitive Processes, p257).

Here attention is able to be subject to agency and control (Miyake & Friedman, 2012; Miyake *et al.*, 2000; Yantis, 1998) in what 'must' be top-down cognitive functions of effect. Hence, any attention (as agential and therefore, top-down) may be considered as a 'reduced' Voluntary Control to some extent. Though a working memory provides a hypothesis of neural modularity and architecture (e.g. Executive Function, Episodic Buffer, Visuospatial-Sketchpad, Phonological loop); one 'seemingly' able to offer a fairly comprehensive description of the neural process towards observed behaviour[37]; it is however, open to the behavioural criticism of being, 'behaviourally descriptive' rather than 'causally functional': Such a module-modality risks that observation confounds explanation (see, 8.6.6 – Agential Capabilities and Control in Cognitive Processes, p249), and requires better explanations how any unity function in attentional demand and control might be grounded.

2.24 A Naturalised Drive for Agency

It has been suggested by Van Orden et al. (2011), that reduced Voluntary Control might be considered as indicative of the 'intentionality' evident in cognitive function, a contextual volition of the individual towards the environment rather than of the environment affective on the organism, grounded in Dynamical Theory and Self-Organisation.

In implying the need for a naturalised 'drive' for ecological engagement and agency, any mechanistic law or formulation of Self-Organisation must be able to:

a) Differentiate between relative Effectivity behaviours with regards to their 'efficiency in function' and therefore a relative to an 'absolute' continuum of an objective or coordinating measures of empirical observation.
b) Describe not only agency, but be able to define the 'mechanism or drive' that governs agency.

2.25 Section Summary: Attention and Control

When viewed through cognitive function and behaviour, perception is able to align with ecological engagement through a parallel approach to sensory and contextual 'information-processing' in neural function, and can be modelled within a phase of neural control. This function can be aligned

[37] In particular, the interdependence of composite bottom-up and top-down attentional processes – what Eysenck *et al.* (2007, p338) refer to as the "bi-directional influences of each system on the other"

with the cognitive processes of 'attention' and the functioning of bottom-up (situative) and top-down (contextual) neural processes.

This chapter has considered a proposition of neural-efficiency in perception through the context of Motor Theory and the agential mediation of Voluntary Control. As such, agential-mediations have been able to be attributed to the attentional-processes of bottom-up and top-down functioning and can be set within a Tolerance landscape of relative Effectivity. Perception is derived as an 'awareness of attentional processes', affective cognitions and behaviours that resonate with biological-value. As such, attentional processes are able to describe a reduced Voluntary Control and be modelled in agential Effectivity. The definition of 'Tolerance' can then be made relative in an affective agential-model of attention and neural function, objectively defined in a perception of functional Affordance and able to be empirically investigated.

Though the cognitive processes for a functional Affordance are outlined and supported in this Chapter, they still lack a functional 'mechanism' necessary to be able to naturalise perception in a Universal theory. It will be shown in the next section, that such a defining 'functional' Affordance may be 'mapped' in Self-Organising Criticality (entropic behaviour) as a Divergent Criticality behaviour. When formulated in Voluntary Control, this is able to align neural function with the cognitive processes of attention and allow a testable perception measure to be developed – functional Affordance.

In the next chapter, Self-Organisation as a Non-linear Dynamical Systems theory is explored and coordinated in relation to functional Affordance. This enables the observation of perception as a composite of attentional processes (cognitions of top-down and bottom-up) to be formulated as a state of criticality functioning. If an attentional-awareness as a state of Voluntary Control is able to infer the Self-Organising Criticality function and align a 'feeling of knowing' with a 'state of function', then perceptions become testable as neural function.

Section 3: Non-linear Dynamical Systems Theory

2.26 Free Energy and Entropy: The Physics of Biological Function

"What an organism feeds upon is negative entropy. Or, to put it less paradoxically, the essential thing in metabolism is that the organism succeeds in freeing itself from all the entropy it cannot help producing while alive." (Schrödinger 1926, p71)

This chapter provides some background to the functioning of criticality in Non-linear Dynamical Systems theory. It is in understanding the components of Self-Organisation through free-energy, that allows us to interrogate the behaviours entropic functioning, in particular, the 'phase-breaking' behaviour of 'criticality', for a better understanding of self-organising phenomena and the function of Voluntary Control and agency.

The concept of 'tolerance' in Neural Functioning is founded on the 'emergence' of Self-Organising stability in complex networks such as the neural-network of the brain. The emergence of stability tolerates divergence or 'perturbation' from a stability point of equilibrium (this perturbation is the ecological 'surprise' encountered, i.e. change or novelty). Free-energy theory grounds functional tolerance in such stability formulations, and offers an approach that aligns perceptions with the Universal laws that govern our existence.

The study proposes that through a mechanism of Self-Organising Criticality in the emergence of stability, it is actually the 'tolerance' of the system in maintaining stability within parameters of ecological-value that informs our perceptions and behaviours.

2.27 Defining a Stability and Equilibrium for Neural Systems

Stabilities, in energy terms, might be considered as function around an equilibrium – a point of behaviour in energy, order and change.

2.27.1 'Classical' Stability

Equilibrium is one of the fundamental expression of energy and the laws of thermodynamics (Clausius, 1856; Gibbs, 1876; Helmholtz, 1847), in particular the functioning of free-energy available as 'work'. To consider such equilibrium and how it accounts for energy-stability in neural function, its simplest manifestation is considered: that of a stability around an equilibrium. Such 'classical' equilibrium represents a deterministic, static expression of energy that is known as Time-Symmetry

(T-symmetry) around or 'near-to' a point of idealistic predictability. This is a linearity of existence where the energy in a linear-equilibrium diffuses in ever decreasing variation, to a final-point of finality.

Contrary to such 'classical' equilibrium, we have to reconcile our observations of a world of existential prevarication, one of diverging evolution at odds with such a deterministic finality.

2.27.2 'Non-Liner' Stability

There is another approach to stability, an equilibrium of energy in systems that are 'not-near' to classical equilibrium. Such are asymmetrical stabilities of non-linearity, or 'far-from' equilibrium (Onsager, 1931; Prigogine, 1945).

Non-linear dynamic systems (NDS) permit a non-linear equilibrium to be considered. This is a dynamic stability (Close, 2014), that though able to tolerate perturbations within a defined phase of stability, when reaching a local tolerance parameter boundary, moves away from one equilibrium in a way dependant on the equilibrium and the perturbation – a hysteresis or *"sensitivity to initial conditions"* (Prigogine, 1996, pg 30).

Such equilibrium begs the question: where can stability exist for life and order in such conditions of flux? Onsager (1931) provided a 'reciprocal' stability, a stability held within non-linear dynamics and analogous to classical equilibrium: A stability, subject to, irreversible or an asymmetric trajectory of 'initial conditions', but held in a 'detailed balance' of phase (Boltzmann, 1887), an equilibrium of stability held in place for a moment in time and space.

This emergence of equilibrium and non-linear 'asymmetry', constrains behaviour and function within a localised equilibrium or 'phase of stability'. Phases of stability build on the intensive features of hysteresis, bounded within an extensive quality or phase of reciprocal equilibrium. Further perturbations or 'changes in energy' takes such a phase through intensive states of stability and instability, until local 'extensive' phase parameters are exceeded, and 'symmetry breaking' instability evolves the system to ever new phase transitions.

Importantly, such stabilities can be considered and observed as macro or 'extensive' qualities dependent on these micro or 'intensive' features. As systems are taken through conditions of phase 'far from equilibrium', as the system evolves (Glansdorf & Prigogine, 1971). New stability structures of energy and matter emerge through symmetry breaking (Nicholis & Prigogine, 1977; Prigogine, 1945).

2.28 Mechanisms of Self-Organisation in Non-linear Dynamical Systems (NDS)

Described here is the process of biological function as a product of Self-Organisation in complex, open systems, where matter and energy may be exchanged (dissipate) with its surroundings (Atkins, 2007). Non-linear Dynamical Systems (NDS) are dissipative (Guastello, 2009), and the spontaneous flow of energy defines the dynamic system by its dissipation properties. Such spontaneous dissipation in neural networks will be regarded through the theoretical concept of a "general evolution criterion" (Prigogine, 1996, pg 65), one that takes systems 'far from equilibrium' to behaviours that become "mechanism dependent".

Crucially, NDS behaviour provides a landscape of stability through non-linear steady-states, 'features' analogous with classical descriptions of stability and structure that through Self-Organisation, provide for biological-networks as complex systems, but are able to tolerate the prevarications of ecological engagement. It permits a 'Tolerance' principle to be applied in terms of energy efficiency in neural networks, and offers an biological-value definition to our conscious experience.

2.28.1 The Self-Organisation of Neural-Information

Neurally, we might consider the world in terms of the information signature presented to our sensory system and how that information resonates with the complexity networks of self-organising in the brain. This is the quality and accuracy of energy information as it is able to be represented in our sensorium of experience; our subjective experiences as 'states of information' represented as a 'state of stability' in the information available to us. Neural ensembles of information as energy become functional as phases of stability in relation to ecological engagement.

Energy and stability in terms of neural function are able to be represented in action programmes of cognition and behaviour. Though the linear computational ensembles or schemas of a cognitive science might now be questioned as to their efficacy, the neuronal network principles first proposed by Donald Hebb (1949) in an 'ensemble paradigm' provides in its complexity and networks of interconnected properties, a non-linear approach to cognition through the formulations of Self-Organisation. Non-linear dynamic systems evolve transient or soft-assembly equilibriums of stability, not as a set-behaviour or features of the system, but as a functional 'whole' of its parts, expressing complexity, interdependence and dynamic behaviour: "the whole is greater than the sum of its parts" (Durkheim, 1895/1982). Attaching the descriptor of 'complexity' to such interdependence should not deflect from interrogating NDS, but should compel the investigation into not only the behaviour of the 'whole', but importantly, understand the effect(s) of the parts. This offers a rich field of analysis for neural functioning in psychology (Chialvo, 2010; Guastello, 2009).

2.29 Emergent Stability: Micro States and Macro Phase

"we cannot understand the second law of thermodynamics and the spontaneous increase in entropy it predicts, by starting with individual dynamical trajectories; we must begin instead begin with large populations" (Prigogine, 1996, p20)

Self-Organisation sees stability as emergent within a defined space and time; a phase or phase-space[38] as a 'locality' for functional behaviour to exist. Non-linear Dynamical Systems constitutes a stability emergent at many 'levels' within a network ensemble (Deutsch, 2011)[39], but when observed, this is at the 'local' level of phase – an observational subjectivity to phase-stability that promotes the behaviour of the phase overlooking the function of the 'whole'.

Non-linear stability should therefore be viewed as an extensive property of phase-emergence, supported by the intensive micro-states of its ensemble. Phase stability might be better considered, then, as a 'feature' or 'quality' rather than as any classical concepts of disposition or property[40]. As such, the emergent local stability as a 'phenomena' in Self-Organisation, must be considered through the cascade of stability 'features' in the neural ensemble or 'system of energy function'. This recognition of functioning stabilities as 'features' or 'qualities' at all levels of an ensemble has been proposed for investigating the mechanisms of neural function (Clark, 2013; Friston *et al.*, 2010).

We should therefore look to the function of stability, not to properties or behaviour of a system, but through the 'phases' of stability and behaviour in function. Rather than try to define the properties of phase, they are better considered by defining the parameters of their functioning.

2.29.1 Phase Parameters of Stability Function

Parameters of phase then, recognises stability in respect of feature-change as a change in the dissipative (functional) qualities of energy. It is an emergent macro stability, built on the micro-

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[38] Phase-space is the recognition in population space, of a local or 'observational' level of emergence. It is by definition; a transient phase of order and stability. As an NDS feature, phase, time and space are eddies in the dynamical flow, and formulations of classical definition are not appropriate.

[39] Stability becomes a matter of perspective, the level of our observation. This ontology has defined scientific inquiry, and continues to provide an empirical-onion of almost infinite layers (Feynman, 1994).

[40] Property might not be the most accurate description for NDS observations, features or qualities of ensembles more accurately describe the emergent phenomena.

stabilities which themselves are emergent from every decreasing, intensive populations – *ad infinitum*.

Phase-space (Gibbs, 1885; Liouville, 1838), is the defining of emergent behaviour at local or 'observed' levels, providing a way of bounding the complex interdependent variance of such intensive features, and a quasi-autonomous stability for function to be defined by:

"the behaviour of that whole class of high-level phenomena is quasi-autonomous"

(Deutsch, 2011, p108)

2.30 Neural Functioning in the Free Energy of Phase: Entropy Principles

The second law of thermodynamics is fundamental with regard to the flow of energy. In terms of thermodynamics, the available-energy or 'energy for dissipative work' is expressed in the concept of free-energy (Gibbs, 1876; Helmholtz, 1847). Free Energy embraces concepts of a potential or 'availability' able to be expressed through stability. Entropy[41], as a statement of disorder or instability, constrains a systems functional capability and provides a quality concept with which to

[41] Though entropy is described and thought of as a property, this would be incorrect. Rather than defining a property of energy, entropy describes the functioning of energy or an accuracy of observation in energy behaviour. Entropy is better thought of as a concept of 'description', it provides a way of describing the functioning of energy as we observe it.

In saying that a system imports or exports entropy implies a tangible property, but it should not be considered such; instead entropy should be considered as a working metaphor for the changing qualities of system function at a level(s) of observation.

Statistical formulations of entropy (Boltzmann, 1886), though representing a theoretical 'state', should likewise be considered as a metaphor of energy behaviour describing a state of function: as a point-space of 'probable' behaviour. Entropy is therefore not a property, but better considered a description of feature-change or information-divergence. Such entropic-flux can been described as a functional 'quality' of energy through entropy potential relative to Maximum Entropy Potential (Jaynes, 1957; Massieu, 1869).

Entropy then, better defines the qualities of energy through dissipative flux, as it can be considered as an intensive property of feature-change in point-space. Rather than considering entropy an extensive state, Entropy represents the functioning of general evolution principles as a system optimises to a state of maximum entropy (Prigogine & Stengers, 1997), or stability. Entropy does not exist as a property, the observed energy phenomenon that entropy describes, such as phase-breaking and energy-evolution (Criticality) – do.

measure the 'state' of usable or available (stable) energy. Entropy therefore defines a system's functioning with regards to stability.

As phase represents a transient feature in energy (information) and its dissipation functioning, it is dependent on the uniqueness of its intensive properties in describing its behaviour. Function is therefore described through the intensive features rather than the observed local stability or behaviour, to better define system-behaviour. This functioning of phase offers 'relative' coordinates (to phase) able to be a coordinating-definition for function.

Phase stability observing entropy principles offers a way of defining function founded in the intensive micro features of the phase, its entropy features: and as such, provide an approach to defining functional behaviour.

2.31 Maximal Entropy Production

NDS stability is open to criticism, and the veracity of using principles of entropy to describe non-linear thermodynamic properties has been questioned by Silhavy (2013). Entropy as a property in defining NDS is problematic, in that a Non-linear Dynamical System's stability might be considered a transient feature not able to represent entropy function. However, considering 'local' stabilities of phase as entropic features of 'change' (flux), provides some support for the argument of using extremum boundaries of as an entropy-flux function in defining phase at macro-extensive local equilibrium (Kuzmin, 2012; Niven, 2009). This is able to be functionally-defined by is 'relative' flux behaviour, the change in entropic (flux) density as intensive-features display dissipative inequality behaviour as states of system function (Onsager, 1931; Prigogine, 1945; Prigogine & Stengers, 1997).

This approach of extremum-properties derived from the flow and flux of feature-change, is further supported through the principles of Maximum Entropy Production (Jaynes, 1957; Niven, 2009).

For NDS features to be described as entropy formulations requires us to consider how dissipative flux-density provides a definition of stability of 'phase' within the system to be considered:

1) How to define rather than describe a local equilibrium of 'stability' in the transience of feature-change, and to;
2) Define such non-linear 'phase' through formulations of free-energy.

2.31.1 Defining Free-Energy Through Entropic Flux

Entropy was formulated by the 'statistical' application of Ludwig Boltzmann (1872) in his attempt to define an energy-evolution in much the same way that Darwin had defined biological evolution

(Atkins, 2007). Boltzmann recognised that Entropy could be used to describe free-energy in terms of energy 'states' of ensembles or populations, extensive properties around a 'state of equilibrium'[42] (Boltzmann, 1886).

$$\mathrm{S} = \mathrm{klogW} \text{ (Plank's formulation)}$$

S=Entropy

K=Boltzmann's Constant

W=Number of possible states (energy) a system may occupy

Boltzmann's entropy was an expression of a closed thermodynamic system and therefore, locked in classical invariance, one of ever decreasing variation in energy-flux. It did, however, provide a springboard with which to explore the statistics of probability in population-statistics – probabilities able to describe the entropic features associated with 'states of equilibrium' (Gibbs, 1902; Jaynes, 1957).

These probabilities describe free-energy through their potential behaviour or, the probabilistic behaviour of ensembles system functioning. Stability in complex systems becomes described through their usable free-energy, as determined by their entropy or entropy potential. This is a 'probabilistic behaviour' bounded within the proposition of 'equilibrium from extremum principles'.

2.31.2 Extremum Principles - Spontaneous Dissipation and the Self-Organisation of Free-Energy

Far from equilibrium, non-linear dynamic systems (NDS) are characterised by spontaneous entropy exchange. What is important is the dynamic-exchange or 'flow' of entropy necessary to export the entropy associated within an equilibrium-phase or 'bounded-absolute' of stability. This export is to counter entropic production and avoid a thermodynamic-equilibrium of maximum entropy (Boltzmann's entropy of invariance) and minimum free-energy. Entropy export is the basis of non-linear 'system evolution', and the emergence of complex dynamical structures from such export and dissipation are the hall-mark of biological life (Prigogine, 1996):

It is at the maximal or phase boundaries of equilibrium that spontaneous-change and new stability(s) emerge (Prigogine, 1945, 1996). An 'evolution criterion' resulting in 'dissipative structures' able to

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[42] An equilibrium is a state of invariance. Here, no free-energy is available to dissipate or work. The stability is – absolute, with no prevarication, fluctuation or exchange.

constrain a stability within maximum entropy through free-energy principles (Prigogine & Time, 1977, p263).

Where Boltzmann had failed[43] in his Darwinian ideals of an all-encompassing 'universal' entropy, statistical mechanics is developing 'probability' approaches towards evolving energy systems through the application of non-linear population dynamics.

Dynamic systems evolve and avoid thermodynamic equilibrium through the exchange of entropy with the environment. Irreversible 'symmetry-breaking' drives a system's functional behaviour through evolving entropy-stability(s) at all levels of a stability-phase. Entropy export or flux, is able to constrain entropy through intensive dissipation, producing greater stability able to reduce further entropy increase, therefore tolerating even more entropy production. Dissipative structures provide the stability-landscape for Free Energy to function (Sundarasaradula & Hasan, 2004). For this reason free-energy is sometimes referred to as a negative entropy or a 'negentropy' (Brillouin, 1953; Schrödinger, 1944).

NDS function can now be defined through entropic stability and behaviour. The defining of local phase in spontaneous or dissipative Self-Organisation through the concept of a maximum entropy stability, and in doing so we define function within phase as 'states' through their relative functioning to this extremum (phase) absolute of entropic behaviour.

2.32 Steady-States of Equilibrium through Maximum Entropy Principles

Supporting the hypothesis that population-behaviour can be generalising through intensive-behaviour description, Jaynes (1957) utilised statistical methods to formulate Maximum Entropy Principles (MEP). MEP enable the representation of a system in terms of its probable 'state of entropy'. Probability, therefore, is at the heart of complexity in NDS theory.

Jaynes (1957) formulations of Maximal Entropy Principles, support extremum principles in his analysis of the probability of entropic functioning in stability. This allows system function to be statistically defined through maximum entropy (Smax) as an absolute and the formulation of potential state(s) of function within phase-stability, referenced through a (Smax) phase of equilibrium (Jaynes, 1957; Niven, 2009). Such extremum principles are incorporated in Prigogine's

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[43] Boltzmann's work on statistical evolution in systems, did not produce a time-variant (evolving) statement for non-equilibrium states; his formulations took the energy 'system' back towards equilibrium and invariance (that of an isolated system), rather than an evolving 'open' system of new expressions in energy and state.

(1997) theory of 'Minimum Entropy Production' to define a system's behaviour in terms of asymmetric, non-deterministic behaviour.

Though the suitability of defining extremum principles as 'boundaries conditions' of system description has been questioned (Nicolis, 1999; Silhavy, 1997), Niven's (2009) formulations on steady-state MEP provide a 'local' consideration for extremum principles, one that embraces the 'probabilistic' features underlying NDS in defining and differentiating a steady-state of entropy function within an extremum of phase-boundary.

It is in dynamic formulation or the 'entropic-flux' that a NDS function and Maximum Entropy Principles provide some veracity as to providing suitable definition or 'boundary conditions' with which to define phase functioning (Kuzmin, 2012).

"thus the possibility of finding negentropy through maximum entropy value isn't excluded"

(Kuzmin, 2012, p71).

2.32.1 Defining a Steady-State of function Within a Maximum Phase of Entropy

Maximal Entropy Production (MEP) more precisely termed "maximum rate of thermodynamic entropy production" (Niven, 2009, p1), defines a probabilistic-approach to local flux densities through a generalised formulation of steady-state for systems of dissipative flux. This enables the consideration of self-organising, dissipative, structures of stability (equilibrium), to be defined as and in respect to maximal entropy features[44] (Ebenbauer, Raff & Allgöwer, 2009; Niven, 2009; Sontag & Wang, 1995).

Within a phase, then, Self-Organisation 'drives' a non-linear dynamic system towards a 'gradient-stability', a steady-state (Niven, 2009). Here, MEP principles create the probabilistic equilibrium akin to Onsager's (1931) 'reciprocal relations', stabilities dependent on an asymmetrical proposition for energy, rather than classical symmetrical equilibrium – MEP steady-state is a non-linear 'space' or stability for free-energy to emerge at a local definition.

"In consequence, Jaynes' generic approach can be applied to the analysis of steady state, as well as equilibrium, systems" (Niven, 2009, p6)

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[44] NDS steady-state recognises the macro emergence from micro feature-change. Steady, stable and phase, all describe time-dependent system behaviour. The emergence or 'landscape' for such spatiotemporal features to exist as is contingent on symmetry-breaking Criticality (phase) at some intensive level of the ensemble. Extensive properties or behaviour is then able to be defined by maximal entropy at a local-level of observation.

This emergence of 'steady-state'(Jaynes, 1957; Niven, 2009) is one of a dynamic quasi-equilibrium, robust to change and able to tolerate prevarication (of entropic-flux or 'surprise') within defined local- phase boundaries of function.

A NDS state may now be viewed as able to be defined through 'steady'-state(s) of equilibrium, states that allow the consideration of energy held within an entropic-potential or 'negentropy' of functional phase (Brillouin, 1953; Gibbs, 1873; Hens & De Hemptinne, 1996; Jaynes, 1957; Kuzmin, 2012; Massieu, 1869; Niven, 2009; Planck, 1945).

Observation of such states of entropy-potential within emergent phase presents the possibility of a coordinate of relative-phase for the functional behaviour of NDS.

Such steady-state fulfils Gibbs (1885) 'phase-space' by ensemble populations of micro-states that support a local (macro) emergence of phase-stability; this is a local observation, subject to the function of its intensive-features and their functional evolution. NDS systems are 'driven' to Self-Organise through minimisation principles (Prigogine & Stengers, 1997), this is an 'Optimisation' and evolution of an ensemble as micro 'states' reach criticality in entropic function and evolve new features of intensive stability and ever greater complexity. Such systems are often referred to as 'systems of complexity', reflecting a seemingly, indeterminate probability, associated with the multitude of intensive criticality-states that 'might' be operating within the system.

2.32.2 Determining the Dissipative Quality of Non-Deterministic System functioning

Phase-space is a stability analogous to a classical equilibrium condition. It allows a potential-state to operate within 'absolutes' of phase, these are potentials bounded by maximal entropic-behaviour. Maximal Entropic-Behaviour (MEP), bounds function within an equilibrium-absolute and importantly, enables function to be defined in relation to this absolute. States of behaviour within a phase (a stability of equilibrium), are then able to be described through an entropic-potential (Massieu, 1869; Planck, 1945), a concept of the 'potential' or the functional behaviour of free-energy within an equilibrium.

Free energy as a function of energy stability, therefore represents the potential-state within an equilibrium absolute. Complex systems (as will be determined) may therefore be described through, a potential of 'efficiency in function' relative to the absolute of function (their 'state' of phase-stability). This is the state of quality of the stability, defined by its Entropic-Potential (Massieu, 1869).

Entropy, then, defines both the maximum capability and the quality of function in a steady-state. A ratio function between the 'relative' potential to constrain entropy-production, within a defined local or 'absolute' of phase.

2.33 The Entropic behaviours of Optimisation and Criticality in Dynamical Systems

Self-Organisation is driven by entropy minimisation as a system 'spontaneously' optimises stable function in NDS. This is an 'Optimisation' founded on the function of its micro-states. Self-Organisation recognises the function of asymmetrical dissipation of free energy. Fundamentally, the behaviours of Self-Organisation are to be recognised, if not observed, at all levels of an ensemble. An evolution of symmetry-breaking (criticality) throughout a 'complex' ensemble, not just at the observed level of 'phase'.

"Levels of emergence – Sets of phenomena that can be explained well in terms of each other without analysing them into their constituent entities … ." (Deutsch, 2011, p123).

Therefore, dissipative systems displaying Self-Organisation behaviour minimise entropy through a cascade of ever dissipating criticality[45], there will be criticality at some 'micro' level of the system ad infinitum, resulting in an emergent behaviour of 'Optimisation' in a system. Optimisation takes a system towards a local (steady-state) of equilibrium via Prigogine's 'general evolution criterion' and such convergence is dependent on the dissipative-criticality of the ensemble. Importantly, Optimisation requires criticality, a flow of energy and 'general evolution criterion' at 'some level' of a system's ensemble.

NDS, then, are dependent on change, an entropic-flux through energy dissipation in open systems. Therefore, steady-state(s) as the observed functioning of emergent phase and potential, are transient states from the features of change. Hence, phase and state are non-determinant spatiotemporal features, captured in a moment of time.

Rather than trying to define such a 'will-o-the-wisp'; it is in the flow dynamics of the entropic-function, that we might consider such feature-change in terms of free-energy and be able to define the functioning of the system at that 'moment in time' – a state of function.

2.33.1 A State of Function: Defining Dynamical Behaviour

As a dynamic behaviour, such a state of optimisation is best described through the flow of state(s) of equilibria and the observation of such flow behaviour within phase.

[45] A 'cascade' describes the flow of stability through ever decreasing 'levels' of emergent stability, from macro to micro emergence, ad-infinitum. This sees changes in stability, feature-change states of equilibrium, as states constructed on micro-Criticality – built from the bottom up.

Crucially this allows NDS to be described through a 'singularity' of equilibrium and in the transition from one singularity (steady-state) to another, providing a definition through entropic flux for functional behaviour. That is to say, it may exist as a steady-state in phase-space, but it makes itself known through dynamic feature-change, observable through self-organisation as an equilibrium state, a temporal-stability within the constant flux of state(s). A moment of stability that may be considered through the observation of entropy-function as feature-change, a procession of steady-state(s)[46] and their relative association with MEP or phase behaviour (Niven, 2009).

States of flux behaviour, that when 'within' a local MEP phase, determine and are determined by that phase of entropy, i.e. the system and its functioning are dynamic, so of no fixed function. Such system characteristics are defined through their entropy-potential as a state of flow and may be represented as a phase efficiency of such state-function. State in relation to a boundary of phase (a maximal MEP proposition before local-phase efficient-functioning[47] is exceeded).

Though the entropic-functioning of the system here, then, is a dynamic property, it is able to be defined relatively (to phase extremum) as a system processes through steady-states within a phase of function. Entropic potential as relative to MEP parameterises entropy production, a relative functional efficiency definition that may be considered as a coordinating definition for NDS function. However, it is in criticality going 'beyond' a phase of emergent (at some level) function from which new phase(s) of behaviour evolve in a "general evolution principle" (Prigogine, 1996, pg 65).

A state of non-linear 'dynamic' function can now be described in terms analogous to a classical entropy-function at a local level through the potential or tolerance for free-energy (feature-change) before the phase of entropic functioning is exceeded, a tolerance defined through a relative state in relation of entropic-capability or MEP. Maximum Entropic Principles offer a coordinating definition of Self-Organising Tolerance.

Importantly, in dissipative Self-Organisation, dynamic flux demands there will be criticality at some intensive level of emergence even though this may not be the local level of observation. Even a steady-state in spatiotemporal terms, requires criticality at some level of emergence as entropy

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[46] Change or procession from one phase-space of steady-state to another, invokes the issues of infinite-reductionism that have plagued questions of determinism. An interesting consequence of Self-Organisation is that criticality, as nested proposition, exists as an (theoretical) infinite cascade of intensive micro-features building stability or emergence from the bottom-up, acts to counter such reductionism in a neo-determinism ?

[47] Efficient function as in, maintaining biological-value.

cascades throughout an ensemble and therefore, an Optimisation principle is observed, suggesting a non-zero proposition for criticality (see, 2.35 – Divergent Criticality – Maximal Entropy Production for Biological , p79). If criticality converges (dissipates) toward an equilibrium throughout an ensemble, it takes the system toward a diminishing spatiotemporal state of phase and eventually, invariance.

An increase in entropy production will change the dynamics of Optimisation and Criticality at all levels of an emergence, but will be parameterised by a phase of function, dynamically changing the functioning or stability of that phase. One; 'within' phase parameters where existing stability(s) are strengthened; or when the parameters are exceeded, local criticality overwhelms the system (even at a local 'observation' level), and the system goes onto exhibit phase-breaking criticality and evolution.

The balance of stability and entropic-function in Non-linear Dynamical Systems is driven then by optimisation and criticality, but really, all is criticality. It is in the functional behaviour of criticality that defines whether the system is behaving 'within' a phase of behaviour, or beyond (breaking) local phase equilibrium.

From this, though, function in terms of optimisation and criticality is observed at the macro-phase of function, criticality-functioning at all levels should be recognised. Dissipative complex systems that evolve or minimise entropy production through an Optimisation towards equilibrium, do so throughout a nested intensive functioning with criticality at 'some' level of the ensemble (Jaynes, 1957; Niven, 2009; Prigogine, 1947; Prigogine, 1996).

It is in the equilibrium-stability breaking of criticality that new 'dissipative structures' emerge or 'self-organise' new complexity, and subsequently, a minimisation of entropy through an increase in the stability-tolerance towards further surprise. However, though the local level of emergence is observed, criticality will – must, be occurring at some level as an optimisation or minimisation principle (Prigogine, 1947).

2.33.2 Local Criticality in Self-Organising Dynamical Systems

Such local criticality behaviour is described in non-linear dynamic systems as Self-Organising (Gleick, 1997; Guastello, 2009; Haken *et al.*, 1985), a probabilistic theory driven by non-deterministic intensive-features. Self-Organisation, as spontaneous behaviour of entropy optimisation, provides information on the entropic functioning of the system and therefore, an opportunity for such information to describe complex network behaviour.

Self-Organisation is a theory of networked populations that inform or effect each other. As such, information-theory may be used to look at NDS function in neural-networks through the population statistics of probability and the emergence 'soft-assembly' behaviour in the complexity of neural-function (Friston, 2010; Friston & Stephan, 2007; Kello & Van Orden, 2009).

Systems that are considered as self-organising display functional behaviours of Optimisation and criticality in association with their functional properties of their complexity, 'properties' of stability in behaviour and the evolution of new properties in relation to feature-change[48] (Bak *et al.*, 1987; Prigogine, 1996).

Entropy optimisation (minimisation) in such neural complexity, provides for increasing stability and therefore expertise in network-function (the application of functional efficiency and a frugality through emergent self-organisation as an evolved response to surprise). However, it is a static diminishing proposition. Local increasing or Divergent Criticality a concept applicable for neural-functioning to be applied to biological-value for expansive or dynamic functioning (Chialvo, 2010; Cisek & Kalaska, 2010; Clark, 2013; Gershman & Daw, 2012).

2.34 Optimisation vs Criticality and Tolerance Optimisation

There seems a dichotomy in criticality functioning, i.e. between optimisation and local criticality (as both are behaviours from the functioning of criticality): Surprise and its associated increased in entropy take the system to greater entropy producing criticality, which in itself counters maximum entropy through increasing optimisation. Entropy production to reduce entropy increase, seems the requirement for a 'steady-state' of emergent 'phase-space' (Gibbs, 1873; Helmholtz, 1882; Niven, 2009). Criticality, then, (the dissipation of entropy) may be seen as providing 'space' for entropic-potential and the phase-space of function, a function bounded within phase parameters.

2.34.1 The Defining Property of Relative Entropy Potential

NDS steady-state(s) of function can therefore be considered through the concept of entropy-potential in relation to a maximal phase-space entropy production (production, not entropic increase). This functional state in phase-space and a dynamic 'relative' set within a phase-absolute. A

[48] Behaviours of: critical slowing down, hysteresis, catastrophic collapse etc. Interestingly, the breakthrough in identifying the functional behaviours of criticality came from work on sand-pile avalanches (Bak, Tang & Wiesenfeld, 1987).

dynamic proposition rather than any 'set' relational property(s). States of function might, therefore, be considered through their entropy potentials (negentropy, Brillouin, 1953), rather than any classical 'static' propositions: This enables phase and state-function, to be considered through entropic-potential, a proposition relative to a Maximum Entropy Principles (MEP), as a dynamic maximal or absolute phase of entropy (Jaynes, 1957).

As every 'state of function' is defined by its own intensive steady-state(s) of equilibrium, system-function becomes an intensive procession through steady-states defining their own extensive behaviour at a local phase(s) of observation or function. It is in the fluxes of entropy-production and feature-change that steady-states are observed locally as products of their own intensive function.

Such functional-behaviour not only describes a system in terms of criticality, but in defining the system's functional parameters, MEP allows a relative measure of system-tolerance in terms of functional efficiency, as able to define such behaviours as state-behaviours: If a functional maximal is represented by a dynamic phase-maximal MEP and Tolerance Optimisation , Tolerance then defines the entropic-potential of the functioning 'state'. This is Tolerance in a 'moment' of function, able to be considered through a concept of relative system-behaviour in terms of entropic-flow dynamics:

2.35 Divergent Criticality – Maximal Entropy Production for Biological Tolerance

Entropic-Tolerance, then, may be used to define system-behaviour relative to entropy-function. This is a state of entropic-capability able to be considered through the concept of tolerance to 'further' entropic-flux. Tolerance represents a system's (neural) state of behaviour relative to its own entropic functioning. Though this would seem a relational proposition, one system's tolerance not able to relate to another's, however, it is in the 'capability towards surprise' that the systems are able to be relatively compared or 'coordinated' against other states of entropic tolerance. Tolerance then, provides a coordinating-definition for system function in terms of entropy.

Tolerance is the capability of the system for 'free-energy function' (as an available entropic-potential), before criticality evolves local-phase (MEP) and macro stability function breaks-down.

2.35.1 Behaviour Characteristics of Self-Organisation in Neural Function

Optimisation and criticality are therefore dependent on the initial conditions or complexity of phase of the system, as the state of tolerance; and the flow and dissipation of entropy.

This allows three possible entropic-flux conjectures for the interplay of criticality and optimisation and their behaviour Bak *et al.* (1987). These are observed as states of phase behaviour in Self

Organisation: a) a steady-state, b) symmetry breaking criticality as a local observation, and c) a diminishing state of function. We might extrapolate these observations to reflect the functional dynamics NDS steady-states, and the entropic-behaviour of the system:

1) Stable Criticality (*steady-state of entropy production*)

   A steady rate in the production or flow of entropy, is able to balance a system's criticality commensurate with Optimisation. This produces a stable 'steady-state', within NDS phase. Here dissipative Optimisation towards invariance and minimal free-energy, is countered by entropy production maintaining a dynamic entropic-potential (free-energy).

2) Divergent Criticality (increasing entropy production)

   Increasing entropy-production with its resultant increase in criticality throughout the ensemble, takes the system through ever increasing entropy states. This is a Divergent Criticality: an increase in the rate of entropy production and intensive criticality taking the system through an evolution of steady-state(s). Such Divergent Criticality as dependent on the initial conditions of the system (tolerance) and the rate of entropy-production to display behaviours of:

   a) Divergent Criticality remaining 'within' a phase of functional stability where entropic-production takes the system to greater state(s) of criticality and entropy dissipation, therefore greater (potential) or tolerance within a phase of stability.
   b) Entropy production goes through phase extremum as criticality overwhelms the system's dissipative (Optimisation) capabilities and local-phase evolves to new stability features.

3) Convergent Criticality (*diminishing entropy production*)

   Diminishing entropy production, or flow, will result in optimisation dominant over criticality and a phase-convergence towards equilibrium-stability (and entropy)[49]. This results in the decline of the dynamic properties of negentropy (time variant) and the functional behaviour of the system, as it increasingly adheres to classical equilibrium and invariance.

[49] Maximum entropy is different from Maximum Entropy Principles (MEP). MEP produces phase of stabilities of function in dynamic systems – free-energy of negentropy. Maximum entropy is more an expression of classical T-symmetry and invariance.

2.35.2 Formulating Tolerance Optimisations through Entropy Flux Dynamics

Maximum Entropy Principles (MEP) are supported in describing dissipative behaviours of criticality and Optimisation, behaviours that describe a system's state of function through Entropy dynamics, i.e. Input (dSi), the Output (dSe) and the Product Overtime (S_p) of a system's entropy. Entropy dynamics, then, as dynamic features of ensemble complexity, that might be considered through flux dynamics.

In accordance with Bak (1997); Bak *et al.* (1987) and Self-Organising Criticality (SOC) , entropy-production (S_p) may be considered as describing the functioning of criticality within a system and therefore, a non-convergent or non-diminishing functional stability might be expressed as:

$$\frac{\mathrm{dSi} + \mathrm{dSe}}{\mathrm{dt}} \geq Sp \qquad \text{(De Donder \& Van Rysselberghe, 1936)}$$

Entropy production (S_p) in describing criticality as a product of the increase of entropy in relation to the system's capability to export entropy, might therefore be considered in relation to extremum principles (Ebenbauer et al., 2009).

2.35.3 Divergent Criticality: Functional in Entropic Tolerance

The dynamic behaviours in complex ensembles are seen in the entropic flux (S_p) and are dependent on entropy import and export. However, both import (dSi) and export (dSe) of entropy in complexity, are propositions not only of that systems behaviour, but from that system's 'state' of behaviour. They reflect not only the functioning of Optimisation, but the capability of the system to export entropy.

As an entropic-flux proposition, i.e. increasing entropy production (a Divergent Criticality), though importing entropy (surprise), results conversely in a system's ability to dissipate entropy to better effect, i.e. it increases entropy export potential and Optimisation 'minimisation' (Prigogine, 1947), resulting in increased entropy dissipation making the system more robust to further entropy.

An increase in the system's functional tolerance then, in terms of Self-Organising Tolerance (SOT), is dependent on a Divergent Criticality and an entropy increase in the system, a temporal-inefficiency before increased entropy-flux evolves greater Self-Organising Efficiency and therefore, Optimisation.

It is therefore in the import of entropy (dSi) in Divergent Criticality that, though initially increasing system inefficiency (as the phase approaches local criticality[50]), this results in greater tolerance through increasing the Optimisation (the intensive behaviours of micro-criticality). The system evolves to a greater phase of complexity and therefore stability. This results in an absolute increase in the entropy-potential of a phase, reducing the 'relative' effect of surprise and therefore a greater tolerance towards 'future' surprise. Divergent Criticality provides a future functional-robustness or, increase in relative stability.

2.36 Tolerance Optimisation – An Ecological Proposition

The functioning of Self Organisation Criticality in biological systems might now be described through a Tolerance Optimisation based on entropic flow dynamics. This allows Bak's (1997) behaviour descriptions of criticality to be expressed in terms of 'tolerance' to further entropy or surprise:

1) Steady-States of Criticality – Stable Tolerance

Here, stability seen in the maintenance of a steady-state of entropy-potential (i.e. no 'overall' change in entropy production – this is a flux definition relating to 'rate of change', therefore, Sp = the rate of change in entropy production), is via increasing internal entropy production being balanced by the export of entropy. This balance is dependent on entropy import (dSi) and the dissipation or export of entropy through Optimisation (dSe). However, as Optimisation properties themselves dissipate as equilibrium approaches, causing a loss in its functional 'Optimisation' capability to export entropy, there is a decrease in the rate of entropy export and entropy increases.

A steady-state (Bak *et al.*, 1987), then, requires that tolerance be maintained $(dSi + dSe = dSp)$. As there should be 'no change' in entropy production as a flow or flux formulation (rate of change) then $(dSp = 0)$, we can express a steady state as $(dSi + dSe = 0)$. However, recognising the non-zero proposition (Optimisation in constant dissipation), then maintenance of a functional stability where entropy-flux change is equal to zero, requires a constant increase in entropy-production (import) in maintaining this steady-state. Therefore steady-state requires Divergent Criticality through surprise $(dSi > 0)$ to

[50] Approaching a MEP phase maximal, criticality function is seen in three behaviours: critical slowing, hysteresis, and then catastrophic.

compensate for the decrease in Optimisation $(dSe < 0)$[51], then, for steady-state $(dSi > 0)$ as dSe is a decreasing negative in $(dSi + dSe = 0)$.

Therefore, stable-state requires $(\boldsymbol{dSi > 0})$, i.e. Divergent Criticality.

2) Divergent Criticality (*symmetry breaking Criticality*)

Here, entropy-production increases within phase $(dSi + dSe > dSp)$. In accordance with complexity theory and micro-criticality as an intensive feature; greater Optimisation is dependent on increase in entropy production, thus entropy increase begets entropy dissipation. In an increase in dissipation properties, steady-state(s) of greater complexity emerge. Such entropic-flux recognises the duality of Divergent Criticality, an increase in phase-potential at the cost of temporal (entropy-potential) efficiency. Greater entropy initially decreases the efficiency of phase, but in doing so increases future Optimisation phase-potential. This might be considered as a Tolerance-lag: as entropic-flux first stresses, but then 'general evolution criterion' drives new dissipation structures to emerge, creating greater MEP and entropic-potential (entropy is exported to better effect), greater relative tolerance emerges.

Tolerance better defines a system as it moves through steady-state(s) towards new complexity and functional capabilities. As a relative expression of behaviour over time, more entropy is able to be exported from the local system than produced.

Therefore Divergent Criticality $(\boldsymbol{dSi < 0})$ makes the system more tolerant or robust to future provocation or 'surprise'.

3) Convergent Criticality

The proposition $(dSi + dSe < dSp)$ expresses a diminishing dynamic-flow and convergent-criticality as the system diminishes towards a state of phase equilibrium. Though optimisation dissipates entropy, in doing so it itself dissipates entropy-flux function, reducing future entropy-Tolerance, and therefore, entropy production increases within the system. As an asymmetric stability, criticality is still taking place as some level of the ensemble, but it is a convergent criticality with diminishing phase-space. This convergent-criticality takes the

[51] These are flux or flow approximations around a datum of entropy production stability (dSp), therefore will be greater ($>dSp$) of less than ($<dSp$) the current state of stability in flow.

system towards equilibrium and invariance as progressive steady-state(s) driving the system toward classical equilibrium (Niven, 2009). Convergent-criticality then, sees the local capability of phase to tolerate surprise, diminish.

Therefore Convergent Criticality $(dSi + dSe < dSp)$ behaviour contravenes a functional autopoiesis for continued biological life .

2.36.1 Self-Organising Efficiency: An observation of Tolerance as an efficiency of phase

As a functional-capability to 'tolerate' entropy, Divergent Criticality comes to defines biological function in terms of entropy.

The definition of entropy-potential is analogous to the functioning of classical free-energy and observable as efficiency in entropic function (Carnot, 1824a; Massieu, 1869; Planck, 1945). It is this 'efficiency of behaviour', that a system's functional tolerance is observable, a coordinating-definition able to differentiate systems with regards to their entropic optimisation (Bak et al., 1987; Deutsch, 2011; Prigogine & Stengers, 1997).

Steady-state (Jaynes, 1957; Niven, 2009) as analogous to formulations of free-energy and entropy (Gibbs, 1873), allows a functional capability or Tolerance to be generalised through formulations of free-energy function as described through entropic-potential. This allows an entropic-potential (Massieu, 1869; Planck, 1945) to describe Tolerance functionally through a partition-function of efficiency (Carnot, 1824a):

$$\varepsilon = 1 - \frac{\phi}{\mathfrak{H}}$$

$\boldsymbol{\varepsilon}$ = Efficiency

ϕ = Entropy potential

$\mathfrak{H}$ = Entropic capability (MEP) (see, Box 2 – Ecological Efficiency in terms of Effectivity, p22)

2.36.2 Observing Tolerance – From Thermodynamic to Statistical Mechanics

Intensive states of criticality account for the differentiation seen between states within a phase of behaviour and such differentiation manifests itself in a 'state of Tolerance' to surprise. As a behaviour parameter, Tolerance is observable as an efficiency of function towards surprise. (see also, 3.9 Formulating a Tolerance Optimisation Hypothesis in Criticality, p110).

2.37 Biological Life Demands Divergent Criticality

An evolutionary principle of ecological engagement is that a biological system would want to avoid classical equilibrium and, therefore, avoid a NDS 'diminishing state' of entropy production (see, Convergent Criticality, p83). This leads to a simple functional statement for criticality based on biological-cost: To avoid equilibrium and a diminishing state of entropy a system will need to import entropy at a rate, at the very least, equal to the dissipation ($dSi + dSe \geq dSp$).

In accordance with the 'non-zero' principles of Self-Organising Criticality for biological life, the maintenance of 'Tolerance' in the face of diminishing Optimisation (diminishing entropy export), demands a 'positive-definite' entropy production in order to counter convergent criticality. Criticality must increase (Divergent) the entropy export and maintain or increase the functional Tolerance (entropic) of the system ($dSe > dSp$) – biological life as temporal (future oriented) demands a Divergent Criticality function.

Such a statement may be further extrapolated with regards to selectionist principles that: 'dynamic environments of greater (temporal) change require greater dynamic adaptability in the organisms that inhabit them' – Life in dynamic environments of greater entropic surprise, requires correspondingly, greater Divergent Criticality.

2.38 The Beginnings of a Divergent Criticality Hypothesis

In a dynamic environment, a system that is able to adapt to surprise with greater 'relative' efficiency, will have a selectionist advantage. As such, dynamic environments will evolve functionally robust or tolerant organisms that are able to better respond to increases in entropic-flux.

Divergent Criticality, therefore, may be used to define biological systems in terms of functional effectiveness with regards to dynamic environments.

As a selectionist proposition, greater dynamic flux (ecological-surprise) requires a Divergent Criticality, which requires a greater engagement with ecological-surprise in order to maintain Divergent Criticality. We see this 'drive', as the evolution of an affective behaviour(s) towards maintaining Divergent Criticality in ecological engagement. This resonates with the 'core' affective behaviour as observations of Divergent Criticality 'drive' are observed in core affective behaviours: e.g. 'wanting' (Richard & Berridge, 2012; Zahm *et al.*, 2013); and 'seeking' (Damasio & Carvalho, 2013; Panksepp & Biven, 2012).

As a parameter of future robustness toward surprise, an optimum selectionist proposition of Divergent Criticality would see a maximal proposition for Divergent Criticality, where it operates at the edge of functional tolerance, Tolerance Optimisation. This is observed as a complexity behaviour – a critical slowing down, but would be better considered as a temporal complexity function creating greater entropic robustness (Bertschinger & Natschläger, 2004; Chialvo, 2010).

2.39 Section Summary: Non-linear Dynamical Systems

This Chapter developed entropic behaviour as an imperative for biological function through a proposition of 'Divergent Criticality', as a spontaneous, agential requirement for life in dynamic environments. Divergent Criticality, through increasing the entropy in a system, conversely, increases the capability of the system to export entropy by 'optimising' (criticality) the system's Tolerance towards further entropy. This is a prerequisite for biological life – "freeing itself from all the entropy it cannot help producing while alive" (Schrödinger 1926, p71).

In Section 1 – A Feeling of Perception (p10), a coordinating-definition of 'Tolerance' was developed for subjective perceptions to be considered as an objective measure, and in Section 2 – Attention and Control (p33), aligned Tolerance in cognitive processes of Voluntary Control and attentional awareness. Attentional-awareness as indicative of neural function, is viewed as a perception 'awareness' of functional Affordance set within an agential or 'relative' Effectivity and defined as a state of neural efficiency (Tolerance) towards ecological demands.

This chapter, developed Tolerance as an entropic-function within an agential or relative Effectivity, and provided a naturalistic 'drive' for Tolerance Optimisation, that of Divergent Criticality. However, such a simple 'mechanistic' approach is still not able to accommodate the agential-complexity and functional-nuance in perception. The next Chapter takes the above proposition of entropic behaviour in biological cognition and functioning – those of Tolerance, relative Effectivity, Optimisation and Divergent Criticality – and formulates a new theory of neural function for cognition and behaviour. This is a Divergent Criticality hypothesis for perception as a biological-value construct. This hypothesis requires that the following tenets be addressed:

Neural stability and tolerance to entropy (surprise) will reflect the dynamic features of the ecological landscape, informing a Tolerance Optimisation for entropy production.

1) Environments of greater dynamic-change require entropic features of greater dynamic-flexibility and therefore greater Divergent Criticality and Complexity.
2) Continued biological replication (a selectionist autopoiesis) requires that biological-value functions within control parameters of agential Effectivity.

3) Neural function for biological-value (cognitive) will select action-control(s) (cognitive-Voluntary Control and behaviour) to 'affect' a Divergent Criticality and Tolerance Optimisation.
4) Such 'affective' behaviours are characterised as cognitive-emotional behaviour and are made cognisant as a sensory awareness or 'attending'. This awareness is relational to a 'state of neural functioning' as a functional Affordance state of relative Effectivity.
5) Functional Affordance is therefore an awareness of agential Effectivity and a measure of the 'state' of the neural functioning as an entropy proposition.
6) Perception, as an attentional-awareness, is able to be empirically observed as an awareness or 'perceived-phenomenon', of and from the functioning of neural entropy. This is a self-organising (naturalistic) response to an agent-environment resonance with biological-value.

A perception measure able to self-report as a functional Affordance state, therefore, will reflect entropic-function and can be objectively coordinated as an agent-environment, Divergent Criticality hypothesis of Tolerance Optimisation.

If Divergent Criticality is able to be formulated in terms of agential-mediation of Tolerance Optimisation, self-report of perception in terms of neural function should be able to predict cognition and behaviour in accordance with the Divergent Criticality hypothesis and naturalise perception in entropy function.

The next Chapter considers affective cognitive behaviour then, as 'driven' by Divergent Criticality towards Tolerance Optimisation, and the agential maintenance of Tolerance Optimisation. This is now formulated in a Divergent Criticality Hypothesis:

3 CHAPTER THREE – The Divergent Criticality Hypothesis

3.1 Developing a Divergent Criticality Hypothesis

In dynamically changing environments, organisms that are able to evolve greater tolerance to change (surprise) will have a greater selectionist advantage. Increasing surprise tolerance through Divergent Criticality becomes dependent on engagement with uncertainty and surprise, therefore Divergent Criticality provides a framework for affective behaviours that seek and engage with surprise, and might be considered through a selectionist approach as fundamental to our understanding of cognition and behaviour. This asks – how does the brain know Divergent Criticality and Tolerance?

Neural function may be explored as an agential proposition 'from' and 'of' Divergent Criticality, a 'predictive processing' of selectionist worth for a possible 'anticipated' future predicated on our perceptions of the now and our phenomenological experiences of the past.

Divergent Criticality and 'affective' behaviours are constrained within the complexity capabilities of the system, and therefore dependent on increasing criticality. Such a suggestion for the functioning of Divergent Criticality is theoretically evident and supported in cognition and behaviour with respect to maximal propositions of free-energy function (Bertschinger & Natschläger, 2004; Chialvo, 2008, 2010; Chialvo & Bak, 1999; Friston, 2010; Friston & Stephan, 2007; Grigolini, 2015; Kello, Rodny, Warlaumont & Noelle, 2012).

Affective behaviours are an agential drive for entropy production (and therefore entropy minimisation through Optimisation) in dynamic environments, and as all life might be considered as dynamic to some extent, Divergent Criticality might be considered as ubiquitous and differentiated dependent on ecological constraints of entropy surprise. Such a biological mechanism of life maintenance and replication through affective criticality should be evident throughout the biological record[52].

[52] There is some support for this proposition: see slime-moulds (Yanai *et al.*, 1996), bacteria quorum sensing (Hastings & Greenberg, 1999), etc.

3.2 Formulating Tolerance as a Self-Organising Function

Tolerance becomes defined through a system's functioning in relation to surprise (entropic-flux) and efficiency, and represents a dynamic-capacity for free-energy in this function (Friston, 2010). NDS States might be better represented by their tolerance to surprise, a relative 'efficiency of function' in terms of surprise, and it has been suggested by Grandy (2008) that the 'dissipation rates' of a system might provide a more useful formulation for determining boundary conditions of phase transition in non-linear systems than other 'extensive' properties.

The greater the complexity of an ensemble, the greater the tolerance in accordance with Divergent Criticality. Non-linear dynamic systems might therefore be defined by their tolerance as described through Self-Organising Criticality processes and behaviours. The observational functioning of the system's entropy tolerance towards the surprise encountered. MEP and steady-state in dissipative flow, enables an analogy with state(s) classical equilibrium (Niven, 2009) and enables us to derive a statement of such tolerance as a statement of entropy potential.

The Self-Organisation found in Non-linear Dynamical Systems theory has been applied to neuroscience and complexity in many formulations (Guastello, 2009). In the psychology of behaviour and control, the most prominent and successful experimental formulations has been through Dynamical Theory (Haken *et al.*, 1985; Kelso, 1995) . Entropy and steady-state stability in behaviour through Dynamical Theory.

3.3 Dynamical Theory – a Basis for Describing Criticality Behaviour

Dynamical theory provided a window into the workings of such self-organisation in neural function through the coupling of behaviour and agency control (Haken *et al.*, 1985; Kelso, 2012; Kelso, Del Colle & Schöner, 1990; Tuller, 2005; Tuller, Case, Ding & Kelso, 1994; Wallot & Van Orden, 2011; Zanone *et al.*, 2010). Through 'Coordination Dynamics', Haken, Kelso & Bunz (1985) developed a dynamical model that has become one of the most used models in Non-linear Dynamic System (Guastello, 2009; Kaufer & Chemero, 2015). The Haken-Kelso-Bunz (HKB) model, is one able to model the stability of behaviour in an environment-behaviour function as a 'potential of probable' function: A Stability of coordination in relation to environmental surprise engaged through control parameters. Entropy (at some level of the ensemble) increases and the system goes through "Criticality-points" until a catastrophic (local) phase collapses in behaviour.

The function that models the data as a Potential Function $V(\phi)$ is:

$$V(\phi) = -a\cos\phi - b\cos\phi \text{ (Haken \textit{et al.}, 1985)}$$

Here ϕ is used to represent the maintaining of a phase stability in coordination dynamics, a measure of the ‘quality’ or robustness of behaviour across a control parameter a – b. Control parameters can be thought of as creating a ‘divergence’ entropy flux or ‘surprise’ between (a) and (b). It represents the divergence from a steady-state where (a – b = 0)[53].

This has been extended by Kelso et al. (2012) as a formula to generalise for multiple control variables:

$$V(\phi) = -\text{ɗ}w\phi - a\cos\phi - b\cos 2\phi$$

Where ($\text{ɗ}w$ = w1 – w2) represents intrinsic differences between the components (multiple intensive variables).

Though dynamical theory has provided an experimental design for the measurement of affective behaviour, it uses a cognitive correlation ‘theory of behaviour’ and we should be wary of the behaviourism trap (behaviour not function). As a measure, the HKB (1985) model utilises ‘behaviour-coordination’ to couple phase accuracy with neural function, this cannot be considered with great certainty, only a ‘functional’ outcome.

However, the influence of such coupling theoretically aligns self-organisation with behaviour through its agent-environment control parameter(s) and is formulation through coordinating (behavioural) dynamics. This accounts for the success in the models accuracy of modelling behaviour and Self-Organisation, but does not define neural function objectively. The behaviour accuracy does not adequately accounting for the possibility of duality in control parameters (as being dependent and/or independent) when defining the functional mechanism at work. If we are not able to isolate a functional ‘causal’ mechanism, we cannot adequately predict and test our understanding of how the brain works. This is the objectivity dilemma of phenomenal observation.

We consider those behaviours below from a Dynamical Theory perspective and then provide a Tolerance hypothesis function (see, Figure 15, p92).

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[53] dSi+dSe=0 (see, 2.35, Divergent Criticality – Maximal Entropy Production for Biological , p82)

3.3.1 Criticality in the KHB Model of Dynamical Coordination

Here, the entropic behaviour of intensive features of a phase stability are represented through steady-state behaviour, this provides a landscape of stability emergence or ‘dynamical attractors’ for behaviour control (Kelso, 1995). An agential end-point of ‘nested’ stability(s) for a macro or local phase of function and behaviour. This has been extensively modelled in limb coordination or bi-manual behaviour dynamics; e.g., fingers, leg swinging, etc. (Haken *et al.*, 1985; Kelso, 1984; Kelso, 2012; Kostrubiec, Zanone, Fuchs & Kelso, 2012; Zanone *et al.*, 2010). The limitations of bi-manual phase have been highlighted however in Zanone *et al.* (2010), where ‘other’ phase propositions become emergent within the dynamical landscape: behaviour outcomes of increasing complexity that question the validity of the HKB model as to what is being modelled and the accuracy of the measurement as a functional proposition. Though a behavioural phase-stability (as representing the coordination of limbs) is displayed through coupling (‘phase’ as an entropic behaviour of Self-Organising Criticality), such coordinating Dynamical Theory should be critiqued through its entropic function validity: The HKB model (1985) as a model of extensive behaviour provides a graphical representation of criticality at a local ‘extensive’ level (Bak, 1997), but does not accommodate for the intensive functioning in considering its behaviour. The neural mechanisms of functioning are hidden under emergent local-phase behaviour.

We might therefore apply a functional Tolerance hypothesis to the Kelso (2012) model (see, Figure 15, below).

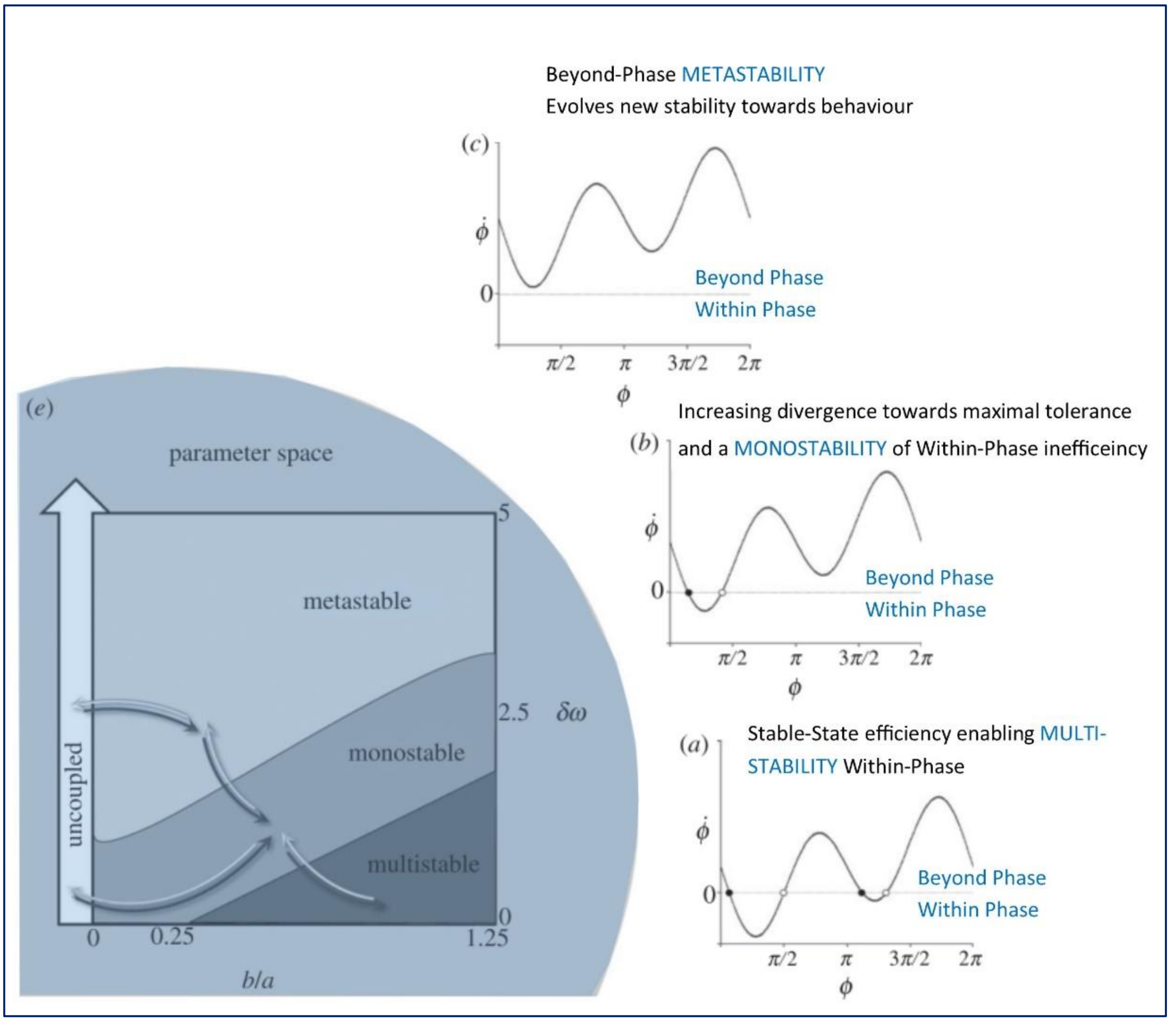

Figure 15 –Trajectories of the extended HKB model of coordination dynamics illustrate how new phases of metastability (c) emerges from a multistability (a) as a control parameter (b/a) changes. Adapted from Kelso (p913, 2012).

In Figure 15 (above), a steady state of (a) Mutli-stability within phase is possible via efficient neural function allowing many stabilities to be nested in response to the demands of dynamic animal-environment coupling. As control parameters stress the system (b), there is an increase in entropy production ($\sigma' > \sigma$), and a decrease in Self-Organising Efficiency. This is a proposition of less tolerance, and the model moves through (a) Mutli-stability to Mono-stability (b)

Increasing criticality throughout the system should take the system to Meta-stability (c), and there will be an evolving local phase representing a cusp phase function and with it, the criticality 'phase' markers and possible catastrophic loss of behaviour, stability and function and catastrophic behavioural change. This becomes observable at a local level of phase as (c).

However, there is the tendency to avoid Meta-stability (c) and a seeming, tolerance-inefficient, self-regulation around Mono-stability (b). This we would suggest is the Tolerance Hypothesis evident in behaviour.

This leads to the question of the interpretation of coupling dynamics in explaining function: Primarily, coupling reflects neural behaviour that is control (parameters) dependent. Though extensively viewed as independent variables, control variables in NDS assume a complex relationship that also become 'dependent' (Guastello, 2009). Within a changing landscape of entropic flux dynamics, control parameters become both functionally independent and dependent in the criticality outcome behaviour: What function are we observing – the behaviour of the cognition or the behaviour of the control parameters? That is to say, that though HKB-stability reflects the constraints of the control parameters on neural function, this might actually be behaviour reflecting externally dependent variables (of the control parameters) rather than agency neural function[54]. This proposition offers a functional critique to contemporary Dynamical Theory (see, 8.4.1 – Divergent Criticality: A Theory supported in Dynamical Theory, p224). The Application of the Divergent Criticality Hypothesis In NDS Theory did not specifically experiment to parse functional determinants. However, in not adequately accounting for such situational and contextual determinants, they might be critiqued on using a limiting theoretical approach as to isolating and distilling behavioural into a function from its many behavioural manifestations. The function is simple – the behaviours are not – complexity.

3.3.2 A Functioning Critique of HKB Modelling

It is in the consideration of flow dynamics and entropy flux, effective intensive-micro and therefore extensive macro criticality, that system or phase 'Tolerance' functionality might better reflect neural functioning and stability rather than its emergent, extensive, macro-level. Tolerance considered an exoentropogenic effect[55] of a micro-macro symbiotic system. Though macro-phase is able to define behaviour in Dynamical Theory, its lack of functionality determination questions the validity of coupling behaviour as, 'function made evident'. We might better consider a criticality model through

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[54] Apparent function is specified in (Zanone *et al.*, 2010). Here, dual processes or pathways to learning are specified, reflecting the coordinating dynamics of stability emergence. It might be argued that these stabilities reflect the function of the control parameters to a greater extent than reported in explaining neural function. This would cause us to question Zanone's duel pathway explanations to learning.

[55] "From ancient Greek: exo-, outer or external; tropos, transformation (used by Clausius) and -genic, generating or producing" (Niven, 2009, p9)

the Tolerance hypothesis of 'efficiency in function', an approach through the entropic functioning of all variables. Though the variables will exert the same 'functional' effects as the HKB model, a tolerance approach in neural-function provides a relative (coordinating) explanation of objectivity from behaviour observation. It is in being able to provide a relative differentiation that reveals actual neural function from the behaviour(s) of functioning.

Through the relative functioning of tolerance in respect to feature change in ecological engagement, we might unravel the complexity in control variables into statements of how they (situational and contextual) impact neural function rather than impact behaviour. However, rather than dispel the findings of Dynamical Theory, this still recognises the agential-environment autonomy of perception but, Tolerance considers both internal and external control parameters, in its helping differentiate how functioning relates to behaviour. Here the function of tolerance better explains cognitive processes (such as perception and learning) rather than behaviour.

3.3.3 Unravelling Behaviour through a Functional model Tolerance

As a measure of function relative to system capability, 'tolerance' can be considered an 'efficiency in function' and better defines the functioning of the system 'and ALL its constituent parts' in a state of stability or 'entropic potential'. This is tolerance potential-function is in relation to neural capabilities (in consensus with Dynamical Theory formulation). However, we might better interrogate this entropy function through a tolerance approach of agential constraint (reduced Voluntary Control creating a 'relative' Effectivity of reduced functional landscape). Rather than unravel the multitude of control processes; through defining of effects of agency on the system we might extrapolated an objective measure of function. This is done using the Tolerance hypothesis to represent the behaviours of a functional 'relative' Effectivity, enabling agency and its function to be identified, therefore, absolute and relative function to be revealed.

The model of tolerance in functional Affordance (Figure 16, below) is therefore re-represented, formulated within entropy equivalence statements for Effectivity-tolerance and Affordance Surprise.

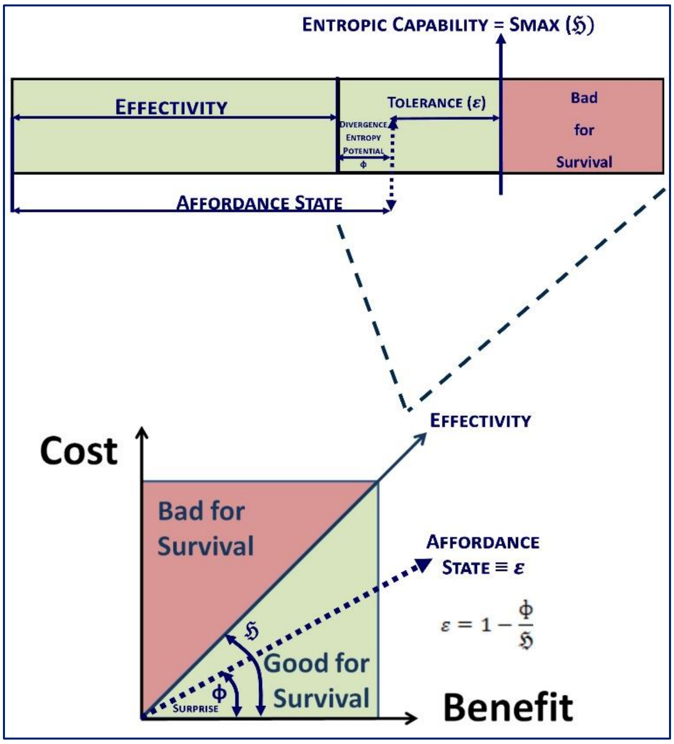


Figure 16 – Functional Affordance as an Expression of Entropy

3.3.4 The Application of Entropic Potential Within a functional Affordance Model

It is in entropy potential (entropy-potential = ɸ), relative to an Effectivity phase in the functional Affordance model, that enables function as a 'state' of relative Effectivity to be graphically represented as a ratio. It is then possible to consider this entropic state against an Effectivity tolerance (Smax = ℌ – as the maximum entropy the system can tolerate before local phase collapse). This entropy point represents a capability for Maximum Entropy Production (MEP) in the system. The realising of such MEP however, as exoentropogenic, is determined and determining of the entropy-potential ɸ, a state of functional Affordance reflecting Effectivity capability of entropy function (as tolerance to further entropic flux).

The entropy-potential ɸ, therefore, determins the ability of the system to tolerate further entropy within a maximal functional state – its tolerance to further entropy flux as opposed to static or fixed capability. Such tolerance can be formulated from first principles from an expression of Carnot's (1824a) 'functional efficiency' (see, Box 3 - A functional Affordance State as a State of Tolerance function, p28).

We might therefore represent an Affordance state as a coefficient of tolerance:

$$\textit{Coefficient of Tolerance} = \frac{1}{\left(\frac{Affordance}{Effectivity} - 1\right)}$$

Therefore, a state of functional Affordance as an efficiency formulation, might also be derived as a represented an Optimisation or functional-efficiency (an equivalence statement of efficient function within Non-linear Dynamical Systems derived from a coefficient of tolerance):

$$\textbf{\textit{Coefficient of Tolerance}} = \frac{1}{(\frac{\phi}{\mathfrak{H}} - 1)}$$

A tolerance state of Affordance as a functional efficiency:

$$\varepsilon = 1 - \frac{\phi}{\mathfrak{H}}$$

ϕ = An Affordance State as an Entropic Potential taken from (Massieu, 1869; Planck, 1945).

$\mathfrak{H}$ = Statement of the Maximum Entropy Production (MEP) allowed in the system (a local S-max).

$\boldsymbol{\varepsilon}$ = Efficiency in relation as ecological engagement.

Though tolerance provides a coordinating definition, this is a snap-shot of a moment in function describing the system, it does not describe the system's dynamic functioning in order to explain for behaviour in relation to feature change. A formulation of tolerance as such a dynamic proposition is now discussed.

3.3.5 Tolerance as Efficiency in Entropy Optimisation: a Dynamic Function

Entropy potential as an entropy steady-states (ϕ) also defines its Maximum Entropy (Smax= $\mathfrak{H}$) as an exoentropogenic relative function. Such a relative measure allows neural function towards behaviour now to 'relatively' differentiated between different phase states, therefore presents the opportunity to explore behaviour in the flow from one tolerance function to the next.

3.4 Formulating Divergent Criticality within an Efficiency Model of Function

Revisiting the formulation: $\mathfrak{H}$ presents as a phase, 'absolute', in that, potential entropy (ϕ) is relative to this $\mathfrak{H}$ MEP (whatever the antecedents of the entropic flux and boundary conditions in NDS). This not only allows the formulation of an entropic potential to represent an 'efficiency of function towards surprise', but also as a relative function, allows a 'continuous' formulation for 'probable' dynamic behaviour (this 'relative' Effectivity landscape of function is 'continuous' on both an agential and a contextual behaviour: the multi-dynamic components of entropy surprise)[56]. This 'continuous' function enables dynamic efficiency to be modelled from the relative formulations from Carnot's efficiency statement (efficiency = $\boldsymbol{\varepsilon}$).

Entropic efficiency ($\boldsymbol{\varepsilon}$) can now be used to determine not only the state of function relative to phase, but be extrapolated to an efficiency of dynamic functioning and a trajectory of relative efficiency-behaviours.

3.4.1 A Trajectory of Entropic Behaviour as Efficiency Behaviour

As a 'continuous' measure, entropy derivations allow the application of the divergence between the absolute and a relative (potential) measures. These can be approached through a Kullback-Leibler (D_{KL}) divergence formulations (Kullback, 1959). Such a statistical representation of the functioning of entropy as an intensive feature, recognises the flux dynamics of entropy production as a statistical probability or 'density', as such, a state of functional Affordance is able to be conceptualised through probability densities:

Firstly, a generative 'probability' density is a statistical-statement of the absolute or Effectivity-tolerance of the systems dynamic function (in entropic capability terms of both situational demand and contextual (agential) approximations). This might be considered as a maximal proposition (Smax) of system entropic function ($\mathfrak{H}$). This generative density is then compared against a second 'actual' information signature or *posterior* (expectation informed by experience). In probability density terms, this is the divergence from the generative *a priori* ($\mathfrak{H}$) of the sensory informed *posterior* state of entropic function (ϕ).

The Kullback-Leibler divergence (D_{KL}) is formulated as:

$D_{KL}(P||Q) = \sum_i P(i) log \frac{\boldsymbol{Q}(i)}{\boldsymbol{P}(i)}$ where:

P = ϕ – The *posterior* distribution (entropic-potential or state of 'functional Affordance')

Q= $\mathfrak{H}$ – The generative or *a priori* distribution (defined MEP or 'Effectivity')

As a continuous variable, entropic flux may be used to model a state of functional Affordance through a Hessian tensor (Pearlmutter, 1994), as a state of information transference. What is

[56] Top-down intentionality will change the continuous landscape by its reduced Efficiency potential, therefore, will change the formulation of continuous efficiency behaviour.

produced is a second-derivative as a function of 'rate of change' in the divergence, one that allows the D_{KL} function, as rate of change in the functional efficiency of a phase of behaviour, to be modelled as an efficiency tensor or trajectory.

As 'continuous', the divergence may be formulated as an integral function:

$$D_{KL}(P\|Q) = \int_x log\left(\frac{dP}{dQ}\right)\frac{dP}{dQ}\ dQ$$

This is a statement of the divergence between entropy states as finite propositions (defined within a relative maximal – entropy production σ and σ' being within a maximal proposition ($\mathfrak{H}$).

σ = Entropy produced and exported from system
σ' = Rate of production of entropy
$\mathfrak{H}$ = Local entropy production maximum

As a flux potential, entropy, here, is an exoentropogenic state in that it helps define its own system's emergent behaviour. If we consider behaviour commensurate with entropy production in criticality and optimisation, where we derived a Divergent Criticality proposition for biological function as $(dSi > 0\ \equiv\ \sigma' > \sigma)$ see, Tolerance Optimisation – An Ecological Proposition, p82). This finite proposition allows the accommodation of the Radon–Nikodym derivative of function (Hobson & Cheng, 1973):

a) At a steady-state ($\sigma' > \sigma$), as the potential for stability increases (the attractor deepens). Through criticality principles this can only happen if finite ($\sigma' <$ MEP).
b) Or as an increasing state of stability, but within-phase ($\sigma' > \sigma$).
c) Within a finite proposition of phase ($\sigma' < \mathfrak{H}$), continuous function defines behaviour.

At state of 'phase breaking' ($\sigma' > \mathfrak{H}$) the system is taken beyond local phase and the distribution cannot be considered continuous and therefore the Radon–Nikodym derivative needs to be re-formulated to 'new' continuous parameters.

An integral function (below) for determining efficiency can now be used; one that can be graphically mapped.

$$D_{KL}(P\|Q) = \int_x p\ log\frac{p}{q}\ du : \text{(Where p and q are continuous to } u\text{)}$$

This allows differentiating efficiency behaviour of different continuous landscapes or 'relative' Effectivities to be considered (see, Figure 17, below):

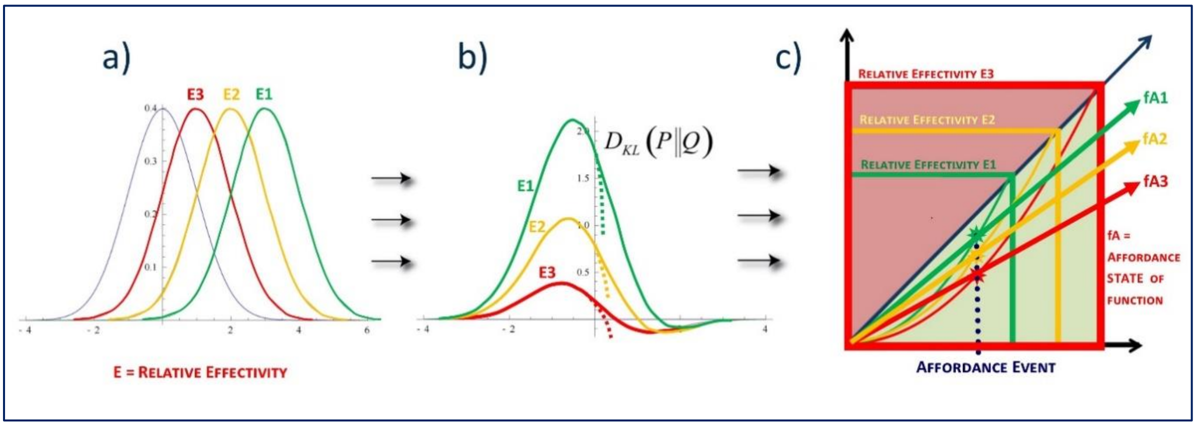


Figure 17 – Relative Effectivity Trajectories of D_{KL} relative to Effectivity Tolerance (adapted from, Mundhenk, 2009, p254)

Using the Kullback-Leibler divergence function it is possible to map efficiency behavior. The distributions above (Figure 17) are represented as Gaussian probability densities. However, a better approximation would be to use a Non-Parametric Regression (NPR) in a process formulation of density function for NDS. The dashed approximations in (Figure 17, b) define this NPR at collapse as phase approaches maximal approximations $(\sigma' > \mathfrak{H})$. Non Parametric approximations are referred to as a training or training of Mean Square Error regression, Predictions predicated on previous iterations in a multi-variable regression model of *a priori* and *posterior densities (James, Witten, Hastie & Tibshirani, 2013)*. As the regression curve approaches a relational target point (a shared absolute between entropic variables). The inability to maintain function in the model is observed in the deviance and a collapse from linear to non-linear 'catastrophe' as entropy stabilities are overwhelmed. As such, NPR has been found useful for modelling failure in tolerance in biological (organism) parameters in Non-parametric (multiplicative) regression (McCune, 2006). Therefore NPR is a better regression model for Effectivity tolerance.

Considering the model Figure 17,above (a) Displays three relative Effectivity propositions for 3 Relative Effectivity-tolerances. (b) Sees approximations of the D_{KL} function of efficiency (as derived from the functioning of entropy 'within phase'). Here a continual function allows functional states as effectivity, to be mapped along (c) exponential trajectories (of entropy efficiency). As the functional Affordance state approaches maximum entropy and goes beyond phase-boundary, a catastrophic collapse in function occurs (see dotted line (b) above).

Of interest here are the relative trajectories of efficiency in function (b) & (c): It is not only the capability limitations of the Effectivity that define differing relative function, but important is the 'rate of efficiency change' in relation to the surprise.

Efficiency in function is seen to be steeper in its efficiency 'rate of change' in reduced Effectivity.

It is in this efficiency-trajectory behavior as reflecting relative function, that we can differentiate tolerance-behaviour through its reflecting of a reduced Voluntary Control in relative-Effectivity its efficiency behaviour (slope of). This therefore allows us to probe Dynamical behaviour to better effect through attentional processes and their reduced Voluntary Control behaviour(s).

3.5 A reduced Voluntary Control and Steepening relative Effectivity Function

Criticality functions in Voluntary Control, through the sensory engagement with the world, in being dependent on being represented by an Effectivity capacity. Any internal top-down cognitions exact a cost and are 'limiting' on that generative capacity, reducing the Effectivity. Increasing top-down components not only reduce the relative tolerance to constraining the surprise from bottom-up sensory information, but also effect the efficiency-trajectory in a (relative) entropy landscape resulting in a steeper functioning of the criticality slope (the rate of temporal flux). Top-down demands on the generative reservoir are reflected the relative Effectivity function and its 'reduced Voluntary Control'.

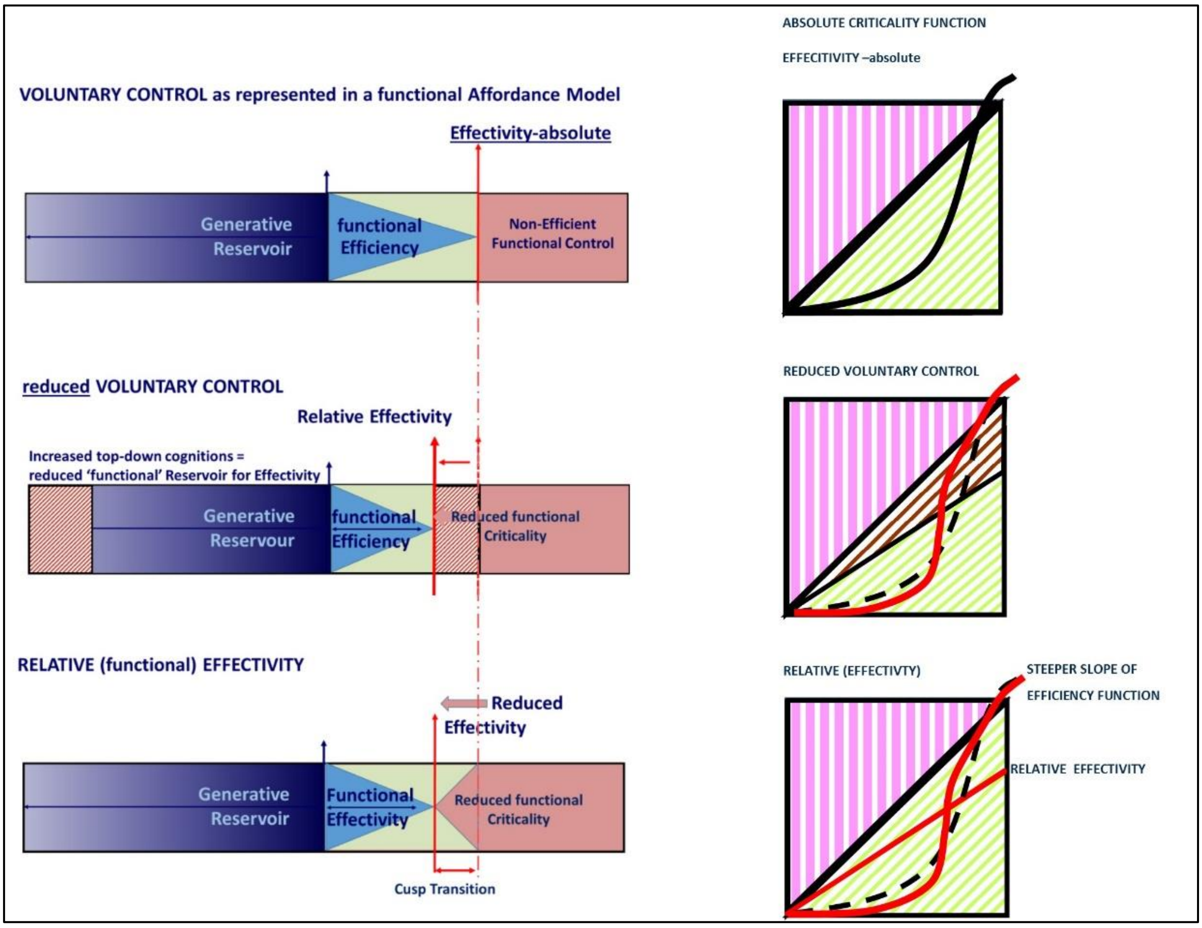


Figure 18 – Reduced Voluntary Control

This provides the prospect of differentiating functional efficiency (in Affordance – as relative Effectivity) as determined through the trajectories of a reduced Voluntary Control. These relative Effectives are applicable to differentiate not only difference as 'relatives of function' – relative to each other in the concept of tolerance (i.e. different Effectivity capabilities), but also relational (within system) as function of different reduced states of reduced Voluntary Control due to agential functioning. These are all 'relative' Effectivities, that through a Tolerance hypothesis, are able to be defined through their efficiency behaviour as steeper trajectory profiles (Figure 18, above).

Top-down cognitions exert a reduced Voluntary Control effect on the generative model of Effectivity. Relative-Tolerance is therefore reduced in the effect of a 'relative function'. As affective behaviour of decreased tolerance to Affordance and a steeper efficiency slope of behaviour, as displayed in the trajectories (Figure 18, above).

3.5.1 To Maintain Criticality: The Reduced Catastrophe Effect

Once an Effectivity 'phase' is reached, an absolute of catastrophic function ensues and phase transitions become evident at the macro level, as phase breaking behaviours display: critical slowing down, hysteresis, and then catastrophic-collapse. However, 'relative' phase, if a reduced Voluntary Control (within system or phase), may avoid catastrophe by the re-appropriation of attention resources (here Affordances are re-appropriated towards relative Effectivity): Though the rVC function of phase transition is consistent with catastrophe (and therefore similar affective cognitive-emotions are present: worry, anxiety avoid etc.); Importantly, a 'reduced' functional Affordance is not an 'absolute of function' – Criticality has somewhere to go.

It is possible for a change in a cognitive landscape of attentional processes to permit the maintenance of tolerance (Effectivity), as top-down attentional processes are diverted to bottom-up processes – an agential mediation on sensory behaviour and performance over of contextual cognitions. Such 'extended' catastrophe might be better explained within a Divergent Criticality hypothesis, rather than previous Cusp-Fold model(s) (Hardy & Parfitt, 1991; Thom & Fowler, 1975; Zeeman, 1976). Here we present Divergent Criticality hypothesis as a Cusp-Hopf formulation (Buzzi, De Carvalho & Teixeira, 2012; Guardia, Seara & Teixeira, 2011; Harlim & Langford, 2007; Hopf, 1942), allowing better modelling of catastrophe (and therefore cognitive) function and behaviour.

Divergent Criticality is primarily a hypothesis of the maintenance of control in a phase of ecological function. Such a phase of control or cognitive and behavioural stability is defined by an expression of efficient function in relation to ecological demand. It is in performance surface (see,

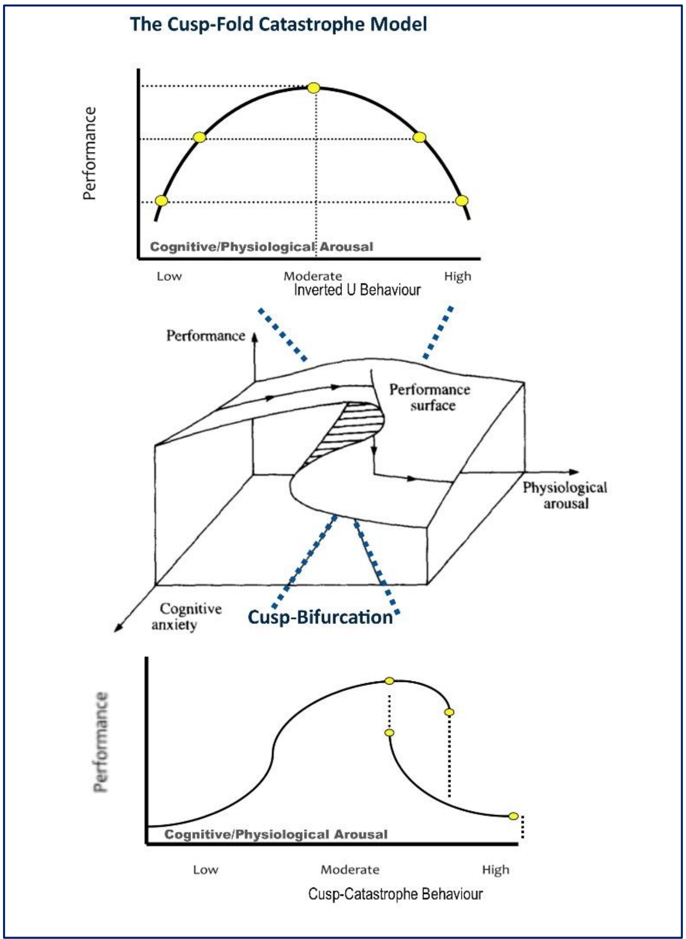
Figure 19, over) that such entropic functioning postulates two dominant ‘theories of function’: 1) A smooth equilibrium of stability such as the ‘Inverted U-Theory’ (Yerks & Dobson, 1908), as a ‘fold’ model sees control or performance oscillate around an optimal of performance and; 2) A Cusp Catastrophe model where an optimum of performance, function and behaviour/performance, is followed a collapse of functioning (e.g. Cusp Catastrophe Theory (Hardy & Fazey, 1987)). Both are manifestations of two dimensions of control (e.g. cognitive demand and anxiety) and have been formulated in Catastrophe theory as a Cusp-Fold (Thom & Fowler, 1975; Zeeman, 1976).

Thom and Fowler (1975), in developing catastrophe theory classified seven elementary models of catastrophe function, a hierarchy of the more complex models subsuming the fundamental function of lower order models. Such is the ‘intensive’ complexity of Non-linear Dynamical Systems, that Divergent Criticality would seek to theoretically-ground catastrophe theory in a simple mechanism, but with a complexity of functional possibility or outcome.

Psychological and philological applications of Catastrophe Theory (Guastello, 2009), as it offers a response-surface (performance outcomes) that can observe ‘change’ in cognition and behaviour, modelling dimensions of control in physiological performance and neural function.

It is in a Cusp-Fold catastrophic model, that much interest in the psychological sciences has been instigated as a model that accommodates the basic symmetric ‘fold’ of smooth function, extrapolated to an asymmetric ‘Cusp’ of sudden change and local collapse of phase and stability.

These two approaches to catastrophe theory with which to explain function and behaviour, represent a ‘Cusp-Fold’ approach (Guastello, 2009; Thom & Fowler, 1975) is able to be described as a two dimensional manifold of (unfolding) behaviour, and is formulated around two control dimensions of criticality – (a) the asymmetric landscape and (b) bifurcation function where potential function surface (y) may be mapped as a 2nd derivative of criticality, $\mathrm{d}f(y) = y^3 - by - a$:



$$\mathrm{d}f(y) = y^3 - by - a$$

$\mathrm{d}f(y)$ = Performance Surface (landscape)

a = Asymmetry in Physiological Control

b = Bifurcation dimension as Cognitive anxiety

$\underline{by}$ = Internal criticality dimension

Figure 19 – Cusp-Fold Catastrophe Model, adapted from (Yerks & Dobson,1908; Hardy & Parfitt,1991; Zeeman, 1976)

Above, two of the more popular applied catastrophe theories: Yerks and Dobson (1908) Fold Inverted U-hypothesis and Hardy and Parfitt (1991) Cusp Catastrophe Theory, are reformulated applying an agential control dimension, therefore, able to accommodate the variation and vagaries that have confounded previous literature on the function of catastrophe in perception and behaviour (performance):

Though 'cusp' and 'fold' formulations of catastrophe produce a two dimensional surface for function in $\mathrm{d}f(y)$, this formulation still might be considered as linear and static, in its functionality as co-dimensional, 'two fold' bifurcation (Gavrilov, 1978; Langford, 1979). Hardy *et al.* (2007) have encountered a richer and more complex landscape of cognitive-physiological interaction confounding such two dimensional function. Though they have tried to accommodate this confounding of model behaviour in a cognitive 'effort' and control-function, they have not fundamentally altered the two dimensionality of the Cusp-Fold catastrophe models therefore, might have not provided a functional 3rd 'agential dimension: Though Hardy's use of the cusp-fold model takes account of cognitive (agential) variation, it is still a model that could be considered as a static landscape of functional processes, processes that do not adequately account for the attentional-bias and the behavioural dynamism seen in research (e.g., Cohen *et al.*, 2003; Tenenbaum & Becker, 2005).

The catastrophe model 'seems' to accommodate attentional (cognitive) demands, but in Cusp-Fold catastrophe modelling, this is done on a trajectory that utilises an absolute or normal 'landscape of Effectivity', one that is negotiated in two dimensions of control. This landscape, provides a psychological and cognitive 'diffeomorphism up to transversely' (Guastello, 2009, p29), one that does not adequately account or explain the agential dimension or mediation in naturalised function (rather Hardy *et al.* cusp-fold models are an observation of behaviour rather than function). The outcome is that affective behaviour is incorrectly allocated function, therefore, further behaviour can be contradictory to the modelling of such incorrect, 'cusp-fold' functional expectations or predictions (e.g. behaviours thought to be reflective of a catastrophe function landscape are observed as 'both' cusp-catastrophic and fold-catastrophic (Inverted-U), confounding expectations based on Cusp-fold models (*ibid*)).

This confounding between modelled and observed behaviour, Hardy explains through the functioning of cognitive anxiety control (e.g. effort) in catastrophic behaviour. Though this has been vigorously defended (Hardy *et al.*, 2007), the inability of the cusp-fold model to explain such behavioural-duality persists. Hardy, however, does recognise an 'agency' in cognitive processes in the acknowledgement of the 'effort' function (a concept from Attentional Control Theory (Eysenck & Calvo, 1992; Eysenck *et al.*, 2007)), however, this does not provide adequate functionality to delineate and describe the variation observed in Cusp-Fold behaviour.

The Divergent Criticality hypothesis, in a 'relative' formulation of Effectivity, requires a dynamic 'diffeomorphism' of three-dimensions; the re-formulation of catastrophe theory's 'two-fold' dimensions (process of cognitive and physiological arousal or demand), to accommodate 'all' functional determinants on cognition (including agency) for a Dynamical System to be truly functional. Divergent Criticality hopes to address these inadequacies (observed between model and behaviour in the Cusp-Fold model), by introducing an agential 'dimension' to relative Effectivity – a reduced Voluntary Control dimension effective on criticality behaviour as a 'limited' function in catastrophe theory – a Cusp-Hopf formulation (Buzzi *et al.*, 2012; Harlim & Langford, 2007; Hopf, 1942) for criticality behaviour.

3.6 Cusp-Hopf Function: An Agential Approach to Criticality and Catastrophe

The Divergent Criticality hypothesis in modelling a 'beyond' relative Effectivity function as an 'agential' dimension in criticality and Catastrophe function), is better explained through a 'Cusp-Hopf' formulation in Self-Organising Criticality for neural function and behaviour.

The problems of cusp-fold catastrophe seen in Hardy and Fazey (1987), are accommodated in a Divergent Criticality hypothesis, by bringing an extra dimension of agential control, an intentionality – to the functioning of criticality in a Tolerance Optimisation. A Cusp-Hopf Tolerance-maintenance function (of optimisation) can be defined and modelled through an agential 'control' dimension. This allows two probable behaviours from a Cusp-Hopf formulation in catastrophe modelling, the criticality functioning of 'near' and 'far' from cusp (relative Effectivity), and emergent as the observations of 'fold' and 'cusp' behaviour (behaviours that have incorrectly been attributed as function in previous cusp-fold models, e.g. Hardy and Fazey).

It is in the Divergent Criticality hypothesis that agential-mediation can be considered as the control parameter in a 'Cusp-Hopf' proposition, a 'three-fold' co-dimensional model providing an agential dimension that is in addition to the cognitive and psychological demand parameters (see agential dimension A-B, below). This is a 'limited' behaviour (non-normal temporal-optimisation, i.e. dissipative), of criticality function at the 'edge of stability', with the behavioural outcomes of a shifting-phase criticality as it maintains and/or collapses (bi-furcates) a phase-cusp of stability. Rather than a 'normal' trajectories of fold or cusp (which, functionally, cannot now be considered as 'behaviour' from 'normal' function), an agential goal-oriented 'intentionality' dimension, prosaically, 'surfs' the cusp optimisation and the behaviours associated with catastrophe of cusp and fold emerge dependent on the agent (see, below):

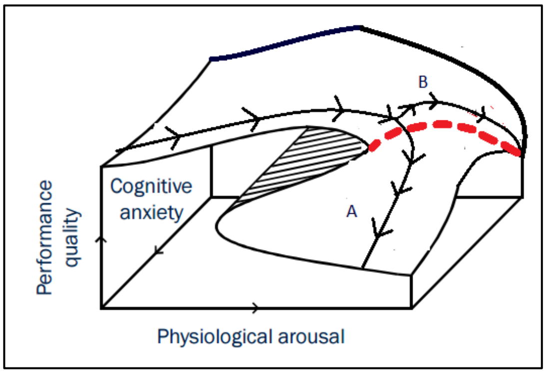


Figure 20 – A Cusp-Hopf Agential Mediation (A – B) dynamic dimension: adapted from (Zeeman, 1976)

(A) The first, a collapse, if function goes far (beyond) 'cusp' with stability-breaking, then performance-collapse behaviours are observed;

(B) The second, a maintenance of stability 'close to cusp', allowing functioning to maintain Tolerance Optimisation, but at the cost of 'relative' phase as a dissipative or a 'truncated-normal' (Harlim & Langford, 2007); a temporal equilibrium (non-stable) that allows smooth or 'fold like' catastrophic behaviour along a cusp-optimisation dimension (this will be aligned with an 'Intentionality-dimension', see, 8.6.6 – Agential Capabilities and Control in Cognitive Processes, p249). The red-dashed line represents a 3rd dimension of Agential Intentionality and a 'Limited' Tolerance Optimisation function

Such theoretical formulation of three fold criticality is described by the Tolerance Optimisation within a congruent hypothesis of agential relative-Effectivity. Divergent Criticality provides the theoretical formulation to answer how intentionality in 'cusp' behaviour might self-organise (and come to be). Three-fold cusp catastrophe 'allows' 'beyond' criticality function to thermodynamically persist as a cusp-maintenance of Tolerance Optimisation, a non-stable equilibrium, in dissipative systems. Intentionality is, therefore, able to be functionally grounded in self-organising theory as a Catastrophe Theory of a reduced Voluntary Control function:

"concept of local structural stability in Ωr is naturally obtained" (Buzzi et al., 2012, p8).

(Ωr) represents a 'Non Smooth Vector Field (Filippov systems), allowing a topological extension of stability to exist: "*if there an orientation preserving homeomorphism*" (*ibid*). This is an agential 'orientation' permitted with 'relative' Effectivity 'preserving homeomorphism' in a functional buffer-zone (not exceeding absolute Effectivity). Here, agential 'mediation' may be 'paid' for at a cost to Effectivity and efficient functioning. Such a relative agential mediation of Effectivity is formulated in the Divergent Criticality hypothesis as a 'reduced Voluntary Control'.

In such agential-mediated 'Voluntary Control', function can either display: (A) collapse, as an absolute (normal function)[57], or (B) a cusp-maintenance behaviour (through a reduced relative Effectivity) as the 'orientation' of reduced Voluntary Control, and phase function able to maintain stability. As a behaviour of optimisation, Tolerance 'maintenance' is seen in a temporal 'cusp' state of 'limited' function. This, however, is not an easily realised cognitive-capacity or state; to extend such cusp-criticality requires the agential 'mediation' (as cognitive 'effort'), and a functioning of inefficiency (from the demands of top-down cognitions), that still represents a 'less than optimal' proposition for functional Affordance (Eysenck *et al.*, 2007).

Attentional components and their interaction can be graphically represented through the formulation of relative Effectivity as an entropic Kullback-Leibler divergence, but with Cusp-Hopf reduced function (in Voluntary Control). It is in the interplay of reduced Voluntary Control and the functioning of Divergent Criticality (the steepness of the functional slope), that differentiation around function in relative Effectivity is able to be defined in behaviour terms, reflecting the functioning of agency in Self Organising processes.

Considering the behaviour of criticality in biological functioning (see, 2.35, Divergent Criticality – Maximal Entropy Production for Biological , p79). If Tolerance in (neural) functioning provides a state of optimum function for ecological engagement and surprise (entropy); how does such Divergent Criticality function become affective in cognition and behaviour and the 'affective' mechanism that

[57] 'Limited' in catastrophe terminology refers to behaviour outside or beyond 'normal' function.

connects Divergent Criticality with biological function and behaviour. This is discussed in the next section.

3.7 Affective Behaviour for a Divergent Criticality Hypothesis

One possible approach to achieve the optimal tolerance hypothesis would be to align behaviour with ecological engagement for 'surprise' (change) through life-affective behaviours.

Affective behaviour for life-regulation has provided neural mechanisms that epitomise biological-value: good for survival (reward and attraction); and bad for survival (repulsion anxiety and aversion). One of the relationships between affective cognitions and behaviour is that of the reticular activating system – the 'Dopamine Reward System' (DRS) (Olds & Milner, 1954). Here, the importance of neurotransmitters and ecological function in neural networks was aligned with affective behaviour. More recently, DRS as 'the reward' mechanism, is found to be nuanced, parsed between eliciting a hedonic 'pleasure' or 'liking', but with a 'wanting' that might be considered as the mediator of motivation, rather than liking. This suggests multiple components to reward-based affect, one that combines a) the liking or hedonic-affect for pleasure, with b) a volition or motivation for the 'wanting' of that pleasure (Berridge & Kringelbach, 2013; Thompson & Swanson, 2010; Zahm *et al.*, 2013).

Here importantly, it is the volition or wanting agency that is seen to be innate, a sub-cortical affective drive or 'seeking' (Damasio & Carvalho, 2013; Damasio, Grabowski, Bechara, Damasio, Ponto, Parvizi & Hichwa, 2000; Panksepp, 1998; Richard & Berridge, 2012). Such innate 'drive(s)' of affective behaviour provide the possibility of an affective base for constructing adaptive behaviours on.

Research has prioritised such innate sub-cortical propositions as our affective behaviours (see, Craig, 2014; Damasio, 2010; Merker, 2007; Panksepp, 1998; Thompson, 2007) as primary in what Damasio has termed the 'brain-body' loop (2010) – a resonant feedback of brain, body and environment; communicating sensory, and homeostatic information for life-regulation. Damasio describes these behaviours as being encoded in 'programmes of affect', a cascade of affective behaviour in response towards life-regulation.

These programmes of affective behaviour are 'emotions' of hereditary neural programming for survival, replicated and refined through their 'selectionist' worth. This evolution lineage may be traced back to the emergence of trophic behaviour from the first organic life, exhibiting behaviour towards biological-value (see, Hastings & Greenberg, 1999). However, it can't simply be an affective behaviour for Divergent Criticality (however well this affective behaviour might be informed); as an uncontrolled, run-away process, Divergent Criticality would be a catastrophic biological-value proposition, taking the body-environment system through increasing criticality to collapse. How, then, does the brain know when its functioning is optimal, and then moderate Divergent Criticality?

As a behavioural regulatory system acting on an innate drive, neuro-affective regulation has been found in a similar, but 'counter-opposing', moderating, response behaviour to reward stimuli (Nithianantharajah, Komiyama, McKechanie, Johnstone, Blackwood, Clair, Emes, van de Lagemaat, Saksida, Bussey & Grant, 2013). Genome research is providing support for not only the evolutionary robustness of a 'moderated' affective behaviour hypothesis, but behavioural regulation and diversification in the biological lineage. This is now being experimentally observed in neural diversification (Ryan, Kopanitsa, Indersmitten, Nithianantharajah, Afinowi, Pettit, Stanford, Sprengel, Saksida, Bussey, O'Dell, Grant & Komiyama, 2013).

It is in the how such a Divergent Criticality might regulate or inform 'affective behaviour', both as to an optimal, but in the maintenance of biological-value, that we might consider to a self-regulation for a Tolerance Optimisation. If Divergent Criticality were able to self-regulate around a Tolerance optimal, then this would provide for a 'brain-body/environment' Tolerance hypothesis. The question is posed: 'How does the brain know when its functioning is optimal'. If this is going to be answered, such self-regulating 'affect' needs to be naturalised through Divergent Criticality in order to avoid the theoretical and physiological pitfalls of idealism – the brain needs to know (not through an *a priori* knowledge), but through affective optimal functioning in reference to biological-value.

3.8 Criticality has a Noise

It is in the functioning of Self-Organisation Criticality that we again find a possible way forward: criticality (as entropy function) has a noise, a signature of criticality emergence in the brain.

With increasingly accurate measurement, correlations of differing amplitude and frequency start to emerge from brain-environment behaviour, this is seen in electroencephalography [EEG], but also coupling behaviour, limb movement, bird singing, social interaction, etc. – this is the emergence of 'fractal scaling' in neural 'noise'. Fractal-scaling is a 'state' where the whole system resonates with itself throughout its levels of criticality and self-organisation; it is when correlation with the 'scaling' of observation level becomes a power-law 'scale of similarity' in criticality behaviour (entropic dissipation), that a scaling-exponent[58] emerges. Functioning is now able to be differentiated through a neural-function as fractal scaling.

A scaling-exponent reflects a change or divergence in the scaling-relationship between wave amplitude and frequency scales of an observed (data) sine function. This scaling relationship when spectrally plotted, delivers a scaling exponent (α) as a measure of just how similar the fractal level(s) of emergence are (consider Russian Doll similarity: similar within similar). It is the signal of the similarity in 'criticality' functioning of the intensive-features of a self-organising system, that the 'state' of entropic function may be determined. If no similarity exists, this emergent scaling-exponent would approach the value of α=0; conversely, if similar in 'all' parts (levels), then the scaling exponent would approach the value of α=2.

The data that from the seeming chaos of complexity systems, stability (as a temporal states description) reveals a scaling exponent of α approaching 1 ($\alpha \approx 1$), a scaling-exponent that in ecology science is described as a 'Fractal Pattern'. This should not have been a total surprise: from the initial break-through in avalanche behaviour[59] (Bak *et al.*, 1987), observations of 'nature' often display this fractal pattern of $1/f^1$ (e.g. branching of trees and geometric patterns of flowers; heart rate variance, etc. – all are described as fractal scaling $\alpha \approx 1$ [$1/f^1$]).

With the scaling-exponent of ($\alpha \approx 2$) interpreted as Brown-noise and ($\alpha \approx 0$) interpreted as White-noise, then ($\alpha \approx 1$) is Pink noise, and seen as an emergent behaviour between White and Brown-noise, neither rigid nor random. This duality has been called a "third Kind of Behaviour" (Van Orden *et al.*, 2011, p654), and as ubiquitous in nature, it has been suggested that ($\alpha \approx 1$) represents an entropic attractor for Non-linear Dynamical Systems (Van Orden *et al.*, 2011).

This would seem to suggest Pink noise as a possible attractor to which a self-organizing system would be naturally draw – a stable-state of criticality. This might be questioned in relation to a

[58] This is done through a power-law/lognormal distribution, here 'power' is used in its statistical context; a power-law relationship using logarithmic-coordinates.

[59] Although not organic, avalanches express a dynamic self-organising proposition.

Tolerance Hypothesis where, a stable-state of criticality as we have shown, requires a non-zero proposition for Divergent Criticality: A Divergent Criticality in fractal scaling is a 'White-shift'[60].

White-shift represents a shift in entropic-flux that causes 'entropy production' ($\sigma' > \sigma$) and a 'shift' from the basis of Pink noise (α≈ 1), 'towards' White-noise (α≈ $1^{\mathbf{minus}}$). Its antithesis is a Brown-shift ($\sigma' < \sigma$) towards Brown-noise (α≈ $1^{\mathbf{plus}}$). As a flux, such 'shift' represents a change in the 'rate' of production; a second derivative function represented in the Tolerance hypothesis as the system diverges toward optimal tolerance function. From this White-shift, a self-regulating Affective mechanism is able to be formulated informed by scaling emergence, and aligned with differentiated surprise as a tolerance demand in dynamic environments:

3.9 Formulating a Tolerance Optimisation Hypothesis in Criticality

As a dynamical effect, White-shift is an attraction to the chaos and surprise of a Tolerance Optimisation maximal. We see a phase being taken to the edge of control by increasing entropy production ($\sigma' > \sigma$). The White-shift is the rate of change of criticality as entropy 'cascades' through intensive levels of emergence, with decreasing scaling similarity (α≈ approaches 0). Therefore increasing White-shift as a signal able to coordinate[61] surprise-affective behaviour (seeking, play, increased cognitive demands etc.), that drive the system towards a Tolerance Optimum 'attractor'.

What makes White-shift applicable as an attractor is its 'inflection' point in criticality as it reaches 'maximal' parameters of behaviour (α≈ 0). At this point of 'seeming' collapse in complexity, two behaviours can be exhibited in biological systems dependent on Tolerance capability of the agent (phase stability to export entropy); a relative or an absolute (like) Effectivity in relation to the dynamic demand on cognitive resources:

1) In an absolute of functioning (Effectivity-tolerance) and a catastrophic behaviours see a White-shift collapse of the system – Divergent Criticality as a 'runaway' proposition.

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[60] 'Shift' as in White-shift, Brown-shift etc. is analogous to 'noise' in its fractal signature (α≈ $1^{\mathbf{minus}}$). Shift is used here to define the behaviour of criticality, however, noise and shift are fungible in this respect.

[61] How the signal is 'perceived' and able to coordinate affective behaviour is not in the scope of this study. However, it would represent just another 'bottom-up' sensory information signal to be appropriated by the neural system.

2) However, in a reduced-Effectivity 'cusp' state of criticality, going beyond the 'relative' optimal will result in White-shift ($\alpha \approx 1^{\mathbf{minus}}$) becoming Brown-shift ($\alpha \approx 1^{\mathbf{plus}}$), as only the 'relative' criticality capability is exceeded not an absolute. The cusp-function can be moderated by its access to 'Effectivities' available within a reduced Voluntary Control mediation (until the 'absolute' of entropic behaviour is reached). The resultant cusp entropic behaviour results in entropy loss as more entropy is dissipated, and therefore will see an attractor of fractal scaling move towards a brown stability ($\alpha \approx 1^{\mathbf{plus}}$).

This agential behaviour around a cusp-criticality provides; a naturalised, self-regulating, entropic mechanism of 'White-shift' for Divergent Criticality's adherence tolerance parameters. When agential mediation is applied as a third dimension to a relative Effectivity, a Cusp-Hopf formulation of criticality permits the self-organising attractor to 'drift' or be mediated towards Brown-shift as a volition or intentionality affective on Tolerance Optimisation – This is how the brain knows.

All organic life may considered as 'reduced Effectivity' in displaying agential self-replicating behaviour (Feinberg & Mallatt, 2016; Macklem, 2008; Thompson, 2007), then biological life might be considered to be on a continuum of reduced Effectivity and increasing agential volition. This allows a simple hypothesis: that Tolerance Optimisation is self-regulated or orientated to a White-shift signal. In this fundamental simplicity, criticality is easily and universally extrapolated to animal-environment autonomy.

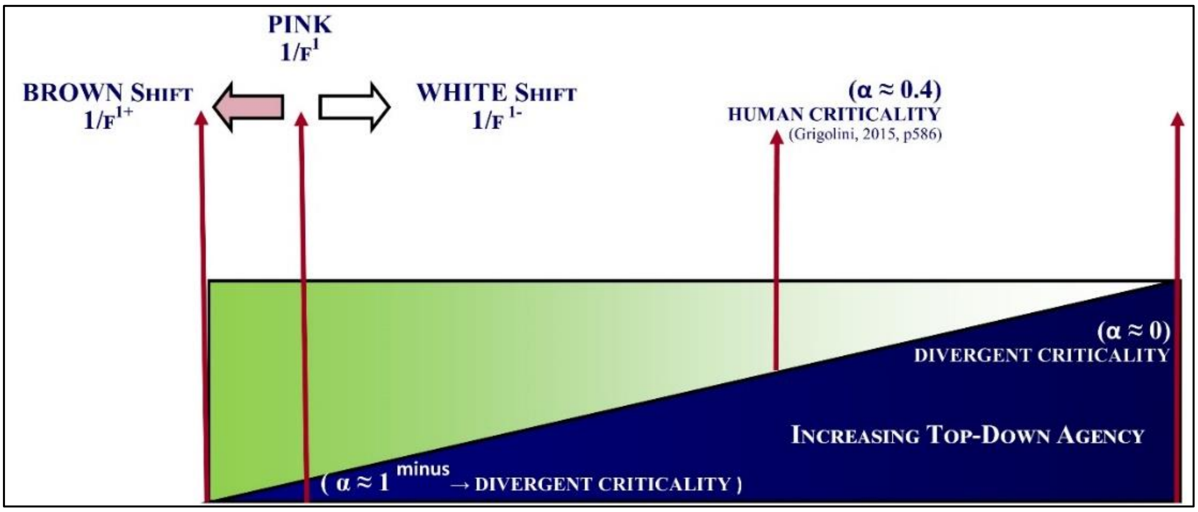

Figure 21 – White Shift Continuum

In avoiding entropy, all organic life must display non-diminishing entropy production for flux dynamics to export entropy. This might be translated as, 'tolerance in an animal-environment autonomy is relational to dynamic demand, therefore, as dynamic demand increases, entropy production increases, requiring greater White-shift for optimal tolerance'. This allows a tolerance-demand 'continuum' for increasing Divergent Criticality to be visualised: from trophic (almost dispositional); to agential predictive (Figure 21, above). Instead of parsing dispositional and predictive models, here, they form part of the same evolutionary lineage of generative agential affective.

It can now be surmised that a minimum Divergent Criticality scaling of ($\alpha \approx 1^{\mathbf{minus}}$), a White-shift would need to be found in all biological-life behaviour. Therefore, much of nature thought to be displaying 1/f will actually have a small White-shift ($\alpha \approx 1^{\mathbf{minus}}$) from pink noise. Findings of this 'pink' noise are fairly ubiquitous in biological studies (Hausdorff, Zemany, Peng & Goldberger, 1999; Kiefer, Riley, Shockley, Villard & Van Orden, 2009; Kloos, Kiefer, Gresham, K. Shockley, Riley & Van Orden, 2009; Wijnants, Bosman, Hasselman, Cox & Van Orden, 2009); however, rather than a pink attractor, a white-shift at a level just below 1 is predicted. It may be that fractal-signals from many studies have not accurately been extrapolated from the fractal scaling (He, 2014).

Indeed Hausdorff *et al.* (1999) in their gait analysis found *"while exponents for adults were distributed narrowly and closer to pink noise (on the white side of pink noise)"* (Van Orden et al., 2011, p650):

This was in adults performing what might be considered the most 'expert' / habituation example (gait/walking), therefore of little surprise (dynamic demand). Of interest, is that children reported Brown-noise in these gait experiments. Here, the Tolerance hypothesis has two possible explanations: 1) There was so little surprise/challenge, that they were in a neural-state of 'convergent criticality'; or 2) They were in a neural-state of cusp criticality 'beyond' a relative criticality in an extreme learning state. The latter explanation would be suggested here.

At the divergent end of the criticality-phase, one would expect to see greater white-shift closer to ($\alpha \approx 0$). This, it seems, is becoming more evident in neural scaling for human behaviour: (Bertschinger & Natschläger, 2004; Chialvo, 2010; Clayton & Frey, 1997; Correll, 2008; Grigolini & Chialvo, 2013; Kello & Van Orden, 2009; Tuller, 2005; Tuller *et al.*, 1994; Ward, 2002).

Of particular interest is Grigolini (2015, p586) where temporal criticality was found at a power index of($\mu = 1.6$) equivalent to ($\alpha \approx 0.4$).

3.10 How the Brain Knows: Tolerance Optimisation

It is hypothesised that affective behaviour is informed by White-shift, this is how 'the brain knows' how to self-regulate around a Tolerance Optimal state of criticality-function.

A White-shift in criticality-function, enables the brain-body emotional system to function at the edge or 'cusp' of criticality, an optimal learning state conducive to the 'dynamism' in the environment. This is a true agent-environment autonomy – a Tolerance hypothesis for Divergent Criticality. If a Brown-shift occurs, then there has been loss of 'capability' to dissipate entropy: either as the system dissipates[62] towards a 'convergent criticality'; or the relative 'tolerance optimal' has been exceeded.

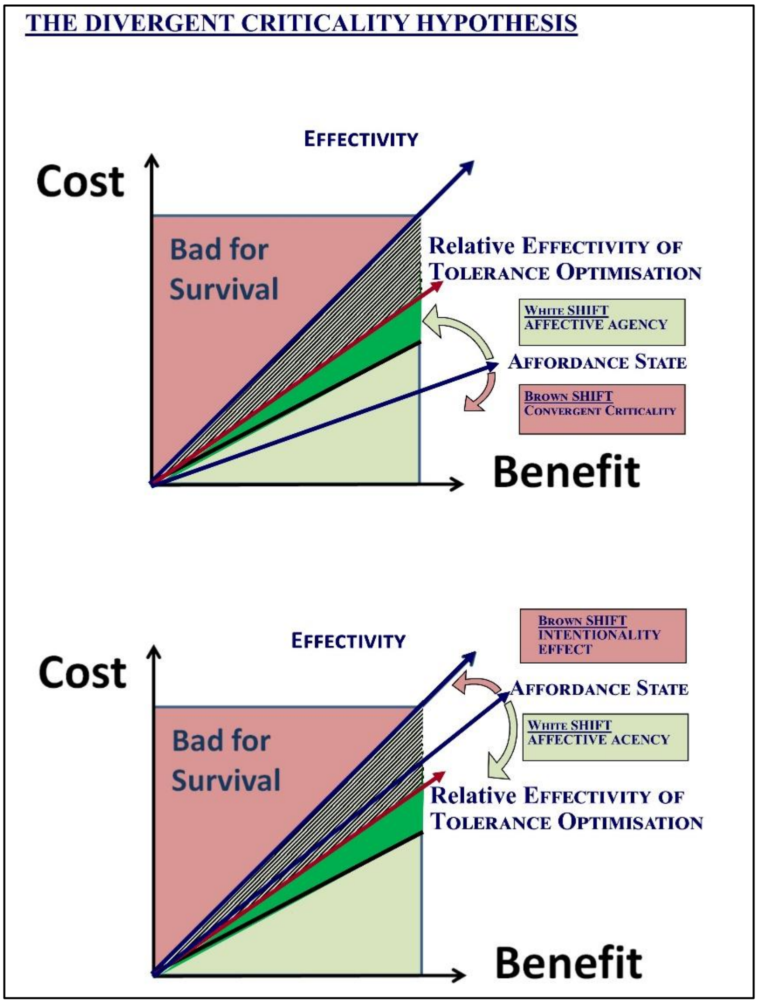

Figure 22 – White Shift of Divergent Criticality: Self-Regulation in Relative Function

[62] Such 'dissipation' is the dynamic flux characterising all entropic systems, and is referred to as an entropic 'optimisation' in Dynamical Theory. It is named here as 'dissipation' in order not to confuse Tolerance 'Optimisation'.

In all cases, a white-shift elicits returning the system to tolerance optimal behaviour in reduced Effectivity/ Voluntary Control (see, Figure 22, above).

White-shift self-regulates organisms and biological-life at all levels of complexity. As an ecological tolerance proposition, organisms in dynamic environments are driven through affective behaviours (wanting, seeking, etc.) to engage with surprise through reward and life-enhancing phenomenological feeling. If they exceed relative criticality (and optimal tolerance), then adverse cognitive-emotions (anxiety, dislike, aversion), affect avoid behaviours for dis-engaging with further surprise.

These are ‘co-opted’, affective emotional-cognitions from the primary processes of approach-avoid in biological-value (Panksepp & Biven, 2012). We can therefore expect that primordial behaviours will be retained (primary affective 'systems' are often displayed in extremis, such a fear[63]), in addition to evolutionary moderated ‘tertiary-regulated’ emotions.

3.11 Summary of Divergent Criticality hypothesis

As a selectionist proposition for explaining human cognition and behaviour, the Divergent Criticality hypothesis, has made the case for entropic behaviour underpinning neural-function for perception and leaning as; a perception of and from the state of cognitive function for life-effectiveness. To be able to set perception in neural-function requires that we attempt the problem of coordinating a subjective perception towards an objectivity in explanation. This is approached through a state relative Effectivity considered as a ‘Tolerance’ definition – a measure of perception as ‘a state of functional Affordance’ is able to provide such empirical objectivity.

The methodology now develops a perception measure able to be considered as such a ’state of functional Affordance’ and then tests the Divergent Criticality hypothesis through a number of research designs. It should be noted that this PhD study represents a constructivist approach in its evolving research question and methodology, in that both the research design and the validity of its methods evolve in a ‘maturing’ methodology that starts with a guiding research question –

[63] As well as more obvious, fear-inducing cascades of uncontrolled emotional behaviour, it has been hypothesised that once you achieve what you are driven towards, e.g. ‘food’, that the ‘seeking-wanting’ motivations are ‘switched-off’ in order that you may actualise (ingest) biological-value (Berridge & Kringelbach, 2008)

Can our perceptions of ecological engagement as reported through Situational Interest and Self Concept, be indicative of neural efficiency and a state of functional Affordance?

To address this three studies were conducted:

Study One – Measure Investigation

1) A pilot study sets out to investigate if Divergent Criticality can be explored through perception measures of 'attentional awareness': First a Situational Interest measure of perceptions thought to infer a state of cognitive efficiency in function; and Secondly, a Self-Concept measure (self-effectiveness, self-efficacy, locus of control, etc.) were used to infer cognitions of life-effectiveness considered to reflect neural-function. It was thought that these measures might offer some inference of the functioning of Tolerance Optimisation, in accordance with the Divergent Criticality Hypothesis.

Study Two – Questionnaire Development

2) Built on the findings from the first study, further development to the measures of Situational Interest and Self-Concept in order that they might better align within the Divergent Criticality hypothesis was conducted. This employed Factor Analysis to test the veracity of this questionnaire development. This study two was used to inform the final study, Study Three's, research design and methodology.

Study Three – An Exploratory Model of Divergent Criticality Function

3) Study three brought together the findings of previous studies in a multi-faceted research design, to test Tolerance Optimisation (within a Divergent Criticality Theory), and Factor Analysis helped further develop a Structural Equation Model (SEM). In accordance with SEM protocols, the resultant structural model's significance in assuming Divergent Criticality function is given further quantitative validation through a model building analysis using 'Conditional Independence'. SEM and Conditional Independence models require caution in inferring causality, as they may become confounded in a structural dependence on the data (Bollen & Pearl, 2013; Mueller, 1997); therefore, to provide further validity, an SEM (modelled) 'Interdependence Profile' as a state of functional Affordance was triangulated against an independent measure of affective-cognitions – Self-Concept.

4 CHAPTER FOUR – Methodology Study One: Measure Investigation

Can our perceptions of ecological engagement as reported through Situational Interest and Self Concept, be indicative of neural efficiency and a state of functional Affordance?

4.1 Study One: Introduction

A pilot study was carried out to evaluate if there is support for a state of functional Affordance reflecting a Divergent Criticality Hypothesis of Tolerance Optimisation in neural function, and investigate if this is accessible through perception measures of Situational Interest (Chen, Darst & Pangrazi, 1999) and Self-Concept (ROPELOC, Richards, Ellis & Neill, 2002). These perceptions are hypothesised as affective-cognitions of attentional processes made consciously 'aware', and infer a state of cognitive efficiency in relation to the ecological functioning of the individual – a functional Affordance state.

This Study One addressed two exploratory hypotheses to investigate the use of perception measures in inferring a Divergent Criticality effect:

1) The first, that a difference test using an Analysis of Variance (ANOVA) on the constructs within both measures, to determine if situational domains had an effect on perceptions of Interest (Situational Interest) and life effectiveness (Self-Concept);
2) The second, a correlation between Interest and Self-Concept using a Pearson's Independent Correlation between the measure constructs[64].

This first Study One analysis would be found 'not' able to provide the power or questionnaire-nuance necessary for investigating the complexity in cognitive function through these perception measures (as an awareness of a state of neural-function). However, the analysis of the ANOVA results for Situational Interest did point towards some form of differentiated-reporting dependent on the sampling criteria supporting the premise of affective cognitions of Divergent Criticality function. To provide some direction for future questionnaire item development, the Situational Interest measure was subject to a pathway analysis:

3) A Post Hoc, Structural Equation Modelling of Situational Interest was conducted to investigate the construct relationships and interdependent effects.

[64] Both main constructs and sub-construct levels would be investigated.

4.2 Methodology Overview

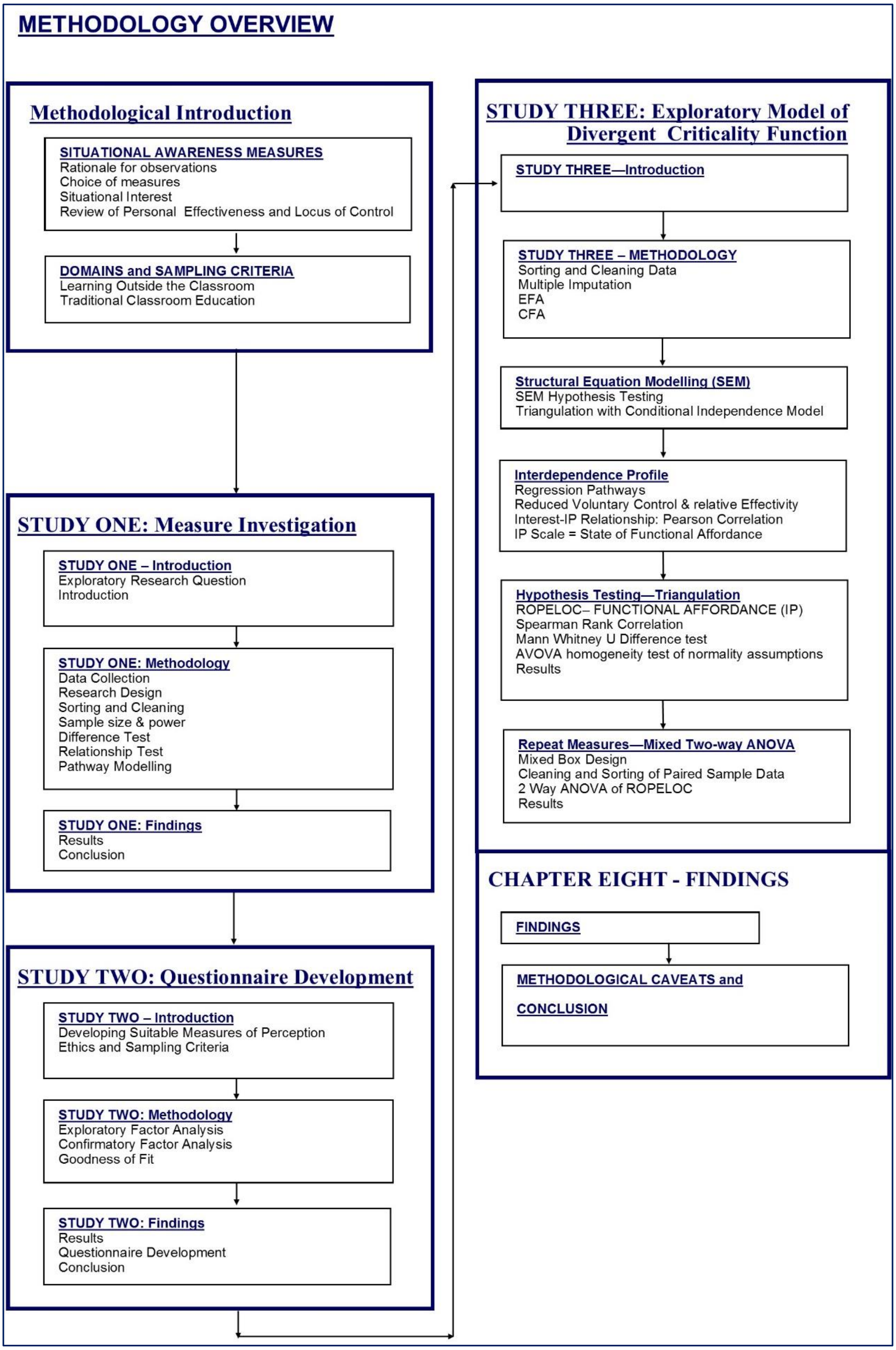

Figure 23 – Methodology Overview

Study One: Methodology

4.3 Date Collection

4.3.1 The Choice of Measures

The sampling rationale was that learning-domains, as reflecting cognitive demand in ecological engagement, would illicit cognitions as states of neural function in relation to surprise and challenge. Therefore, different learning-domains as situational determinants 'affective' on cognition, should report differentiated affective-cognitions as perceptions of attentional-awareness concurring with a Tolerance Optimisation hypothesis. To adequately address the Divergent Criticality hypothesis, measures that might report affective cognitions as to their veracity towards the functioning of Divergent Criticality should be able to reflect:

i) Ecological-demand or surprise[65].
ii) The composite effects of expectation demands and situative demands for action selection.
iii) Hedonic perceptions of affective behaviour, a 'seeking' or innate motivation.
iv) Like or dislike perceptions as 'selectionist' approach or avoid affective-cognitive behaviour.
v) Agential drive or goal-oriented cognitions of approach towards end-point cognitions.

To test the Divergent Criticality hypothesis of Tolerance Optimisation, two measures are explored:

4.3.2 Measure 1 – A State of functional Affordance within Relative Effectivity

Awareness as a state of ecological functioning suggests a cognition situated within the agent's experience; a temporal, real-time awareness or perception set within ecological engagement. Such a 'situated' awareness has been a key determinant in theories of action, especially so in the philosophies of agency and intentionality (see, Dancy & Sandis, 2015, for overview) and explored in relation to the antecedents of 'situational assessment' (Endsley, 1995; Suchman, 1987; Tremblay, 2017). Endsley (1988, 1995) proposed such an awareness of situated-intentionality in her 3 Level model of perception, comprehension and projection. According to Endsley, these are ecological situated cognitions of conscious sense-making, drawing from both knowledge and experience. To

[65] The new, different or novel in an agents experience or knowledge.

this end, measures of Situational Awareness (SA) were investigated as to their veracity in addressing the situational awareness thought to infer a state of functional Affordance, namely measures of:

- Situation Awareness Global Assessment Technique (SAGAT, Endsley, 1988)
- Situation Present Awareness Procedure (SPAM, Durso, Dattel, Banbury & Tremblay, 2004)
- Situational Awareness Rating Technique (SART, Taylor, 1990)

Though recognising many situational antecedents towards action-selection, these measures were considered ambiguous in relation to how an awareness might be affective, the ‘cognitive processes’, for an attentional-awareness as a perception (Bong & Skaalvik, 2003; Lave, 1988; Suchman, 1987). To address the ambiguities, the investigation of greater ‘immediacy’ and naturalistic sampling in a measure (real-time cognitions towards the sense-making and experience) requires the parsing of action and comprehension as separate constructs within a composite of cognitive processes (Suchman, 1987) – a more ‘dynamic’ appraisal of situational interaction.

``the organization of situated action is an emergent property of moment-by-moment interactions between actors, and between actors and the environments of their action.'' (Suchman, 1987, p179)

The suggestion that greater focus is needed as to the cognitive demand(s) of action and comprehension (seen as synonymous within situational awareness), sees a ‘situated agency’ constructed in action, requiring that the origins and functioning of ‘agency’ might be accessed (Lave & Wenger, 1991) – a cognitive ‘functioning’ that might be accessible through *In Situ* sampling. This is not a new ontology; Kant’s “antinomy of teleological judgement” presents ‘intrinsic purposiveness’ and ‘relative purposiveness’ (1987, p133); the ‘effect’ (or goal) possible, not only through the idea of that ‘effect’ as an agential ‘intentionality’ emergent through attentional processes as a ‘means towards an end’, but an ‘effect’ mediated through ecological effectiveness.

Perceptions as attentional constructs from such intentionality in a ‘Situational Awareness’ then may present themselves through cognitive processes of bottom-up (action control) and top-down (conceptual sense-making, Knudsen, 2007). A cognitive demand-biasing along situational and contextual pathways as Kant’s ‘purposiveness’ of intrinsic and ‘relative’ value, presents a parsing of goal-orientation and comprehension in cognitive-demand and an awareness of such demand. This is the cognitive processes of attentional-awareness, therefore, better considered through a ‘Situated Cognition’ – that of ‘attending’ to such value-perceptions *In Situ*.

4.3.3 Determining a Situational measure from a Composite of Attentional Cognitive-Processes

Perceptions or appraisals of intrinsic ‘purposiveness’ and goal-relatedness are extensive in Self Determination Theory (SDT, Deci & Ryan, 1985, 1991; Deci & Ryan, 2008), and out of the panoply of tests and measures, a subjective measure of perceived intrinsic motivations that offered a situational and agential ‘purposefulness’ is the Intrinsic Motivation Inventory (IMI, Ryan, Mims & Koestner, 1983). However, the prerogative of parsing action (goal-orientation) and comprehension (sense-making) was considered compromised in this IMI questionnaire. In particular, how the use of IMI was not able to differentiate ‘state’ cognitions (as required) – the Intrinsic Motivation Inventory constructs are longitudinal ‘trait-like’ perceived attributions of ‘competence’, ‘usefulness’ and ‘relatedness’. However, the IMI did identify perceptions that could be considered intrinsic measures or ‘hedonic’ markers of cognitive-efficiency: those of *Interest*, *Enjoyment* and perceived *Effort or Demand*. Such constructs have been explored as a ‘Situational Interest’ (Deci, 1992; Mitchell, 1993; Renninger, Hidi & Krapp, 2014), particularly in learning environments (Chen & Darst, 2002; 1999; Harter, 1978; Hidi & Anderson, 1992).

Situational Interest is, here, considered to offer a ‘state’ of cognitive function and intentionality as an ‘interest’ perception; this has been aligned with agential cognition and behaviour (Bandura, 2001; Chen *et al.*, 2001a; Deci, 1992; Levesque, Copeland & Sutcliffe, 2008; Ryan & Deci, 2008). At the core of these studies is a composite-appraisal of subjective experience and intentional engagement. This would suggest that ‘Situational Interest’ might infer an affective-cognition as a hedonic ‘state’ (an affective cognition of like or dislike), mediated by agential sense-making as a goal-oriented cognition (approach or avoid). Such situational interest-awareness might therefore be considered as a perception measure for neural-functioning in ecological engagement, providing the necessary criteria for reporting a state of functional Affordance as an awareness of composite cognitive (attentional) processes able to be parsed into situational purposefulness and contextual relatedness.

4.3.4 A Situational Interest Questionnaire

A multi-construct questionnaire of Situational Interest (Chen, Darst & Pangrazi,(1999; 2001a) as an examination of situational interest and its constructs, was used to measure perceptions of interest as inferring attentional cognitive-processes (Clark, 2013; Graziano, 2013). It is hypothesised that cognitive processes will be evident in an appraisal of Situational Interest (Chen et al., 1999), as a cognitive efficiency-function representing a state of functional Affordance.

Situational Interest delivered five constructs of Attentional Awareness: 1. *Exploratory Interest* (Eng); 2. *Instant Enjoyment* (InsEn); 3. *Novelty* (Nov); 4. *Attention Demand* (Att); 5. *Challenge* (Chall), and also a universal measure of *Situational Interest* 6. (ToIn, see, APPENDIX II: Questionnaire Development and Providence, p294).

4.3.5 Measure 2: A Perception Measure of Contextual Sense-Making:

To provide an alternative measure, one able to be correlated with the state 'Interest' measure, it is in the very composite of action and sense-making that an 'agency' in sense-making (comprehension) is considered to be synonymous with such perceptions (Lave, 1988): Situational determinants will be affective on sense-making in recognition of Kant's 'intrinsic purposiveness', 'trait-like' cognitions made aware as perceptions of personal agency. Here, 'traits' are seen as affective-cognitions of greater longitudinal stability than a dispositional 'state'. Importantly, here, traits themselves are not fixed or invariant to ecological demands, but self-attributions mediated through situational engagement.

In order to adequately infer sense-making through an in-situ 'value' perception, such a contextual measure should be able to address constructs of:

i) An attentional awareness of personal agency or Self-Concept.

ii) An affective cognition of capability function (relative Effectivity) towards ecological engagement.

This inferring of agential capability cognitions towards ecological demand as affective on 'comprehension', offers a complementary 'state' measure of functional Affordance. If both measures correlate and are congruent with the Tolerance Optimisation hypothesis, this should be able to provide some triangulation to the Situational Interest model inferring

4.3.6 Determining a Contextual Sense-Making state through Self-Concepts of Functional Affordance

Self-Concept perceptions of competency and control are thought to infer a self-belief or trait-like awareness of cognitive function accessible through self-report (Rickinson, Dillon, Teamey, Morris, Choi, Sanders & Benefield, 2004) and therefore, self-concept as an awareness, is hypothesised to infer that perceptions of competency and control align with ecological determinates (Cason & Gillis, 1994; Hattie, Marsh, Neill & Richards, 1997; Marsh, Pekrun, Parker, Murayama, Guo, Dicke & Arens, 2018; Miron-Shatz, Stone & Kahneman, 2009; Neill, 2002).

What and how to measure such self 'attribution' has broadly fallen into two theoretical perspectives: that of perceptions of 1) self-concept including self-confidence, self-worth, self-acceptance, competence, and ability (Shavelson, Hubner & Stanton, 1976); and that of 2) self-efficacy and agency (Bandura, 1997). A commonality between these various constructs is the increasing acknowledgement of domain and task-specification states, as being effective on both. However, these epistemologies diverge in their 'frame of reference' (Bong & Skaalvik, 2003; Pajares, 2009); for example, the influence of a negative self-concept in questionnaires, may lead to self-efficacy beliefs being perceived wrongly as outcome-expectations or global-specific 'states' of function. This is a particular issue with questionnaire items measuring 'general' self-concept items confounding self-efficacy measures for outcome expectations. To obviate such confounding effects, a broad spectrum of psychological and behavioural items as a 'measure of self-concept' was investigated:

Neill (2003) examined perceptions of self-concept through life-effectiveness, a measure that resonated with the desired criteria of a 'state of function' in a sampling domain (Ecological Engagement), and formulated a series of Life Effectiveness Questionnaires (LEQ -G, LEQ-H, LEQ-YAR, LEQ-Corporate). Of particular interest was the development of Review of Personal Effectiveness with Locus of Control (ROPELOC) (Richards *et al.*, 2002), a measure specifically directed to 'experiential interventions' of Outdoor Learning and Personal Development.

4.3.7 A Self-Concept Measure – Review of Personal Effectiveness and Locus of Control

For a perceptual measure of self-concept towards life-effectiveness, this study uses the measure 'Review of Personal Effectiveness and Locus of Control' (ROPELOC). ROPELOC (Richards *et al.*, 2002). ROPELOC is a multidimensional instrument with 10 scales that are factored to three constructs of Self-attributions and belief:

1) Personal Abilities and Beliefs (PAB) – including sub-scales of; Self-Confidence, Self-Efficacy, Stress Management, Open Thinking;
2) Social Abilities (SA) – including sub-scales of; Social Effectiveness, Cooperative Teamwork, Leadership Ability;
3) Organisational Skills (OS) – including sub-scales of; Time Management, Quality Seeking, Coping with Change).

Four other scales are included: an energy scale called *Active Involvement* (AI), a measure of *Overall Effectiveness* (OE) and two attribution scales, *Internal Locus of Control* (IL) and *External Locus of Control* (EL). In addition there is a 'check' *Control Item* (CI), to flag the veracity in reporting (see MK1: APPENDIX II: Questionnaire Development and Providence, p294).

4.4 Domains and Sampling Criteria

As the central hypothesis explores neural states of function in relation to state(s) of ecological determinants, it was considered that 'learning' environments would provide affective 'situational' differentiation to enable such function to be reported.

4.4.1 Situative Learning Domains for best inferring functional Affordance States

Learning that would seemingly confer a 'dynamic functionality' in neural states was conducted in many different learning environments thought to induce:

"any process that in living organisms, leads to a permanent capacity change, and which is not solely due to biological maturation or ageing" (Illeris, 2007, p3).

Learning environments were then delineated into two domains: a) the familiarity of Traditional Classroom Learning (TCL); and b) Learning Outside the Classroom (LoTC), environments that are new and different. Learning Outside the Classroom (LOtC) suggests a broad palette of experiential and situative learning and may be seen to encapsulate many dimensions of learning from experience, a major constructivist approach to learning in a resonance of body, mind and environment (Barrows & Tamblyn, 1980; Noë, 2008; Schmidt, Loyens, Van Gog & Paas, 2007). Learning is therefore classed as LOtC through the following criteria:

1) They are 'outside' and removed from the individual's 'normal' learning and/or educational situation.
2) They embody experiential learning through some form of ecological engagement.

This 'embodied' approach to learning as a cognition of experience in physical engagement and social environments may be aligned with key pedagogic learning perspectives: The 'Situative-perspective' of collaboration within a social-cultural environment and the inclusion and maintenance of collaborative relationships (Bruner, 2009; Lakoff & Johnson, 1999); An 'Associative-reinforcement' of experience and knowledge (Engestrőm, 1987; Kolb, 1984; Mezerow, 1985; Pavlov, 1927); and the 'Constructivist' making meaning for experience past and present (Illeris, 2003a; Mezirow, 1985; Piaget, 1958).

What seems evident from research on the perceptions of participants in these categorisations is that the implicit 'context or situation' of the learning is a fundamental property over and above 'knowledge and content'. For example, it has been consistently reported in longitudinal measures (see, Hattie *et al.*, 1997; Nundy, 1999; Rickinson *et al.*, 2004, for review) that long-term memories seem to be of the experience itself, with low content-knowledge. Situational and contextual experience is retained over specific knowledge.

"the self-perceptions of the participants, and to the way each person absorbed the experience into his or her self-structure" (Hattie et al., 1997, p.46).

Differentiated Learning Domains

Study one was conducted across six different learning domains (situated as LoTC or TCL), with the intention of providing differentiated data where sampling might reflect different states of neural-function reported across perceptions of Situational Interest and Self-Concept (ROPELOC).

The six sampling domains (Table 1, below) were allocated an *apriori* functional Affordance (state) of high (3), medium (2) and low (1). The participants in the sampling domains were sampled with both measures consecutively, after a specified learning period for that particular activity (e.g. a classroom lesson or residential fieldtrip). Important here was that both measures were presented together as close to the experience or 'situated' learning event as possible.

Table 1 – Learning Domains

Sample	Description - Situational Domain	Hypothesised Affordance State
i (n=24)	Half Day Problem Based Learning (PBL)	2:Medium(Beyond relative Effectivity)
ii (n=18)	Half Day Sport Activity Practical (Sport Act)	2:Medium(Beyond relative Effectivity)
iii (n=27)	One Hour Theory Lecture (Theory)	1:Low (Within relative Effectivity)
iv (n=23)	Recall -Half Day Learning outside The Class	1:Low (Within relative Effectivity)
v (n=8)	Five day Residential Outdoor Activities Out Act 5	3:High (Beyond relative Effectivity)
vi (n=27)	Two day Residential Outdoor Activities Out Act 2	3:High (Beyond relative Effectivity)

4.5 Study One: Research Design

Statistical Analysis 1: Difference Analysis

1) Learning domains as considered differentiated by 'higher', 'medium' and 'lower' functional Affordance states, will display difference effects when compared using a One Way ANOVA. Difference tests were applied to the both the Situational Interest and Self-Concept data.

Statistical Analysis 2: Correlation

2) A correlation of the Situational Interest constructs was conducted against the constructs of the Self-Concept (ROPELOC) measure. In considering the two measures as sampling the same 'state' of neural efficiency, a series of inter-measure correlations were explored for correlation, supporting such perception measures inferring states of functional Affordance.

Post Hoc Pathway Analysis

3) Partial-correlation and regression analysis was conducted on the Situational Interest data in order to suggest an *apriori* model for path analysis. This model was then modified to explore

a maximum likelihood to explain the variance observed in the data. Further pathway analysis was conducted using Structural Equation Modelling (SEM): $AMOS_{IBM24.}$

4.5.1 Sample Size and Power Considerations for T-Test and Correlation

To determine how many subjects would be required to achieve a power of β = .70 at the confidence level of p=.10 (considered reasonable in exploratory statistical terms) with an estimation of effect sizes between 0.2 – 0.5 (Cohen, 1988)[66], a statistical power calculator (Kohn, Senyak & Jarrett, 2018) was used and suggested a sample minimum of 19 participants per predictor. This supports Hair, Black, Babin, Anderson and Tatham (2013) and Steven's (2002) estimates for a generalised sample selection of "about 15 subjects per predictor for multiple regression designs when used in social sciences" (p.143). The minimum sample size in the 6 predictor design (based on Situational Interest constructs) would be n=90 – 114. The sample size achieved after cleaning and sorting was (n=127) and considered of sufficient power for this exploratory design.

4.6 Sorting and Cleaning of Data

Sorting and cleaning of data was conducting using $SPSS_{IBM24}$ and Microsoft Excel statistical packages. All questionnaire data was subject to the following sorting and cleaning procedures:

Firstly the question sheets were transposed on to Microsoft Excel sheet (MSO, 2013). All data was made either categorical (e.g. female=1, male=2); or ordinal (e.g. age banding reflected key-stages in education and agential-development: 1=age11-16; 2=age16-18; 3=age18-26; 4=age 26 plus).

The Likert data of the questionnaires was considered quasi-parametric[67] in this exploratory study, permitting the use of a one-way analysis of variance (ANOVA) test[68]. Next the data was interrogated for outliers, missing values and unengaged responses. Likert scales as a bounded data set should limit any outlier issues more commonly associated with continuous data. However, inputting errors might lead to confounding values similar to outlier issues. To this end, a search for Likert data

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[66] Initial results from similar studies and meta-analysis reflect such 'medium' effect size (Chen *et al.*, 2001a; Hidi & Anderson, 1992; Renninger *et al.*, 2014; Zhu, Chen, Ennis, Sun, Hopple, Bonello, Bae & Kim, 2009).

[67] The Likert data is considered as polychoric (quasi-parametric under assumptions of normality). In the final study (three), the non-linear properties of the data would require non-parametric tests to be used.

[68] ANOVA offers a difference analysis with greater statistical validity than conducting a series of Student's T-tests when more than one Independent Variable is applied over multiple difference tests

greater than 8 (the scale maximum), was conducted using Excel. Where found, such imputations were set to no-entry, allowing for treatment as missing data later.

4.6.1 Missing Variables and Maximum Likelihood Imputation

All data is considered information, and therefore, should not be rejected. This follows an 'intention to treat' ethos, and according to Newman and Sin (2009) ''a fundamental principle of missing data analysis''. Accordingly, missing data treatment by Listwise-deletion and Pairwise-deletion were eschewed in favour of a Maximum Likelihood (ML) imputation (under multivariate normality and missing at random (MAR) assumptions). Maximum Likelihood is of particular efficacy in missing data, where a 'mean and covariance' matrix of multiple-items, may be parameterised through an 'expectation' and 'maximisation' method (EM Algorithm), producing new estimates for the missing data.

Omissions for 'overall' missingness of more than 10% (Newman, 2014), provide some guidance for the possible randomness of missing data (or not), and the inference of one variable and the missingness observed in relationships with at least one other variable. Given a spectrum of missing data (Collins, Schafer & Kam, 2001) from Missing *Completely* At Random (MCAR) to Missing *Not* at Random (MNAR), Little's (1988) 'test of missingness' allows consideration as to which assumptions and guidance for replacing data might be applied (Allison, 2003; Gaskin, 2016c).

However, there are caveats with the use of ML as to Standard Error. Such Standard Errors (SE) have been found not to be consistent in ML imputations (Glasser, 1964), and provides a validity issue in hypothesis testing (which require non-bias SE in imputation). If bias is introduced in ML imputation, then such SE assumptions cannot be met and negates validity in the confidence intervals and *p*-values necessary for hypothesis testing. This Study One did not aim to make any such causal assumptions in its testing, therefore an Expectation Maximization method (using an EM Algorithm) was considered as a satisfactory method to impute missing data if 'missing as random' is able to be assumed (Newman, 2014). In order to meet these requirements (of multivariable normality), both measure data sets were subject to a 'Missing Completely at Random' test (MCAR, Little, 1988):

Missing Completely at Random Test

1) ROPELOC – Little's MCAR test: Chi-Square = 290.447, DF = 260, Sig. = .094

2) SITUATIONAL INTEREST – Little's MCAR test: Chi-Square = 77.432, DF = 69, Sig. = .228

MCAR looks for missing data patterns or dependence. Here the null hypothesis is proved allows the assumption that there is no pattern in the missing data and we may accept the Missing Completely at Random (MCAR assumption).

Unengaged Responding

The quality of the sampling data was interrogated for the possibility of unengaged responding. Identifying such issues was approached via a 'diligence test' using 'paucity' in Standard Deviation: SD <.8. The data rows that were flagged by these criteria where subject to a face-validity test (Gaskin, 2016c). Here, a line-graph of the suspect data was compared against a background of complete sample data, this allowed overt reporting issues to be inferred (such as single value reporting across many consecutive variables). 11 rows exhibited poor SD, of which only 2 were thought to display overt unengaged responding (e.g. continuous reporting of only one value across the variables). This unengaged responding was thought to represent a 'construct-level' of missingness in the questionnaires (Newman, 2014), allowing the unengaged responding to be imputed using the EM Algorithm.

Imputation of missing variables through EM was applied. Sixty five missing variables were imputed across the two measures using the EM Algorithm. They were imputed using sub-sets related to factor or scale (multivariable) to ensure the most appropriate conditional-imputation (within factor) for maximum likelihood (Allison, 2003; Little & Rubin, 1987).

4.6.2 Tests for Normality of Data - Skewness and Kurtosis

$SPSS_{IBM24}$ and AMOS $_{IBM24}$ provide univariate and multivariate normality tests. If a multivariate normal distribution is assumed; *".....that will suffice. Multivariate normality of all observed variables is a standard distribution assumption in many structural equation modelling and factor analysis applications*" (Arbuckle, 2016, p.36). Factor and scale data for both measures was investigated using Skewness and kurtosis was tested using $SPSS_{IBM24}$ and thresholds for Standard Deviation (SD) from a normal distribution: (within ± 1xSD) = 'Great' or; (within ± 2xSD) = 'Good'; alternatively cut-off or acceptable value not greater than three times the standard error of skewness (Sposito, Hand & Skarpness, 1983).

Skewness

Situational Interest Data (within ± 1xSD) = Situational Interest not skewed

Self-Concept Data (ROPELOC) Skewness (within ± 2xSD) = ROPELOC not skewed

Kurtosis

Situational Interest Data Kurtosis (within ± 1xSD) = Situational Interest not kurtosis.

Self-Concept Data (ROPELOC) Kurtosis (within ± 2xSD) = ROPELOC not kurtosis.

In both measures, the multivariate constructs exhibited no significant Skewness or Kurtosis Issues. Issues arising with Skewness and Kurtosis are able to be relaxed in Structural Modelling programmes and Factor Analysis (see, 6.3.2 – Tests for Normality of Data - Skewness and Kurtosis, p170), where non-centrality model fit-indices are able to obfuscate, somewhat, such normality issues. This allows normality assumptions and parametric treatment to be applied to the data.

Study One: Findings

4.7 Hypothesis (1): One Way ANOVA between Learning Domain Groupings

Research for Self-Concept measures, as being dependent on situational determinants, exists; There is support for ‘Novelty’ and ‘Problem Solving’ affecting perceptions of Self-Concept and affective-motivation (Barker, Semenov, Michaelson, Provan, Snyder & Munakata, 2014; Greffrath, Meyer, Strydom & Ellis, 2011; Howard-Jones & Demetriou, 2009; Neill & Dias, 2001; Ofsted, 2008; Outdoor-Council, 2010; Purdie, Neill & Richards, 2002; Renninger *et al.*, 2014; Rotgans & Schmidt, 2014); in particular, Learning Outside the Classroom (LoTC) experiences (see, Fiennes, Oliver, Dickson, Escobar, Romans & Oliver, 2015; Kendall & Rodger, 2015; Rickinson, Dillion, K, Morris, Choi, Sanders & Benefield, 2006, for review).Therefore, different learning domains as ‘affective’ situational determinates should reflect differentiation in hypothesised functional Affordance states.

Table 2 – One way ANOVA between 3 Groups (Differentiated Learning Group Domains)

Scale	Between Groups -	Sum of Squares	df	Mean Square	F	Sig.	Levene* Statistic	Sig.
AI	**ROPELOC**	1.512	2	0.756	0.118	0.889	0.248	0.781
OE		5.206	2	2.603	0.306	0.737	1.316	0.272
IL		2.436	2	1.218	0.157	0.855	5.112	**0.007**
EL		114.357	2	57.178	2.928	0.057	0.176	0.838
PAB		72.820	2	36.410	0.341	0.712	0.693	0.502
SA		7.417	2	3.708	0.055	0.946	0.270	0.764
OS		36.964	2	18.482	0.236	0.790	0.635	0.532
ExIn	**Situational**	569.532	2	284.766	32.987	**0.000**	3.161	**0.046**
InEn	**Interest**	748.194	2	374.097	32.236	**0.000**	6.081	**0.003**
Nov		67.806	2	33.903	3.312	**0.040**	1.599	0.206
Att		391.974	2	195.987	15.444	**0.000**	5.961	**0.003**
Chall		45.607	2	22.804	3.120	**0.048**	0.224	0.800
ToIn		737.803	2	368.901	29.163	**0.000**	7.652	**0.001**

Notes: *see Homogeneity Considerations (over).

ROPELOC Constructs

Action Involvement –	**AI**
Overall Effectiveness –	**OE**
Internal Locus of Control –	**IL**
External Locus of Control –	**EL**
Personal Attributes and Beliefs of Control	**PAB**
Social awareness –	**SA**
Organisational Skills –	**OS**

Situational Interest Constructs

Exploratory Interest –	**Exp**
Instant Enjoyment –	**InEn**
Novelty –	**Nov**
Attentional Demand –	**Att**
Challenge –	**Chall**
Total Situational Interest	**ToIn**

4.7.1 ANOVA Results

Situational Interest Difference Results

Significant difference is seen between the learning domains in all Situational Interest constructs (see, Table 2, above).

ROPELOC Difference Result

No significant difference is seen between the learning domains in the self-concept (ROPELOC) constructs. As to some explanation for the lack of significance seen in the ROPELOC measure; this may be due to the 'model power' not adequately isolating state effects in Self-Concept, where such perceptions are hypothesised as a composite of state and trait cognitions and subject to complex 'frame of reference' issues confounding self-efficacy with self-confidence (Bong & Skaalvik, 2003; Pajares, 2009). This may be an issue with the multivariate factor modelling of ROPELOC constructs. To this end, it is thought that a Factor Analysis of the ROPELOC measures would assist model power for future testing of the ROPELOC measure.

Homogeneity Considerations

Though the $SPSS_{IBM24}$ ANOVA adjusts for homogeneity between the groups, this assumption of linearity is questionable in consideration of the hypothesised Kullback-Leibler divergence as a non-liner function (see, **3.4.1**, p97). An independent analysis of variance was therefore applied to all possible pairwise domain groupings using a Levene test (1960) to investigate this assumed homogenity (see Table 2 above). Though all the Situational Interest measures displayed significance, Levene's test suggested a significant variance (non-homogeneity) in grouping domain homogeneity. However, though questioning the veracity of normality assumptions, and therefore, the significance found; such varience supports the non-normality expectations of the non-liner Divergent Criticality hypothesis. Further studies will require the use of a more robust design(s) to account for such non-linearity and to accommodate homogeneity issues[69].

4.8 Hypothesis (2): Correlation between Interest and ROPELOC measures

As part of the exploratory nature of this design, correlations were conducted between the two measures and their constructs. This looked to provide support for the hypothesis that perceptions of Situational Interest and Self-Concept would reflect cognitive demand perceptions, as hypothesised as a functional Affordance state.

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[69] A repeat-measure sampling method to obviate homogeneity and non-parametric issues will be used in Study Three, 6.22 – Situative verses Contextual Learning: A Repeat-Measures Hypothesis (H3), p210).

If these correlations are seen to show significance, the inference is that some construct(s) are reflecting a differentiation in affective-cognitions dependent on the situational learning-domain. Though correlation is not causation, it is hypothesised that correlation between different measures, may be indicative of Divergent Criticality congruent in Situational Interest and ROPELOC measures.

Table 3 – Correlation Between Situational Interest and Self-Concept (ROPELOC)

Scale		AI	OE	IL	EL	PAB	SA	OS
ExIn	Pearson	0.074	0.040	0.109	-0.114	**.177***	0.046	**.222***
	Sig. (2-	0.410	0.659	0.223	0.202	0.047	0.605	0.012
	N	127	127	127	127	127	127	127
InEn	Pearson	-0.020	0.042	0.103	-0.125	0.095	0.102	0.132
	Sig. (2-	0.822	0.643	0.250	0.162	0.286	0.253	0.138
	N	127	127	127	127	127	127	127
Nov	Pearson	0.153	0.117	0.024	-0.044	**.176***	0.078	**.243****
	Sig. (2-	0.086	0.192	0.791	0.621	0.048	0.386	0.006
	N	127	127	127	127	127	127	127
Att	Pearson	0.115	**.176***	**.194***	-0.023	**.305****	**.223***	**.330****
	Sig. (2-	0.199	0.048	0.029	0.800	0.000	0.012	0.000
	N	127	127	127	127	127	127	127
Chall	Pearson	-0.069	-0.135	-0.083	0.130	-0.012	-0.122	0.027
	Sig. (2-	0.442	0.129	0.354	0.144	0.894	0.173	0.766
	N	127	127	127	127	127	127	127
ToIn	Pearson	0.007	0.012	0.070	-0.126	0.075	0.068	0.132
	Sig. (2-	0.941	0.894	0.432	0.157	0.400	0.445	0.138
	N	127	127	127	127	127	127	127

Notes **. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

ROPELOC Constructs

Action Involvement –	**AI**
Overall Effectiveness –	**OE**
Internal Locus of Control –	**IL**
External Locus of Control –	**EL**
Personal Attributes and Beliefs of Control	**PAB**
Social awareness –	**SA**
Organisational Skills –	**OS**

Situational Interest Constructs

Exploratory Interest –	**Exp**
Instant Enjoyment –	**InEn**
Novelty –	**Nov**
Attentional Demand –	**Att**
Challenge –	**Chall**
Total Situational Interest	**ToIn**

4.8.1 Correlation Results

Situational Interest and ROPELOC Correlations

Here, weak to medium effects (significance, $p<.10$) with the ROPELOC factors across *Exploratory Interest* (ExIn), *Novelty* (Nov) *and Attentional Demand* (Att) are positive and suggest that the hypothesised Divergent Criticality might be evident in an Exploratory Interest for Surprise (Novelty)[70] and be made aware through affective-cognitions of *Attentional Demand*, *Novelty* and *Exploratory Interest* as awareness of Divergent Criticality in cognitive processes (Table 3, above).

There are no correlations supporting relationships with *Challenge* and *Instant Enjoyment*. This would seem unusual as these constructs were thought to infer a hedonic assessment of cognitive demand. However, it might be that these constructs provide an influence on other dependent constructs of Situational Interest, that such a simplistic construct-model does not adequately represent these measure's mediating effects (the intra-relationships between the Situational Interest and ROPELOC measure constructs).

That Self-Concept of *External locus of Control* (EL) displayed no significant correlation across any of the Interest correlations may be a measurement issue: One conjecture is that the learning environments used in the study, predominately conferred a self-guided or internal locus environment, emphasises internal over external 'locus of control' (Barret & Greenaway, 1995; Cason & Gillis, 1994; Darley & Fazio, 1980; Hans, 2002; Hattie *et al.*, 1997; Neill, 2002; Rickinson *et al.*, 2004; Weiner, 1986, 1997; White 1959).

Active Involvement (AI) also displayed no significance. Again, this may be a bias due to the 'active' nature of the predominately experiential learning domains used most domains in the study one.

ROPELOC Sub-Scale Correlations

As the ROPELOC constructs (of multiple sub-scales): *Personal Abilities and Beliefs* (PAB), *Social Abilities* (SA) and *Organisational Skills* (OS), had all displayed significance with the Situational Interest measure of Attentional Demand, these ROPELOC constructs were further correlated at a Sub-Scale level of analysis in order to further extrapolate possible inference.

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[70] Surprise will be used interchangeably with 'Novelty' as terminology in free-energy and non-linear criticality.

Table 4 – Correlations for Interest and ROPELOC Sub-Scales

		Personal Attributes and Belief				Social Awareness			Organisational Skills		
	Sub-Scale	SC	SF	SM	OT	SE	CT	LA	TE	QS	CH
ExIn	Pearson	0.118	0.126	0.095	**.244****	-0.029	0.084	0.093	**.223***	0.073	**.212***
	Sig. (2-tailed)	0.187	0.159	0.286	0.006	0.748	0.346	0.301	0.012	0.412	0.017
	N	127	127	127	127	127	127	127	127	127	127
InEn	Pearson	0.047	0.073	0.048	0.155	0.043	0.111	0.011	0.161	0.107	0.132
	Sig. (2-tailed)	0.602	0.412	0.590	0.083	0.631	0.214	0.903	0.071	0.232	0.139
	N	127	127	127	127	127	127	127	127	127	127
Nov	Pearson	0.137	0.117	0.086	**.235****	0.033	0.136	0.151	**.260****	0.032	**.177***
	Sig. (2-tailed)	0.125	0.191	0.334	0.008	0.710	0.128	0.090	0.003	0.722	0.047
	N	127	127	127	127	127	127	127	127	127	127
Att	Pearson	**.253****	**.193***	**.194***	**.341****	0.146	**.215***	0.145	**.342****	**.198***	**.297****
	Sig. (2-tailed)	0.004	0.029	0.029	0.000	0.102	0.015	0.103	0.000	0.026	0.001
	N	127	127	127	127	127	127	127	127	127	127
Chall	Pearson	0.066	-0.086	-0.133	0.129	-0.151	0.006	0.005	0.035	-0.140	0.022
	Sig. (2-tailed)	0.459	0.334	0.136	0.150	0.090	0.950	0.954	0.698	0.116	0.807
	N	127	127	127	127	127	127	127	127	127	127
ToIn	Pearson	0.040	0.025	0.025	**.180***	0.008	0.128	0.008	0.171	0.046	0.124
	Sig. (2-tailed)	0.655	0.777	0.782	0.043	0.932	0.151	0.927	0.054	0.611	0.165
	N	127	127	127	127	127	127	127	127	127	127

Notes ** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

In Table 4 (above), although correlation provides no causal confirmation, it does suggest possible sub-scales of the ROPELOC constructs that might be used to further explore 'state' cognitions as reflecting correlation with the Situational Interest measures. Of particular interest was the positive reporting of the construct of *Organisational Skills* (OS). This addressed variables for scales '*Coping with Change'*, '*Quality Seeking'* and '*Time Management*'. Though OS is not immediately suggestive of a 'situational' perception of competence (it is hypothesised that OS cognitions represent more stable 'traits'[71]); that *Time Management* (TE) in particular is found to resonant with the Situational Interest measure, might suggest that this sub-scale is better considered a 'state' construct rather than trait.

A functional Affordance state as congruent with surprise is supported in the positive reporting seen across the *Novelty* in the ROPELOC correlations. However, as all perceptions are considered cognitions of 'Attention made Aware', *Attentional Demand* not surprisingly, displayes the strongest correlations with ROPELOC.

4.9 Post Hoc – Analysis

4.9.1 Pathway Modelling

The aim of Study One was to investigate if it is plausible to infer states of functional Affordance from the perception measures as Situational determinants towards cognitive functioning. If so, this would enable some inference to how perceptions might reflect Divergent Criticality functioning in different 'learning' domains and be able to test the Tolerance Optimisation hypothesis.

Both the ANOVA and Pearson's Correlation results would seem to infer the greatest state effect from situational or ecological influences observed in the Situational Interest measure. It would therefore suggest looking to the modelling of the Situational Interest measure to better understand the relationships of the constructs and how these might be in effect in future analysis (the mediating and partial effects that might be applied for more nuanced analysis). Pathway analysis, as a form of iterated model building, is used for the testing of a measures intra-construct effect(s) using modelled relationship-assumptions aimed at improving a model's fit to represent the data under analysis. It may be that in any interpretive questionnaire (perception as subjective), that the convergence of items on factors or constructs is more complex than simple direct-relationships.

[71] Here, we might consider a 'trait' as a temporally more stable 'state'; that is to say, traits as 'cognitive islands' of stability in times of neural flux, a resilience that might confound situational measures.

Structural Equation Modelling (SEM) offers such analysis through the researcher informed 'assumptions' of model function. Pathway analysis allows data to be 'ideally' utilised in an assumed model, by looking at the relationships between data-variance in the modelling of constructs (in particular the Standard Errors (SE) associated with the accuracy of the assumed-model of dependent and independent variables). This is an inference from the 'unknown' rather than the 'known' in assuming a model, and a 'goodness of fit', might be more accurately considered as; making the 'least wrong' assumption(s). It is in the model-fit of this variance that a model-quality (researcher assumed) is predicated:

"SEM does not aim to establish causal relationships from assumptions alone" (Bollen & Pearl, 2013, p309)

What is produced is a model of most 'probable' interdependence between its construct's effects, one reflecting the mediating and inferential effects between the model's variables. The external validity of such a model is dependent on the quality of this data, the conditions of observation and the causal assumptions of the researcher as supported through model-fit to the data available.

Structural Equation Modelling (SEM) is a statistical technique that provides some validity to untangling these pathways and complex multivariate relationships. It parametrises a "causal knowledge" providing some veracity to the researcher's assumptions (Pearl, 2011).

4.9.2 Situational Interest: Structural Equation Model Building

In that such complex models contain exponential permutations[72] in relation to the number of their factors (constructs), this demands that they are built on some *a priori* reasoning, which may then be further developed within a robust methodological paradigm. In this first 'Study One', guiding the initial pathway analysis was an *a priori* assumption based on correlation analysis: that perceptions as measured by Situational Interest (SI) were most effected as a hypothesised 'state' of neural function in relation to ecological determinants. Such correlations suggested a model that could be conceptualised as dependent on SI constructs of *Novelty* (as ecological surprise awareness), *Attentional Demand* (Cognitive Effort) and *Exploratory Approach* (Innate seeking cognitions).

To this end, a procedure for building and developing an *aprior* pathway model was pursued in accordance with the author's original procedures (APPENDIX I: Initial Pathway Analysis, p292)

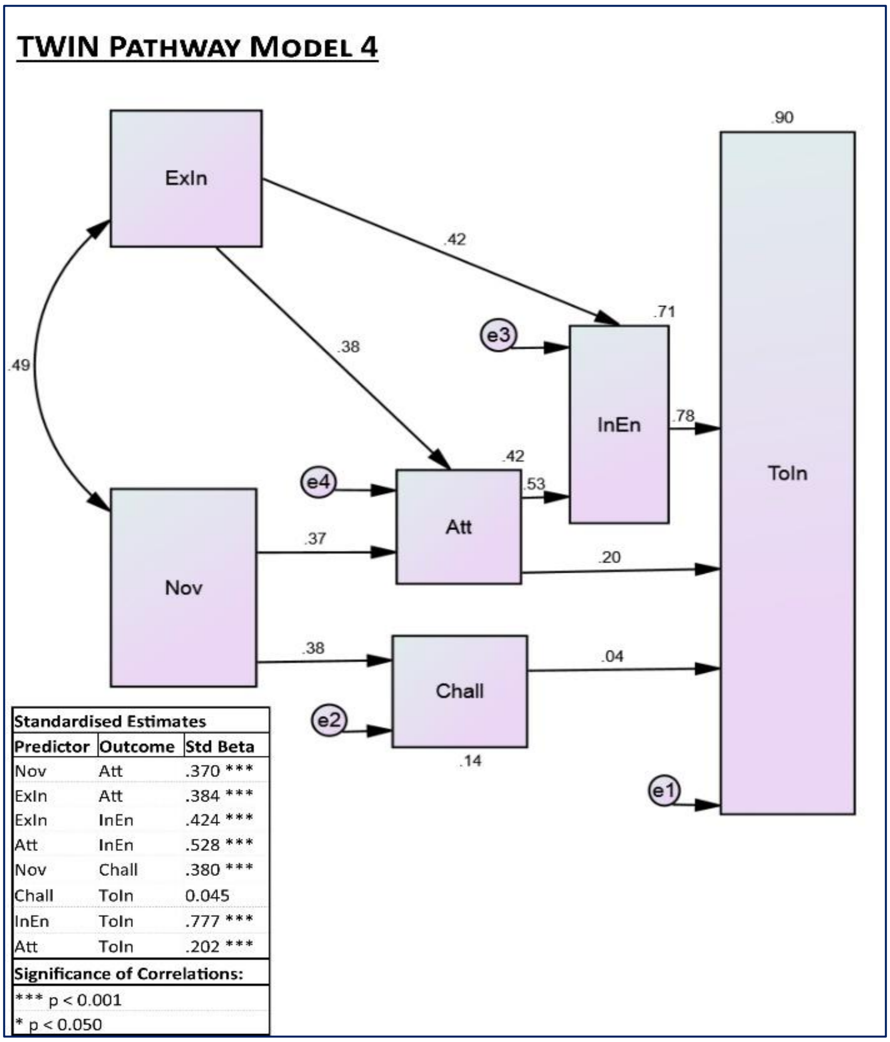
[72] Exponentially increasing permutation (pathways) in multi-factor modelling provides a mathematical uncertainty, that of being able to explore all the possible options in order to arrive at the correct solution.

4.9.3 Findings –Twin Pathway Model

What emerged was a twin-pathway model of perceptions from *Novelty* towards a dependent *Total Interest* (see, Figure 24, below). The intention being to provide some justification for Situational Interest reflecting a cognitive-appraisal within a Divergent Criticality hypothesis. Here it is assumed that twin-pathways from *Novelty* and *Exploratory Interest* reflect life-regulation in ecological engagement:

1) An 'approach' or hedonic 'enjoyment' pathway; mediated by *Attentional Demand* and *Instant Enjoyment;*

2) A perception of 'control' or antagonistic 'avoid' pathway mediated by *Challenge*.



Standardised Estimates		
Predictor	**Outcome**	**Std Beta**
Nov	Att	.370 ***
ExIn	Att	.384 ***
ExIn	InEn	.424 ***
Att	InEn	.528 ***
Nov	Chall	.380 ***
Chall	ToIn	0.045
InEn	ToIn	.777 ***
Att	ToIn	.202 ***
Significance of Correlations:		
*** p < 0.001		
* p < 0.050		

Figure 24 –Twin Pathway MODEL 4 (AMOS$_{IBM24}$)

Conceptually different from Chen's model (1999; 2001a), in this twin-pathway model it was assumed that the 'approach-pathway' would work through *Novelty* perceptions being mainly mediated by *Attentional Demand* and *Instant Enjoyment* mediating (affectively rewarding) an 'innate' drive of *Exploratory interest* for surprise (aka, Divergent Criticality). However, it was conceivable that

Challenge might act as the 'regulating' or antagonistic 'avoid'[73] pathway to *Instant Enjoyment* and might be better modelled in a direct pathway toward *Total Interest*, acknowledging such a possible mediator pathway concurrent with a self-regulation around a Tolerance Optimisation (limits of Effectivity function).

4.9.4 Goodness of Model Fit

A twin pathway MODEL 4 (Figure 24, above) emerged from this *apriori* model analysis, but with some question to the validity of this model. Although offering a model that would seemingly resonate with a life-regulating Tolerance hypothesis, guiding the analysis was 'local' fit through 'pathway-significance' of the model's assumptions; rather than a more robust statistical of 'model goodness of fit' . We therefore need to considered the model assumptions through 'global fit' indices as suggested by (Bollen & Pearl, 2013)[74].

Absolute Fit Indices

Bollen and Pearl (2013) and Jöreskog and Sörbom (1978), suggest one of the bases for a Global fit indice, is in an 'Absolute' model. Here, coefficients are considered constant over all individuals and a Chi-square (χ^2) produced to test for adherence to normality (i.e. the null hypothesis is accepted). This Chi-square (χ^2) test forms the bases of many 'fit indices' and is almost ubiquitously reported in SEM. However, χ^2 comes with inherent issues in relation to the data used ((Newsom, 2012, p1) – see, APPENDIX III: Goodness of Fit Indices, p303).

Choosing Global Fit Indices to best reflect Interest Modelling

Though Study One did not reach the 200 participant criteria suggested by Newsom (2012) as effected by sample size, future studies were expected to exceed this number, therefore Bollen's BL89 ('IFI' in $AMOS_{IMB24}$) was considered a good normed-relative index to consider. Retrospectively, a number of global 'fit' indices were selected to test the model assumptions as recommended over a reliance on just one (Newsom, 2012).

Therefore, indices considered appropriate for large samples and non-centrality fit indices (CFI and RMSEA) and an Absolute indices of fit, SRMR (considered as 'less' affected by χ^2 than RMR (*ibid*)), are a menu of fit-indices that are intended to provide a 'Goodness of Fit' accounting for the assumptions and issues with Chi-Square (χ^2). Model fit, was therefore based on broad fit-index spectrum, as

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[73] Such an avoid factor might be hypothesised to express overt challenge perceptions (e.g. fear, anxiety, uncomfortable or negative feelings).

[74] Future SEM would use relevant Global Fit Indices to guide model building.

deemed a 'confirmatory requirement' for determining 'fit' in multiple criteria (Hu & Bentler, 1999): Comparative Fit Index (CFI) (Bentler, 1990); Incremental Fit Index (IFI) – (BL89, Bollen, 1990) the Root Mean-Square Error of Approximation (RMSEA) (Browne & Cudeck, 1993)& Standardized Root Mean Square Residual (SRMR).

As study one described an exploratory methodology, SEM sees a model development of improving fit indices. Therefore, Absolute indices of fit, though questionable, do provide some guidance for model iteration decisions[75]. Accordingly, CMIN (χ2 /df) and PCLOSE (Cochran, 1952), and Goodness of Fit Index (GFI) (Bentler, 1983; Tanaka & Huba, 1985) were also investigated (see, Table 5, below).

4.9.5 Post SEM: Memory 'Recall'

There is the possibility of an emotional-biasing of memory (Sample 4). Accordingly, the sample domain of RECALL used in the data collection may be of concern: Confounding memories and 'peak-end associations' (Kahneman, Fredrickson, Schreiber & Redelmeier, 1993), risk a 'recall' rather than a past-'actual' memory. This is a past-recall of 'salient' cognitive emotions within that experience over and above the actual experience. Recall memory might be considered then, as distilled cognitions of peak cognitive-emotions (instants of high emotional states) and it may be these that are recalled as peak 'significant' divergence over any specific 'state' – a bias or 'difference from the mean' (Kahneman *et al.*, 1993; Kahneman & Riis, 2005).

Table 5 – Model-Fit Thresholds for Twin Pathway Model 4

Recommended Threshold	Twin Pathway Model
Chi-square/df (cmin/df) <3-5	2.834 good
p-value for the model <.05	.0001*
CFI >.95	.981 good
GFI >.95	.958 good
IFI >.95	.981 good
SRMR <.08	.0533 good
RMSEA <.06	.121 poor
PCLOSE >.05	.040 poor

Note: Thresholds from Hu and Bentler's "Cutoff Criteria and Fit Indexes" (1999)
* Large sample size so not unexpected

[75] (Newsom, 2012) recommends rather than over reliance on one or two model fit indices, that a number of 'Absolute' and 'Relative' fit indices, that account for the confounding issues of Chi-Square (χ^2) be chosen. Fit indices that reflect the sampling and research design.

Recall sampling risks confounding the hypothesised ‘state’ of functional Affordance in Interest perceptions. In consideration of this, the Twin Pathway Model (4) was run excluding the recall group data (n=104, see Figure 25, below).

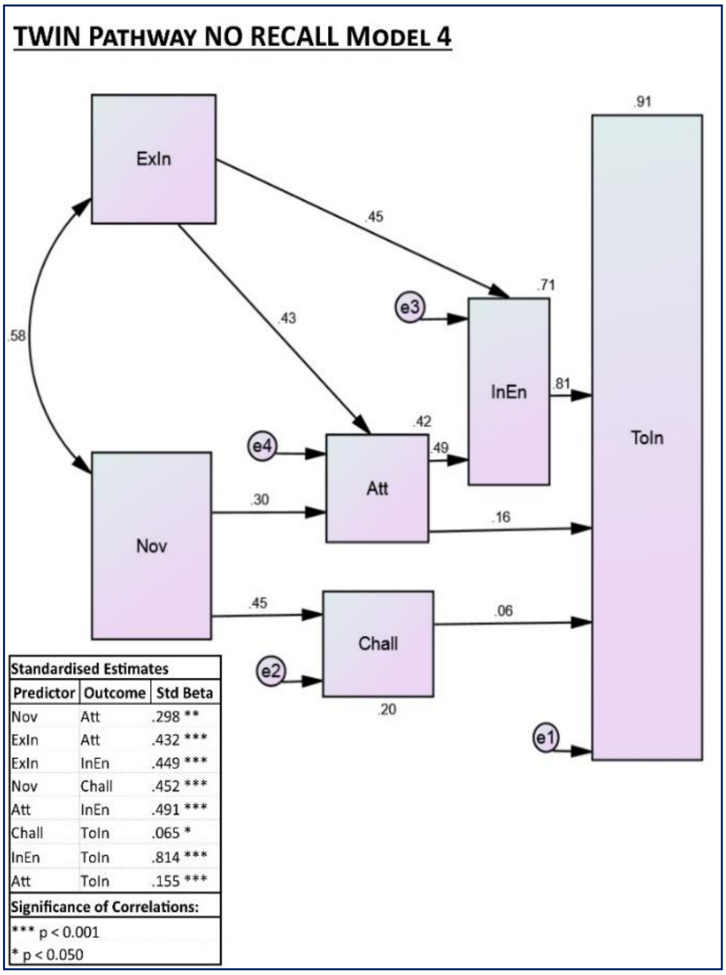

Figure 25 – Twin Pathway Group 4 NO RECALL

Table 6 – Twin Pathway NO RECALL - Fit Indices

Recommended Threshold	Twin Pathway Model
Chi-square/df (cmin/df) <3-5	1.441
p-value for the model <.05	.0001
CFI >.95	.995 good
GFI >.95	.974 good
IFI >.95	.995 good
SRMR <.08	.0283 good
RMSEA <.06	.065 accept
PCLOSE >.05	.040 poor

Note: Thresholds from Hu and Bentler’s “Cutoff Criteria and Fit Indexes” (1999)
* Large sample size so not unexpected

The improved model fit with ‘recall’ removed suggests there may be a confounding effect from ‘memories’ as state-measures of affective cognitions, and therefore recall should be avoided.

4.10 Study One: Conclusions

The Difference and Correlation tests do provide some significant effects, though small, in suggesting a Divergent Criticality hypothesis and the affective cognitions of Tolerance Optimisation. These favoured the perception measure Situational Interest as most likely to report a 'state' differentiation towards situational determinants and possible inference of a state of functional Affordance (i.e. able to measure differentiated functional Affordance in different learning domains).

Using the Situational Interest measures in Structural Equation Modelling (SEM), when global fit indices are considered using Hu and Bentler's (1999) thresholds (Table 5, p138), there is good 'model-fit' found across all the primary, normed, relative goodness fits (CFI, IFI, SRMR), but not RMSEA and PCLOSE. However, that these indices approach 'good-fit' allows the consideration that a better model might emerge, especially if future sampling and measures are better aligned to the study's investigation of *Novelty*, *Challenge* and *Attentional Domains,* in relation to a hypothesised Divergent Criticality.

A way forward would be through improving the questionnaire validity [allowing a robust SEM to use such a measure for inferring a 'state of function' (see, 6.10 – Structural Equational Modelling: Findings, p185) and support future correlations of Interest with Self-Concept]. If a state of functional Affordance were able to be inferred from Situational Interest, this might then be triangulated with ROPELOC's 'salient' scales to develop a SEM methodology for validating a Situational Interest measure as a perception of functions Affordance.

Though the measures of Situational Interest and of Self-Concept ROPELOC (Chen *et al.*, 1999; Neill, 2003; Richards *et al.*, 2002, respectively) had exhibited some significance in the correlation analysis (and in the difference test with the Interest measure), these effects may not be as powerful as required[76] in reflecting perceptions of a state of affective awareness. It may be that the questionnaire items are not adequately addressing affective cognitive-emotions (Pessoa, 2013). To this end, adapting these 'items' to reflect Interest as a cognitive-emotional construct, and then validating through Factor Analyses (EFA) and Confirmatory Factor Analysis (CFA), this new Situational Interest measure will better explore 'pathway analysis' and functional Affordance inference through SEM model building.

Though there had been little support for the ROPELOC measure in the difference analysis, correlations of ROPELOC with Situational Interest 'did' exist. It was therefore considered that the

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[76] Type II error – a significance exists, but the research-design 'power' is not able to significantly identify.

ROPELOC model used did not reflect the required 'state' measures of perception powerfully enough; possibly a framing issue of incorrectly identifying state as 'trait' in the measures (Bong & Skaalvik, 2003). To address this, the pilot study's results were used to identify the most probable scales within ROPELOC constructs that might best infer a state-effect due to 'situational' determinants. Going forward it was considered more relevant in providing a more focused ROPELOC measure of 24 items (similar in length to the Situational Interest measure)[77] and would require factor analysis towards an adjusted ROPELOC questionnaire.

Further Structural Equation Modelling (SEM) reflecting a better model fit, might allow future studies to better reflect construct interdependence and therefore improve the power of the measures by identifying the relationships in effect in the measure of situational interest as to states of perception function in any future analysis. Rather than using linear analysis of the constructs in difference and relationship tests, a more complex construct-relationship and modelling through SEM could better represent affective cognitions in terms of inferring a state of functional Affordance. This will be addressed in Study Three.

As evident in the recall cognitive-emotional biasing, it is important to consider if the self-report measures used accurately reflects perceptions as a state of functional Affordance or whether some other confounding effect is being observed. That significant improvements in model fit (Table 6, above) are seen when recall perceptions are withdrawn, supports such emotional bias as a confounding issue. This requires that the possible confounding in sampling is adequately addressed and considerations of possible confounding should be made in respect of age, activity, duration, expectancy and 'frame of reference' issues[78] (see, APPENDIX IV: Bias Considerations In Situational Domain Sampling, p304).

The conclusions from Study One suggest that 'Situational Interest' offer the most probable 'state' measure of awareness able to be differentiated in sample learning-domains, and should correlate significantly with perceptions of Self-Concept (ROPELOC) to investigate a Divergent Criticality

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[77] It was also felt that ROPELOC exhibited a questionnaire fatigue. Focus group follow-ups of questionnaire participants had highlighted two key issues with the ROPELOC questionnaire: the language was not as easily understood as the un-ambiguous Situational Interest questionnaire ("I like" (*Sit In*) was though easier to cognitively-emotionally frame, than "I feel" (ROPELOC), and the length of the ROPELOC questionnaire resulted in some questionnaire fatigue when presented with another questionnaire (the Situational Interest questionnaire).

[78] The confusing of trait cognitions with state cognitions.

hypothesis of Tolerance Optimisation. This hypothesis may be explored through differentiated functional Affordance states in relation to these sample-domains. To achieve this, it is proposed that future studies should pursue the following elements:

Study Two – Questionnaire Development

1) The adaptation of the Interest measure to accommodate a more cognitive-emotional approach.
2) The reducing of the ROPELOC questionnaire to salient sub-scales and to 24 items.
3) Provide validity to the adapted questionnaires through Exploratory (EFA) and Confirmatory Factor Analysis (CFA).

Study Three – An Exploratory Model of Divergent Criticality Function

4) Final factor analysis.
5) Structural Equation Modelling (SEM) of the Situational Interest measure; 'goodness of fit' and model-hypothesis testing (direct and indirect effects), towards inferring a functional Affordance measure through an Interdependence Profile.
6) The triangulation of SEM through a purely quantitative 'Conditional Interdependence' analysis (Dawid, 1979).
7) Correlation and relationship triangulation of the functional Affordance measure with self-concept (ROPELOC), accommodating the function of the 'non-liner' Divergent Criticality hypothesis through non-parametric analysis.

5 CHAPTER FIVE – Methodology Study Two: Questionnaire Development

5.1 Study Two: Introduction

The aim from the Study One was to correlate Situational Interest questionnaire against the ROPELOC questionnaire, in that different learning domains would instigate differentiated states as ecological determinants, and investigate if this would be evident as 'affective cognitions' in perception.

The findings from Study One were taken forward to further develop the two perception measures (Situational Interest and Self-Concept) with sufficient power to investigate the Divergent Criticality hypothesis. Study Two aimed to provide validity to the measures and their modelling in order to build on the findings of Study One.

In this way, more exacting statistical analysis was applied to the questionnaires through Exploratory and Confirmatory Factor Analysis, testing the validity of the questionnaire adaptations. Factor Analysis would further inform refinements in measures to take forward.

Study Two pursues a questionnaire development methodology.

Study Two: Methodology

5.2 Questionnaire Development

Adaptations to the questionnaires were made, informed by Study One's findings, but also in consideration of questionnaire feedback where concerns were expressed regarding the ROPELOC questionnaire length and language in the Situational Interest:

1) Firstly, that some of the language was 'culturally' ambiguous in the Situational Interest measure; therefore the following changes were made:

CHALL151 – *"This is a complex activity"* became ***"This activity is complicated"***

ATT141 – *"My attention was high"* became ***"My attention needed to be high"***

NOV434 – *"This is an exceptional activity"* became ***"This is a unique type of activity"***

EXIN111 – *"I wanted to discover all the tricks of this activity"* became

"I wanted to discover all the ways of doing this type of activity"

TOIN464 – *"This is an interesting activity for me to do"* became

"This is an interesting activity"

2) Secondly, it was thought that there were too many ROPELOC questions when the two questionnaires were presented consecutively, causing a possible reporting-fatigue.

Using the correlation thought to reflect a ‘state’ cognitive affect from findings in Study One, the ROPELOC questionnaire was reduced from 49 items (15 scales) to 24 items (8 scales) see (APPENDIX II: Questionnaire Development and Providence, p294):

5.2.1 ROPELOC Scales to be Included

Personal Abilities and Beliefs (PAB) (Factor constructs given in bold).

1) Open Thinking (OT)
2) Self-Efficacy (SF)
3) Self-Confidence (SC)
4) Stress Management (SM)

Social Awareness (SA)

5) Cooperative Teamwork (CT)

Organisational Skills (OS)

6) Time Efficiency (TE)
7) Quality Seeking (QS)
8) Coping with Change (CH)

5.2.2 ROPELOC Items Excluded

The following scales were considered as not representing state differentiation in Study One so were questioned as to their suitability for Divergent Criticality hypothesis testing:

Internal Locus of Control (IL)

Though initially removed because of lack of support in Study One, this would be later reintroduced in Study Three as a locus of control/self-confidence factor emerged as significant in Study Two’s EFA (see, APPENDIX II: Questionnaire Development and Providence, p294).

External Locus of Control (EL)

This construct was seen to report only in Traditional Classroom ‘theory’ Lesson (TCL), in what was considered a low state of Affordance (a didactic, theoretical lecture with little Novelty). That it was not seen in other ‘dynamic’ learning domains questions its veracity in Divergent Criticality reporting. This construct was therefore not taken forward in the study.

Action Involvement (AI)

Though seen in all (active) domains, this construct of perception measure was considered to be universal in learning, but was not considered able to clearly reflect any differentiation sample domains. This construct was therefore not taken forward in the study.

Overall Effectiveness (OE)

This construct is considered as a 'dependent' scale within a questionnaire model. Though this would inform a causal pathway model building, this was not the aim of the ROPELOC questionnaire (to provide valid state perception that could be triangulated with a Situational Interest model). This construct was therefore not taken forward in the study.

Control Item (CI)

This control item was included in the original questionnaire as a quality measure of participant responding. It was thought that the sorting and cleaning of data would adequately provide for such participant-response quality. This construct was therefore not taken forward in the study.

Leadership Ability (LA)

Again, this measure did not display notable reporting or correlation across Study One's domains, and so was not taken forward in the study.

Social Effectiveness (SE)

A measure of a Social Awareness construct that had not displayed notable correlations across Study One, and so was not taken forward in the study.

The above changes were applied to the questionnaires and the adapted Situational Interest and ROPELOC questionnaires underwent Factor Analysis using a second study (Study Two; n=281).

Study Two –Sampling Criteria

To enable a form of embedded-triangulation from the two questionnaires (Creswell & Clark, 2011), the sampling criteria and sample-size considerations were made, reflecting direction from the literature and Study One's findings, and applied to participants as a group-domain 'stratified' samples: Domains of Traditional Classroom Learning (TCL), or Learning Outside of the Classroom (LoTC - e.g. Physical or 'Out of the Classroom' Activities; Sport, Outdoor Activities, field trips, etc.) reflecting a range of age bandings reflecting key stages in education in the stratification[79] : **(1)** 11-16,**(2)** 16-18,**(3)** 18-26,**(4)** 26 +.

[79] Stratified sampling (where homogeneity 'within' group is maintained), allows statistical analysis to reflect group-effect biasing, as much a part of any individual state perception and therefore, situationally valid in this studies 'between' groups (situational domains) hypothesis.

Sample Size for SEM

Issues with sampling bias such as those associated with Multivariate Normality in Structural Equation Modelling (SEM), is able to reflect some similarity to 'centrality of normality' in pursuing both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis. Such sampling bias may be minimised by accepted ratios of least 15 participants per predictor (Hair *et al.*, 2013; Stevens, 2002). However, Multivariate Normality is not the only consideration necessary in SEM: Hair *et al.* (2013) consider five significant determinants for sample size in SEM:

"(1) multivariate normality of the data, (2) estimation technique, (3) model complexity, (4) the amount of missing data, and (5) the average error variance among the reflective indicators."

(Hair et al., 2013, p573)

Though previous suggestions have set a base of 200 for SEM (Boomsma, 1982), Hair et al. (ibid) consider a rough guidance for sample sizes of between 150 and 300 dependent on the above determinants (with a convergence correlation of about r > .60 on the predictors and no more than 7 predictors. 300 samples as a target sample would support similar proactive sampling for SEM (Tabachnick & Fidell, 2007; Wolf, Harrington, Clark & Miller, 2013, e.g. Monte Carlo simulations).

Sample Domains

The sample 'domains' were categorised as 'ordinal', referencing a wide range of hypothesised functional Affordance states: low, Medium and high divergence (see, Table 7, below).

Table 7 – Study Two Sampling Domains

Sample	Learning Domain	functional Affordance	n
1	Half Day Outdoor Problem Based Learning (Medium functional Affordance)	2	47
2	Half Day Outdoor Activity (High functional Affordance)	1	8
3	Half Day Outdoor Activity (High functional Affordance)	1	8
4	Recall of past LoTC (Low functional Affordance)	3	47
5	Five day Residential Outdoor Activities (Medium functional Affordance)	2	31
6	1 Hour Theory Lecture (Low functional Affordance)	3	35
7	Half Day Outdoor Problem Based Learning (Medium functional Affordance)	2	28
8	One day Outdoor Activities (High functional Affordance)	1	40
9	One day Outdoor Activities (High functional Affordance)	1	37

Note: Study Two (n=281)

5.3 Factor Analysis

The Questionnaire Mk2 data set was first sorted and cleansed in Excel and SPSS as in Study One (see, 4.6, p125). This cleansed data was then entered into $SPSS_{IBM24}$.

The missing data was subject to Little's MCAR test to help designate the imputation method best suited to the missing data.

1) **SITUATIONAL INTEREST – Little's MCAR test:** Chi-Square = 320.899, DF = 329, **Sig. = .615**

2) **ROPELOC – Little's MCAR test:** Chi-Square = 465.131, DF = 374, **Sig. = .001**

Here, the Situational Interest only was found to be MCAR and presented for ML imputation (see .4.6.1, p126).

The ROPELOC questionnaire did not prove to be MCAR. Investigating the data, 4 rows exhibited overt 'unengaged' responding presenting a 'person' and 'construct-level' of missingness in the ROPELOC data; however, as only a few cases (less than 5%) offer little loss of power in relation to sample size (kCheema, 2014, p61), and certainly within the 10% of non-response threshold of Newman (2014, p374), it was accepted to treat the ROPELOC questionnaire as MAR at an item or construct level.

"In typical social science applications, I believe that such strong correlations between causes of missingness and outcomes are the exception rather than the rule, and assuming MAR will probably not lead us far astray." (Schafer, 2003, p20)

It should be remembered that missingness represents a continuum as to the inference of missingness observed in relationships with other variables (Collins *et al.*, 2001). Though no 'within-construct' issues were evident, there may be some systematic or other factor issues that cannot be ignored when imputing missing values. However, as Study Two is of a questionnaire investigatory design (non-hypothesis testing), there can still be value in the data set from such items (Schafer, 2003; Schafer & Graham, 2002). A Maximum Likelihood (ML) imputation through an EM Algorithm was thought appropriate to impute the missing valuables at a latent construct level (previous research informed).

5.4 Exploratory Factor Analysis: Study Two – Situational Interest

5.4.1 Measures of Sample Adequacy

That the data collected is appropriate for the research design was first explored using Bartlett's Test of Sphericity and the Kaiser-Mayer-Olkin (Kaiser, 1974) Measure of Sampling Adequacy Index (Table 8, below).

Table 8 – KMO and Bartlett's Test

Measure	Threshold		Test
Kaiser-Meyer-Olkin	**>.90**		.925
Bartlett's Test of Sphericity		Approx. Chi-Square	4645.327
		df	276
	p **<.05**	Sig.	.000

Note: Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy

Kaiser-Meyer-Olkin

The Kaiser-Meyer-Olkin test assesses the data set for adequate correlation that will allow variance to factors, however, not too much variance to a common factor (common to all variables), as this reduce discriminatory power to identify other factors in effect. Using a threshold > .8 – 1. the KMO was seen to be >.90 (.93) implying an adequate sample for the Multiple Regression analysis necessary in order to determine the latent factor loadings.

Bartlett's Test of Sphericity

This uses a correlation-matrix to identify any shared variance between variable residues, might be attributed to a shared latent factor. Bartlett's test was significant, providing indication of at least one latent variable being significantly correlated with another. This suggests that at least one factor might be loaded from two or more variables presented to the factor analysis.

Such positive reporting of KMO and Bartlett's might be expected considering the sample size, i.e. - large enough to provide sufficient power of 'about' 300 participants (Tabachnick & Fidell, 2007; Wolf *et al.*, 2013).

5.4.2 Factor Extraction

Extraction is use to statistically identify the important latent factors or variables that the other variables relate to. Though not an exact analysis, it provides some guidance as to mapping possible extraction factors (Brace, Snelgar & Kemp, 2012). Factor Extraction was performed using a 'Maximum Likelihood' method. This was selected to provide continuity of method in further analysis using $\text{AMOS}_{\text{IBM24}}$ for Confirmatory Factor Analysis [CFA] and Structural Equation Modeling [SEM].

Table 9 – Initial Maximum Likelihood Components

Total Variance Explained

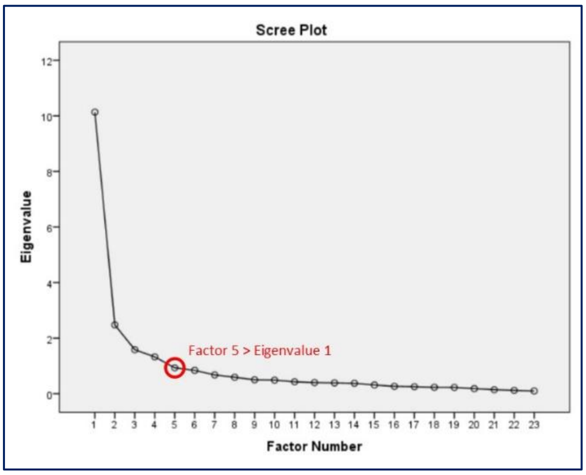
	Initial Eigenvalues				Parallel Analysis - Study 2		
Component	Total	% of Variance	Cumulative %		Mean	SD	95 percentile
1	**10.134**	44.061	44.061	F_1	**1.5373**	0.0502	1.6201
2	**2.478**	10.774	54.835	F_2	**1.4521**	0.0357	1.511
3	**1.585**	6.889	61.724	F_3	**1.3785**	0.0305	1.4288
4	**1.326**	5.767	67.491	F_4	**1.3142**	0.0307	1.3649
5	0.934	4.060	71.551	F_5	1.2631	0.0283	1.3097
6	0.840	3.653	75.204	F_6	1.2091	0.0235	1.2478
7	0.677	2.942	78.146	F_7	1.1649	0.0221	1.2013
8	0.593	2.577	80.723	F_8	1.1223	0.0209	1.1569
9	0.502	2.183	82.907	F_9	1.0757	0.0191	1.1072
10	0.491	2.135	85.042	F_10	1.0352	0.022	1.0715
11	0.430	1.870	86.912	F_11	0.9983	0.0214	1.0337
12	0.401	1.745	88.657	F_12	0.9591	0.0182	0.9891
13	0.390	1.694	90.351	F_13	0.9188	0.0168	0.9465
14	0.376	1.634	91.985	F_14	0.8797	0.0185	0.9104
15	0.316	1.375	93.360	F_15	0.8426	0.02	0.8756
16	0.267	1.160	94.520	F_16	0.8093	0.0207	0.8435
17	0.253	1.098	95.618	F_17	0.7731	0.0194	0.805
18	0.232	1.009	96.627	F_18	0.737	0.0217	0.7728
19	0.227	0.987	97.614	F_19	0.6983	0.0226	0.7355
20	0.184	0.800	98.414	F_20	0.6546	0.0231	0.6928
21	0.145	0.632	99.045	F_21	0.6125	0.0257	0.6548
22	0.120	0.522	99.568	F_22	0.5644	0.0277	0.6101
23	0.099	0.432	100.000	F_23	0.5434	0.028	0.5895

Note: Extraction Method: Maximum Likelihood Analysis.

Factor extraction simplifies the matrix values from the linear transformations of correlation loadings. It provides an Eigenvalue for each possible variable that signifies how much of the variance in all the data is explained by a single factor (Eigenvalue values greater than 1.0 – the default in SPSS) might now be used to indicate significant discrimination and compare how the latent variables load towards significant factors). Four factors displayed Eigenvalues greater than 1.0 using $\text{SPSS}_{\text{IBM24}}$ (see, above). As a comparative test, a parallel 'Random Data Eigenvalue' analysis was conducted using bootstrapped resampling (Vivek, Singh, Mishra & Todd, 2007). By comparing the Random Data Eigenvalue (Random-Factor Mean= Initial Eigenvalue) with the Maximum Likelihood Extraction, this should be equal to or higher than the 'comparative' means. Only the first 4 of the factors accounting for 67.491 of the total variance was confirmed (Table 9, above).

However, in lieu of the '*a priori*' model from (Chen *et al.*, 1999) suggesting Six factors, rather than discarding the 5th factor, it was investigated with a Scree Plot (Table 10, below). The Scree Plot was used to gauge the visual difference of the 5th factor when compared to the leveling-off of the scree-profile. If considered above the mean, then some discriminatory validity in such a 5th factor might be considered acceptable. This, in addition to the Eigenvalue being close to 1.0, was considered to display sufficient face-validity in order for a 5th factor to be taken forward for further analysis. Five extracted factors were therefore taken forward.

Table 10 – Scree Plot Displaying Independence of Factor 5



Oblique or Orthogonal Factor Relationships

Next a further factor extraction was performed using a 'Direct Oblimin' rotation on the 5 latent factors. Oblimin was used to determine if the data could be considered Oblique (with strong correlations) or Orthogonal (not so strong) and determine the best fit of rotation for the data set: For an oblique relationship between the factor data, rotation would be expected to produce a 'factor correlation matrix' with correlations between factors greater than .50 ($r > .50$). This indicates relationships between factors as moderately to strongly related. If correlations are less than .50 ($r < .50$), then the factors are considered not obliquely related and therefore an orthogonal rotation is used such as Varimax ($SPSS_{IBM24}$).

Table 11 – Factor Correlation Matrix

Factor	1	2	3	4	5
1	1.000	0.621	0.182	0.509	0.433
2	0.621	1.000	0.241	0.350	0.349
3	0.182	0.241	1.000	0.201	0.369
4	0.509	0.350	0.201	1.000	0.252
5	0.433	0.349	0.369	0.252	1.000

Note: Extraction Method: Maximum Likelihood.

In (Table 11, above), correlations between factor 1 and the other factors (bar factor 3), displayed strong to moderate oblique relationships. With such obliqueness, the matrix was considered best investigated through an Oblimin-rotation and therefore Direct-Oblimin (AMOS $_{IBM24}$) was used to extract factor loadings from the variables.

Communalities

From an initial factor analysis, it is possible to explore the Communalities between the variables.

Table 12 – Communalities

INEN121	0.717
CHAL151	0.577
CHAL252	0.429
ATT141	0.270
TOIN161	0.724
ATT242	0.636
EXIN212	0.542
NOV434	0.481
EXIN313	0.458
INEN424	0.714
TOIN262	0.835
NOV333	0.500
INEN222	0.816
EXIN111	0.646
NOV232	0.557
NOV131	0.458
ATT343	0.800
ATT444	0.818
TOIN363	0.803
CHAL353	0.496
TOIN464	0.766
INEN323	0.615
CHAL454	0.502

Note: Extraction Method: Maximum Likelihood.

Here, analysis expects variables that load sufficiently with a latent factor to display reciprocal communality with other similar variables. In this instance, strong communalities suggested that communality above .30 would provide a guide to the initial investigation of the variables, but a more stringent .40 could highlight variables which would be less likely to cause validity problems further down the factor analysis.

(ATT141 = .27) was highlighted as having potential issues, and though not removed at this stage, it was monitored through the remainder of the Exploratory Factor Analysis (EFA) and future Confirmatory Factor Analysis (CFA). A Structural Matrix (Table 13) was produced suppressing loadings less than (0.40).

Structural Matrix

Many cross-loadings were seen at this .40 threshold. Of concern were variables (Chall353) as this did not express high loadings (r > .60) towards any one particular latent factor. This variable was not removed at this point, but was noted for future consideration (if there was a problem in later Confirmatory Factor Analysis). To help simplify the loading matrix further, a pattern matrix was now produced, suppressing loading less than 0.40 (Table 13, below).

Table 13 – Structural Matrix Suppressed to 0.40 loadings

	Factor				
	1	2	3	4	5
TOIN262	0.924	0.538		0.488	0.439
INEN222	0.914	0.597		0.468	0.450
TOIN363	0.867	0.684			0.492
INEN121	0.829	0.592			0.400
INEN424	0.806	0.531		0.601	
TOIN161	0.786	0.556		0.597	0.426
TOIN464	0.777	0.657		0.559	0.543
INEN323	0.724	0.590		0.496	
ATT444	0.614	0.937			
ATT343	0.600	0.935			
ATT242	0.658	0.731		0.413	
CHAL151			0.858		
CHAL454			0.655		
CHAL252			0.644		
CHAL353	0.410	0.413	0.599		0.429
ATT141			0.461		
EXIN212				0.806	
EXIN111	0.603	0.430		0.796	
EXIN313				0.674	
NOV131					0.769
NOV333	0.444				0.746
NOV232	0.577	0.485			0.652
NOV434	0.504			0.434	0.614

Note: Extraction Method: Maximum Likelihood.
Rotation Method: Oblimin with Kaiser Normalization.

5.4.3 Confirmatory and Discriminatory Validity

The end product of EFA is to produce a Rotational Pattern (Factor) Matrix with clear (singularity) in Convergence values and Discriminations values for variables with clear ‘distinction’ between these variables towards ‘latent’ factors. These properties are known as Convergent and Discriminatory Validity, and suggest that the sampling method (e.g. the questionnaire) is adequately assessing the separate factor constructs (in this case psychological interest and emotion constructs). A strong

Convergence would expect to see loading above .70 (Convergence correlation r > .70) for variables within a factor, perhaps with an overall average above .60 towards a particular factor (Hair *et al.*, 2013).

A strong Discriminatory validity would require loadings of below .80 (r < .80) between factor correlations (i.e. there is little cross-loading of latent variables on different factors).

Table 14 - Rotated Pattern Matrix Suppressed to .40 loadings

	Factor				
	1	2	3	4	5
TOIN262	0.922				
INEN222	0.863				
INEN121	0.775				
TOIN363	0.720				
INEN424	0.649				
TOIN161	0.576				
INEN323	0.484				
TOIN464	0.442				
ATT343		0.909			
ATT444		0.896			
ATT242		0.522			
CHAL151			0.880		
CHAL252			0.676		
CHAL454			0.602		
CHAL353			0.478		
ATT141			0.419		
EXIN212				0.825	
EXIN313				0.685	
EXIN111				0.662	
NOV131					0.803
NOV333					0.689
NOV232					0.469
NOV434					0.456

Note: Extraction Method: Maximum Likelihood.
Rotation Method: Oblimin with Kaiser Normalization.

Reliability of Factor Loading

As part of this initial Structural Matrix analysis (see, Table 13, p152), Factor 1 displayed many variables with oblique rotations with three other factors (close to, or above r>.50). As this might infer a cross-loading, a further rotation using a Direct-Oblimin on only the Factor (1) variables was performed, to investigate the convergence and robustness of the variables towards this dominant factor, and to identify if secondary or sub-factors might be hidden within the orbit of such a dominant factor.

As an *aprior* assumption – the variables loading on factor 1 were thought to be indicative of Enjoyment and Total Interest constructs. This therefore highlights a possible divergent confounding of constructs or psychological domains of emotion (*Instant Enjoyment*) and attention (*Total Interest*) on one factor. Alternatively, as convergent variables, enjoyment and interest might be representing one dominant emotional-attentional factor that might be best treated as one construct (Factor 1).

To this end, a further Exploratory Factor Analysis was conducted using a 3 factor rotation on the variables loading to latent factor 1 (3 instead of the 1 recognised factor, acknowledging the possibility that other 'unrecognised' or 'shared' factors might be in effect).

Variables that display cross-loading values that are similar (i.e. difference no greater than .2) question their convergence validity towards factor 1 and, might be in effect as factor confounding.

Table 15 – Sub-Factor Structure Matrix

	Factor 1		
	1	2	3
TOIN262	0.945	0.327	
TOIN363	0.945	-0.327	
INEN222	0.881		
INEN121	0.809		
TOIN464	0.774		0.357
INEN424	0.755		
TOIN161	0.741		0.479
INEN323	0.709		

Extraction Method: Maximum Likelihood.
a. 3 factors extracted. 12 iterations required.

No such poor values are seen for all the variables in the Factor Matrix for the original Factor 1 items (Table 15). Therefore Factor 1 variables were considered convergent on Factor 1 only, and the Rotation Patter Matrix , (Table 14, p153) considered viable to be taken forward.

5.4.4 Rotational Pattern Matrix

Using the Exploratory Factor Analysis Pattern Matrix (Table 14, p153), a basic model with all factors co-varied was built in $AMOS_{IBM24}$ (see below, Gaskin, 2016d), allowing the EFA to be taken forward for convergent and discriminatory validity within a model fit – a Confirmatory Factor Analysis.

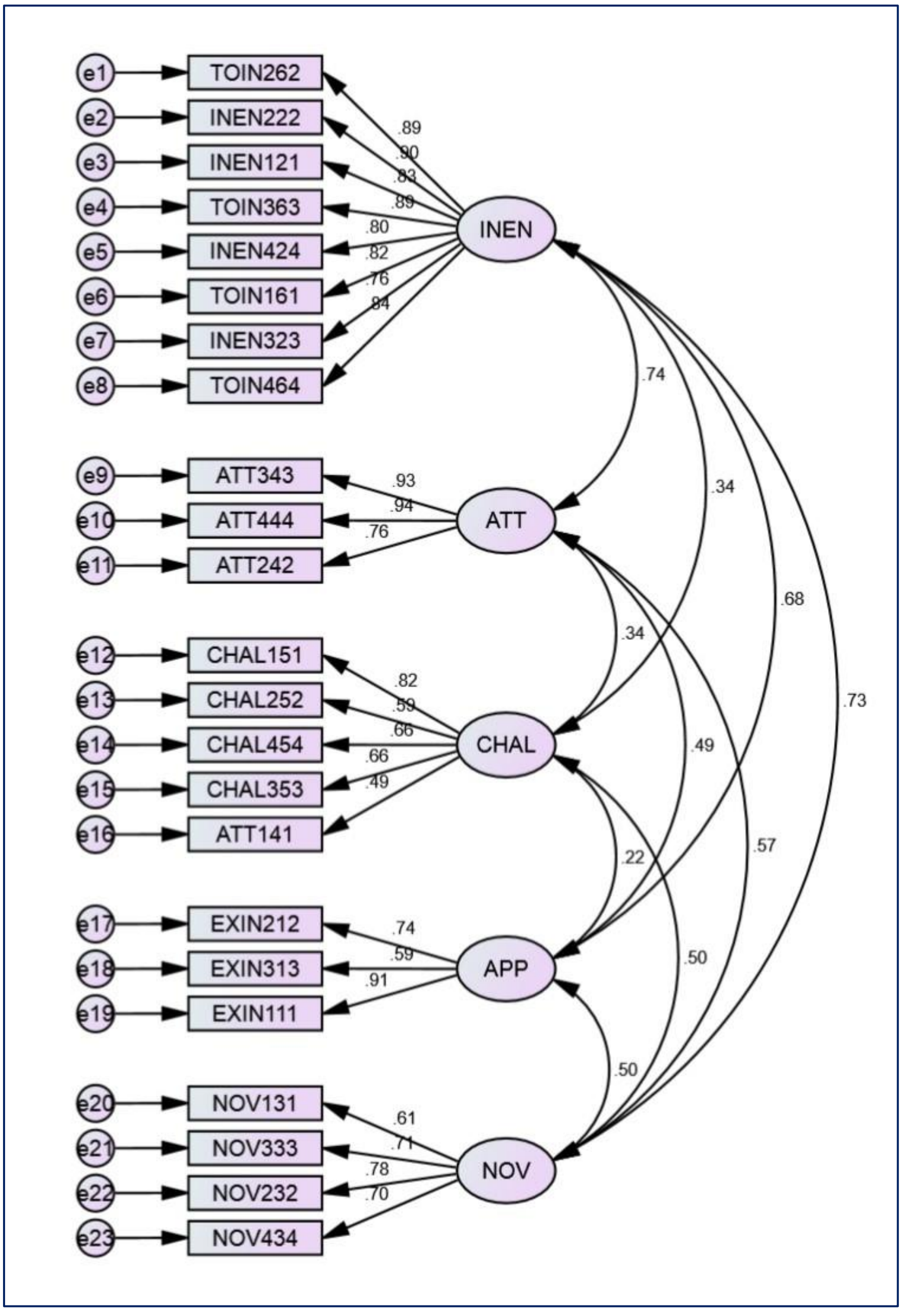


Figure 26 – EFA Pattern Matrix for Taking Forward to CFA ($AMOS_{IBM24}$)

5.5 Exploratory Factor Analysis: Study Two – ROPELOC

Exploratory Factor Analysis was now conducted for the adapted ROPELOC measure (Appendix V).

5.6 Confirmatory Factor Analysis: Study Two – Situational Interest

A standardised Pattern Matrix (Figure 26 – EFA Pattern Matrix for Taking Forward to CFA, above) was used to analyse Convergence and Discriminatory validity.

Initial Confirmatory Model Analysis

The following guidance metrics were used in an initial-fit model to gauge validity.

Convergence and Discriminatory validity

High correlations on latent factor loading for convergence validity requires correlations greater than 0.7 (r >.70) for variables towards a factor with an overall average above 0.60 towards a particular factor (Hair *et al.*, 2013).

Low factor co-variance for discriminatory validity requires correlations less than 0.8 (r <.80) between factors with strong discriminatory validity requiring loadings of below 0.70 (ibid).

5.6.1 Validity Issues

Attention Demand 141

The initial convergence validity (Figure 26, above) required the variable ATT141 (r=.49) to be questioned. This is seen to provide a significant effect on the poor overall convergence validity for Challenge, and needs consideration in light of its poor 'Communality' Analysis (ATT141= .27). The variable ATT141 was therefore removed from this CFA model analysis.

Exploratory Interest 313 and Challenge 343

Although variables EXIN313 and CHALL252 approached a low convergent loading (r =.59), they had displayed sufficient 'Communality' (EXIN313=.458) and (CHALL=.429) and were therefore retained, but noted for possible future analysis.

Modification Indices

Available co-variances were applied to variables displaying high Modification Indices ($AMOS_{IBM24}$) where *a priori* knowledge (e.g., item similarity) provided enough face explanation for covariance: Nov131 and Nov333 are thought to express the 'unusualness' of an activity. Nov131 and Nov333 were therefore co-varied.

Chall151 and Chall252 described the complexity of a perceived challenge, Chall151 and Chall252 were co-varied.

InEn424 and InEn222 were co-varied with ToIn262; these were all thought to represent hedonic 'fun' perceptions and so co-varied.

A model with ATT141 removed and co-variances applied (Figure 27, below) was now used for confirmatory analysis.

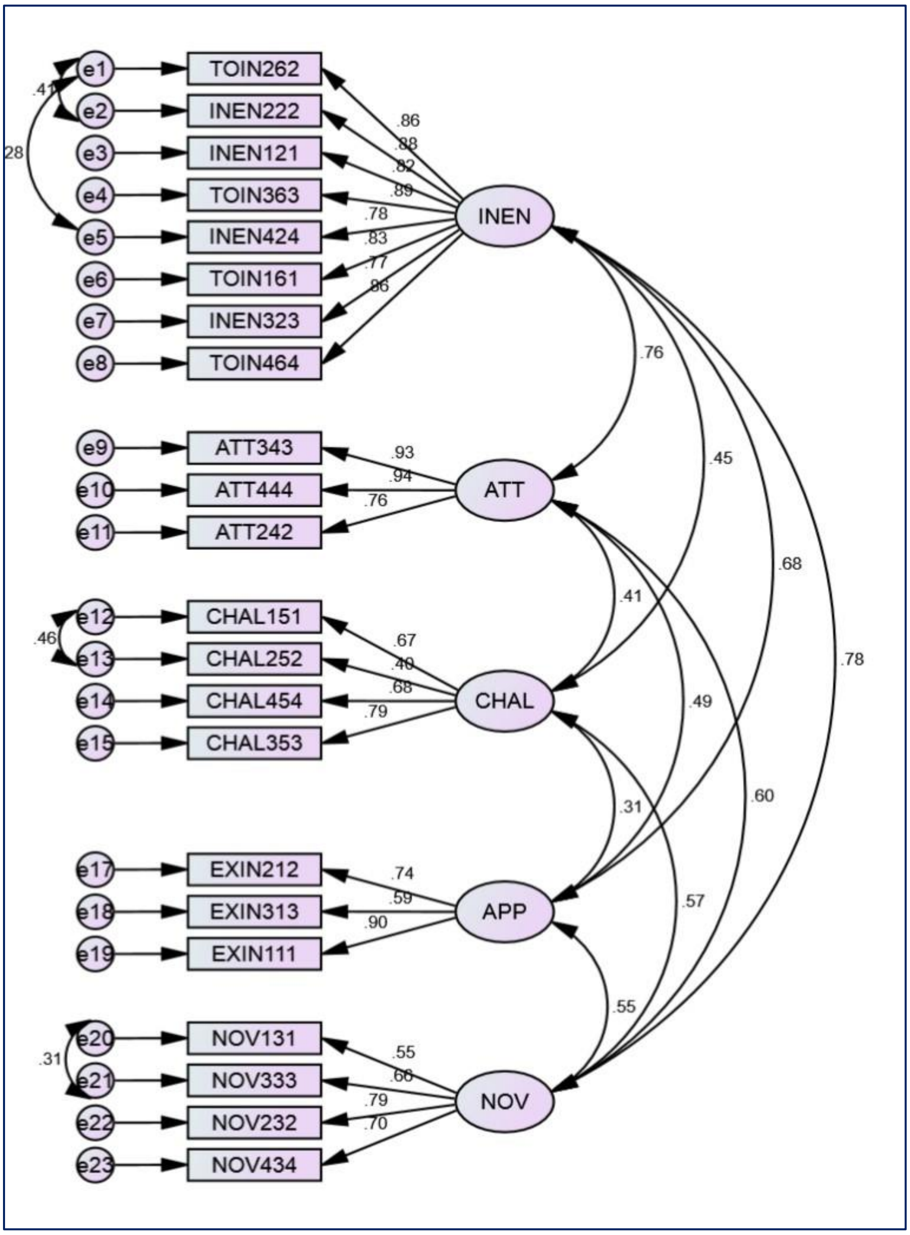


Figure 27 – Initial Confirmatory Analysis Model $AMOS_{IBM24}$

Study Two: Findings

5.7 Findings for the Structural Equation Modelling of Situational Interest

Using the model fit indices (below) to test the validity of the model, the following was derived:

Table 16 – Model-Fit Thresholds

Recommended Threshold	Twin Pathway Model
Chi-square/df (cmin/df) <3-5	2.914
p-value for the model <.05	.0001
CFI >.95	.917
GFI >.95	.836
IFI >.95	.787
SRMR <.08	.072
RMSEA <.06	.083
PCLOSE >.05	.000

Note: Thresholds from Hu and Bentler's "Cutoff Criteria and Fit Indexes" (1999)

A poor fit was achieved from this Initial Model apart from the absolute indices of CMIN where significance might be considered questionable as number samples were 200-plus (Newsom, 2012, p1), resulting in Chi-square ($\chi 2$) being overly significant and so of little reliability for model fit (Kenny, 2015). As 'Confirmatory Factor Analysis' reflects a suite of 'increasingly' stringent confirmatory tests applied to the data in a hierarchy of validity and reliability, if 'Model fit' is not met in the Initial modelling, this questions the efficacy in continuing with the CFA (Gaskin, 2016b; Hu & Bentler, 1999). The analysis was considered as 'better applied' to improving the measure's items, in order to reflect the new Situational Interest model of 5 factors emerging.

5.7.1 Improving the Measure for Situational Interest in Perception

To investigate how perceptions of 'challenge' might be better represented in the questionnaire, the construct of *Challenge* was investigated through perceptions of control, in particular, emotional states relating behavioural or achievement appraisal of control and their associated affective cognitive-emotional perceptions (Bandura, 1997; Deci & Ryan, 1985; Hanin, 2003, 2007; Pekrun, Elliot & Maier, 2006; Pekrun, Goetz, Frenzel, Barchfeld & Perry, 2011; Weiner, 2000).

Of particular note in Study One's SEM pathway evolution (MODEL 2, APPENDIX I: Initial Pathway Analysis, p292), was that when a *Challenge→ Total Interest* pathway was mediated through *Instant Enjoyment,* it produced an 'inverse' or negative reporting. When the twin pathway (MODEL 4, APPENDIX I, *ibid*) was assumed and *Challenge* allotted a separate pathway to the Dependent Variable of *Total Interest*, the negative reporting was diminished. This effect should not be taken as an indication of *Challenge* as a positively scaled factor (as *Total Interest* may be dependent on many mediating factors in the model); in consideration that *Challenge* might well be inversely related to affective hedonic cognitions of Instant Enjoyment, it maybe that *Challenge* should be reporting an inverse (antagonistic) scale in relation to Instant Enjoyment and the other Situational Interest measures. To infer a more tangible construct within the Situational Questionnaire, *Challenge* may be better investigated through a negative or inversed scaled *Challenge* construct: increasing *Challenge* representing an increasingly 'avoid' affective-cognition (i.e. increasing distress or anxiety).

From this, a series of questions that might report such a factor of antagonistic '*Challenge'* were adapted from an Achievement Emotions Questionnaire (AEQ, Pekrun *et al.*, 2011); Perceptions of anxiety, uncertainty and control. These items were thought salient as emotional metaphors (Lakoff & Johnson, 1980), reflecting an 'awareness' of avoid-cognitions, perceptions of 'beyond' optimal control. This is a perception of how ecological engagement 'feels', rather than an actual or quantitative appraisal of performance. Such a phenomenological, situative-appraisal, was considered appropriate to fit the 'reporting' and 'style' of the Situational Interest measure, one able to align with the other Situational Interest's constructs.

Accordingly, a *Challenge* pathway was considered 'better' represented by antagonistic items (e.g. anxiety and uncertainty), as 'avoid' or 'negative' emotional metaphors, in such 'overt' (beyond) cognitive-function. These were considered affective cognitions of *Challenge* reflecting a regulatory-pathway (antagonistic to the hedonic 'agonistic' pathway *of Instant Enjoyment*). Both pathways were thought to combine as a composite self-regulatory perception of attentional processes towards an Effectivity.

As the learning domains were not expected (ethically) to result in undue stress for the participants, the *Challenge*-item questions were determined as emotional metaphors considered to reflect perception of engagement-control in activities considered as learning engagement (Hanin, 2003, 2007; Pekrun & Perry, 2014). Here, *Challenge* becomes a recognition of the 'intensive-accumulative' nature of Divergent Criticality (where such a self-regulating 'inhibition' construct will increase functioning around a Tolerance Optimisation). These items were: "This was a tense activity"; "I felt nervous at times" and "I felt uncertain at times" (see, over).

Challenge as an antagonistic pathway marks an ontological shift in how this Interest construct has been approached in learning and education, from one of an Interest perception or determination (see, Berlyne, 1971; Danner & Lonky, 1981; Harter, 1978, in predominately – classroom situated 'top down' reporting), to one of an emotional appraisal of attentional-awareness. Though Situational Interest had shown validity and reliance (Chen *et al.*, 1999), its affective-cognitive function might be questioned as to its validity distinguishing between such differing theoretical bases of motivational

Interest and emotion. Such conflating of emotional arousal and of Interest has been cautioned by Chen (2014). It is considered that by approaching Situational Interest as an attentional awareness, reporting may be better representative of a conscious-awareness of behavioural affective regulation – attentional control-perceptions as hedonic appraisal (states of, Berridge & Kringelbach, 2008; Northoff & Hayes, 2011). This is a new ecological perspective for Interest perceptions towards life-regulation. One that sees the measure of Situational Interest able to infer perception as an attentional-awareness of a state of life-regulation function in accordance with the Tolerance Optimisation Hypothesis.

To accommodate this new ontology of *Challenge* as ecological control, the original *Challenge* and *Attentional demand* items were re-considered in consideration of the hypothesised duel effective Twin Pathway Model– a Top-down bias of (*Attentional Demand → Instant Enjoyment*) pathway and a Bottom-Up bias (*Challenge → Total Interest*), and new items for both constructs considered:

The following changes were made:

Chall151 – '*This is a difficult Activity'* - ***removed***
Chall252 – '*This activity is complicated'* - ***removed***
Chall353 – 'This activity *is a demanding task'* – **re-appropriated to Att242** (see below)
Chall454 – *'It is hard for me to do this activity'* – ***remains***

This now provided a *Challenge* construct which was considered as a better metaphoric-fit for representing an antagonistic of inhibitory cognitive-function[80]:

Chall151 – *'This was a tense activity'* – ***New***
Chall252 – *'I felt nervous at times'* – ***New***
Chall353 – *'I felt uncertain at times'* – ***New***
Chall454 – *'It is hard for me to do this activity'* – ***remains***

As Top-down processes (contextual appraisal of the agent) are often associated with purposeful effort (Eysenck *et al.*, 2007), it was felt that this was adequately reflected in Att343 – '*I was focused'* and Att444 – '*This activity is complicated'* but not in the two items that had displayed poor

[80] It should be noted that the Divergent Criticality hypothesis recognises the 'intensive' functioning of such inhibition cognitions (*Challenge)*: in that there will be always be some intensive 'criticality' in ALL functional states, and so allows a continuous scale for *Challenge* perceptions – there will always be uncertainty, be it a scintilla of control-doubt through to a collapse in cognitive control stability.

convergence reliability in the EFA: Att141 – '*My attention was high'* and Att242 – '*I was very attentive all of the time'*.

Att141 '*My attention was high'* had a better fit with the construct, Total Interest (this item was thought to reflect an overall appraisal without overt cognitive-emotional value), so was moved to ToIn363 and replaced by '*I was determined during this activity'.*

Likewise, Att242 *'I was very attentive all of the time'* was removed and replaced with the re-appropriated Chall353 '*This activity is a demanding task'*. Again, this was thought to better reflect the perception of cognitive-effort in *Attentional Demand* rather than *Challenge*.

Att141 – '*My attention was high'* – **re-appropriated to Toin363**
Att242 – '*I was very attentive all of the time'* – **removed**
Att343 – '*I was focused'*– **remains**
Att444 – '*I was concentrated'* – **remains**

This now provided an Attentional Demand construct made from the following items:

Att141 – '*I was determined during this activity'* – ***New***
Att242 – '*This activity* is a demanding task' – **re-appropriated from Chall353**
Att343 – '*I was focused'* – **remains**
Att444 – '*I was concentrated'* – **remains**

Adjustments to the Total Interest construct were made to reflect its hypothesised cognitive-emotional state of Divergent Criticality function, and accommodate the *Attentional Demand* item Att141 – '*My attention was high'*:

ToIn 262 '*I was curious to try this activity'* was thought to be less hedonically-biased than '*This activity* looked fun to me', and the following changes were made to Total Interest to better reflect an Interest construct derived from both the *Attentional Demand* (hedonic affective drive) and *Challenge* (antagonistic-inhibitory regulation) pathways:

ToIn161 – '*This activity is interesting* – **remains**
ToIn 262 – '*This activity* looked fun to me'– **removed**
ToIn 363 – '*It's fun to try this activity'* – **removed**
ToIn 464 – '*This is an interesting activity'* – **removed**

Therefore:
ToIn161 – '*This activity is interesting'* – **remains**
ToIn 262 – 'I *was curious to try this activity'* – **New**
ToIn 363 – '*my attention was high'* – **from Att141**
ToIn 464 – *'This can be considered a challenging activity'* – **New**

Further re-phrasing in accordance with the observations made in the sampling feedback (from questionnaire gatekeepers), provided further items that were considered culturally (language) sensitive; e.g.

EXIN111 – *"I wanted to discover all the tricks of this activity"* became

"I wanted to discover all the ways of doing this type of activity"

Situational Interest Adapted Questionnaire MkIII (See, APPENDIX II: Questionnaire Development and Providence, p294)

5.8 ROPELOC Factor Analysis

Exploratory and Confirmatory Factor Analysis was performed on the ROPELOC questionnaire data (see, APPENDIX V: Study Two – ROPELOC Factor Analysis, p305) the following Pattern Matrix was derived.

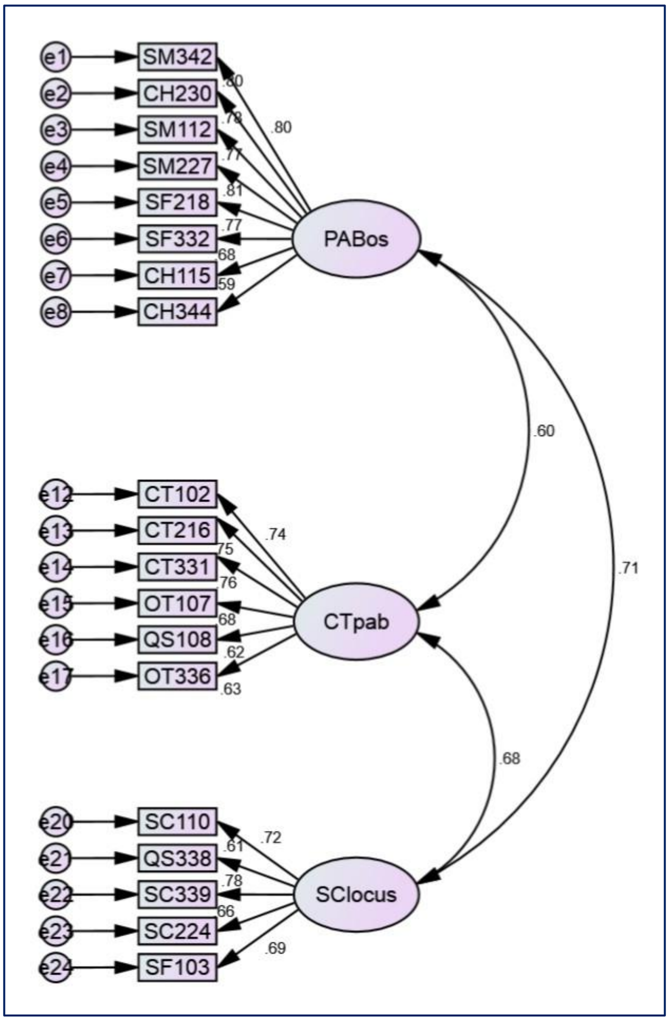


Figure 28 – ROPELOC Study 2: Confirmatory Analysis Model (AMOS$_{IBM24}$)

5.9 Findings for The ROPELOC Questionnaire Measure

5.9.1 Model Fit

Using the model fit indices to test the validity of our model, the following was derived:

Table 17 – Model-Fit Thresholds

Recommended Threshold	Twin Pathway Model
Chi-square/df (cmin/df) <3-5	3.687
p-value for the model <.05	p<.0001
CFI >.95	.862
GFI >.95	.829
IFI >.95	.863
SRMR <.08	.0745
RMSEA <.06	.098
PCLOSE >.05	.000

Note: Taken from Hu and Bentler's "Cutoff Criteria and Fit Indexes" (1999, p.27)

The CFA model produced, did not mirror the sub-scale convergence on factors as seen in the original validated model, with much cross-Construct variation from the original, validated model. This was somewhat surprising as the sub-scales informing such factors were largely un-adapted. As with the Situational Interest measure, thresholds for fit were not adequately achieved from the model, apart from the absolute indices of CMIN and SRMR where the Chi-square (χ2) bias overly significant results and so of little reliability (Kenny, 2015; Newsom, 2012). As these 'fit' criteria are not met in this Initial Model, this questions the efficacy in continuing with the CFA and SEM (Gaskin, 2016b). Again, as with the Situational Interest measure, might better apply the results of the CFA to improving the ROPELOC measure's items further, in order to better interrogate the Divergent Criticality hypothesis

There emerged three factors of some concurrence to constructs of Personal Abilities Beliefs (PAB) and Cooperative Teamwork (CT), though with sub-scales spread across the three emerging factors. This spread was thought to display perceptions of a state of ecological management as 'locus of control' attributions. As developing 'perceptions of control' theme was emerging in Study Two in relation to state cognitions, the sub-scale of Locus of Control (IL) was re-considered.

In Study One, the Internal Locus of Control (IL) scale had shown significant correlation with Attentional Demand (r=.195, p<.05). It was felt that IL might provide increasing convergence power to the SClocus factor. Stress Management had provided the least correlations in previous sub-scale analysis and was therefore replaced and Internal Locus IL items re-introduced.

To accommodate the loss of a sub-scale within a construct of Social Awareness, the sub-scale of Time effectiveness (with strong correlations seeming to infer cognitive 'state' determinants (Table 4, p133) was reintroduced and Self Confidence (SC) as a trait-like scale that had displayed poor correlations in Study One, removed. These changes were taken forward in the Study Three analysis. In addition, the Study Three questionnaires were re-worded to reflect the metaphoric and language thought better representative of participants perceptions as had been done in the Interest Questionnaire (see Questionnaire and Providence, Study Three, APPENDIX II: Questionnaire Development and Providence, p294).

5.10 Study Two: Conclusions

Though the EFA and CFA supported somewhat a Divergent Criticality hypothesis of *Novelty* and *Exploration,* seemingly rewarded through a dependent variable of *Instant Enjoyment* for increasing surprise, the CFA for Study Two did not meet initial threshold criteria for further SEM analysis. That Confirmatory Factor Analysis reflects a suite of increasingly stringent confirmatory tests applied in a hierarchy of validity and reliability. To proceed with further Structural Emotional Modelling iterations would require an item validity not available from this initial Factor Analysis (any further SEM Pathway analysis requires validity assumptions that not able to be supported by current questionnaires items and factors). In not achieving 'Model fit' questions the efficacy in continuing with the SEM analysis. Therefore, the results of Study Two were thought to be better interrogated towards improving the Situational Interest and ROPELOC measure's, in order to better interrogate the Divergent Criticality hypothesis.

A new ontological shift in how to view Challenge now directed the adaptation of the Situational Interest questionnaire. To address the poor reporting in convergent and discriminatory validity of the constructs, significant changes were made to the measure: Particularly in the scaling of antagonistic items for the *Challenge* factor (see Questionnaire and Providence, Study Three, APPENDIX II). To accommodate the new items of anxiety, nervousness and discomfort, a re-appraisal informed by Studies One and Two was conducted in producing an 'adapted' Situational Interest Questionnaire. Such a shift required further Factor Analysis in Study Three. This should then allow pathway analysis using SEM to suggest a Profile of attentional processes between the new constructs. Such a SEM-profile may infer a 'state of functional Affordance', a scale or measure able to be triangulated against another perception measure (e.g. ROPELOC) in accordance with the Divergent Criticality hypothesis.

The ROPELOC Factor Analysis displayed similar issues with Situational Interest in its Global Fit. Again, the constructs may be questioned as to their veracity in representing Self-Concept as a 'state' cognitions. It was considered that some of the constructs may be subject to more complex 'frame of reference' issues (Bong & Skaalvik, 2003; Pajares, 2009), confounding self-reporting with a bias towards reporting more 'trait' like rather than 'state' cognitions. To this end, ROPELOC constructs thought to reflect state perceptions to better effect (considering the Divergent Criticality hypothesis and its sampling criteria of learning environments), were re-introduced, e.g. 'locus of control'. Again, such adaptations would require further Factor Analysis to enable salient construct of Self Concept (ROPELOC) to be able to triangulate against a Situational Interest measure derived – state of functional Affordance.

6 CHAPTER SIX – Methodology Study Three: An Exploratory Model of Divergent Criticality Function

6.1 Introduction

A key objective of the methodology was to be able to differentiate 'states of Functional Affordance' from a questionnaire in order to test the Divergent Criticality hypothesis of Tolerance Optimisation. Bringing together the findings from the Study One and Two's Questionnaire Development required now, further factor analysis in order for the MkIII adapted questionnaires, to be to applied with any veracity toward a Structural Equational Modelling (SEM) of Divergent Criticality function. Study Three questionnaire data therefore undertook a number of methodological steps:

I) Factor Analysis of the new questionnaires

II) Pathway Analysis of the Situational Interest Constructs.

III) Structural Equation Modelling for an Interdependence Profile of functional Affordance.

IV) Triangulation tests with a self-concept measure (ROPELOC).

Study Three: Methodology

Interest – Questionnaire Analysis Steps

Sorting and Cleaning Data Set

Transpose Questionnaire Data onto Microsoft Excel 2010 and SSPS$_{IBM24}$
Sorting of data to provide a multi-item measure for its factor analysis
All data made nominal, ordinal or interval
Missing Variables investigated:
- None completion
- Unengaged reporting
- Outliers

Missing Variables imputed Multiple Imputation (MI)
Tests for Normality:
- Skewness/Kurtosis

↓

Exploratory Factor Analysis (EFA)

Principle Components Analysis of measure values:
- Bartlett's Test of Sphericity
- Kaiser-Mayer-Olkin (KMO) Index

Factor Extraction (Maximum Likelihood Analysis)
Rotation of Factor Matrix:
- Oblique or Orthogonal Factor Relationships
- Reliability of Factor Loading
- Cronbach's Reliability

Rotational Pattern Matrix to take forward to CFA

↓

Confirmatory Factor Analysis (CFA)

The EFA Pattern Matrix was used to suggest a possible factor loading model for –
Initial Confirmatory Model Analysis
Convergence and Discriminatory validity:
- Model-Fit Thresholds

Measurement Invariance (Non-Independence Threats from Data Groupings):
- Configurable Invariance
- Metric Invariance
- Scalar Invariance

Validity and Reliability Tests:
- Construct Reliability
- Convergent Validity
- Discriminant Validity

Metric Validity Assumed CFA Model
Common Methods Bias:
- Test of a Common Latent Factor
- Validity Check of Model Including Common Latent Factor

Final Model Fit for Common Latent Factor Adjusted Model:
- Tests for Multivariate Influence and Multi-Collinearity Test
- Multivariate Influence using Cooks Distances

The Confirmatory Factor Model, partialed and imputed factor variables were now applied to Structural Equation Modelling (SEM)

↓

Structural Equation Modelling (SEM)

The CFA was used to provide the factor loading in order to build a model of the relationships between the Interest construct in order to explore an Interdependence Profile:
Structural Equation Modelling (SEM)
Apriori Hypothesis
SEM Causal Model Building:
- Final Global Fit Indices
- R-Squared Tests
- Significance

SEM Hypothesis Testing
The Valid SEM was used towards an Inductive Interdependence Profile
Conditional Independence (CI) Triangulation

↓

Interdependence Profiling Scale (SEM)

Structural Equation Modelling (SEM)
A State of Attentional Function in Direct and Indirect Effects
- SEM Interdependent Profile as States of Functional Affordance
- Investigating the Interdependence Profile

Interdependence Profile Scale as a State of Functional Affordance

↓

Triangulation of Interest (Functional Affordance) and ROPELOC Analysis

Functional Affordance determined by the Interest SEM Interdependence Profiling) is now used to test the Divergent-Criticality hypothesis in triangulation with a self-concept measure (ROPELOC).

Figure 29 – Situational Interest Factor Analysis and SEM

6.2 Sorting and Cleaning

Sample Domains

In accordance with the sampling criteria and ethical submissions of Study One and Two, the final questionnaire was sampled across 24 learning domains (Figure 30, below).

SAMPLE DOMAINS AND CODES

No	Sample code	Descrition—Domain	Domain	Domain Ordinal	IP
1	3.5A	Biology Trip	9	2	6
2	3.23A	Mountaineering Review	7	1	7
3	3.1A	Swanage Geography Field	9	2	2
4	3.2A	Canoe Award	7	1	3
5	3.3A	Moel-Fameau Hill Walk	7	1	1
6	3. 6 A	Team Building	9	2	2
7	3.4B	HE Lecture	3	3	7
8	3.9B	Team Building	7	1	2
9	3.10B	HE Lecture	3	3	2
10	3.11B	Secondary Lesson	3	3	2
11	3.12B	Outdoor Activity	7	1	1
12	3.13B	Outdoor Activity	7	1	1
13	3.142B	HE Lecture	3	3	5
14	3.15B	HE Workshop	3	3	2
15	3.16B	Team Challenge	7	1	5
16	3.17B	Skiing	7	1	5
17	3.19A	Secondary Lesson	3	3	3
18	3.20B	Glacier Walking	9	2	3
19	3.21B	Team Building	9	2	1
20	3.22B	Mountaineering	7	1	4
21	3.24 B	Paddlesport / Review	9	2	7
22	3.25B	DoE 2	10	4	2
23	3.26B	Geography Lesson	3	3	3
24	3.01A	DoE 4	10	4	3

Domain	Description
9	Half Day Team Build
9	Half Day Sport Activity
3	2 Hour min Theory Session
4	Recall of Past Activity
10	4 Plus Day OE Residential
10	2 Day Expo
7	OA Activities
7	1 Day Outdoor Activities
9	Field Day - Residential
10	4 Day Expo - Doe

KEY

n=874

Domain = **Situational Sampling**

Domain Ordinal = **Domain Sorted**
(Used in Conditional Independence)

IP = **Interdependence Profile**
(SEM inferred functional Affordance)

Figure 30 - Sample Domain-Groups

Data Screening

Sorting and cleaning of descriptive data from Phase Three followed the same procedures as the previous studies; however, rather than a Maximal Likelihood (EM algorithm) method for missing data, the pattern of 'missingness', determined a Multiple Imputation (MI) method be used. The Questionnaire MkIII data set was first sorted and cleansed in Excel and $\text{SPSS}_{\text{IBM24}}$ as in Study One (see, Outliers, Missing Variables, Unengaged Responding, 4.6, p125). This cleansed data was then entered into $\text{SPSS}_{\text{IBM24}}$.

6.3 Missing Data and the Use of Multiple Imputation

Missing data was evident at 'item', 'construct' and 'person' level in the questionnaire returns. In such large samples, item and construct missingness present few issues as imputation methods can be easily applied to account for such omissions (Allison, 2003). Greater consideration must be applied to person-level missing data, however, as it presents a system issue (in providing no empirical basis for imputation as there is no person-level data with which to draw information). Therefore, missing data was analysed; and if missing data was found to be missing at a 'system' level of missingness (no information evident in either questionnaire), was removed.

<u>Situational Interest Measure</u> – 4 rows represented missingness at person-level and therefore, as a sampling system issue, removed: n =870 (person-level of missingness = 0.5%).

<u>Personal Effectiveness Measure (ROPELOC)</u> – 20 rows represented missingness at person-level and therefore, as a system issue, removed: n =853 (person-level of missingness = 2.4%)[81].

The Situational Interest questionnaire exhibited 89 missing values (0.4% item-level of missingness) at item and construct level that were subject to Multiple Imputation (MI). In the ROPELOC questionnaire exhibited 106 missing values (0.5% person-level of missingness) at item and construct level that were subject to MI.

6.3.1 Multiple Imputation

The quality of missingness and 'level' (item, construct and person/measure) provides some indication as to the treatment of the missing data, the imputation technique and the necessity (or not) of Sensitivity Analysis (Newman, 2014). The missing data therefore was subject to Little's MCAR test:

<u>Situational Interest</u>: Little's MCAR test: Chi-Square = 1037.602, DF = 688, Sig. = .000$_a$

<u>ROPELOC</u>: Little's MCAR test: Chi-Square = 1169.990, DF = 755, Sig. = .000$_a$

Both measures displayed Missing Not at Random (MNAR) level of missingness. This might present problems with imputation, however, it should be remembered that missingness represents a continuum between Missing at Random (MAR) and Missing Not at Random (MNAR) as to the inference of one variable and the missingness observed in relationships with at least one other variable (Collins *et al.*, 2001). Whereas the percentage of 'missingness', provides some measure as to

[81] The person level missing data disparity between the Situational Interest and ROPELOC was thought to represent questionnaire fatigue (7.4.5, p213).

the randomness of missing data in a consideration for how MAR and MNAR might be differentiated and guide assumptions for replacing missing data (Allison, 2003; Gaskin, 2016c; Newman, 2014). Though bias issues cannot be ignored when imputing missing values, with such low levels of missingness in the observable data (n<10%), this may allow a MAR assumption in the data-set, even though Little's (1988) test suggests none-MCAR (Allison, 2003; Schafer & Graham, 2002): This is acceptable in understanding how, the likelihood of obtaining a particular pattern in the missing data may 'not' be depend on the values of missing-data, but on how the values observed might have been effected in the data sampling, an understanding of how the data is missing[82];

"Of course, the importance of this rule (imputation model) depends on the proportion of cases with missing data. If that proportion is small, it is not so critical that the imputation model closely track the model of interest." (Allison, 2003, p554)

It was intended to use the data for further 'hypothesis testing', therefore, a Multiple Imputation method (Rubin, 1986) was applied to the data set. Multiple Imputation (MI) does not require such stringent MAR assumptions, especially when associated with large sample size n>60 (Schafer & Graham, 2002, p170) and the use of auxiliary variables has been highlighted by Collins et al. (2001) and Newman (2014):

"Auxiliary Variables Can Convert MNAR Missingness Into MAR Missingness."(Newman, 2014, p391)

The use of Multiple Imputation has, in addition, been suggested for imputation for model hypothesis testing, as it has been shown to be less-susceptible to Standard Error bias with MI providing greater accuracy in confidence intervals for future hypothesis testing (Glaser & Strauss, 1967; Schafer, 2003). A predictive mean MI imputation ($SPSS_{IBM24}$/$AMOS_{IBM24}$) was therefore conducted at a construct level to provide salient auxiliary variables for the MI.

6.3.2 Tests for Normality of Data - Skewness and Kurtosis

Possible Skewness and Kurtosis issues are able to be relaxed in Structural Modelling programmes such as $SPSS_{IBM24}$ and $AMOS_{IBM24,}$ where non-centrality 'Fit Indices' are able to obfuscate such issues somewhat. However, in both measures, the variables exhibited no significant Skewness or Kurtosis Issues ($SPSS_{IBM24}$). The data sets were now subject to Factor Analysis.

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[82] Missingness across the perception (psychometric) data here, is considered to reflect the interpretation of questionnaire items (e.g. Nov232 – 'This activity is fresh'; though patterned as significantly missing, actually reflected some confusion in the contextual language "I don't understand"). This item's missingness is therefore considered as not dependent on missing data and MAR is accepted on the observed data.

6.4 Factor Analysis: Study Three – Situational Interest Questionnaire

The use of an 'adapted' measure of Situational Interest (Chen *et al.*, 2001a) employed the adapted 'Interest' and Emotional-control variables (e.g. an antagonistic *Challenge* factor). In this Study Three, the adaptation of Interest's constructs and the re-allocation of 'Challenge' as an antagonistic factor, explored how 'cognitive-emotional' questionnaires can now infer a functional Affordance state, able to be differentiated between sample domains and groups. Such differentiation, in accordance with a Tolerance Optimisation hypothesis, is considered congruent with other perceptions of affective appraisals of self-concept. Accordingly, Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) was conducted as per Study Two, to provide validity and define the variable loadings for the adapted Situational Interest measure (See APPENDIX VI: Study Three – Situational Interest

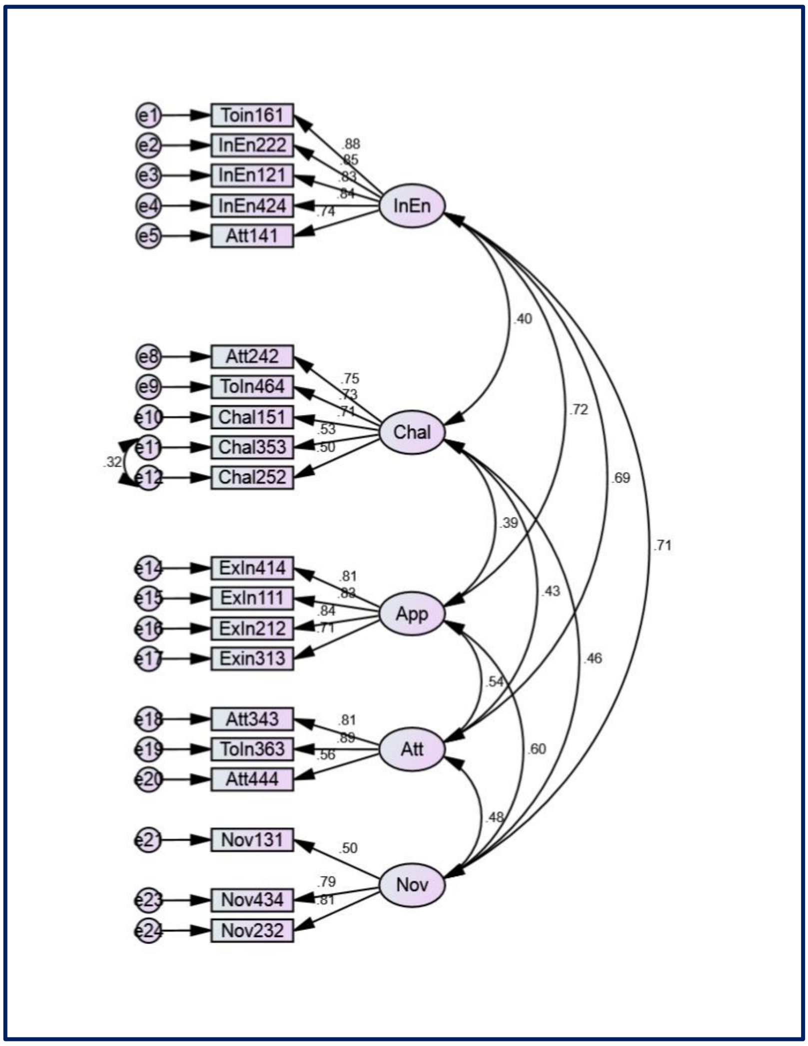


Figure 31 - Initial Confirmatory Analysis Model (AMOS$_{IBM24}$)

EFA and CFA, p311). A model with Chal454, InEn323, ToIn262 and Nov333 removed and co-variances on (Chal353 &252) applied was now used for initial confirmatory analysis (see, Figure 31, above).

Table 18 – Model-Fit Thresholds for Initial CFA

Recommended Threshold	CFA Pathway Model
Chi-square/df (cmin/df) <3-5	5.731
p-value for the model <.05	.0001
CFI >.92-.95	.923
SRMR <.06-.08	.061
RMSEA <.06-.08	.074

Note: Strict Thresholds (Hu & Bentler, 1999);

Acceptable Thresholds (Hair *et al.*, 2013; Lomax & Schumacker, 2004)

Model fit, was based on broad fit-index spectrum, as deemed a 'confirmatory requirement' for determining 'fit' in multiple criteria (Hu & Bentler, 1999) (Newsom, 2012). Therefore using (Byrne, 2008) guidance the following 'fit' indices were considered suitable: Comparative Fit Index (CFI) (Bentler, 1990); the Root Mean-Square Error of Approximation (RMSEA) (Browne & Cudeck, 1993), and the Standardized Root Mean Square Residual (SRMR). The 'χ^2 CMIN' fit, utilises Chi-square (χ^2) and is therefore susceptible to large sample and complex-model confounding. However, this indice was retained allowing 'degrees of freedom' to be considered in SEM model assumptions. The following indices were now used reflecting the sampling and research design.

The model (Figure 31, above), did not achieve the model-fit thresholds (above) under Hu and Bentler (1999). However, Hair *et al.* (2013, p584) and Lomax and Schumacker (2004, p112) have suggested acceptable model-fit at 'less strict' thresholds in consideration of sample size and the number of measure-items (e.g. RMSEA < .06 - .08) and therefore, this Initial CFA was thought to be acceptable in confirmatory analysis as non-hypothesis testing and able to continue the validity metrics.

6.5 Measurement Invariance: For Non-independence threats

There is a threat to the model validity if the sampling includes data sets where grouping parameters display a confounding bias effect through overt independence (i.e. groups display significant bias to the latent variables, questioning the homogeneity of the data and implying a possible threat to inferential results). Such data measurement bias is addressed through a number of measurement-invariance tests that enable hypothesis analysis ($AMOS_{IBM24}$) in multi-group analysis[83], to be attributed to the specified hypothesis rather than unspecified group reporting differences. (e.g. male

[83] Within the Divergent Criticality theory, social and situational reporting is hypothesised to exhibit stereotypical reporting (e.g. gender and age biasing) though these biases are expected 'within' domain groups, (and part of the social/situational milieu), here we examine 'between' domains to accommodate possible sample Type I 'grouping' bias effects.

vs female bias). To allow the assumption of model independence towards groupings identified in the Phase I (Study One), gender' and 'age' were therefore subjected to invariance testing using Chi-Square χ^2 and multiple-group analysis in $AMOS_{IBM24}$.

6.5.1 Measurement Invariance Tests for Age and Gender

Measurement invariance tests are described in order of increasing stringency, where subsequent tests build upon ever greater constraining of model parameters in homogeneity testing. This focuses invariance with ever increasing constraints on the general model, the latent factors, and the variable items (Bialosiewicz, Murphy & Berry, 2013).

1) **Configurable Invariance** – Running a model-fit test using freely-estimated parameters 'across' possible groupings to see if acceptable thresholds of model fit are maintained when the groups are considered separately. Here we look for significant model fit ($AMOS_{IBM24}$). If found, invariance provides a measure of non-independence or non-variance in the grouping data across the model (Gaskin, 2016b).

2) **Metric Invariance** – Running a 'partially' constrained (factor loadings) model across all groups, then using a Chi-Square χ^2-test to compare between this partially constrained and a 'Freely Estimated' (unconstrained) model. Loadings on the latent factors should display equivalence (i.e. invariant) and the χ^2-test found – non-significant (Van de Schoot, Lugtig & Hox, 2012).

3) **Scalar Invariance** – This is conducted by comparing the partially constrained model with a fully constrained model (regression loadings and intercepts). If the two models are found to be equivalent (i.e. invariant), this would display no appreciable or significant difference in item variables towards the latent factor. Non-significance using a χ^2-test infers no difference, therefore, Scalar Invariance is accepted.

Invariance in both questionnaires data-sets was accepted (for full Measurement Invariance tests see, APPENDIX VII: Measurement Invariance Tests, p321). The initial Confirmatory Factor Analysis (CFA) Model (Figure 31, p171), is accepted for the further metrics to establish factor validity and reliability:

6.6 Validity and Reliability Tests

Construct Reliability vs Cronbach's Alpha

Though Cronbach's Alpha is often quoted for item reliability (that questionnaire items address the latent variables they are correlated towards, reliably across all samples). This presents concerns for multi-construct models with large sample sizes as Cronbach's Alpha has a positive relationship with increasing degrees of freedom questioning its reliability as a measure (Hair *et al.*, 2013). More accurate reliability may be found through Construct Reliability (CR). CR measures the internal consistency of the items towards a latent variable or construct, that is to say, the similarity in item(s) reporting towards a latent construct. Construct Reliability, as a more accurate measure of the reliability of the data (than Cronbach's Alpha), and is required as an assumption for Construct Validity metrics (CR>.7 ideally – CR>.5 acceptable, Hair *et al.*, 2013, pg 605).

Convergent and Discriminant Validity Metrics

Construct Reliability (**CR**), Average Variance Extracted (**AVE**), Maximum Shared Variance (**MSV**) and Average Shared Variance (**ASV**), are used to inform Convergent and Discriminatory Validity investigated through the following threshold metrics (Hair *et al.*, 2013).

For Construct Reliability – **CR** > .70 (Hair *et al.*, 2013)

For Convergent Validity – **AVE** > .50 (Bagozzi & Yi, 1988)

(explained variance is greater than residual variance)

Discriminant Validity - **MSV** < **AVE**; (Hair *et al.*, 2013)

Discriminant Validity - Square root of **AVE** greater than inter-construct correlations.

Construct Reliability tests are now applied (*ibid*).

Table 19 – Convergent and Discriminant Validity for Situational Interest

	CR	AVE	MSV	MaxR(H)	Att	InEn	Chal	App	Nov
Att	0.806	0.589	0.472	0.864	0.768				
InEn	0.917	0.688	0.514	0.923	0.687	0.829			
Chal	0.783	**0.426**	0.207	0.807	0.427	0.401	0.653		
App	0.874	0.636	0.514	0.882	0.543	0.717	0.394	0.798	
Nov	0.750	0.511	0.497	0.797	0.480	0.705	0.455	0.600	0.715

Note: Metrics using 'Validity Master' (Gaskin, 2016e)

Convergent Validity: the AVE for Chal is less than 0.50

Challenge presented a concern above. It would be possible to further remove *Challenge* variables and improve the convergent reliability slightly (.426). However, an explanation for such moderate convergence on this *Challenge* factor is hypothesised to be a sampling-bias: a necessary sampling of 'within tolerance' (for ethical reasons – not taking participants into a beyond control situations of fear and anxiety), may result in strong convergence being elusive with such a system-bias, but does not negate its influence. As discriminant validity is acceptable and considered the primary structural 'pathway' feature for Structural Equation Modelling (SEM) and that *Challenge* displays only a minor convergent issue, this validity metric was considered acceptable in moving towards investigating possible unknown (common) variables that may be in effect. With Metric Validity 'assumed' acceptable for the Confirmatory Factor Analysis Model (Figure 31, p171), this validity assumed model was taken forward to Common Latent Factor analysis.

6.7 Common Methods Bias: Shared Common Latent Factor

It is possible that an unidentified 'common' item might share variance with the items as well as the factors identified through EFA. To test this, the shared-variance across all model items is tested for significance with a hypothesised Common Latent Factor (CLF) as a correlated residue across all items in the model.

Shared Variance Test of a Common Latent Factor

This is done by creating the Common Latent Factor (CLF) for all variables (Gaskin, 2016a), run as a freely estimated model (see, Figure 32, below), and a model where the CLF is constrained to zero. This is a first correlated residue from all the measures items to identify any latent factor, common to all items, who's sensitivity may have been lost in the first extraction.

If there is significance using a Chi-square (χ^2) difference test between: 1) the freely estimated model and 2) a model constrained to zero; then there is a correlation residue bias from a Common factor with enough shared variance to warrant its inclusion as a latent variable in further analysis.

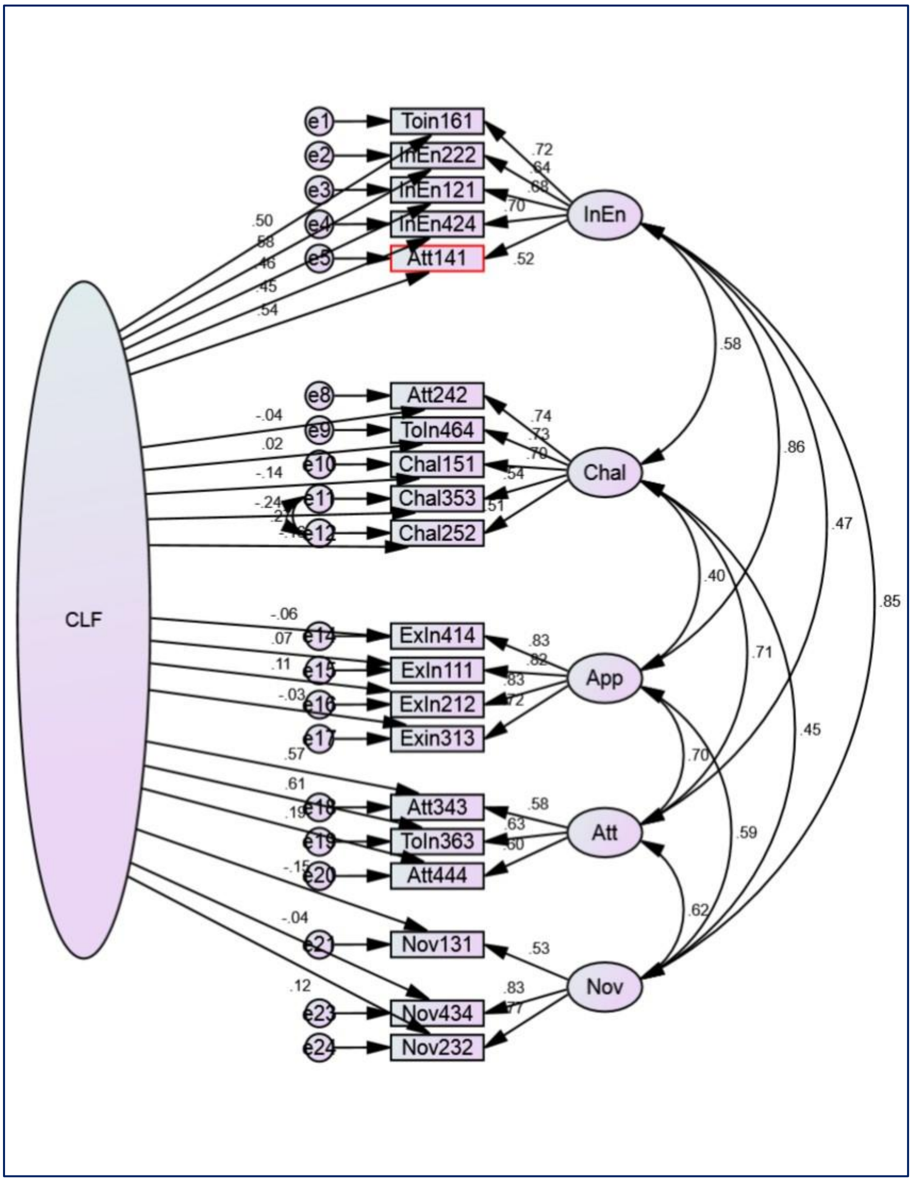


Figure 32 – Common Latent Factor

Table 20 – Chi-square Difference Test CLF

Overall Model	Chi-square	DF	P	Invariant?
Unconstrained	641.1	141		
Fully constrained	947.2	159		
Number of groups		2		
Difference	306.1	18	**0.000**	**NO**

Note: Chi-square Difference Measure (Gaskin, 2017a)

There is significance (p<.001), therefore shared variance with the CLF will need to be assumed.

Validity Check of Model Including Common Latent Factor

As shared variance was significant (not invariant), the model was investigated for convergence and discriminatory validity now that the variables are seen to share variance between the CLF and the latent factors. This initial CLF discriminatory validity seemed confounded with negative-values and some poor discriminant (see, above). The Factor *Instant Enjoyment* (InEn) displaying considerable shared variance within the CLF model with factors 3 (*Approach*) and 5 (*Novelty*). This non-discrimination matched analysis in the EFA, therefore some further adjustment was considered necessary in the model.

Adjustment of Model Including Common Latent Factor

The variables Att141 (Figure 32) displayed poor loading towards its latent factor suggesting cross loading. This concurred with cross-loading observed in the EFA (see, APPENDIX VI: Study Three – Situational Interest EFA and CFA, p311) that had caused the reliability of this Att141 item to be questioned. Att141 was removed and *Instant Enjoyment* (InEn) constrained with *Approach* (App) to 1 (to produce an acceptable model for imputing partialised values towards a factor whilst considering a CLF).

Though some seemingly 'low' convergent validity is seen across bias corrected values[84] (Figure 33, below), the Average Variance Extracted (AVE) exceeds a cut-off value of .40 across all factors and this model is therefore acceptable (Diamantopoulos, Siguaw & Cadogan, 2000). There is a negative regression for some of the CLF correlations, this is inverse effect is not unusual with residue-analysis and therefore such negative values are considered permissible and the model allowed to go forward (Diamantopoulos & Winklhofer, 2001; Henseler, Ringle & Sarstedt, 2015).

[84] Though Chal252 displayed poor loading – as co-varied with Chal353, Chal252 was allowed to remain.

A final model fit was conducted on the unconstrained model with 6 latent variables (including a CLF).

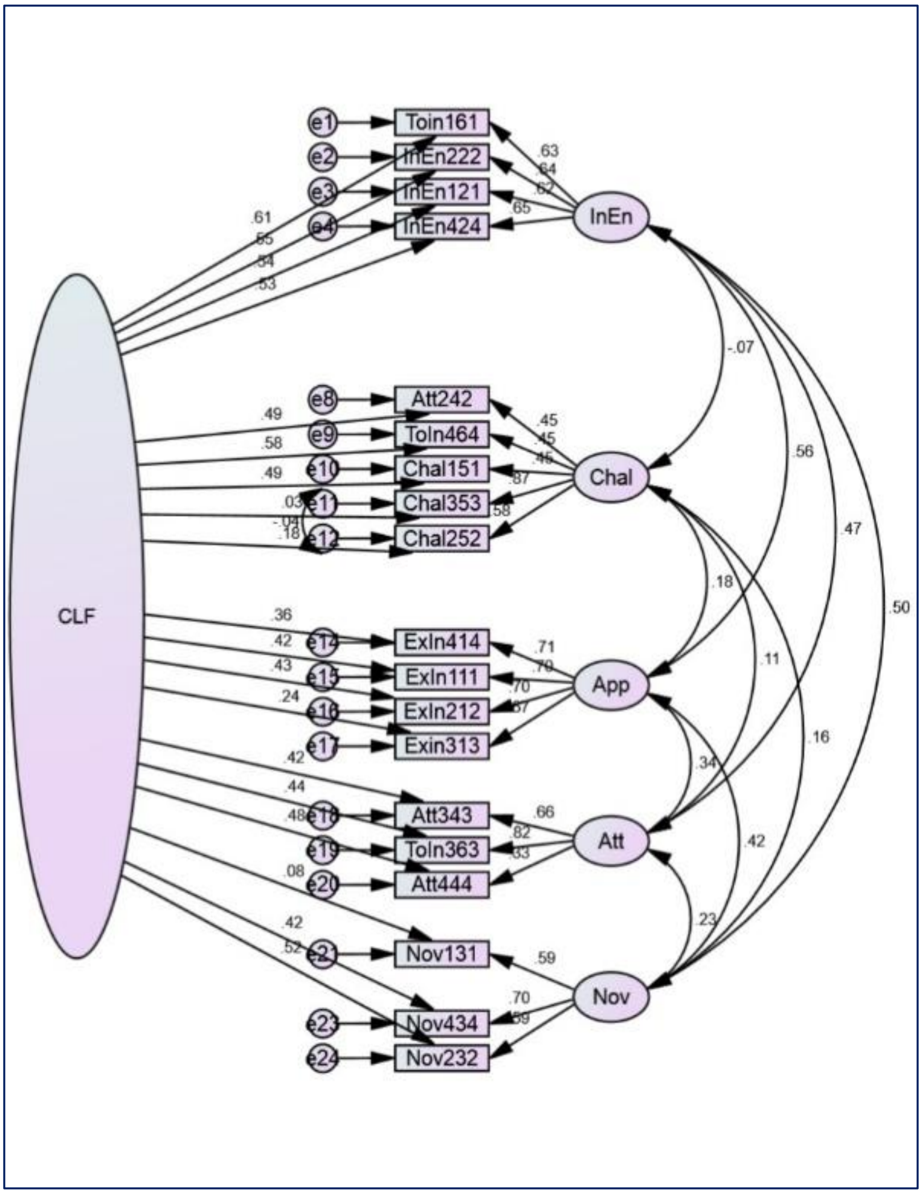


Figure 33 – Final CLF Model

Table 21 – Final Model Fit Metrics for the Situational Interest CLF Model

Recommended Threshold	CLF Pathway Model
Chi-square/df (cmin/df) <3-5	5.000
p-value for the model <.05	.0001
CFI >.92-.95	.944
SRMR <.06-.08	.048
RMSEA <.06-.08	.068

Note: Strict Thresholds (Hu & Bentler, 1999);

Acceptable Thresholds (Hair *et al.*, 2013; Lomax & Schumacker, 2004)

Final Model Fit for Common Latent Factor Model

As an acceptable model fit, the CLF model was used to create factor values for future analysis by partialised imputation of the latent variables, allowing for 'Common Method Bias' to be applied. This is a partialisation of the factor items reflected values in accordance with their CLF: All items are considered to co-vary with the CLF and their latent factor, that is, they are influenced by more than one pathway. Such partialised 'standardised' regression βetas (β) will be a more accurate representative of the true proportion of variance toward a latent factor.

Using these adjusted values, Structural Equation Modelling could now provide a suitable model of Interest perception. Such a multi-relationship model requires multi-variate assumptions for such Interest factors to be made. The next CFA test, therefore, were factor 'Influence' and 'Collinearity' assumptions. No undue influence was found evident and Collinearity was found across the CFA model (see, APPENDIX VIII: Tests for Multivariate Influence and Multi-Collinearity, p324).

The Confirmatory Factor Model for Situational Interest (with corrected and imputed factor variables for a Common Latent Factor) was now applied to Structural Equation Modelling (see, Figure 33, pg178).

6.8 Structural Equation Modelling: Study Three – Situational Interest

The purpose of Pathway model building is to provide a functional model for the Interest measure, one with acceptable global and local significance for the probable relationship between the perception constructs. This allows for the interdependence between such relationships to be analysed as to the functional effects at play (later formulated into a SEM Interdependence Profile).

6.8.1 Global and Local Statistical Tests of Model Fit

The initial 'Study One Twin Pathway' model (Figure 34, below) had used predominately 'local' pathway significance to guide model building.

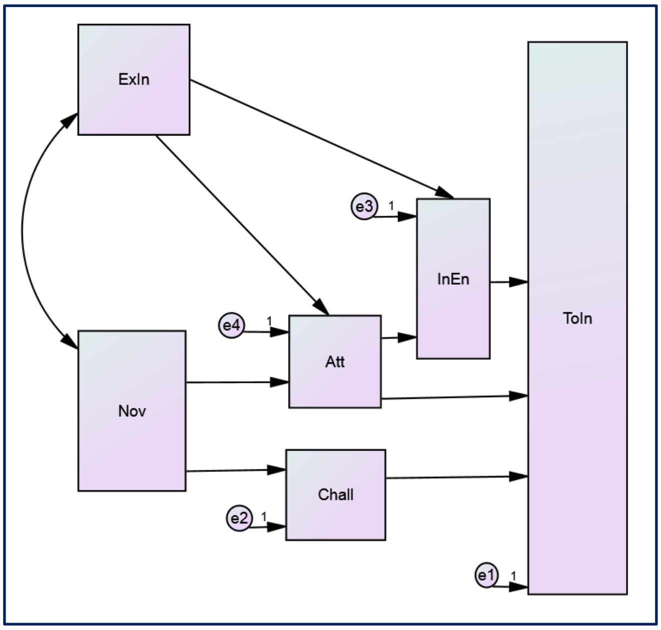


Figure 34 – Study One Twin Pathway Model

This does not ensure model fit, in the hierarchy of model fit indices, 'Global tests' of model fit should be considered first before local tests such as regression and significance.

6.8.2 Developing a Pathway Model

The factor analysis for Situational Interest conducted in Study Three suggested a five factor model, not the six factors in the initial measurement tool. Here, the dependent factor Total Interest (ToIn) was observed to be assimilated into the other Situational Interest constructs of *Challenge*, *Instant Enjoyment* and *Attentional Demand* (see, EFA model)[85], requiring such a fundamental change in

[85] The original variable of Total Interest from a cognitive-emotional perspective might be considered to measure common latent effects of an Interest measure, possibly explaining the shared variance in the CFA constructs seen in the significant 'Common Method Factor', but not self-defining enough in itself to warrant a divergent construct.

latent-factor item loading to be accommodated. In this Study Three, the pathway model is reappraised in accordance with the five factors from the Factor Analysis, with the aim of building a robust model of constructs with which to interpret and later apply an 'SEM Interdependence Profile' from Situational Interest perceptions – as an functional Affordance of affective cognitions.

6.8.3 Interest Perceptions as Cognitive-Emotional Awareness

All measures of self-report are considered here as perceptions from an affective, ecological management perspective. A selectionist self-regulation for biological-value and life-effectiveness. When modelling 'perceptions of Interest', this is exploring the end-point of multiple cognitive processes as they become or are made, attention-aware. It is important then, not conflate self-report measures as 'the' cognitive-processes, but see self-report as a phenomenological 'feeling', a subjective emotional-cognition state of perception, from which neural function may be extrapolated as a Tolerance state of functional Affordance within a relative Effectivity. Perceptions of Situational Interest are therefore revisited as constructs of an affective awareness and used to inform further iterations in the modelling.

Exploratory Approach (Interest)

Exploratory Interest is seen to be aligned with the affective behaviour of 'Seeking-like behaviour', of a motivational drive (Panksepp, 1998, 2003). This intentionality to engage with the world might be thought to align well with the Divergent Criticality hypothesis of Tolerance Optimisation: an affective behaviour mediated or regulated by attentional constructs (of Interest). *Exploratory interest* has been seen to be robust across a number of studies as such a cognitive construct (Chen *et al.*, 2001a; Hidi, 2006; Hidi & Renninger, 2006; Krapp, 2002). Within a Divergent Criticality hypothesis, the integration of affective behaviour that may suggest *Exploratory Interest* as a motivational drive, one mediated by hedonic 'feeling', suggesting a model development that re-assigns Exploratory Interest as a dependent variable of affective behaviour. This is a 'drive' or 'motivation' to Approach, mediated by other independent 'Interest' factors. In recognition of such a mediated behaviour, Exploratory Interest is changed to '*Exploratory Approach'* (App) and is considered as a DV rather than the IV as in previous models[86].

[86] Though this re-appraisal of Exploratory Interest to a dependent construct (on all other perceptions) might seem to question the 'Innate behaviour' of Panksepp (1998) 'Seeking' it does in fact, support such behaviour in the life-regulation of such a fundamental drive as a hedonic appraisal of an Innate drive. The primacy of wanting but mediated by liking (Berridge & Kringelbach, 2008).

Novelty

Novelty as surprise-generating (a hypothesis of Divergent Criticality in dynamic engagement), remains an Independent variable and maintains its position as fundamental in a model of Interest, with pathways to all other interest variables.

Instant Enjoyment

Instant Enjoyment is seen as a hedonic agonistic-barometer of affect based in ecological-value in dynamic function. As a feeling of the state of Tolerance Optimisation, *Instant Enjoyment* retains its dependence on the other constructs of Interest as has been seen across previous studies (Chen & Darst, 2002; Chen *et al.*, 2001a) , but rather than *Instant Enjoyment* being mediated by *Exploratory Approach* as in Study Two. *Instant Enjoyment* is now seen to be a mediating 'dependent', *Exploratory Approach*.

Attentional Demand

Attentional Demand as a perception cognition, might be considered to be an attentional-awareness of neural Effectivity or effort towards surprise or '*Novelty*'. Considered a top-down appraisal of neural function in response to a state of surprise (cognitive effort), it represents a composite of both bottom-up and top-down attentional processes as a cognitive appraisal as to the state(s) functional Affordance in a relative Effectivity. Therefore, though the individual's Effectivity towards surprise is considered to influence *Instant Enjoyment*, rather than dependent solely on a bottom-up processes, *Attentional Demand* as provides top-down appraisal of this surprise (and further cognitive load as all top-down processes exert a price – a reduced Effectivity). *Instant Enjoyment* is therefore better modelled as a co-variant of *Novelty* in an Interest awareness or perception.

Challenge

Challenge is hypothesised as an antagonistic 'avoid' construct, to the hedonic drive of *Instant Enjoyment* via *Challenge* as an awareness of neural 'inefficiency' to the surprise as cognitive function approaches Effectivity (and relative criticality[87]). *Challenge* is seen as mediating *Instant Enjoyment* in in affective pathways from *Novelty* and *Attentional Demand*.

---

[87] At some emergent level, there will be intensive criticality accounting for Challenge as antagonistic throughout a phase of Effectivity function , an extensive affective cognition.

6.9 Model Building and SEM Hypothesis Testing

Novelty and *Attentional Demand* as independent variables of bottom-up and top-down cognitive processes (not dependent on other model variables) are considered as control or extraneous variables and co-varied. In accordance with AMOS24$_{IBM23}$ modelling protocol, these IVs are allocated effect-pathways to all other factors.

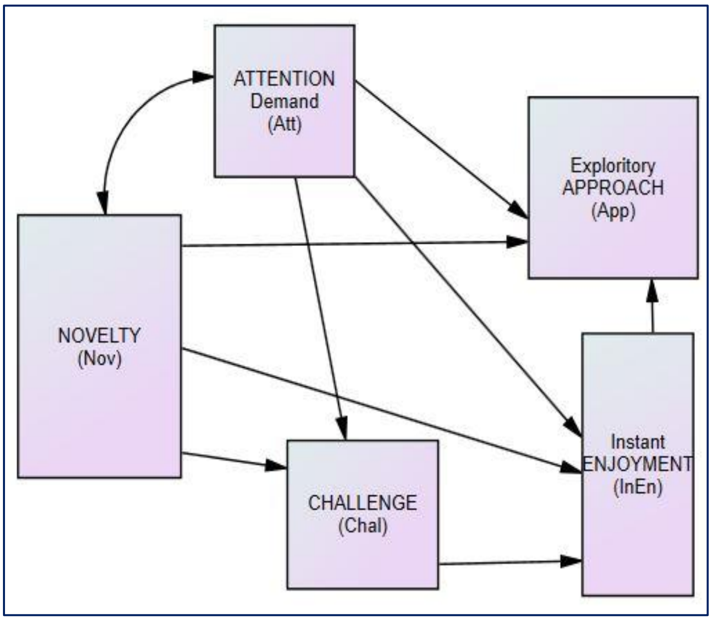


Figure 35 – Study Three SEM Initial Model One (AMOS$_{IBM24}$)

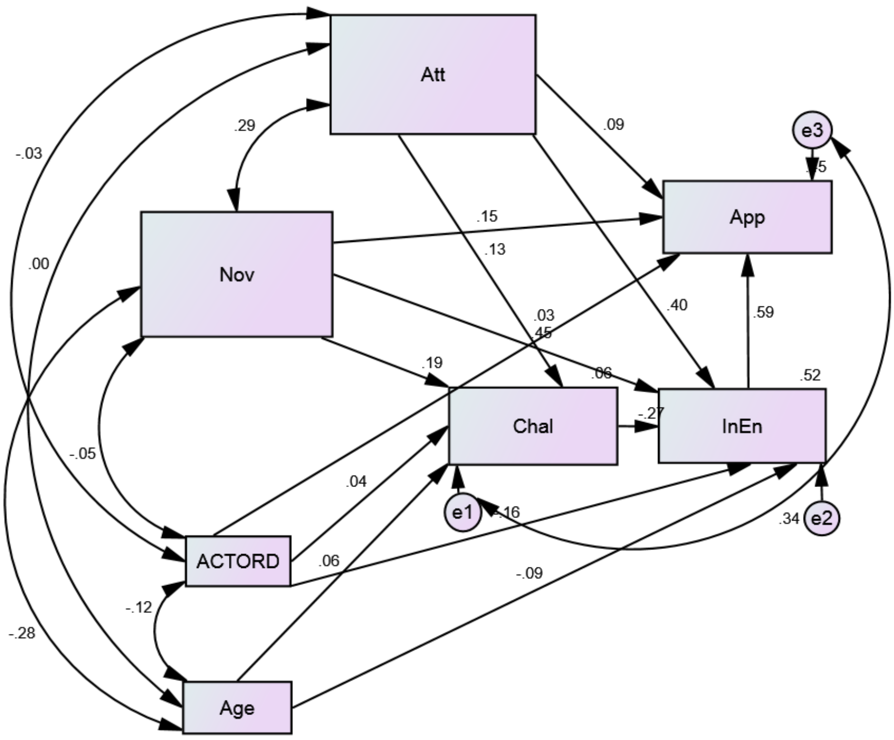
The model was built including the extraneous variables of Activity (ActOrd) and Age (Age) as suggested from Study One. Though control variables can be applied to all latent variables, it is considered acceptable with sufficient *a priori* justification to identify primary targets:

ACTIVITY – Here, it was thought that activity-type (duration and situation) as surprise generating, would be affective on all the dependent factors: *Approach*, *Challenge* and *Instant Enjoyment*.

AGE – Age, was thought to influence awareness of surprise through biased[88] perceptions of *Challenge* and *Instant Enjoyment* dependent on experience. This was based on the proposition that there will be age 'effects' in social and ecological robustness (e.g. the naivety of youth) and produce disproportionally affected perceptions of surprise (*Novelty*). Therefore, age biases are affective on perceptions of *Challenge* and *Instant Enjoyment* in Tolerance Optimisation.

[88] Gender as grouping variable provided Measurement Invariance. However age, though providing some invariance, did not fulfil scalar invariance and so is included in the model as a possible independent variable.

The adjusted pathway model of Situational Interest as an attentional-awareness of affective constructs is now presented for SEM testing. The Causal Model 1 (Figure 36, below), is presented to test a Divergent Criticality hypothesis.



Chi-square/df (cmin/df) <3-5	8.231 – df=1
p-value for the model <.05	.0004
CFI >.92-.95	.995
SRMR <.06-.08	.013
RMSEA <.06-.08	.091

Note: Strict Thresholds (Hu & Bentler, 1999);

Figure 36 – Study Three SEM Final Model 1 Fit Indices $AMOS_{IBM24}$

Though achieving some model fit in the (above) model, it presented a limited number of 'Degrees of Freedom' for variance analysis (only 1), and was therefore considered saturated. To simplify the model and release Degrees of Freedom, a Final Model 2 was produced (over). A number of hypothesised pathway-effects are now considered in order to test the SEM's application towards modelling Divergent Criticality:

Mediation Effects Model Hypothesis (Effect) Testing

SEM H1 – That Challenge would mediate a *Novelty* effect on *Instant Enjoyment*

SEM H2 – That Challenge would mediate an *Attentional Demand* on *Instant Enjoyment*

SEM H3 – That *Instant Enjoyment* would mediate *Novelty* effect on *Exploratory* Approach

SEM H4 – That *Instant Enjoyment* would mediate *Attentional Demand* effect on *Exploratory* Approach

SEM H5 – That Challenge and *Instant Enjoyment* would mediate *Attentional Demand* on *Instant Enjoyment*

Moderation Effects

That Activity and Age would moderate Interest perceptions and so are included in the SEM model.

6.10 Structural Equational Modelling: Findings

Fit Indices are now applied to the below (Final Model 2).

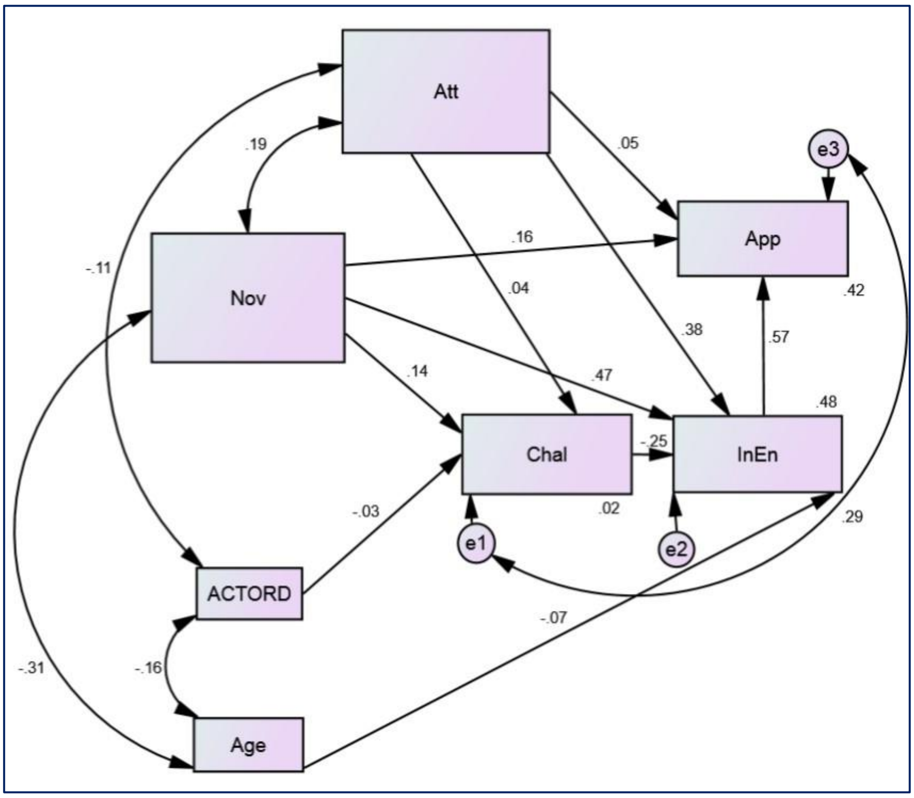


Figure 37 – Final Model 2 (Standardised Regression) AMOS$_{IBM24}$

Table 22 – Causal Model 2: Goodness of Fit

Recommended Threshold	Twin Pathway Model
Chi-square/df (cmin/df) <3-5	*3.711*
p-value for the model <.05	*p<.0001*
CFI >.95	*.964*
SRMR <.08	*.052*
RMSEA <.06	*.025*

Note: Taken from Hu and Bentler's "Cutoff Criteria and Fit Indexes" (1999, p.27)

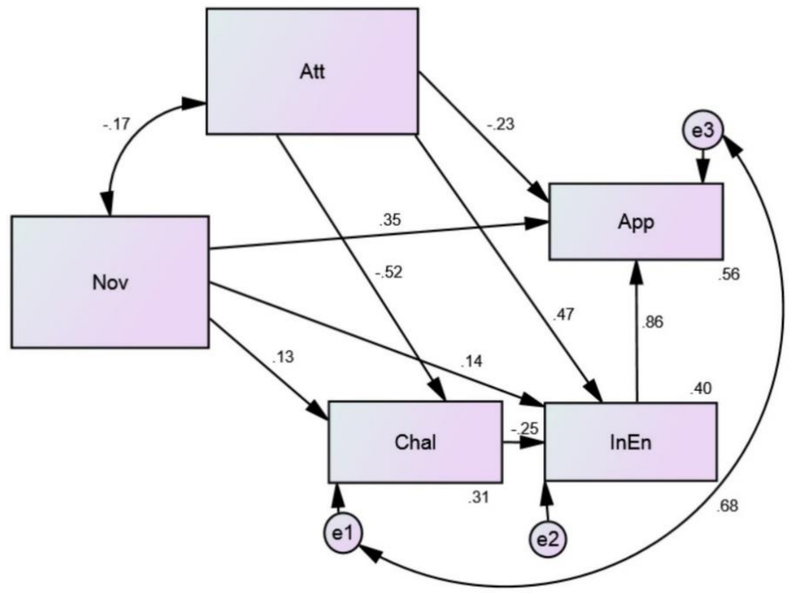
With good model fit found, a hierarchy further 'model-fit' tests may now be considered.

6.10.1 SEM Final Model 2: R-Squared Model Fit

In Figure 37 (above) R-values: *Challenge* $\mathbf{r^2 =.02}$; *Instant Enjoyment* $\mathbf{r^2=.48}$; *Approach* $\mathbf{r^2=.42}$

R-square values for *Instant Enjoyment* (InEn) and Approach (App) were considered permissible, as greater than r>.2 (r^2>.04) in social research (Cohen, 1988). However, the low r^2 for Challenge (Chall – r^2 =.02) r^2 is seen as a consequence of a ‘local’ testing ethical-sampling issue rather than a global model issue. This is limited Challenge (or indeed the reporting of limited Challenge perceptions in relation to feelings of anxiety, a criticality function of non-linear increasing sensitivity).

When only ‘the’ domains thought to be more dynamic and Challenging are tested (ACTORD=1, see Figure 38, below), good r^2values are seen supporting the models integrity:
(Chal $\mathbf{r^2 =.31}$; InEn $\mathbf{r^2=.68}$; App $\mathbf{r^2=.56}$).



Standard Betas		
Predictor	**Outcome**	**Std Beta**
Att	Chal	-.524 ***
Nov	Chal	.126 *
Chal	InEn	-.251 ***
Nov	InEn	.135 **
Att	InEn	.472 ***
Att	App	-.226 ***
Nov	App	.354 ***
InEn	App	.863 ***
Significance of Correlations:		
*** p < 0.001		
** p < 0.010		
* p < 0.050		

Figure 38 – ACTORD-1 R-square Tests (ACTORD and AGE invariant) $AMOS_{IBM24}$

6.10.2 SEM Final Model 2: Pathway Significance Model Fit

The following regression weightings were found significant (below), completing the final model fit statistics for the Final SEM model 2:

Table 23 – Regression Weights

Predictor	Outcome	Std Beta
ACTORD	Chal	.021
Att	Chal	.137 ***
Nov	Chal	.167 ***
Chal	InEn	-.281 ***
Nov	InEn	.471 ***
Att	InEn	.398 ***
Age	InEn	-.063 *
Att	App	.096 ***
Nov	App	.149 ***
InEn	App	.584 ***

Note: Significance of Correlations
*** $p < 0.001$, ** $p < 0.010$, * $p < 0.050$

6.11 SEM Hypothesis Testing

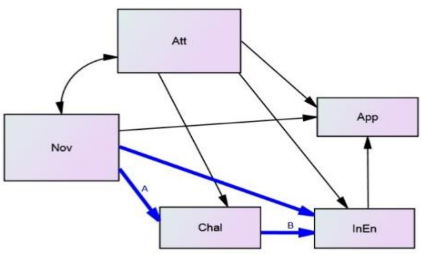
With Final Model 2 now providing permissible Model Fit, the SEM was considered good enough to explore the SEM hypothesis The hypothesised effects in the pathway model were tested by comparing indirect and direct pathway regressions between the factors in the model. The effect of indirect or 'mediating' factors was analysed by estimating the product of the indirect pathways in relation to the direct pathway.

This was tested using a user defined 'estimand' algorithm (Gaskin, 2017b) allowing both mediation-weighting and significance to be given. Significance was estimated using a Bootstrapping "bias-corrected percentile method" ($AMOS_{IBM24}$).

NOTE: Age and ACTIVITY extraneous variables have been omitted from the diagrams below for clarity, though are include in the model estimate-analysis.

SEM H1 – That *Challenge* would mediate a *Novelty* effect on *Instant Enjoyment*

Table 24 – Significant Mediation by Challenge of Novelty on Instant

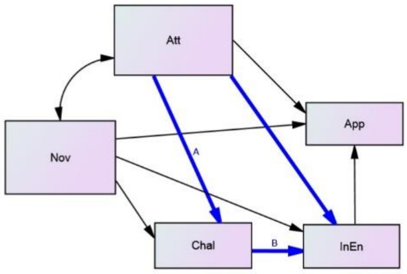


User-defined estimands: AMOS24[IBM]

Parameter	Estimate	Lower	Upper	P
A x B	-.038	-.055	-.025	.001

SEM H2 – That Challenge would mediate Attentional Demand on Instant Enjoyment

Table 25 – Significant Mediation by Challenge of Attentional Demand on Instant

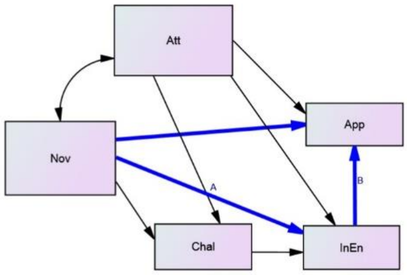


User-defined estimands: AMOS23[IBM]

Parameter	Estimate	Lower	Upper	P
A x B	-.035	-.054	-.020	.001

SEM H3 – That Instant Enjoyment would mediate Novelty on Exploratory Approach

Table 26 – Significant Mediation by Instant Enjoyment of Novelty on Approach

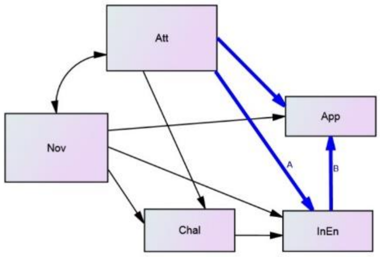


User-defined estimands: AMOS23[IBM]

Parameter	Estimate	Lower	Upper	P
A x B	.290	.248	.338	.001

SEM H4 – That Instant Enjoyment would mediate Attentional Demand on Exploratory Approach

Table 27 – Significant Mediation by Instant Enjoyment of Attention on Approach

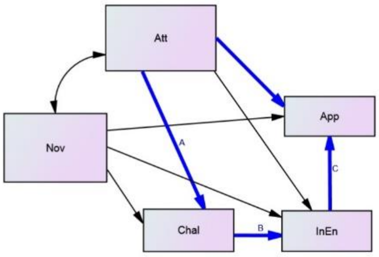


User-defined estimands: AMOS23[IBM]

Parameter	Estimate	Lower	Upper	P
A x B	.276	.232	.321	.001

SEM H5 - That Challenge & Instant Enjoyment would mediate Attentional Demand on Exploratory Approach

Table 28 – Significant Mediation by Challenge and Instant Enjoyment of Attention on



User-defined estimands: AMOS23[IBM]

Parameter	Estimate	Lower	Upper	P
A x B x C	-.027	-.041	-.015	.001

6.12 Triangulating the Structural Equation Model with a Conditional Independence Model

The adaptation of Interest as a cognitive-emotional attention, though finding some contemporary support in Zhu *et al.* (2009) and Hidi (2006), is epistemologically different to that of the original Situational-Interest modelling (Chen & Darst, 2002; Chen *et al.*, 2001a). It was therefore considered that some triangulation to this predominately, 'quasi-parametric' SEM design, might help validate the SEM Final Model 2. A quantitative approach not involving the qualitative inference of *a priori* modelling was conducted, that of Conditional Interdependence.

In order to evaluate the validity of the SEM analysis, a method of bivariate correlation are considered as a means of investigating the causal model suggested in SEM. If using such an univariate approach, standardised correlations can be considered as bivariate-coefficients not subject to the regression (to the mean) issues of MLR (Lane, Scott, Hebl, Guerra, Osherson & Zimmer, 2014).

Conditional Independence (Birnbaum, 1962; Dawid, 1979; Fisher, 1939) offers such a test and was conducted on the Situational Interest data to provide a quantitative model of variable influence. By providing a probability measure of information shared between pairwise variables (information conditional on population interdependence), bi-variable relationships are tested with significance emerging when unaffected by other influences. Conditional Independence (CI) provides a quantitative analysis and offers an alternative methodology to interrogate possible qualitative issues with Structural Equation Modelling (e.g. researcher assumptions).

The Conditional Independence (CI) approach to model building suggests an efficient and accurate approach than structural modelling in the face of large data sets and multi-step methodologies (Bacciu, Etchells, Lisboa & Whittaker, 2013).

Conditional Independence, therefore, was conducted in this study to provide some triangulation to the Structural Equation Modelling and question its efficacy in relation to SEM (see, APPENDIX X: Conditional Independence, p339).

From the CI, a graphical representation of an entropy measure (Ĩ) as a measure of mutual information between variables, provides 'structural' relationships between variables, and allows the pairwise relationships to build a multivariable model (Figure 39, below).

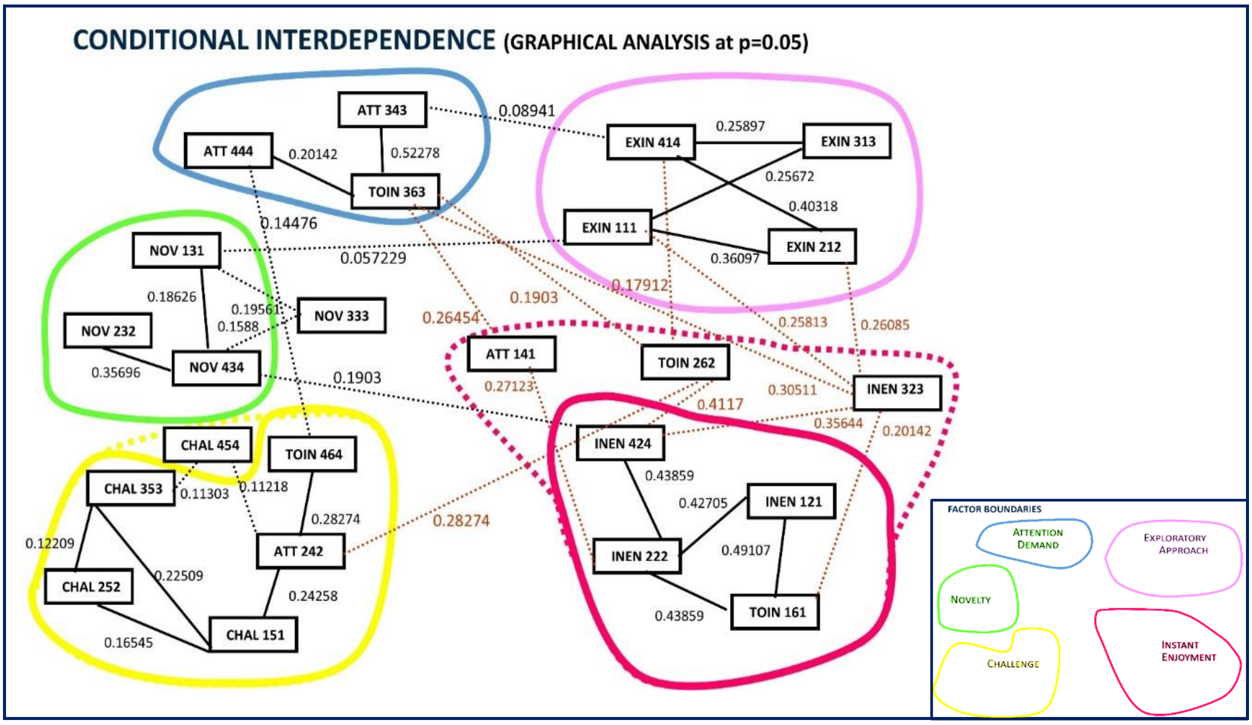


Figure 39 – Conditional Interdependence – Structural Pathway Model

6.12.1 Interpreting the Multivariate Relationships

The above (Figure 39) has been extrapolated from the raw graphical analysis (see, APPENDIX X) to clearly display significant convergent relationships. The weightings are in megabits (mbits) of mutual 'shared' information. Of interest here are the significant *intra*-relationships within what might be considered, 'latent factor groupings'. These generally display stronger grouped relationships than the shared *inter*-factor relationships (brown pathways). Its findings indicate mediating relationships between these item-grouping (factor) centres of shared variance. Again, we see support for a five-factor model as with the EFA.

Variables not obviously incorporated within a factor boundary: InEn323; Att141; Nov333; ToIn262 & Chal454 can be seen to be cross-loaded with another latent variable(s) through 'multiple' relationships. This again would support the confounding seen in Factor Analysis, where it is these very items that are seen to be removed through EFA and CFA.

Though the Conditional Independence approach would seem to offer a quick and efficient approach to model building when compared with CFA and SEM, the interpretation of the relationships benefited from some *SEM* guidance to help identify and understand the raw data output provided. This is discussed in (see, 7.4.4 – Is there a preferred method of Factor Analysis (SEM or Conditional Independence)?, p212)

6.13 From SEM to an Interdependence Profile of Functional Affordance

One of the principle objectives of Study Three's Methodology of Structure Equation Modelling (SEM) was to be able to differentiate functional Affordance states in relation to ecological determinates (sample domains), and explore if the reporting of affective-cognitions in measures of Situational Interest and Self-Concept perceptions, support the Divergent Criticality hypothesis. SEM informs an Interdependence Profile of 'direct and indirect' effects from the SEM, to infer not only a state of functional Affordance, but the 'relative' Effectivity of the neural system, and able therefore, to empirically able to define functional Affordance in a Divergent Criticality hypothesis, that of Tolerance Optimisation in a relative phase of Effectivity.

It was hypothesised, that group and domain sample-analysis using the 'Interest' SEM Final Model 2, might be able to identify possible SEM pathway-profiles, that could infer the relative 'functioning of a criticality' and the Affordance state of tolerance. The SEM-analysis was investigated to see if direct and indirect effects might indeed provide a way of identifying 'affective' situational (bottom-up) and contextual (top-down) attentional processes in ecological engagement. Situational Interest, as a subjective 'experiencing a perception', is able to infer a functional 'state' in relation to ecological determinants, a state of objective – functional Affordance.

Such a model or profile of construct interdependence in Situational Interest, might then be hypothesised as a 'perception' able to infer attentional processes made consciously aware. Through an inductive approach to SEM, an Interdependence Profile is able to infer a measure of functional Affordance states for experimental testing (see, APPENDIX XI: SEM Interdependence Profile – Congruence Assumptions, p344).

6.14 An SEM Interdependent Profile as States of Functional Affordance

In extracting only three SEM-pathways, 64 different possible regression combinations present themselves. Using the Divergent Criticality assumptions and Interdependence Profiles (IP) these may be reduced to seven congruent states on an IP-scale 1 to 7.

Table 29 – Rank Order of IP-Scale for functional Affordance

IP-Scale	Slope Profile	1) Nov→App	2) Att →App	3) Chal→ InEn	Relative Effectivity	Congruence	Interdependence *(Dominance First)*
1)	+ - -	↑↑	↓↑	↑↓	BEYOND Effectivity	Okay	Bottom-Up Dominance
2)	+ + -	↑↑	↑↑	↑↓	BEYOND Effectivity	Okay	Shared Dominance
3)	- + -	↓↑	↑↑	↑↓	BEYOND Effectivity	Okay	Top-Down Dominance
4)	- + +	↓↑	↑↑	↑↑	WITHIN Effectivity	Okay	Top-Down Dominance
5)	+ + +	↑↑	↑↑	↑↑	WITHIN Effectivity	Okay	Shared Dominance
6)	+ - +	↑↑	↓↑	↑↑	WITHIN Effectivity	Okay	Bottom-Up Dominance
7)	- - -	↑↓	↑↓	↑↓	BEYOND Effectivity	NO	Amotivation

Figure 40 (over), presents an overview of the functional Affordance states and their differentiation through the coordinated definition of tolerance in relation to relative Effectivity: These profiles have been induced in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation. This represents a self-regulation around a relative-cusp of criticality function and may be used to differentiate subjective reporting of attentional awareness. This provides an 'order' for the reporting of functional Affordance states in accordance with their Interdependence Profile as a Tolerance Optimisation. Accordingly, an Interdependent Profile (IP) scale, from IP1 – IP7, infers functional Affordance states: with (1) the most optimal function and (7) the least[89]. When set within relative Effectivity this IP-scale of functional Affordance reflects an objective or coordinating definition or measure from Situational Interest reporting.

[89] **NOTE:** The IP 7 profile represents a cusp collapse, an 'amotivation' or avoid cognition rather than congruence with Agential Approach. It therefore presents an anomaly in the Divergent Criticality assumptions (those of Agential 'approach' behaviour), and therefore these domains will not be used in further hypothesis testing.

6.15 Interdependence Profile Scale: States of functional Affordance

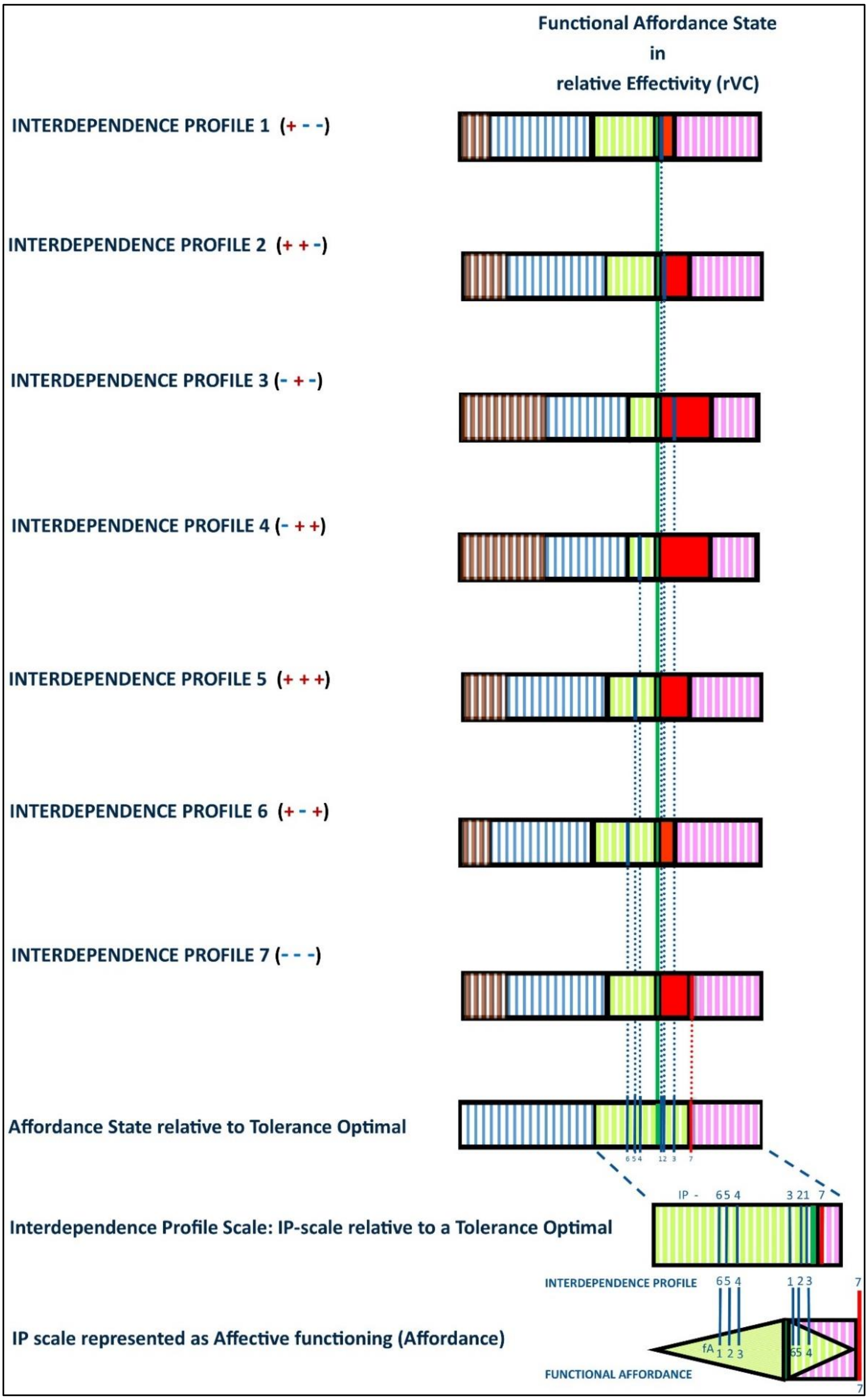


Figure 40 – functional Affordance inferred through an Interdependence Profile (IP-Scale)

6.16 Validating the Interdependence Profile

The Situational Interest constructs of Exploratory Approach and Instant Enjoyment, should correlate significantly with the Interdependence Profile in accordance with the Divergent Criticality hypothesis and concurring with Tolerance Optimisation.

To this end a Spearman Rank Correlation was run between the Interdependence Profile (inferred functional Affordance state as an ordinal scale) and Situational Interest measures of Exploratory Approach and Instant Enjoyment, the SEM derived dependent variables thought to reflect a Divergent Criticality effect (n=768)[90].

Table 30 – Correlations

		IPtrue	App	InEn
IPtrue	Spearman's rho	1	**.317****	**.322****
	Sig. (2-tailed)		0.000	0.000
	N	767	767	767

Note: ** Correlation is significant at the 0.01 level (2-tailed).

Here, Instant Enjoyment (r= .322, p.>0.001) and Approach (r= .317, p.>0.001) both support the Interdependence Profile as reflecting a Divergent Criticality of Tolerance Optimisation. In that both report positive, on first inspection, might suggest to express a reverse relationship with the IP - scaling than expected (in that the scaling of IP-states; IP=1 though a low scale represents a 'high' state of Divergent Criticality close to a Tolerance Optimal, therefore, a 'negative/inverse' reporting should be expected between the IP-scale of functional Affordance and the positive reporting in the two Situational Interest constructs).

6.17 An Agential-Mediation of Tolerance Optimisation

It should be remembered that the Interdependence Profile value is not a continuous value but an ordinal approximation of the non-linear functioning of criticality. This, when mapped as an efficiency function in a Kullback-Leibler divergence (D_{KL}), as a second-derivative of function, sees a non-linear 'spike' of function towards maximal criticality or relative Effectivity (a functional Affordance bias the 'closer' to Tolerance Optimisation an IP state is). Therefore these results should reflect Non-linear functioning in Divergent Criticality as not continuous, but non-linear around a Tolerance

[90] The samples used were those that didn't report an Interdependence Profile IP-7 (n=81) as these, when extrapolated from the Interdependence Profile, displayed an cognitive 'confounding' as criticality-collapse.

optimisation of criticality (relative Effectivity). In addition, when 'beyond' a relative Effectivity, the affective hedonic reporting is reversed in terms with its relationship with the IP-scale, therefore will reflect the Divergent Criticality hypothesis through inverted 'positive' reporting around beyond Tolerance Optimisation:

a) IP6, IP5 & IP4 – as a <u>decreasing</u> scale 'within-Effectivity', should report <u>increasingly</u> positive affective-cognitions and therefore a 'negative' correlation would be expected.
b) IP3, IP2 & IP1 – as a <u>decreasing</u> scale 'beyond-Effectivity', should report <u>decreasing</u> affective-cognitions and therefore a 'positive' correlation would be expected (see, Figure 40, p193).

With 69.8% of the sampling operating 'beyond' relative Effectivity (IP1,IP2 & IP3), a 'positive' reporting in both Enjoyment and Approach can be hypothesised to infer: that Divergent Criticality is in affect and inferred through the Interdependence Profile, reflecting a biasing of function 'beyond' relative Effectivity.

That the SEM reporting of functional Affordance (IP-scale) reflects the Divergent Criticality hypothesis so accurately in its nuanced-functioning, lends support not only for the hypothesis, but also to an Interdependence Profile 'scale', as a non-linear function, requires test-design considerations as to its future application within non-parametric research designs[91].

The power of the SEM and IP-scaling was always in its modelling of perception measures as informing a state of function. Using the SEM derived IP-scale allows differentiation of a state of functional Affordance to be allocated to the sample-domains as ecological determinants. It is in the triangulation of this IP-scale with a separate measure of affective-perceptions Self-Concept (ROPELOC), that the Divergent Criticality hypothesis may be tested.

As the ROPELOC questionnaire had undergone significant alterations from its validated and published version (Richards *et al.*, 2002), Factor Analysis was again conducted(see, APPENDIX IX: Study Three ROPELOC EFA and CFA, p326).

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[91] This requires the consideration of the IP-scale as a non-parametric, non-linear (assumptions of similar non-normality may not apply – see, 6.21.2, p202). To account for the relative Effectivity cusp-inflection reversal in hedonic cognitions, the IP-scale need to be aligned with a tolerance optimisation hedonic scale, where IP6 is the least optimal (Figure 40, p216): IP6=**1**, IP5=**2**, IP4=**3**, IP3=**6**, IP2=**5**, IP1=**4**.

6.18 ROPELOC Factor Analysis

ROPELOC – QUESTIONNAIRE ANALYSIS STEPS

Sorting and Cleaning Data Set
Transpose Questionnaire Data onto Microsoft Excel 2010 and SSPS$_{IBM24}$
Sorting of data to provide a multi-item measure for its factor analysis
All data made nominal, ordinal or interval
Missing Variables investigated:
None completion
Unengaged reporting
Outliers
Missing Variables imputed Multiple Imputation (MI)
Tests for Normality:
Skewness/Kurtosis

Exploratory Factor Analysis (EFA)
Principle Components Analysis of measure values:
Bartlett's Test of Sphericity
Kaiser-Mayer-Olkin (KMO) Index
Factor Extraction (Maximum Likelihood Analysis)
Rotation of Factor Matrix:
Oblique or Orthogonal Factor Relationships
Reliability of Factor Loading
Cronbach's Reliability
Rotational Pattern Matrix to take forward to CFA

Confirmatory Factor Analysis (CFA)
The EFA Pattern Matrix was used to suggest a possible factor loading model for –
Initial Confirmatory Model Analysis
Convergence and Discriminatory validity:
Model-Fit Thresholds
Measurement Invariance (Non-Independence Threats from Data Groupings):
Configurable Invariance
Metric Invariance Metric Invariance
Scalar Invariance
Validity and Reliability Tests:
Construct Reliability
Convergent Validity
Discriminant Validity
Metric Validity Assumed CFA Model
Common Methods Bias:
Test of a Common Latent Factor
Validity Check of Model Including Common Latent Factor
Final Model Fit for Common Latent Factor Adjusted Model:
Tests for Multivariate Influence and Multi-Collinearity Test
Multivariate Influence using Cooks Distances
The Confirmatory Factor Model, partialed and imputed factor variables were now applied to Structural Equation Modelling (SEM)

Triangulation of Interest (Functional Affordance) and ROPELOC Analysis
The ROPELOC factor constructs were now used to test the Divergent-Criticality hypothesis in trinagulation with a functional Affordance 'state' (determined by the Interest SEM Interdependence Profiling).

Figure 41 – Situational ROPELOC Factor Analysis

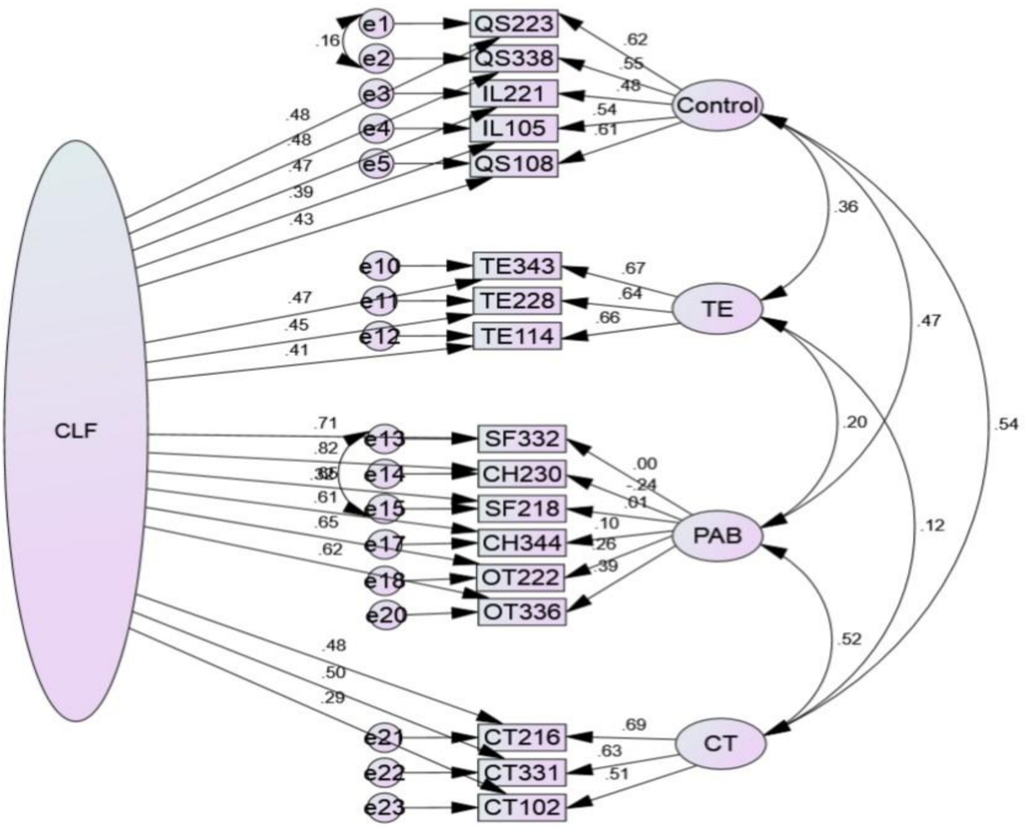
With consideration to the use of a modified version of the ROPELOC measure (Neill, 2009) and the adaption of its constructs, changes were made to the questionnaire to reflect feedback and descriptive findings from the second phase of the study, therefore a Factor Analysis was necessary to:

i) Confirm if the adapted questionnaire variables would display Convergent and Discriminatory validity on the ROPELOC factors.

ii) Confirm if the variables map to latent factors of the adapted ROPELOC and if this can this be considered a valid model.

An analysis of the ROPELOC questionnaire followed a similar EFA and CFA progression to the Situational Interest (see, APPENDIX VI: Study Three – Situational Interest EFA and CFA, p311).

The EFA provided eigenvalues for only 4 factors from Maximum Likelihood Extraction. This differs from the original measure, a final Confirmatory Factor Analysis produced the following model:



Recommended Threshold	CLF Pathway Model
Chi-square/df (cmin/df) <3-5	2.734
p-value for the model <.05	.0001
CFI >.92-.95	.974
SRMR <.06-.08	.030
RMSEA <.06-.08	.078

Note: Strict Thresholds (Hu & Bentler, 1999);

Acceptable Thresholds (Hair *et al.*, 2013; Lomax & Schumacker, 2004)

Figure 42 – CLF Model for Self-Concept Measure ROPELOC (AMOS$_{IBM24}$)

The completion of the Factor analysis on the ROPELOC measure, found validity in Confirmatory Factor Analysis. ROPELOC now provides a triangulation-measure in for hypothesis testing.

Study Three: Findings

6.19 Testing The Divergent Criticality Hypothesis

Perceptions as affective-cognitions are made aware and will reflect the agential mediation of a self-regulating, optimal learning mechanism – A Divergent Criticality Hypothesis

To address the central research question three triangulation hypothesis were tested:

H1: Correlations of measures Self-Concept (ROPELOC) and functional Affordance will report positive in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation.

H2: A measure of Self-Concept will be differentiated between high and low states of functional Affordance in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation.

H3: A Repeat Measures design will find significant difference between 'Learning Outside the Classroom' and 'Traditional Classroom Learning' in accordance with the Divergent Criticality Hypothesis.

6.20 Hypothesis Testing (H1)

H1 – Correlations of measures Self-Concept (ROPELOC) and functional Affordance, will report in accordance with agential-mediation of the Divergent Criticality hypothesis

It should be possible to triangulate the Interest derived functional Affordance perception measure, with alternatively derived measure to test the Divergent Criticality hypothesis, i.e. functional Affordance States will correlate with affective-cognitions of life-effectiveness (ROPELOC[92]). .

The Interdependence Profile value as not a continuous value, but the functioning of non-linear criticality (see, 6.17, p194) and questions the 'assumptions of non-linearity similarity' (see, 6.21.2, p201). As such, the least effect on assumptions may only be assumed for 'beyond' Tolerance Optimisation (see, APPENDIX XIII: Hypothesis (H1) – Initial Correlation Analysis, p361). The following results were obtained through a Spearman's Rank Order One-tailed correlation. The Divergent Criticality hypothesis predicted a positive correlation using $SPSS_{IBM24}$ and was conducted on such 'beyond' relative Effectivity functioning, IP-scales 1-3, n=535 (Table 31, below).

Table 31 – IP Spearman's Correlations BEYOND relative Effectivity

	IPcont	CT	Control	TE	PAB
Correlation	1.000	**.191****	**.129****	**.125****	**.187****
Coefficient	p	0.000	0.001	0.002	0.000
n	535	535	535	535	535

Note:**. Correlation is significant at the 0.01 level (1-tailed[93]).

Here, the Divergent Criticality hypothesis is supported across all life-effectiveness measures:

Cooperative Teamwork – **CT** (rho= .191, p<0.001)

Locus of Control – **Control** (rho = .129, p=0.001)

Time Effectiveness – **TE** (rho = .0125, p=0.002)

Perception of Abilities and Beliefs – **PAB** (rho = .187, p<0.001)

[92] (ROPELOC): Awareness cognition, Self-Concept constructs determined through CFA analysis; Cooperative Teamwork (CT); Time Effectiveness (TE); Locus of Control (Control) and Perception of Abilities and Beliefs (PAB).

[93] One Tailed analysis is used here, as the hypothesis predicts a definite relationship slope, and this is positive.

Of particular interest here, is the positive reporting. If congruent with an affective 'behaviour' hypothesis, the correlations would have predicted self-concept to be negatively correlated with functional Affordance the further away from a Tolerance Optimisation. That correlations reported a positive relationship with beyond (limited) Tolerance Optimisation reflects, the inverse 'affect' of the Tolerance Optimisation inflection in the Interdependence Profile measure (see, 6.16 – p194) Therefore, this contra-indicative finding supports the agential mediation of Tolerance Optimisation as a Cusp-Hopf inflection of criticality (see, p104).

6.21 Hypothesis Testing (H2)

H2 – A measure of Self-Concept will be differentiated between high and low states of functional Affordance in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation

If the Divergent Criticality hypothesis is in effect, there should be a significant difference in affective cognitions between high and low states of relative Effectivity. Here, a state of neural efficiency as a state of functional Affordance parameterised by relative Effectivity, will reflect affective cognitions in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation.

To differentiate high and low neural functioning in relative Effectivity, the Interdependence Profile was parsed into high tolerance function (states 1 & 2[94]) and low tolerance function (states 3,4, 5 & 6).

6.21.1 Difference Test: Mann-Whitney U – Two Group Independent Test of Medians

The Mann and Whitney (1947) U-test was conducted using $SPSS_{IBM24}$. Here, the data is rank-ordered and the test approaches the data-set as similarly distributed around a median value (Tolfrey, 2004). A median approach to the analysis enables a 'Mann-Whitney' to test values when they are sorted (ranked) in ascending order and negates the confounding issues with ordinal data-sets (e.g. the influence of measure or reporting bias in non-parametric sampling). A Mann-Whitney U test (below) was conducted on all the data points and their median data values. A one-tail significance for the Z-

[94] Again, the non-linearity spiking of function close to Tolerance Optimisation biases the IP-scales 1&2 as 'high' functional Affordance states.

variable was able to be given, as the Divergent Criticality hypothesis predicts a direction of difference in relation to increasing Tolerance Optimisation[95].

Table 32 – Mann-Whitney U

			CT	Control	TE	PAB
Mann-Whitney U			58547.000	56258.000	65005.500	58828.500
Wilcoxon W			186818.000	184529.000	99196.500	187099.500
Z			**-2.575**	**-3.362**	-0.353	**-2.478**
Asymp. Sig. (2-tailed)			**0.010**	**0.001**	0.724	**0.013**
Monte Carlo	Sig.		.005b	.001b	.358b	.006b
Sig. (1-tailed)	99%	Lower	0.003	0.000	0.346	0.004
	Confidence	Upper	0.007	0.001	0.370	0.008

a. Grouping Variable: High Low

b. Based on 10000 sampled tables with starting seed 624387341.

Result: This is found significant across all measures apart from Time Effectiveness (TE).

Cooperative Teamwork – **CT (Z= -2.575, p=0.005)**

Locus of Control – **Control (Z= -3.362, p=0.001)**

Time Effectiveness – TE (Z= -0.353, p=0.358)

Perception of Abilities and Beliefs – **PAB (Z= -2.478, p=0.006)**

6.21.2 Assumptions of Similar Non-Normality

The Mann-Whitney U, though often treated as a test where homogeneity need not be assumed (i.e. identified as a non-parametric ranks around a median, able to be accommodated in a homogeneity of centrality of variance), it does therefore, actually assume a form of 'non-normative' homogeneity: 'that the ranked data groups are equally in their non-normality distribution' (this provides the power in the Mann-Whitney tests of variance). Therefore, this assumption of 'similar non-normality' is not true-homogeneity. In recognition of the non-linearity of Divergent Criticality; this was considered not adequate to assume the validity of homogeneity (a TYPE-I issue where significance is confounded by non-homogeneity in the groupings/sample domains reflected in their IP-state). Therefore, a normative analysis for equality was considered necessary using a one way ANOVA between the groups (Levene's test for homogeneity of variance), and requires the consideration as to whether significant homogeneity exists between the IP-scale groupings (despite the non-homogeneity assumption made of the Mann-Whitney U test). If the two groups' data distributions are found 'not'

[95] This is negative as the IP-scale is a reversed scale in relation to the self-construct perception scales.

to be significantly different (accepting the null hypothesis), then homogeneity of 'normative' variance might then be assumed and with it, the significance above in Table 32.

To be able to assume such homogeneity, further analysis of the IP-ranked data was conducted in order to validate the homogeneity assumptions in the Mann Whitney U test. If significant difference between the groups' data distributions is found, homogeneity may NOT be assumed and the Mann-Whitney results (above) are null and void.

Table 33 – Levene's Tests for Equality of Variance ($SPSS_{IBM24}$)

		Levene Statistic	df1	df2	Sig
CT	Based on Median and with adjusted df	9.942	1	764.495	.002
Control	Based on Median and with adjusted df	24.932	1	749.893	.000
TE	Based on Median and with adjusted df	1.260	1	761.732	.262
PAB	Based on Median and with adjusted df	9.547	1	762.710	.002

Note: Levene Statistic for Rank Order of IP-scale – High and Low

In Table 33 above, significance found in the ROPELOC measures Cooperative Teamwork (CT), Locus of Control (Control) and Personal Abilities and Beliefs (PAB) signifies that homogeneity differences exist in Leven's test; the assumptions of homogeneity in the Mann-Whitney U are therefore questioned. Here, the true nature of non-linear function as hypothesised in a Tolerance Optimisation function is evident (James *et al.*, 2013; McCune, 2006), and would display a spiking around the Tolerance Optimisation of relativity Effectivity. This would expect non-linear 'skewed' variance dependent on the IP-scale and should, therefore, not dismiss the result found in the Mann-Whitney U test. However, the significance found cannot be relied on without accommodating for such bias. To this end, it was considered that a repeat measures analysis using a within design would allow the Mann-Whitney assumptions of 'similar' homogeneity to be supported[96].

In addition, such an analysis may be subjected to an alternating of intervention or 'mixed-box' of sampling (alternated sampling-order 'between' different groups undergoing repeat sampling). This allows some quasi-control to the self-reporting measure through a split-plot of: 'within' interaction effect'; and any order-effects 'between' repeat measures.

In a counter-indication to the traditional control design, if there is 'not' an order-effect on the interaction, this assumes that the 'within' effects between the repeat measures are not influenced by unknown determinants (alternated sampling would be expected to eliminate any order-bias from

[96] Such 'within' group analysis addresses the homogeneity and sphericity assumptions above, allowing significance to be considered valid if found.

the proposed intervention, therefore, if bias is reported, this would infer 'other' influences on the effect and question any significance found towards the hypothesis. A null 'between-order' effect infers, then, a form of 'control' on any 'within' effect findings (Jones & Kenward, 2003). A mixed-box design utilises a Two-way factorial mixed ANOVA analysis, offering a more experimentally robust investigation for a 'non-linear' – Divergent Criticality hypothesis.

6.22 Situative verses Contextual Learning: A Repeat-Measures Hypothesis (H3)

H3 - A Repeat Measures design will find significant difference between 'Learning Outside the Classroom' and 'Traditional Classroom Learning' in accordance with the Divergent Criticality Hypothesis

The hypothesis (H3) proposes that a 'high' state of functional Affordance would be seen in Active Learning Outside the Classroom (LoTC) and will elicit a greater effect in measures of affective cognition (ROPELOC self-concept perception measure) than Traditional Classroom Learning (TCL). This analysis used six test sample groups (n=126) that were subject to both interventions, LoTC sampling and TCL sampling in an alternate or 'mixed' order (different sampling order over these two interventions between different groups).

6.22.1 2 Way Mixed ANOVA for Cooperative Teamwork (CoopTW)

Within Effects

A within (repeated measures) difference-test investigates an overall Cooperative Teamwork (CT) effect, if any, considering 'all' samples independent of order (Table 34, below). This effect is regardless of Sampling Order (IV) on the dependent variable of (Cooperative Teamwork).

Table 34 – Measure: Tests of Within-Subjects Contrasts for Cooperative Teamwork

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
CoopTW	Linear	6.333	1	6.333	**9.481**	**0.003**
CoopTW * Order	Linear	0.357	1	0.357	0.535	0.467
Error(CoopTW)	Linear	45.424	68	0.668		

Within-Effect for CT (f=9.481, p=0.003); Result – there is an overall difference-effect.

Between Effects

If the above CT effect has been overtly influenced by the independent variable (IV) order, then a significant influence would want to be seen 'between' the IV effects (order of sampling) on the Dependent Variable (DV), thus rejecting the null-hypothesis that there were no 'order' effects. However, importantly in this quasi-control mixed-box design, the (order-effect) IV is expected 'not' to have a between-effect dependent on its sequencing. None-significance, therefore, in order (between) effects to then able to 'accept' the significance in the DV (within-effects).

Analysis between sampling order (between effects) for Cooperative Teamwork (f=0.357, p=0.552) are non-significant (see, Table 35, below): The null hypothesis (H^0) for a between-effects is therefore accepted and the significance seen in the ROPELOC DV (cooperative teamwork) can be accepted as supporting the Divergent Criticality hypothesis.

Table 35 – Between Effects for Cooperative Teamwork (Coop TW)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	4403.913	1	4403.913	3123.285	0.000
Order	0.504	1	0.504	0.357	0.552
Error	95.882	68	1.410		

The Divergent Criticality hypothesis **is supported** in the DV of Cooperative Teamwork.

The same test procedures were followed for the other Dependent Variables.

6.22.2 Two Way Mixed ANOVA for Locus of Control (Control)

Within-Effects (f=2.715, p=0.104) – Significance not found: The null hypothesis (**H^0**) is accepted.

Between-Effects (f=0.609, p=0.438) – Non-Significant: **H^0** accepted and any confounding order-effect rejected.

The Divergent Criticality hypothesis **is not** supported in the DV of Locus of Control.

6.22.3 Two Way Mixed ANOVA for Time Effectiveness (TE)

Within-Effects (f=8.088, p=0.006) – Significance found: The null hypothesis (**H^0**) is rejected.

Between-Effects (f=0.002, p=0.965) – Non-Significant: **H^0** accepted and any confounding order-effect rejected.

The Divergent Criticality hypothesis **is supported** in the DV of Time Effectiveness.

6.22.4 Two Way Mixed ANOVA for Personal Abilities and Beliefs (PAB)

Within-Effects (f=9.834, p=0.003) – Significance found: The null hypothesis (**H^0**) is rejected.

Between-Effects (f=1.149, p=0.228) – Non-Significant: **H^0** accepted and any confounding order-effect rejected.

The Divergent Criticality hypothesis **is supported** in the DV of Personal Abilities and Beliefs.

6.22.5 Results from the Repeat-Measures Design

All constructs of a self-concept measure (ROPELOC) reported coherent effects with the Divergent Criticality hypothesis; that of an increasing affective perception inferred through self-awareness, in relation to increasing inefficiency states of functional Affordance:

Cooperative Teamwork –	**CT (*f=9.481, p=0.003*)**
Locus of Control –	Control (f=2.715, p=0.104)
Time Effectiveness –	**TE (f=8.088, p=0.006)**
Perception of Abilities and Beliefs –	**PAB (f=9.834, p=0.003)**

6.23 Study Three: Conclusions

This Study Three has opened up a number of new approaches to observing and understanding not only how we perceive and learn, but how the brain functions in regard to a fundamental ecological 'adaptive' or 'learning' mechanism – Divergent Criticality. An Interdependence Profile measure was developed to model perception as the cognitive functioning of a composite of attentional processes and a perception Interest measure as an 'attentional' awareness has been able to infer neural function in an Effectivity state – that of a functional Affordance state.

The measures used in this study were adapted from pre-existing questionnaires, refined to more 'accurately' infer the cognitive processes explored in this study (Attention). Using a more accessible and nuanced questionnaire reporting cognitive-emotional constructs, it has been possible to align perception as a phenomenological tool, as an 'empirical' measure of brain function.

In a series of hypotheses that triangulated a functional Affordance measure (Situational Interest) with a self-concept measure (ROPELOC), a series of relationship and difference tests provided significance in three designs of hypothesis testing. The findings also mirrored the hypothesised nuance expected in affective cognitive behaviour around a Tolerance Optimisation proposition. This not only aligned Divergent Criticality within a Kullback-Leibler divergence in neural 'efficiency', but supported a Cusp-Hopf formulation for criticality in an agential-mediated 'beyond' Tolerance Optimisation behaviour in the maintenance of Tolerance Optimisation. The findings from Study Three are now discussed.

7 CHAPTER SEVEN – Thesis Findings

7.1 Main Findings

The central hypothesis of this study is that of affective cognitions self-regulating around a Tolerance-Optimisation, explaining how perception and learning function towards optimising agential capabilities to engage, tolerate and thrive in relation to life's opportunities and challenges. Tolerance-Optimisation is an optimal functioning proposition for neural-learning within such dynamic environments. Such an ecological function is hypothesised to be mediated by agential goal-orientation (perceptions as Affordances or opportunities for biological-value made consciously 'aware' as affective-cognitions). This enables a 'state of Affordance' to be set in terms of an agential Effectivity and Tolerance, a functional Affordance that is able to reflect an awareness of intentionality and capability as a perception. Functional Affordance is used to explore a Divergent Criticality hypothesis through agential perceptions – that affective cognitions of ecological engagement (an attentional awareness) will reflect the Divergent Criticality hypothesis of Tolerance Optimisation:

Perceptions as affective-cognitions are made aware and will reflect the agential mediation of a self-regulating, optimal learning mechanism – the Divergent Criticality Hypothesis

Using a Situational Interest perception measure, the functioning of the Divergent Criticality hypothesis was modelled through Structural Equation Modelling (SEM) and Conditional Independence modelling. The hypothesis was significantly supported in both the SEM 'effects' and correlations between the dependent constructs (SEM) of Approach and Instant Enjoyment. These correlations reflected the expected behaviour of affective cognitions in accordance with the Tolerance Optimisation hypothesis:

Table 36 – Structural Equation Modelling - Correlations

		IPtrue	App	InEn
IPtrue	Spearman's rho	1	**.317****	**.322****
	Sig. (2-tailed)		0.000	0.000
	N	767	767	767

Note: ** Correlation is significant at the 0.01 level (2-tailed).

The Interdependence Profile scale as inferring a state of functional Affordance and neural function, was able to be triangulated against another affective measure of perception, that of self-concept (ROPELOC).

7.2 Findings: Situational Interest Triangulated with Self-Concept

H1 Correlations in measures Self-Concept (ROPELOC) and functional Affordance, will report positive in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation.

If a Divergent Criticality hypothesis is in effect, then perceptions of self-concept will report positive with states of functional Affordance closer to the cusp criticality of relative Effectivity. The following results were obtained through a Spearman's Rank Order One-tailed correlation using $SPSS_{IBM24}$. The correlation tests (6.21 – Hypothesis Testing (H2), p200) supported Divergent Criticality, subject to a Kullback-Leibler divergence in Tolerance Optimisation (a 'preferred' or behavioural bias, supporting the selectionist proposition of ecological Tolerance) and when applied to all Tolerance Optimisation (the Cusp Hopf functioning functional 'states' – IP-scale 1-3), the two measures were able to be triangulated. Correlations displayed a small but significant relationship for the Divergent Criticality hypothesis of Tolerance Optimisation across all of the ROPELOC self-report components.

ROPELOC Correlations with IP-scale of functional Affordance

Cooperative Teamwork –	**CT (rho= .191, p<0.001)**
Locus of Control –	**Locus (rho = .129, p=0.001)**
Time Effectiveness –	**TE (rho = .0125, p=0.002)**
Perception of Abilities and Beliefs –	**PAB (rho = .187, p<0.001)**

Such small correlations should not be unexpected; effect sizes in Social Science have been shown to be mainly small to medium, (0.2 – 0.5, Cohen, 1988). However, it is not that the effects observed are small, it is that they are observed at all that is significant. That such a 'state' of cognitive differentiation is able to rise above the noise of a cognitive-cacophony of motivational drives, traits and biases, offers support to Divergent Criticality as an affective 'selectionist' neural mechanism.

Such correlation also provided 'triangulated' validity to the inductive IP-scale, as representing functional Affordance around a Tolerance Optimisation, and thus enables the IP-scale to address the central research question. If the IP-scale can be differentiated as perceptions of high and low functional Affordance, then such differentiation should also be expressed in perceptions of self-concept as affective cognitions in accordance with Divergent Criticality hypothesis.

7.3 Difference Tests between High and Low states of functional Affordance

H2: A measure of Self-Concept will be differentiated between high and low states of functional Affordance in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation

This differentiation was tested using a non-parametric Mann-Whitney U test to reflect the quasi-parametric data of self-report questionnaires (n=767).

Cooperative Teamwork –	**CT (Z= -2.575, p=0.005)**
Locus of Control –	**Control (Z= -3.362, p=0.001)**
Time Effectiveness –	TE (Z= -0.353, p=0.358) – no significance
Perception of Abilities and Beliefs –	**PAB (Z= -2.478, p=0.006)**

The hypothesis was supported across CT, Control and PAB. That significance was found, not only reports differentiation in functional Affordance states reflecting the Divergent Criticality hypothesis, but again, reports the behavioural bias for Tolerance Optimisation in Divergent Criticality function [Time Effectiveness (TE) was not supported in this difference test]: this may question the value of Time Effectiveness as a state measure and it may be that this construct better reflects a trait cognition of life-effectiveness as discussed.

As the Mann-Whitney test of ‘difference’ assumes similar non-normality (as non-parametric), these results must be considered in relation to the non-linear function of Divergent Criticality and accommodate the non-linear, and therefore non-similar, homogeneity issues (between high - low sampling groups). Therefore, a repeat measures test was conducted in order to be able to ‘assume’ sample Homogeneity and Sphericity (the participants being the same people).

H3: A Repeat Measures Two-way boxed-design will find significant difference between ‘Learning Outside the Classroom’ and ‘Traditional Classroom Learning’ in accordance with the Divergent Criticality hypothesis

Here, Divergent Criticality was predicted to favour 1) Learning Outside the Classroom (LoTC) in inducing high affective cognitive state(s) of Tolerance Optimisation over 2) Traditional Classroom Learning (TCL). That this was an *apriori* classification that reflected post hoc IP-scale analyses provided further support for the IP-scale (i.e. Learning Outside of The Classroom domains displayed higher Divergent Criticality than Traditional Classroom Learning):

Mann-Whitney test of Difference between TCL and LoTC Learning Domains

Cooperative Teamwork –	**CT (f=9.481, p=0.003)**
Locus of Control –	Control (f=2.715, p=0.104)
Time Effectiveness –	**TE (f=8.088, p=0.006)**
Perception of Abilities and Beliefs –	**PAB (f=9.834, p=0.003)**

Three out of the four Dependent Variables (ROPELOC constructs) reported coherent effects with the Divergent Criticality hypothesis; that of increasing affective perception(s) in relation to *apriori* functional Affordance states considered closer to Tolerance Optimisation. That Locus of Control perceptions did not report significance can be explained, in that although greater perceptions of 'control' might be expected in higher Divergent Criticality functioning, there may be extrinsic determinants in effect where an educational context is sampled (the environments of learning and goals may not always be the agential volition of the participant).

The Divergent Criticality hypothesis of Tolerance Optimisation was significantly supported in rejecting the null hypothesis, in the SEM functional Affordance modelling, and was also supported in triangulation analysis with correlation tests (H1) and difference tests (H2) and in the repeat measures design (H3). There is also support in the multiplicity of the analysis: the Divergent Criticality theory as an inductive IP-scale, found significance at a modelling level of analysis (SEM & CI) and that such modelling when analysed against an independent measure of self-concept in correlation and difference testing, offered both control and triangulation to support the universality of the Divergent Criticality hypothesis.

As an evolving methodology, this study has attempted to appraise the methods used in the research design as they were encountered. Further considerations are now addressed in Methodological Caveats:

1) How can the inference of an Affordance state of Tolerance Optimisation be made and differentiated from other affective properties (e.g. of more sunshine or rain)?
2) How can the Divergent Criticality hypothesis be inferred from such findings?
3) Why is the null hypothesis found in some of the constructs and not others (e.g. Locus of Control)?
4) Is there a preferred method of Factor Analysis (SEM or Conditional Independence)?
5) Are there alternatives to the assumptions of bias made in the sampling?
6) Does any ethical confounding introduce doubt to the findings (e.g. domain, homogeneity)?

7.4 Methodological Caveats

Throughout the methodology, considerations and questions regarding validity were discussed within each section; however, other methodological questions arose throughout the study and these are discussed here.

7.4.1 How can the inference an Affordance state of Tolerance Optimisation be made and differentiated from other affective properties?

Is it possible to use subjective perceptions to infer not only a state of neural function, but also as a means of delineating top-down and bottom-up attention processes ?

How do we know we are measuring a state of Tolerance Optimisation through the inductive Interdependence Profile, and that this measure (from Situational Interest) provides an indication of this functional Affordance state and are not reflective of some other property (e.g. the weather)?

Previous studies into the construct of ‘affective perception’ have found positive report across many samples and many Learning Outside The Classroom domains (LoTC): This study’s sampling was developed from the recognition of such positive-effect reporting in LoTC (Cason & Gillis, 1994; Dillon, Morris, O'Donnell, Reid, Rickinson & Scott, 2005; Hattie *et al.*, 1997; Malone, 2008; Neill, 2002). However, might other factors, not associated with Divergent Criticality, be influencing and confounding one or more of the study variables.

Such confounding considerations may have been an issue if the study had been conducted by only testing the hypothesis through ‘direct’[97] behavioural measures, i.e. not functionally supported. In such a ‘behavioural defining’ of the effects and by not applying a functional prerogative to a hypothesis or methodology, studies may fail to account for the multitude of affecting variables and how these might influence such an empirical measure, regardless of the robustness of the factor analysis and construct-modelling. Without a ‘functional’ methodology, one formulated from first principles (i.e. the predictions made ‘for’ observation not from), such deterministic questions might be questioned in their veracity of the results.

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[97] ‘Direct’ referring to data when used in a methodology applied to use only observational data. This may seem behaviourally robust and applicable to the ‘seeming’ observation-target of the study, but not adequately address the functional determinants, and so cannot be inferred to be generalised in theory.

In order to address this functional imperative, the methodology used in this study was formulated from a 'coordinating definition,' and naturalised from physical 'first' principles. The Divergent Criticality theory was then able to be aligned in a central 'functional' mechanism. From this, an inductive-methodology for an Interdependence Profile was formulated using the Divergent Criticality hypothesis. The formulation of a 'functional' hypothesis, enabled predictions to be made about the behaviours (e.g. Tolerance Optimisation) if operating in accordance with the central functioning or 'mechanistic' – Divergent Criticality hypothesis.

7.4.2 How can the Divergent Criticality hypothesis be inferred from such findings?

The findings were found to be statistically significant in both the Divergent Criticality model 'Profiling' (SEM) hypothesis and the Tolerance Optimisation behavioural hypothesis (triangulation testing with ROPELOC). If the Tolerance Optimisation hypothesis testing had been predicated on the SEM profile, then there is the danger of internal confounding with the model effects influencing the model hypothesis (Mueller, 1997). However, that an alternative self-concept measure with counterintuitive predictions from Divergent Criticality function are made, and these are found significant, adds a triangulation generality to the findings supporting a Divergent Criticality hypothesis.

This is a synthesis of application and theory supporting the validity of the hypothesis and dispelling the effect of other possible 'confounding' determinants affecting the findings. In this regard, this study's methodology is considered as a nomothetic approach to function over behaviour, and its findings may be generalised.

7.4.3 Why is the null hypothesis found in some of the constructs and not others?

The methodology employed to investigate the central hypothesis was an exploratory approach, aligning life-effectiveness constructs to an attentional Interdependence Profile. The constructs chosen were to provide the necessary power for a life-effectiveness 'measure' able to parse bottom-up and top-down affective cognitions, and not to investigate the overall life-effectiveness influence cognitions towards a perception. Therefore, to comment on such 'null' results at the construct level, is to speculate as to their function and relevance to perception rather than on the Divergent Criticality hypothesis as affective on perception.

What remains important, is the significance that there was 'any' positive reporting supporting the functional hypothesis, that of agential effect on top-down and bottom-up cognitions, as a functional Affordance state. That 'any' empirical observation is able to report such a functional hypothesis significantly above the noise of the multitude of perception iterations (the traits and bias of consciousness and perception), is exciting.

However, there are some considerations supporting the perception constructs used: That the Personal Abilities and Beliefs (PAB) construct and the Cooperative Teamwork (CT) were considered significant across all analysis, may well be an indication of the 'situated' learning domains affecting the agential attentional demands and therefore, the functioning of perception. Indeed, the sampling was conducted to access the hypothesised 'social and situational' determinates of ecological function in humans (we are social, niche-dynamic organisms). However, this social and situational 'state' may affect 'self' oriented perceptions and traits, such as Locus of Control and Time-Effectiveness: If you are not in an environment you can control, such as a social environment, you might not have 'situational' perceptions of self-oriented 'Locus of Control'. Here, the PAB and CT perceptions are socially situated perceptions where the 'agency of perception' may well be reflecting the 'environment' over the 'self'. This would seem to support a 'grounding' of cognition in bottom-up sensory perspectives, with top-down abstractions reflecting (to some extent) this 'situational' prerogative over contextual-abstractions such as Locus of Control.

This 'situated' perspective might go some way in explaining why findings based on the constructs of Locus of control and Time Management where not consistent across testing: They reflected a perception that was not exercised to great extent in these socially-situated 'learning' domains.

7.4.4 Is there a preferred method of Factor Analysis (SEM or Conditional Independence)?

Rather than dismissing or promoting either method of model building, the strengths of both are valuable in using a quantitative triangulation: Though Conditional Independence (CI) will provide a quantitative result, it is, like all tests, subject to the quality of the data used and the interpretations of the researcher. CI as a probabilistic model 'at input' (that is to say, an unbiased reflection of the data inputted), though truly quantitative in respect of data-processing, it is such a 'sharp' instrument that its appropriateness could questioned for the unravelling the 'fuzzy' complexity in psychological relationships (a non-deterministic complexity) or its appropriateness towards the quasi-parametric (questionnaire) data of the sampling method.

Alternatively, Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM) are subject to issues of homogeneity and sampling bias, together with the bias brought by the observation (researcher '*apriori'* assumptions). This bias provides both information but also subjectivism to the observations. However, within such empirical dissonance, a richer understanding of the data-set is possible, allowing post-hoc adjustments, an idiographic-tendency that would seem to allow function to emerge from the complexity within the research. However, such SEM confounding is 'subjective' and, therefore, open to criticisms as to any causality in research design.

In Study Three, the use of both methods served to support and inform the research design. This is particularly useful in an 'exploratory' study such as the Divergent Criticality hypothesis: The knowledge acquired through the CFA and SEM, helped inform interpretations of the Conditional Independence data and accordingly, assumptions made in the SEM 'should' be supported in the Conditional Independence and, if not, the model may not be assumed. This is a mixed-methods approach; if we consider the Conditional Independence as 'truly' quantitative method and SEM (as quasi-quantitative), a subjective or Qualitative method.

7.4.5 Are there alternatives to the assumptions of bias made in the sampling?

The development of measures to reflect the hypothesis of attentional awareness can be interrogated: These measures were suited to the exploratory nature of the study and underwent a robust factor analysis, supporting the adaptations and the modelling through two distinct methods (Structural Equation modelling and Conditional Independence modelling). This approach has been constructed within a robust qualitative methodology, reflecting the statistical power of 'population analysis' in its application. It was in the situated and social determinants sampled in the learning domains, that such a statistical approach was thought to reflect best, the Divergent Criticality hypothesis for social-situated organisms towards biological-value (see, 2.21.1, p58). If such an approach is applicable to isolated populations or individual analysis is open to reliability questions.

It may be that a more targeted measure (i.e. in the choice of 'state' constructs), can be derived as a specific attentional-cognition questionnaire, in accordance with situational awareness as an attentional constructs of bottom-up and top-down cognitive processes (see, 7.5, A Way Forward, p215); this might enable a refined measure with which to apply the Divergent Criticality hypothesis for individual analysis. Such an individual application of an Interdependence Profile would allow a mixed approach of inferential phenomenology (a functional Affordance state) and empirical measurement (the use of neural-scanning, e.g., electro-encephalogram EEG) and offer more causal evidence for the Divergent Criticality hypothesis as to its behavioural predictions.

Sampling

To extend the scope of the study across the different learning domains and age samples, ethical approval was sought for the use of third party sampling of the questionnaires. It was thought that in recruiting third party samplers, a greater sample reliability would provide the following improvements:

1) There should be a better participant-investigator relationship in getting students to complete questionnaires;

2) There would be a greater opportunity for a true situational ‘state’ to be measured with the third parties intimately involved within the learning domains;

3) It was thought that a multiple investigator application would reduce investigator-influence across a number of potential confounding biases (heuristic bias, expectancy bias, stereotypical reporting, euphoric effect, social surprise effect, etc.). These issues might be alleviated by not having the same investigator at more than one sample-taking. This seemed particularly important during the repeat measure design, Hypothesis (H3).

During the sampling, to a greater extent the sample returns were successful; however, there were some samples received that confounded the methodological protocols and therefore were not able to support the hypothesis testing. Of note, was that these reflected, to some extent, the involvement (or not) of the principle investigator. It could be seen that the greater the communication and proximity of the principle investigator, the more reliable the sample taking. This was particularly evident in the repeat measure design, where, third-party sampling fell afoul of maturation, washout and order effect confounding. This was due to a convenience approach sometimes taken by the third-party investigators (timetabling, access, curricula time-management), rather than the methodological rigor needed for the sampling criteria.

Barring the usual ethical caveats (e.g. consent, instructions, etc.), this third party involvement had strengths and weaknesses. Ultimately, however, the adversity found in this sampling methodology provided useful in support for the Divergent Criticality hypothesis: any confounding displayed itself in unusual or ‘unexpected’ reporting (in accordance with the Divergent Criticality hypothesis), a reporting at odds with the predicted domain Divergent Criticality expectations (e.g. an exciting glacier walk reporting as if it were a classroom learning activity). On follow up with the investigators, it was found that the questionnaire had been delivered in an evening classroom lesson, rather than on the activity!

The most reliable sampling took place with greatest proximity and guidance from the principle investigator, where a more detailed training-protocol was able to be delivered and administered. Despite the instructions and details of the supporting, sampling-guidance, a more reliable training-protocol would be advantageous in future study.

7.4.6 Ethical Limitations – Does any ethical confounding introduce doubt to the findings?

Throughout the sampling and results, though the overall results reported significance, Challenge reported weaker regressions than other constructs of the Interdependence Profile. This may be due, quite reasonably, to ‘protective’ ethical parameters avoiding taking participants close to their edge of their neural control or stability (an optimal tolerance point 'at the limit' of physical or psychological control). This ethically protective limitation might be addressed as to its possible test-effects in challenge-restricted 'learning' samples.

To truly test the Divergent Criticality hypothesis in an experimental design across the 'continuum of surprise and challenge function', in being able to push the Divergent Criticality hypothesis predictions to the extreme of its hypothesised control parameter (both sensory excess and cognitive demand), would require some innovative and well-crafted research designs to accommodate the ethical-necessity of protecting the participant throughout.

7.5 A Way Forward for Divergent Criticality and Tolerance Optimisation

The study has opened up a number of new approaches to observing and understanding not only how we perceive and learn, but how the brain functions in regard to a fundamental ecological 'adaptive' or 'learning' mechanism.

The Divergent Criticality hypothesis has been predicated on a number of theoretical propositions formulated from 'fundamental' laws. Further research would, therefore, need to be conducted using a similar 'functional' approach in order to support, test and clarify the Divergent Criticality hypothesis.

The fundamental tenets of Divergent Criticality, as formulated in this study, are discussed below, along with pathways of further research in each case:

1) **Divergent Criticality** is defined as the behaviour of Self-Organising Criticality in respect of an increasing entropic criticality, necessary for all biological life.
2) **Tolerance Optimisation** is a selectionist proposition for optimal dynamic resilience or ecological Tolerance in biological complexity (non-linear dynamical systems such as the brain). Here, the fundamental entropic behaviour of Divergent Criticality (Self-Organisation /adaptation) will spontaneously self-organise towards a maximal Optimisation function.

Divergent Criticality and Tolerance Optimisation demands a non-converging or increasing entropy-production, and may be explored through a Divergent Criticality signal (White-shift in fractal-scaling). As a 'proposed' fundamental property for biological life, this should be evident throughout behavioural and functional observation. This 'White-shift' signal has been aligned with 'intentionality' by Van Orden *et al.* (2011); however, what is important here is that Tolerance Optimisation recognises an 'agential' selectionist proposition, allowing the differentiation of agency between affective behaviour and mediated behaviour. Such a relative (to the individual) agency when applied through an Effectivity, provides a relative Effectivity functionality that allows agency to be with biological-value. As such, it can be shown that a White-shift is better considered as a composite of agency, but not able to be parsed as intentionality. Relative Effectivity, however, as providing a counter affective function in beyond cusp entropic-behaviour, produces a Brown Shift that can only be appropriated to an intentionality mediating affective-behaviour. This 'historic' parsing (Van Orden *et al.*, 2011) of 'intentionality' over Voluntary Control is now addressed:

3) **Relative Effectivity** proposes a phenomenological definition to coordinate subjective perceptions within a model of Tolerance Optimisation in ecological engagement. As an agential proposition of capability and efficiency, a relative Effectivity enables perception to be parsed as: 'within' Effectivity function (bottom-up affective behaviour) and 'beyond' Effectivity function (top-down intentional mediation of affective cognitions).
4) **Functional Affordance** is a 'state' of function in a 'phase' of agential capability or relative Effectivity.
5) **The Divergent Criticality Hypothesis** is a selectionist proposition, which brings together Divergent Criticality, Tolerance Optimisation and relative Effectivity. It proposes that affective agential behaviours aligned with Divergent Criticality, will drive cognition and behaviour to an Tolerance Optimisation and maintenance, the self-organisation around the 'relative' cusp point of maximal criticality.

Relative Effectivity is the relative functioning of Tolerance Optimisation, and approached through a functional Affordance 'state' (as inferred through the interdependence of attentional processes). Functional Affordance has been proposed as a Tolerance definition able to align perception with 'state' of neural function in response (or resonance) to ecological demand.

Within a control paradigm (behavioural), it should be possible to differentiated 'entropic-phase' function in the fractal-scaling signal. Different 'relative' neural-networks, will display different dynamical properties in relation to entropic-surprise (criticality). This would be discernible from the White-shift behaviour 'within phase' and the Brown-shift behaviour 'beyond phase', revealing the phase behaviour in accordance (or not) with the Tolerance hypothesis. Electroencephalography (EEG) provides one route for measuring a holism of brain function and could provide a productive tool for further exploration.

It is in a functional imperative in explaining behaviour, that Tolerance Optimisation and its relative functioning might be considered ubiquitous across cognitive and behavioural studies. Tolerance Optimisation operationalised by Divergent Criticality, may be applicable to a wider body of research into neural function and behaviour. Such application is discussed in relation to key psychological Effectivity (phase) and agential control concepts, in the 'Discussion' chapter.

In regard to the functional prerogative of the Divergent Criticality hypothesis, Optimisation is one of agential adaptation to the ecological demands (situated, social and self), fundamentally, an ecological ‘learning’ hypothesis. Perception might then be considered as reflecting the functioning of learning. This study, therefore, investigated perception as reflecting the Tolerance Optimisation function, using self-report as the basis of measurement.

One possible way forward would be to explore the hypothesis further through the stability and learning behaviours in coordination dynamics (Haken *et al.*, 1985; Kelso, 1995) as a mirror of neural functioning, which has been experimentally tested across many disciplines through the use of coupling *“The non-random linking between two or more processes”* (Root-Bernstein & Dillon, 1997 , p449). Through the observation of stability in non-random movement-fluctuations – a stability of relative phase (Effectivity) – it is possible to access ‘control parameters’ to empirically explore learning behaviour in action-perception tasks (Kelso, 2012; Zanone & Kelso, 1992; Zanone & Kelso, 1994; Zanone & Kelso, 1997).

Another option would be to explore the ‘inverse’ of perception studies; not so much what is unconscious, but what is ‘perceptually’ missed. Attentional biases have provided a rich context for cognitive function from a perceptual perspective, it might be that these can be explored from the perspective of functional properties rather than the behavioural effects. What is biased for and why, and how might such bias relate to the Divergent Criticality hypothesis?

6) **An Interdependence Profile** measure was developed to model perception as the cognitive functioning of a composite of top-down and bottom-up attentional process – perception as an ‘attentional’ awareness, able to infer neural function and an Effectivity state – functional Affordance.

The measures used in this study were adapted from pre-existing measures. It therefore should be possible to refine such a measure for more ‘accurately’ inferring the attentional processes explored in this study (see, Sampling, p213). Using more accessible or nuanced questionnaire, it might be possible to align such a phenomenological tool with an empirical measure of brain function. Measurements in the criticality-signature (as theoretically aligned with the Divergent Criticality hypothesis) may be investigated from the examples given above (e.g. Electroencephalography and the phenomenon of ‘Brown-shift’ as an indication a Tolerance Optimisation state). The application of the Divergent Criticality hypothesis is discussed now in relation to key psychological theory and modelling of cognition and behaviour.

If formulated within a mixed methodology of phenomenological experience and neural-function, this amalgamation of perception and function (neural) offers a triangulation in the study of brain, behaviour and experience (Roepstorff & Jack, 2004), providing a better understanding of not only the Divergent Criticality hypothesis, but as a dynamic learning moment of not only what and why we learn, but 'how' we learn and importantly how we might learn 'best'. This offers a new 'landscapes' of ontology in the field of Pedagogy research and its applications.

8 CHAPTER EIGHT – Discussion

The Divergent Criticality Hypothesis has developed a theory of agential mediation around an ecological Tolerance Optimisation proposition – the optimal function of a learning mechanism.

Perceptions as affective-cognitions are made aware and will reflect the agential mediation of a self-regulating, optimal learning mechanism – A Divergent Criticality Hypothesis

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As a learning theory, Divergent Criticality naturalises perception as the ‘awareness’ of neural functioning in ecological engagement and a self-regulating ‘Tolerance’ mechanism. Affective-cognitions drive behaviour towards an ‘edge’ of agential Effectivity (control) as a selectionist proposition for cognition and behaviour. It is hypothesised that attentional-awareness will reflect a ‘state’ of neural self-organisation (Criticality) as a perception of Effectivity towards ecological demands – The Divergent Criticality Hypothesis.

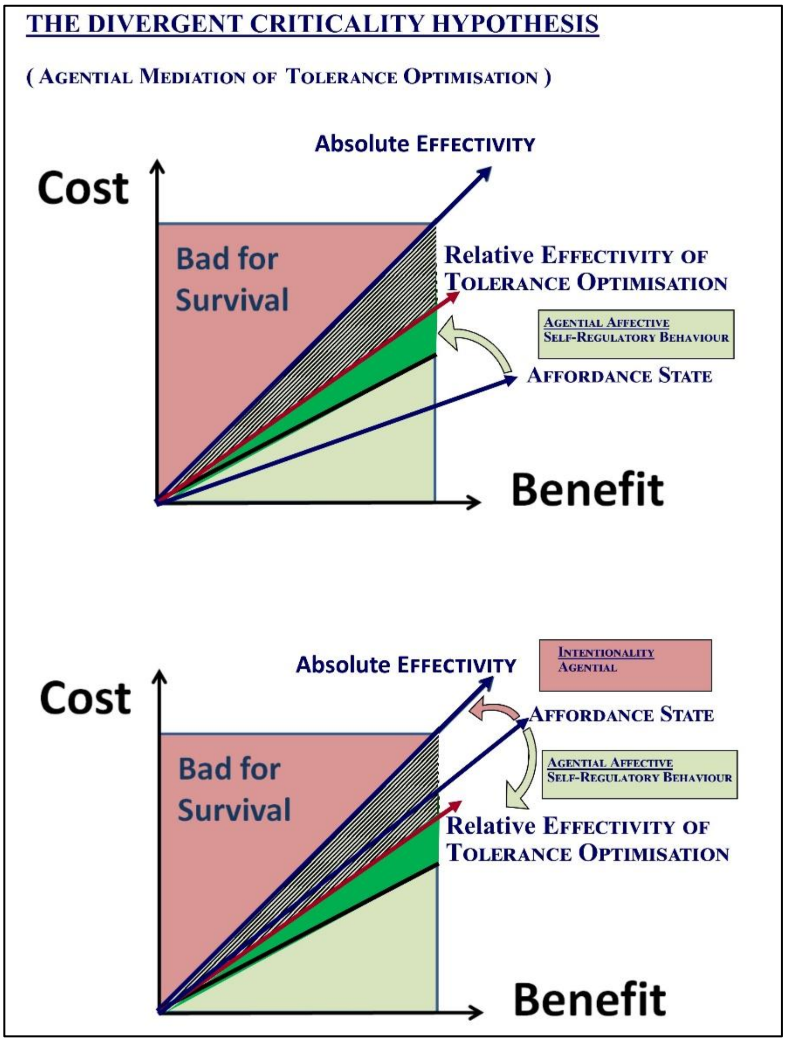

Figure 43 – Divergent Criticality: An Agential-Mediation Hypothesis for Tolerance Optimisation

Discussion Part One: Divergent Criticality – A Research Question

"One motivation for neuroscience to look at the physical laws governing other complex systems is the hope that universality will give the field an edge. Instead to search for ad-hoc laws for the brain, under the pretence that biology is special, most probably a good understanding of universal laws might provide a breakthrough since brains must share some of the fundamentally laws of nature." (Chialvo, 2010, p6)

This study has developed a theory of Divergent Criticality which can be formulated in terms of a coordinating-definition of Tolerance Optimisation. Divergent Criticality provides a 'universality' to perception as an objective neural efficiency (or entropic-functioning of Self-Organising Criticality); a functional Affordance relative to a state of Effectivity. Perception as functional Affordance can, in this regard, be equated to functional determinants, and not only behavioural observation (i.e. ensuring it is not the 'behaviour' being assigned causality, but the functioning of a an ecological mechanism). This study investigated Divergent Criticality as an entropy function, one able to naturalise perception in a Tolerance definition of maximal entropy production. The Divergent Criticality hypothesis is one of an agential-mediated Tolerance Optimisation for biological-value.

This Research Question was pursued through the testing of perception as an 'awareness of the cognitive processes', able to be modelled as the functioning of entropy in complex (neural) systems – Self-Organising Criticality. An inductive analysis of the Situational Interest perception questionnaire, informed the development of a measure of functional Affordance able to infer a state of Tolerance Optimisation. Supported through the Structural Equation Modelling of Divergent Criticality, significant model effects conferred with the hypothesised model across all functioning (see, 6.11 – SEM Hypothesis Testing, p187), and further triangulation found significance across all hypotheses supporting both Divergent Criticality and the Tolerance Optimisation hypothesis as functional (see, 7.2 – Findings: Situational Interest Triangulated with Self-Concept, p207).

- **H1** – Correlations of measures Self-Concept (ROPELOC) and functional Affordance, will report in accordance with agential-mediation of the Divergent Criticality hypothesis.
- **H2** – A measure of Self-Concept will be differentiated between high and low states of functional Affordance in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation.
- **H3** – A Repeat Measures design will find significant difference between 'Learning Outside the Classroom' and 'Traditional Classroom Learning' in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation.

This thesis was able to naturalise perception and learning objectivity as a state of functional Affordance relative to an Ecological Effectivity, and the findings supported the Divergent Criticality hypothesis of Tolerance Optimisation as a self-regulating mechanism for perception and learning. The research findings are now discussed in relation to contemporary theory and how the findings contribute to the literature, along with the pragmatic application for learning of Divergent Criticality.

8.1 Divergent Criticality a Dynamical Theory of Perception

***H1** – Correlations of measures Self-Concept (ROPELOC) and functional Affordance, will report in accordance with agential-mediation of Tolerance Optimisation*

The reporting of 'beyond' relative Effectivity agential perceptions concurred with the agential-mediation hypotheses of agential 'approach' behaviour. Such agential mediation of 'affect' when set within the Divergent Criticality hypothesis, is able to modelled as a beyond-cusp function in Catastrophe Theory through the agential-mediation of Self-Organising Criticality (SOC). This finding of 'beyond' cusp function in criticality, is developed in a Cusp-Hopf formulation of Catastrophe behaviour, a new approach accommodating an agential-mediation behavioural dimension. This finding better explains previous variation and confounding observed in Cusp-Fold criticality function (see, 0, p104). Such criticality function in perception is able to be triangulated against another affective 'perception' measure, Self-Concept.

In the hypothesis (H1), correlations reported a positive relationship supporting the Cusp-Hopf behaviour as affective in perception (states of functional Affordance) as predicted in the Divergent Criticality hypothesis of Tolerance Optimisation. This has implications for optimisation outcomes (e.g. learning) in agential behaviour and the maintenance of Tolerance Optimisation:

Tolerance Optimisation as a selectionist proposition supporting a dynamic mechanism for learning, in particular, needing to be specific to the individual or agent. This finding requires a shift in the understanding of the criticality or 'catastrophe' function as applied to biological dynamic-function and value. It redefines the Cusp-Fold model in a more complex model of agential 'Cusp-Hopf' function, where it is not affective behaviour as parameterised by catastrophe we are observing, but the agential-mediation of catastrophe and affective behaviour (e.g. agential goal motivations). The pragmatic applications of such agential mediation around a Tolerance Optimisation function are discussed in (Discussion Part Three: The Application to Learning of the Divergent Criticality Hypothesis, P258).

Previous observations in cusp-function (e.g. Croll, 1976; Hardy *et al.*, 2007; Sussmann & Zahler, 1978; Thom, 2018; Zeeman, 1976), are better explained within an agential Cusp-Hopf formulation. This is discussed now in relation to Dynamical Theory (8.4 – Setting Divergent Criticality within

Dynamical Theory, p224), and how agential-mediation of the Tolerance Optimisation model allows a spectrum of criticality behaviour, underpinned by a fundamental mechanism – Divergent Criticality.

8.2 Divergent Criticality for Agency and Intentionality

SEM *– Structural Equation Modelling of Situational Awareness perception supports a 'beyond' Effectivity function (Intentionality)*

H1 *– Correlations of measures Self-Concept (ROPELOC) and functional Affordance, will report in accordance with agential-mediation of Tolerance Optimisation*

The function of agential mediation around Tolerance Optimisation is able to be situated within the literature of agency and motor control, as to its functioning and behavioural outcomes. Here, Divergent Criticality is hypothesised to being able to differentiate agential affective-behaviour and agential-intentionality through the observed Tolerance Optimisation behaviour in the SEM and hypothesis (H1) correlations. This differentiation (an affective bias for functional Affordance states beyond relative Effectivity) allows the exploration of intentionality as agential 'end-goals' or motivations, over and above affective behaviour for dispositional biological value. That the Divergent Criticality hypothesis accommodates such a 'beyond' Tolerance Optimisation proposition, and that this is seen to be supported in the SEM analysis and triangulated (H1) hypothesis testing, allows the consideration of how volition or intentionality can be theoretically aligned to perception reporting: A functional and identifiable distinction between *"consciously controlled, strategic, voluntary behaviour versus unconscious, involuntary behaviour"* (Van Orden *et al.*, 2011, p658). This has long been sought in neuroscience, and whereas Van Orden *et al*. proffer a White-noise or shift (fractal signal) identification for intentionality, the Divergent Criticality hypothesis critiques this and provides an alternative 'Brown-noise' proposition, fractal scaling able to naturalise intentionality in a criticality function (see, 8.5.1 – Intentionality as an Extension of Agential Perception, p234).

This beyond Effectivity function emerges from the Structural Equation Modelling of self-concept (as an attentional awareness) where an Interdependence Profile is able to align a top-down dominance in Divergent Criticality function (of bottom-up and top-down attentional processes) favouring a 'beyond' or a 'limited', Cusp-Hopf functional Affordance state (7.1 – p206; 7.2 – p207). This Cusp-Hopf state of beyond relative Effectivity, was observed in 15 of the 24 sample domains, 69.8% of the sampling (see, 0 – APPENDIX XV: Sample Interdependence Profiles, p363) with functional Affordance states concurring with observations of self-concept as – intentionality. This is a top-down 'beyond' relative Effectivity dominance, able to isolate the functioning of intentionality in Divergent Criticality and allows the hypothesised 'Brown-shift' Criticality to be considered through the concept of 'learning optimisation'.

8.3 Divergent Criticality as a Mechanism of Perception and Learning

***H2** – A measure of Self-Concept will be differentiated between high and low states of functional Affordance in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation*

***H3** – A Repeat Measures design will find significant difference between 'Learning Outside the Classroom' and 'Traditional Classroom Learning' in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation.*

The Divergent Criticality hypothesis is applied to learning domains as either a high functional Affordance state (of Tolerance Optimisation) or a low functional Affordance state. Increased affective cognitions (hedonic) was found to be significantly supported in the hypothesis testing of (H2 – p200) and (H3 – p209) – that functional Affordance states as a 'Tolerance' function reflect a composite of situative and contextual prerogatives towards learning. It is as a composite learning hypothesis, that Divergent Criticality is able to be differentiated in its Tolerance Optimisation for either the functioning of a situative 'learning-potential' and/or a contextual 'learning-gain'. These learning functions and behaviours are discussed in terms of learning prerogatives (see, 8.6 – The Functioning of Divergent Criticality: , p243) and the biasing of a situated learning-potential supported in the (H3) testing of contextual 'Traditional Classroom Learning' (TCL) verses more situative 'Learning Outside the Classroom' (6.22 – p203). The pragmatic applications of this finding are discussed in Application 2: Learning Centred on the Learner (p259).

Support for greater learning optimisation (higher functional Affordance states) and importantly, learning motivation, was found in positive situative Learning Outside the Classroom (LOtC) effects, over and above the TCL sampling; adds to the understanding of educational methodologies. A case is made for greater 'situative' experiential learning approached through less-guided, agential oriented educational practices. An engagement-oriented approach of biasing learning-potential, towards providing a constructivist-platform on which to build specific learning-gain (see APP1 – APP5, p258).

It is in the recognition of Divergent Criticality as a selectionist hypothesis, that perception as a dynamic adaptation or ' learning-state' is explored as a neural-efficiency or learners Tolerance or capability towards ecological challenges; whether contextual knowledge or skills acquisition – Divergent Criticality is a learning mechanism for life.

Discussion Part Two: The Theoretical Application of Divergent Criticality

8.4 Setting Divergent Criticality within Dynamical Theory Literature

Dynamical 'self-organisation' in Non-linear Dynamical Systems Theory (NDS) has provided one of the more successful approaches to explaining perception in agent-ecological coupling (Guastello, 2009). Perception explained through Dynamical Theory has provided two dominant models for neural functioning of cognition and behaviour:

(1) Dynamical Self-Organisation: the coupling of perception and behaviour in Non-linear Dynamical Systems Theory (NDS) through Self-Organisation (e.g.,Kelso, 1995; Kelso, 2012; Tuller, 2005; Turvey & Carello, 2012; Zanone *et al.*, 2010);

(2) Attentional Control and Agential Mediation: attentional and agential processes on neural capabilities (e.g.,Baddeley, 1986; Baddeley, 2007; Derakshan & Eysenck, 2009; Eysenck *et al.*, 2007; Hardy & Fazey, 1987; Miyake & Friedman, 2012; Miyake *et al.*, 2000; Yantis, 1998).

Both these functional models may be challenged by setting Divergent Criticality function within Non-linear Dynamical Systems Theory, and is discussed here in relation to Dynamical Theory, as to how Divergent Criticality contributes to this research body.

8.4.1 Divergent Criticality: A Theory supported in Dynamical Theory

The 'functional' as opposed to 'behavioural' robustness of NDS has been commented on (see, Section 3: Non-linear Dynamical Systems, p65), where the functional-attributions made towards 'coupling observation and inference'[98] in Dynamical research are found wanting in the literature as to their universal application, therefore, Dynamical Theory might be questioned as to its functional validity in perception research (as in addressing behavioural-complexity rather than functionality).

Dynamical Theory in behavioural coupling (e.g. Haken *et al.*, 1985; Kelso, 1995), though incorporating nested Self-Organising behaviour, does not adequately describe a Self-Organising function able to accommodate the behaviours observed in research (such an agential drive for mono-stability, Kello, Beltz, Holden & Van Orden, 2007; Kelso, 2012). The Haken, Kelso & Bunz model (KHB, 1985; Kelso, 2012) as the "most widely discussed example of a dynamical model in cognitive science" (Kaufer & Chemero, 2015, p198), though accommodating multi-stability of nested

[98] Coupling defines the agreement between functionality (theory) and observed outcome behaviour, *"The non-random linking between two or more processes"* (Root-Bernstein & Dillon, 1997 , p449).

Criticality and a ‘potential’ function (in an updated HKB model – see, 3.3.1, p91), the HKB model does not provide the functionality as to ‘what drives’ nested stabilities towards such mono-stability? This is a seemingly inefficient and less stability-robust behaviour than a multi-stability in behaviour (e.g. of expert habitation) which would seem to offer a more functionally efficient proposition.

Divergent Criticality, is able to accommodate such obtuse behaviour observed in stability through the application of agency-mediation towards Tolerance Optimisation. Support for this Tolerance Optimisation proposition was found throughout the SEM testing and in the triangulation hypothesis in perception measures of Situational Interest and Self-Concept (see, Chapter 7 – p206). Divergent Criticality, therefore, can offer a number of better explanations for observed behaviour in Dynamical Theory, than offered by the KHB model:

1) By representing an ensemble of intensive and extensive entropic-function, Divergent Criticality provides for the observation of criticality function ‘emergent at a local level’ in response to the demands on the system. Importantly, relative Effectivity is able to provide a dynamic-landscape of criticality to model ‘behaviour in function’, not only through affective agency and towards a Tolerance Optimisation, but also through agential mediation to ‘maintain optimisation’. Observations of local criticality[99] are better viewed as behaviour ‘driven’ toward Tolerance Optimisation and a criticality behaviour dependent on agential mediation. This agential ‘Cusp-Hopf’ function allows criticality to be observed as either ‘shifting’ and/or ‘switching’ behaviour[100] (evident across many cognitive and behavioural studies using dynamical theory, e.g. Grigolini & Chialvo, 2013; Hardy *et al.*, 2007; He, 2014; Humphries, Schaefer, Fuller, Phillips, Wilding & Sims, 2016; Kelso, 2012; Kostrubiec *et al.*, 2012; Rhea, Kiefer, D’Andrea, Warren & Aaron, 2014; Scheffer *et al.*, 2009; Zanone *et al.*, 2010). In particular, attentional perception models of neural function and behaviour (Eysenck & Calvo, 1992; Eysenck *et al.*, 2007; Hardy *et al.*, 2007; Kelso, 1995), might be better analysed through a Divergent Criticality and agential mediation.
2) Importantly, the Divergent Criticality hypothesis drives systems towards Tolerance Optimisation as a mono-stability proposition (see, 2.6, Tolerance and Generative Models of

[99] Bi-furcation observations at a local level of criticality (Scheffer, Bascompte, Brock, Brovkin, Carpenter, Dakos, Held, Van Nes, Rietkerk & Sugihara, 2009)

[100] Shifting and Switching (Updating) may be considered synonymous with a local criticality phase change. Mediated inhibition (shifting) though functionally determined by criticality at a micro/intensive phase, emerges as a shift in a local criticality phase of observation, rather than switching.

Control, p25). Here, a 'Cusp' of mono-stability is selected-for rather than an 'equilibrium of multi-stability': Though this represents a seemingly counterintuitive 'inefficient' proposition to further 'prevarication' or surprise[101], when considered through the Divergent Criticality hypothesis, however, it is at this tolerance 'cusp' that criticality behaviours (as observed in hysteresis, critical slowing down, and other catastrophe behaviour), emerge as an adaptive (learning) functioning of affective-agency and mediation, thus increasing the system's future optimisation Tolerance-capabilities to cope with future surprise. These entropy expressions for Tolerance towards dynamic environments both support the literature (e.g. Chialvo, 2010; Grigolini & Chialvo, 2013; Kelso, 2010) and are experimentally supported in the Divergent Criticality findings through affective adherence towards an optimisation function (Hypothesis testing H1, 6.20, p199) and affective cognitions rewarded at such functional Affordance states of criticality (Hypothesis testing 3). This functional prerogative supports neural entropic-behaviour for neural-function 'At the Edge of Chaos' a mono-stability (Kelso, 2012) – An observation that has been not yet been adequately addressed functionally in Dynamical Theory (Hollis, Kloos & Van Orden, 2009; Kauffman, 2000).

The Divergent Criticality theory addresses the long sought naturalistic[102] explanation for neural function and its effects; how cognitions and behaviours as 'outcomes of function', might be better explained and understood in relation to Tolerance Optimisation. This hypothesis when applied to the literature, is better able to identify and better explain the behaviours and properties criticality such as the modelling of reduced Voluntary Control in the maintenance of Tolerance Optimisation as observable the hysteresis-effects observed in a phase-stability coupling (perception-action) learning paradigms (Kelso, 2012; Kostrubiec *et al.*, 2012; Zanone *et al.*, 2010). Tolerance Optimisation determines not a duality in neural function, but a fundamental mechanism of learning (adaptive) functionally dependent on agential mediation. This is the prerogative for learning in dynamic ecologies, and the agential mediation of Tolerance Optimisation for a composite of situational or contextual ecological demands.

[101] A selectionist confounding that is not adequately addressed in Dynamical Theory

[102] Naturalistic referring to conforming to the 'laws of nature'.

8.4.2 Divergent Criticality: Contributions to Dynamical Theory

When interrogated, explanations of neural-function in Dynamical theory are often confounded by exoentropogenic[103] effects on the control-parameters within coupling-designs, which may be both dependent and independent in any emergent phases of behaviour being observed (Deutsch, 2011; Guastello, 2009). This questions the functionality being observed in coupling-behaviour (Kelso, 2012; Zanone & Kostmbiec, 2004), and requires the reappraisal of the inference made in functionality (such as by Zanone *et al.* (2010) – where a scanning probe in a duel task approach suggested different 'novice' and 'expert' mechanisms of learning (e.g. Shift and Switch behaviours) [104]. Zanone's (2010) duel-function hypothesis would seem to contradict a frugal approach to neural resources in a functional-redundancy (Clark, 2015); therefore, is theoretically questionable in its 'inefficiency' (of different 'functionality' approaches respond to a dynamical ecological-demand). Such dualism presents a dispositional rather than representational function – an approach now discredited as 'limited' in explaining cognition and behaviour.

These explanations are not only subject to selectionist criticism as inefficient, but their observations may also be questioned as to their accuracy and sensitivity in recognising the dynamic functionality being presented: Though the scanning probe suggests a difference between a 'shifting' function and a 'switching or updating' function, dependent on expertise, it maybe that the observations made are not supported by the necessary theory to interpret them correctly. The Divergent Criticality hypothesis is able to accommodate 'phase' patterns as observations of the same 'functional' mechanism as it flows through 'nested' criticality (levels of) – a functionality absent or not addressed in many coupling observations (Haken *et al.*, 1985; Kelso, 2012; Kelso, 2010; Zanone *et al.*, 2010).

Previous dynamical-models such as Kelso's and Zanone's might be critiqued as to their interpretation of observations of observed 'phase-patterns' when viewed through these limitations and functional confounding in coupling/phase observations. It is suggested here that such behaviour (observation) has been wrongly defined as function (e.g. Zanone's duel-learning hypothesis, 2010). If a Divergent

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[103] There is a confounding in the level of observation that questions whether macro (extensive) behaviours or micro (intensive) properties are in effect; this questions the accuracy of observing true function and not just 'macro' outcome behaviour. A Divergent Criticality of relative Tolerance Optimisation seeks to functionally interrogate observation through a coherent functionality applicable to 'all' behavioural outcomes of the Non-linear Dynamical System.

[104] Switching and Shifting behaviours are extensively reported across agent-environment research, and have been theorised in neural Executive Function and Attentional Control ((Baddeley, 2007; Eysenck & Calvo, 1992).

Criticality hypothesis is applied as a mechanism for explaining the emergence of such diverse and complex behaviours (a simple mechanism with 'many' behavioural outcomes that provides a more efficient and therefore more robust explanation in evolutionary terms as to what is being observed), then Divergent Criticality as a unifying function is able to accommodate such seeming duality: The steepening of the 'hysteresis' observed in shifting patterns and switching patterns in Zanone *et al.* (2010, p112) can be explained by the criticality function in a Tolerance Optimisation of 'beyond' relative Effectivity. Here a 'reducing' Voluntary Control and Tolerance (of phase, see 3.5 – p100) predicts the observed 'steeping' in functional efficiency (Tolerance) terms. This again, is seen supported in the SEM and Hypothesis H1 testing (7.1 – p206), therefore, Zanone may be critiqued as displaying a duality of behaviour, rather than a duality of function.

When coupling behaviours are observed as nested criticality (Bak *et al.*, 1987; Thom, 2018; Thom & Fowler, 1975), stability-profiles of 'shifting' and 'switching' (Kelso, 2012; Zanone *et al.*, 2010) reveal a 'hysteresis' outcome or behaviour as an 'asymmetrical' direction of 'steepening' of entropy-function. This hysteresis profile may now be related to the non-linear formulation of entropic criticality in the Divergent Criticality hypothesis, and the agential-mediation of Tolerance Optimisation (i.e. the agential differentiation or mediation of relative Effectivity). Here, observations as macro-effects from intensive features, emerge as phase behaviours and are able to be observed at a 'local' level as switching or shifting behaviour. At such local-observation (emergent phase), though the 'measures' used may not be able to isolate and observe the 'intensive' nested-stabilities, the Divergent Criticality hypothesis allows the interrogation of such macro stability profile(s), as 'relative' landscapes of phase 'hysteresis' able to be interpreted in consideration of their intensive criticality-functioning, rather than as isolated macro-function (an isolation that has led to macro behaviour being considered as causal, rather than the actual micro-functionality of criticality being causal). Divergent Criticality is a theory accommodating such micro functionality and therefore, able to interpret the relative Effectivity behaviour observed in a steepening of entropic-function (see, 3.5, p100) as the predicted behaviour in a 'hysteresis profile', from the reduced Voluntary Control of agential mediation (a shifting catastrophe rather than switching collapse of phase).

The observed 'learning' behaviours that emerge (Zanone *et al.*, 2010) are able to be better explained as states of a relative Effectivity function, either in a 'shifting' of phase through intentionality (a limited Cusp-Hopf criticality), or a 'normal' cusp collapse and 'switching' of phase (at the emergent level of observation)[105]. It is, however, in the 'intensive' functionality of criticality that observations of macro-phase stability are functionality grounded (indeed, all phase behaviours), including an affective Divergent Criticality for Tolerance Optimisation observed as a 'drive' for mono-stability over multi-stability (see, 3.3.1 – p91). Shifting and switching might be better considered as the agential 'tuning' of Divergent 'Criticality' for optimal learning. In this way, Divergent Criticality surmises not two separate 'learning' mechanisms, but one Self-Organising Criticality, functional at all levels (intensive and extensive), but observed in a local-phase as the emergence of extensive criticality behaviours as either a macro phase of 'switching' in a cusp-collapse response to surprise, or a phase of 'shifting' dependent on the agential mediation of criticality behaviour – a Cusp-Hopf maintenance of 'Tolerance' Optimisation. Such iterations of criticality function around a Tolerance Optimisation proposition, as agential mediation, are discussed further in 8.5 – Setting Divergent Criticality within Agency and Intentionality, p233.

8.4.3 Divergent Criticality: Contributions to Cusp Catastrophe Theory

The Divergent Criticality hypothesis testing provided support for Tolerance Optimisation as a relative 'phase of function' (Effectivity). In particular, that a hypothesised Tolerance-state (as a state of functional Affordance) correlates with a limited,[106] 'beyond' normal-function of relative Effectivity. The findings from the SEM hypothesis and the Triangulation correlations with self-concept (H1) (7.2 – p207) were found to be concurrent with a Cusp-Hopf of reduced Voluntary Control beyond 'normal' function (the maintenance of Tolerance Optimisation), and supported function around a relative Tolerance Optimisation, a cusp of criticality. The Divergent Criticality hypothesis of Tolerance Optimisation was also supported in the Structural Equation Modelling of the differentiation in functional Affordance states at a cusp of Tolerance Optimisation – the dominance of top-down processes functioning beyond relative Effectivity as effortful, but 'preferred' states of function (6.15 – p193).

Divergent Criticality, through a Cusp-Hopf function, allows the parsing of agency into affective behaviour and intentionality behaviour within a composite of an agential mediated Effectivity function. Agential 'affective' cognitive behaviour utilises a Tolerance Optimisation to favour dynamic

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[105] Criticality as a flux proposition of time and space requires that there was always be criticality at some 'level' of the intensive structures of emergent phase, a non-zero proposition of intensive criticality. When criticality is observed at the macro-level, that, cusp-observation sees an observed 'local' phase become intensive to a greater – macro proposition as new phase structure emerges.

[106] 'Limited' and 'normal' are functional exponents or descriptions of Cusp-Hopf behaviour.

adaptation (learning) with intentionality maintaining a Tolerance Optimisation function towards agential 'end-points' or goals. Divergent Criticality requires, then, not only a re-designation of criticality function and behaviour in terms of agency and intentionality, but the defining of a third dimension of agent intentionality in catastrophe theory – a Cusp-Hopf asymmetrical control parameter. If cognitive processes are considered as affective and intentional on a continuum of agency affect, then all agency (as a reduced Effectivity) should accommodate 'some' Cusp-Hopf of catastrophe functioning and reduced Voluntary Control (again the intensive criticality function supports a macro phase of efficiency function). This challenges previous models such as fold and cusp and their inability to formulate how variation in 'macro' (phase) catastrophe behaviour emerges as either cusp or fold from (e.g. 'fold' behaviour such as Inverted U-hypothesis may emerge through agential 'effort' from what should theoretically be a hypothesised cusp catastrophe and visa-versa). When Divergent Criticality is applied to interpret such variation, rather than be tied to a two dimensional 'control dimension' (as in cusp-fold behaviour), a better explanation emerges that allows not only an agential proposition for 'maintaining' Tolerance Optimisation (criticality) at the cost of Voluntary Control (reduced Voluntary Control) but delivers the variation seen in cusp and fold behaviour[107]. Divergent Criticality is able to be universal in its application to the observed Cusp-Catastrophe behaviour.

The Divergent Criticality hypothesis had allowed catastrophe theory to be developed as a Cusp-Hopf formulation (see, 0, p104). This is a change of theoretical focus for catastrophe models of 'affective' cognition and behaviour, to include the mediation of an agency dimension (intentionality) as a dynamic Cusp-Hopf function and the maintenance of Tolerance Optimisation.

[107] Of ethological interest here is that the original Inverted U hypothesis (Yerks & Dobson, 1908), would suggest that rodents (the sample), if considered through Divergent Criticality as reduced Voluntary Control function of a Cusp-Hopf, must have been displaying 'intentionality' for such an Inverted U to be observed. This demands that research not only reappraises the validity of many animal-behavioural experiments that do not take account of intentionality in animal behaviours (Cloutier, Panksepp & Newberry, 2012), but also considers what and how such observed behaviour(s) might be agential-situated and how this might impact on experimental results: Not just considering the goal-directed agency in animal experiments (most animal experiments are predominantly 'affective' oriented), but also the possible salience and 'intentionality' of our animal cousins in such interventions – experimental end-point determinants beyond simplistic 'affective' manipulations.

Here, the associated behavioural-outcomes become dependent on both internally generated (top-down) and externally constrained (bottom-up) cognitive demands. Importantly, an agential 'end-goal' of intentionality is able to 'drive' optimisation function and behaviour beyond 'hedonic-affect' towards 'intentional-affect' in maintaining a relative Tolerance Optimisation avoiding catastrophic collapse. When neural-efficiency is mapped through such a relative dimension, the behaviours associated with Cusp-Fold can be better explained and mapped in Cusp-Hopf criticality (see, Figure 44, below), as trajectories of stability and behaviour: **(A)** Intentionality appeases catastrophe via a reallocation of resources in a reduced Voluntary Control (at the cost of internal entropic-dissipation), then a Tolerance Optimisation as non-stable equilibrium is maintained, and fold 'like' behaviours are observed; or **(B)** the 'cusp control' determinants of agential and external constraint demands (arousal and cognitive anxiety), exceed the intentionality control (effortful reallocation of attentional resources), then the system is taken far away from cusp, and a phase collapse results (see below).

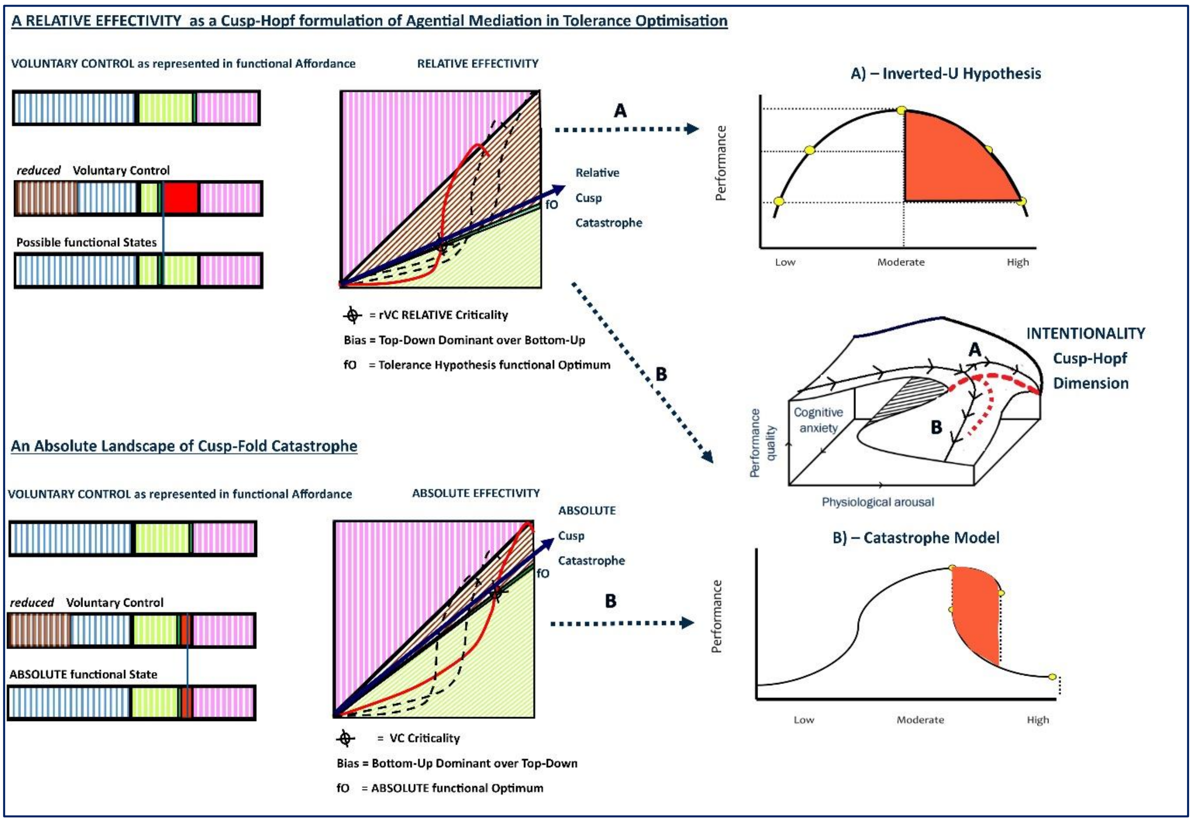

Figure 44 – Cusp Criticality in a relative Effectivity Divergent Criticality hypothesis

Whereas the 'absolute' landscape of two dimension Cusp-Fold may only ever deliver a catastrophic collapse of behaviour, not the fold like 'effortful' behaviour often observed, when a Divergent Criticality model is applied to a relative cusp-catastrophe function (Figure 44, above), the behaviour(s) of both the Inverted U and 'cusp-catastrophe' models are observable (Cohen *et al.*, 2003; Hardy *et al.*, 2007; Tenenbaum & Becker, 2005).

The determining factor in a 'relative' Effectivity is the interaction of the attentional processes of top down or bottom up resource components. Absolute Effectivity has to collapse in accordance with criticality and bifurcation theory – entropic function has no-where to go but phase collapse. However, a Cusp-Hopf of entropic-function, though displaying the behaviours of a criticality, (relative-cusp) attracts an agential mediation of Tolerance Optimisation and was observed in the SEM and Hypothesis H1 testing (7.1 – p206). It is therefore possible to divert neural resources to off-put entropic phase collapse (i.e. diminishing top-down demand allowing entropic export within the system). This behavioural-outcome, as recognised as 'effort' by Hardy and Hutchinson (2007), is able to be formulated as an expression of intentionality as an agential-control of cusp function (Baddeley, 2007; Eysenck & Calvo, 1992).

Though some of the criticisms of catastrophe modelling and catastrophe-testing (Croll, 1976; Sussmann & Zahler, 1978), were addressed by Hardy *et al.* (2007), the functional determinants still needed to be theoretically 'situated' (Chemero, 2008). This reallocation of neural resources as top-down cognitive processes are recognised in ecological theory as; 'Affordance demands attentional-resources to be shifted from top-down to bottom-up cognitive processes, allowing an increase in agential (relative) Effectivity (Chemero, 2003; Van Orden *et al.*, 2011). Divergent Criticality, when applied to catastrophe, not only offers an explanation for the duality of behaviour observed (of near-cusp and far from cusp-criticality), but is functionally able to accommodate observations of intentionality and effort (Eysenck *et al.*, 2007; Hardy *et al.*, 2007). Divergent Criticality allows for the concept of a deliberate agency of 'intentionality' for going 'beyond' cusp criticality in what will be discussed as 'the Brown-shift of intentionality' (see, 8.5 – Setting Divergent Criticality within Agency and Intentionality, over). This is a deliberate 'goal-oriented functioning' of cognitive agency in the maintenance of Tolerance Optimisation, where affective-cognitions are mediated towards agential behaviour and goals.

Divergent Criticality not only provides the mechanistic basis to situate behaviour, but also theoretically grounds Cusp-Hopf function in a continuum of physiological, psychological and agential dimensions. The application of Divergent Criticality to Catastrophe Theory, then, requires the consideration of neural function in terms of Tolerance Optimisation and suggests a shift in methodology for phase-coupling research (perception-environment): not only to re-appraise observations of behaviour as agential 'relative' affective cognitions, but in considering intentionality, agential mediated 'goal-orientation' or 'end-point' motivations on affective behaviour. If the physiological and cognitive affective demands dominate over an 'agential-intentionality', when analysed using Divergent Criticality, perceptions will be observed with a greater Cusp-catastrophic tendency (Tolerance Optimisation, but less robust towards cusp collapse); Conversely, greater intentionality behaviours will affect a Cusp-Hopf, maintenance that in avoiding collapse reports a diminished functional Affordance state (this was observed in the sampling domains (see, APPENDIX XV: Sample Interdependence Profiles higher functional Affordance states for learning activities that might be considered as 'intentional' (e.g. Duke of Edinburgh, Canoe Awards, Glacier Geography, etc. – see APPENDIX XV: Sample Interdependence Profiles). We should therefore attribute such observed behaviour as not only indicative of a cognitive demand, but also as an end-point (or agential-goal) of intentionality.

Intentionality then, as an agential 'mediation' has the potential to affect hedonic behaviour as a predictive end-point cognition – a future oriented cognitive-belief system that becomes motivationally-affective over hedonic-affective (wanting over liking). Divergent Criticality, if proven to be robust, offers a theory with which to better understanding such motivations and agential end-points. Future body and brain research might consider the application of a composite of affective and intentionality cognitions in experiment and observation.

8.5 Setting Divergent Criticality within Agency and Intentionality

It has been suggested by Van Orden *et al.* (2011), that reduced Voluntary Control might be considered as indicative of an 'intentionality' evident in cognitive function, a contextual volition of the individual towards the environment rather than 'of' the environment, affective on the organism:

"The proposal presents a historical opportunity. Since Freud, the distinction has been made between consciously controlled, strategic, voluntary behavior versus automatic, unconscious, involuntary behavior. However, no empirical evidence for reduced voluntary control has yet stood the test of time. …………… Presently, the distinction is supported by intuition alone but if whiter noise[108] in task coupling (departing from pink) is a reliable consequence of reduced voluntary control, then we have naturalized intentionality." (Van Orden et al., 2011, pg 658)

Van Orden's *et al*. (2011) observation of white-noise scaling (a divergence from the $1/f^1$ fractal as a 'signature' in Self-Organisation), as a signal of reduced Voluntary Control and intentionality presents a quandary: though the 1/f scaling exponents can be aligned to a hypothesis of agency, such fractal

[108] Nomenclature such as 'white' and 'pink' refers here to patterns of feedback in a scaling function. It originates from the descriptions of excess 'noise' or uncontrolled signals in radio transmissions, the clarity and ability of a radio-receiver to accurately represent an electromagnetic signature or a stability within the static. Such accuracy is explored in probability and information theory, as a state of entropy, the 'quality of the information' with regards to the accuracy of the system to represent the information presented. These concepts will form the theoretical foundations for Divergent Criticality as White-shift.

scaling actually represents a signature of 'all' criticality-function, therefore, will represent both agential and ecological determinants. This consideration of using a White-noise (which concurs with affective Divergent Criticality towards a Tolerance Optimisation) as indicative of intentionality, demands the acceptance that these observations may be due to 'other' ecological demands causing reduced Voluntary Control. Even if all possible sensory demands could be constrained and accounted for, is the white-noise observed, agency or intentionality? Divergent Criticality, through its entropic criticality profile, is able to offer a way forward for developing a 'reliable consequence of reduced Voluntary Control': Rather than Van Orden's White-noise, it is the 'Brown-shift' (noise) of Cusp-Hopf function in the maintenance of Tolerance Optimisation, that is able to parse intentionality from agency.

8.5.1 Intentionality as an Extension of Agential Perception

Bandura (2001) in defining the behaviours of agency as planner, fore-thinker and self-regulator (motivation), offers some precedence in parsing of agency. Here, intentionality and volition might be considered as different manifestations of an 'affective' agential cognition: not only a hedonic 'drive' towards Tolerance Optimisation, but also a goal-mediated 'drive' towards 'agential' intentionality. The problem is that within a Tolerance Optimisation driven by the White-shift of Divergent Criticality, all agency; affective behaviour, volition and intentionality, may be considered confounded in an agential-homogeny. In this thesis, the dynamic ecological learning perspective towards biological-value, hypothesises that all biological life is affectively driven towards Tolerance Optimisation and therefore has 'some' agency and a Divergent Criticality of White-shift. Intentionality, therefore, cannot be confidently isolated from this agential-composite through White-shift alone (as suggested by,Van Orden *et al.*, 2011). Such issues with Van Orden's *et al.* proposition are now critiqued and the agential-confounding exposed (using the functionality of White-shift in Divergent Criticality Theory).

Three very different behaviours; Entrainment, Accuracy Feedback and Expert Behaviour – rather than a 'reliable distinction' of intentionality are observed when white-shift is interrogated through criticality function. Though all three deliver White-shift as a fractal signature ($\alpha \approx 1^{\mathbf{minus}}$, *ibid*), such White-shift, is found to confound assumptions of intentionality. However, when set within Divergent Criticality functioning, they are able to be functionally-defined as different agential behaviours of very different functioning (though all produce White-shift). This infers very different affect and intentional determinants to Van Orden's *et al.* 'white-noise' proposition (see, Figure 45, over). When considering function for behaviour from a Divergent Criticality hypothesis, such White-shift is better considered as agency-affect towards Tolerance Optimisation rather than agential-mediated intentionality, and white-noise better explained as the functioning of a homogeneity of all 'agential' processes (affective and intentional) and unable to naturalise intentionality. Even what might be surmised as a clear-'intentionality' (e.g. Expert Practice), when attributed to White-shift as a "*reliable consequence of reduced voluntary control*" (Van Orden et al., 2011, pg 658), is confounded in the agential-homogeny encompassed within the White-shift signature (see, Figure 45, p235). White-shift in relation to an 'agency', has been explored in studies that have observed the behaviours of reduced Voluntary Control: (1) Entrainment as 'bottom-up' demands (Chen, Ding & Scott Kelso, 2001b; Hausdorff *et al.*, 1999); (2) Feedback Accuracy as a maturation-effect of 'reduced' accuracy from biological ageing (Hausdorff *et al.*, 1999) and ; (3) The Expert Behaviour, or 'over training' of expertise (Schmit, Regis & Riley, 2005) . All display a White-shift ($\alpha \approx 1^{\mathbf{minus}}$) in their fractal signature.

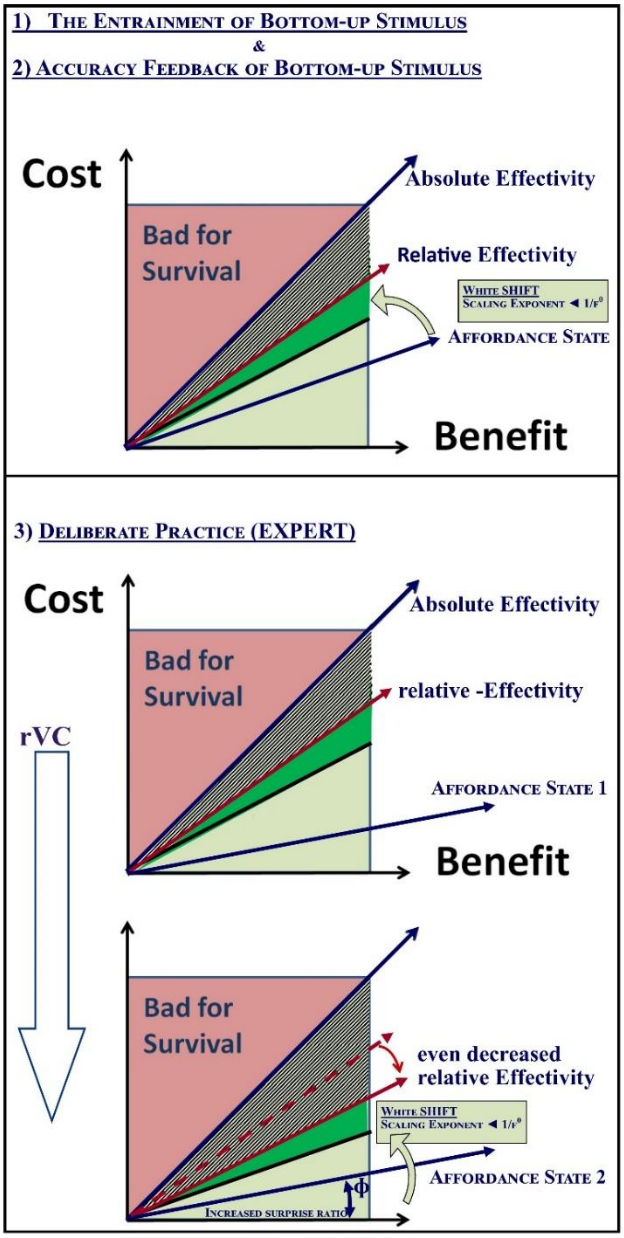

Figure 45 - White-shift in 1) Entrainment, 2) Accuracy Feedback, and 3) Deliberate Practice (Expert)

The White-shift observations (above), when explored through the Divergent Criticality hypothesis, see White-shift functionality in **(1)** Entrainment[109] and **(2)** Feedback Accuracy, subject to agent-environment 'surprise' (surprise from engaging with the new, or conversely, constrained ecological-information or information-accessibility), and driven from one functional Affordance state towards Tolerance Optimisation by Divergent Criticality.

However, in example **(3)**, Deliberate or Expert Practice, Divergent Criticality sees a constrained expertise and the functioning of rVC operating within 'normal' phase, not a 'limited' Cusp-Hopf function (as with 'normal' Effectivity function, such White-shift cannot be considered an unequivocal signal of intentionality). Here, White-shift is seen in the 'expert' constraining of behaviour (e.g. a ballerina's over-trained posture), as an agential 'deliberate practice' easily constrained within the expertise or habituation of the agent (Schmit *et al.*, 2005). In such agential 'expert practice', White-shift is due to increasing top-down 'agential' demands, mediating a 'cognitive dampening' of Effectivity (see, Figure 45, above). The result is a decreasing ratio-function of available Effectivity-to-Affordance (state), and the resultant White-noise signature observed in neural function.

Though this expert or deliberate practice is clearly indicative of 'intentionality' (such as the non-efficient constraining behaviour seen in the dancers), it cannot be isolated from the other agential behaviours displaying White-shift signatures in criticality. Deliberate behaviour might well be intentional; however, such 'intentionality' is not qualitatively or functionally equivalent to 'normal' (affective behaviour) Divergent Criticality function of Entrainment or Accuracy Feedback, their neural behaviour displaying the same 'White-shift' signature.

However, in applying the Divergent Criticality hypothesis to intentionality, this enables consideration as to how an intentionality might be 'functionally' parsed from other 'agency', and be identified, obviating the confounding issues presented in White-shift. It is in a neural system being taken beyond its affective 'normal' Tolerance Optimisation, that intentionality must be recognised as agential-mediated, a "consciously controlled, strategic, voluntary control" over affective behaviour (Van Orden *et al*., 2011, pg 658). Such 'beyond' Tolerance Optimisation (relative Effectivity) is

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[109] The White-shift of 'entrainment' provides an interesting proposition: A selectionist interpretation, is that we are driven to entrain as a Tolerance Optimisation proposition, an agential-environment resonance with entrainment, ecologically informs the individual as a societal and/or environmental response as vicarious cognitive-emotional behaviour. A selectionist value of experience of ecological-demand at a distance. Entrainment then becomes an 'extra'-perceptual information re-'source' of ecological-demand (surprise) and of an ecological 'learning' that will 'eventually' pay associative or future dividends.

identifiable in entropic-function as a ‘Brown-shift ($\alpha \approx 1^{\text{plus}}$)’ in fractal scaling and offers the opportunity to naturalise intentionality over and above the white-noise of agency.

In the Divergent Criticality hypothesis, ‘beyond’ relative Effectivity function as an agential-mediated affective behaviour, is proposed as intentionality and volition – an affective (cognitive-emotional) fractal-signature of the neural-system moving beyond from a Tolerance Optimisation affective state. Such a states of hypothesised, neural behaviour, was seen supported in the affective reporting of the SEM hypothesised functional Affordance states, and the triangulation hypothesis H1 (see, 7.1, p206).

8.5.2 Determining Intentionality Through a Divergent Criticality Hypothesis

As an empirical measure, Brown-shift is dependent on the functioning of criticality in the system and may be attributed to divergence or convergence properties in relation to a Tolerance Optimisation. It is therefore necessary to determine a Brown-shift of ‘Divergent’ Criticality as a ‘limited’ maintenance of Optimisation and able to isolate intentionality in Brown-shift. This requires the need to understand better the functioning and behavioural outcomes of the criticality function in a ‘beyond’ Brown-noise and how such a divergent Brown-noise of rVC intentionality or ‘effort’ presents itself over a decreasing or convergent function. Some guidance for ‘direction’ of a ‘divergent Brown-shift’ presents itself in the none-‘normal’ functioning of physiologically inhibited systems (e.g. Morbidity) a Divergent Criticality function akin to intentionality, but via a reduced neural-capacity of ‘ability to function’ within relative Effectivity.

Morbidity, a Function of Reduced Voluntary Control and Intentionality

Morbidity-behaviour (as a degenerative disease affecting neural complexity) seen in elderly people, differs functionally from the White-shift fractal-scaling from the normal ‘maturation’ of ‘accuracy-feedback’ (the effects of getting older in ‘accuracy feedback’ due to loss of sensory-adeptness). Whereas ‘maturation’ reports a White-shift (coupled with reduced information feedback), ‘Morbidity’, interestingly, reports a Brown-shift (Glass & Mackey, 1988; Schmit, Riley, Dalvi, Sahay, Shear, Shockley & Pun, 2006). It is in the different relative Effectivity function of morbidity, that ‘functional differences’ enable the different behaviour to be theoretically explained and in turn, provides an extremum of function to inform how a Brown-shift of ‘intentionality’ might be differentiated from other criticality signatures.

It is in the functional profile of relative Effectivity (as a neural efficiency function) that the difference is seen. Whereas maturation (accuracy-feedback) is not degenerative upon the relative functionality or ‘complexity-capability’ of the entropic system, it is a deficiency in ability to ‘access’ efficient bottom-up information (the mind is willing, but the body weak - neurally). Morbidity, however, sees a 'degenerative' neural-complexity (e.g. Parkinson's effects the synapse behaviour). This is a chronic reduced capability in Effectivity, a permanent diminishing of the complexity opportunities of the system rather than the 'neural' reduced Voluntary Control of maturation.

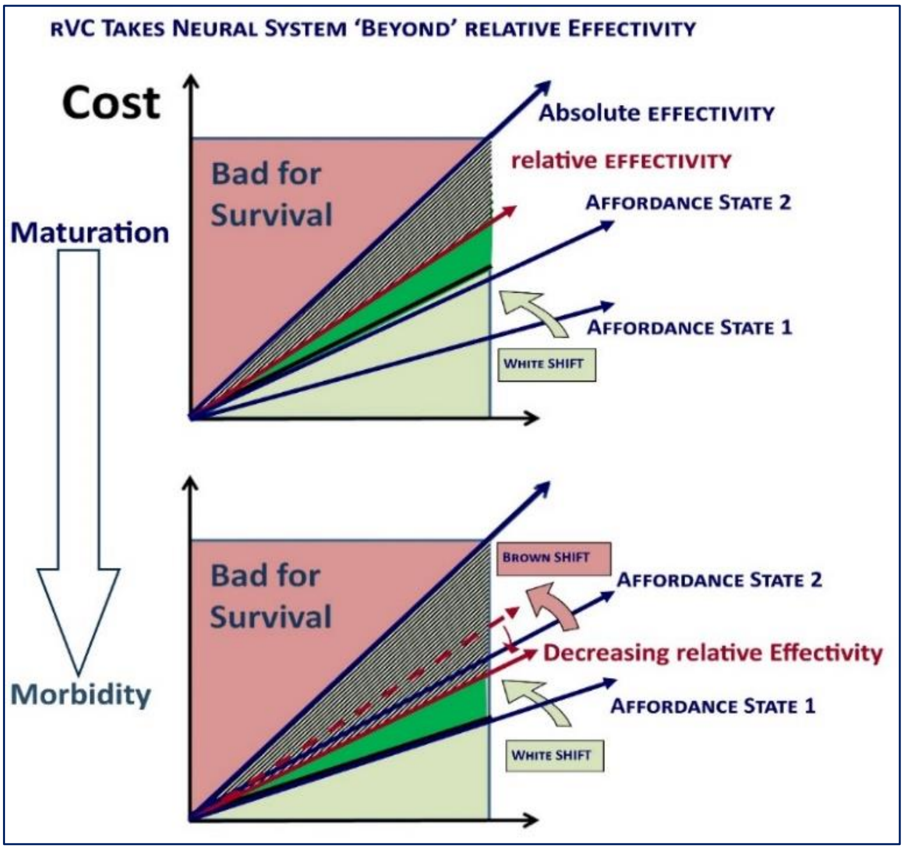

Figure 46 – Reduced Voluntary Control Takes System beyond 'Cusp' and Relative Effectivity

Though there may be a maturation-effect in observed morbidity (a White-noise of feedback inaccuracy from natural ageing), this will be subsumed in the morbid or 'structural-ebbing' of complexity capability, entropic-function, mirroring an extreme reduced Voluntary Control (Figure 46, above). It is the loss of relative-capability (not accuracy-feedback) that dominates morbidity behaviour. Rather than function within 'normal' relative Effectivity (as seen with the 'expert' Ballerinas, Figure 45), morbidity forces a relative Effectivity as a 'limited' Tolerance Optimisation beyond 'normal' function – one that yields 'Brown-shift'. This is akin to a reduced Voluntary Control taken into the 'limits of capability' in function, therefore, morbidity function as 'any',

relative Effectivity, allows the consideration of how criticality functions as an 'intentionality' beyond relative Effectivity affective behaviour, 'at the limits' of agential capability.

Brown-shift, Intentionality and the Limits of Capability

By being able to identify intentionality through the Brown-shift of Tolerance Optimisation 'maintenance', this not only provides for a differentiated signature for intentionality over other possible agency function, but also an optimal proposition for learning[110]. White-shift in expertise cannot delineate itself from other 'agential' function as intentional, as it infers a less than optimal state of criticality function (and therefore a 'lesser' learning proposition in Tolerance Optimisation). However, as criticality is driven towards Tolerance Optimisation, we would expect to see a White to Brown shift as reduced Voluntary Control is taken through cusp optimisation into the 'limits of capability'. It is at this cusp that an optimal learning proposition may be hypothesised:

The diminishment of function at the limits of capability (beyond Effectivity) provides an entropic-profile – a functional efficiency 'slope' able to differentiate between two possibilities: a) Function 'within' reduced Voluntary-Control and a normal Tolerance Optimisation; b) Function 'beyond' relative Effectivity and a limited Optimisation or Maintenance of cusp criticality (see, Figure 47, below). Here, an intentionality of 'beyond' relative Effectivity is theorised to exhibit a steeper efficiency trajectory in rVC (decreasing entropic-function in order to maintain functional stability), than a trajectory 'within' relative Effectivity. Brown-shift therefore will display different trajectories (of efficiency) dependent on 'within' or 'beyond' relative Effectivity as seen in Figure 47 (below) and thus allows a divergent Brown-shift of intentionality to be identified in agential functioning.

[110] The transition from 'affective behaviours' towards Tolerance Optimisation, the 'intentionality' of maintaining Tolerance Optimisation (White-shift to Brown-shift in Divergent Criticality) marks an optimal learning proposition in criticality behaviour. As a composite function of top-down and bottom-up cognitive processes, no two 'optimal' learning propositions are the same – this is discussed in terms of learning-potential and learning-gain see (8.6.7 – Optimising Learning-Potential or Learning-Gain, p262).

If Brown-shift is observed in a steepening efficiency profile, then a 'naturalising' definition may be considered as an objective definition for intentionality. Such 'limited' Tolerance Optimisation (agential mediation), can be identified as a Brown-shift where profiles exhibiting steeper slopes infer a state of function in a 'limited' Cusp-Hopf state of Tolerance Optimisation. If fractal-scaling is seen to progress from divergent White-shift to Brown-shift, it may be considered that the individual is functioning in a 'beyond' relative Effectivity (functional Affordance state), inferring intentionality rather than affective agency.

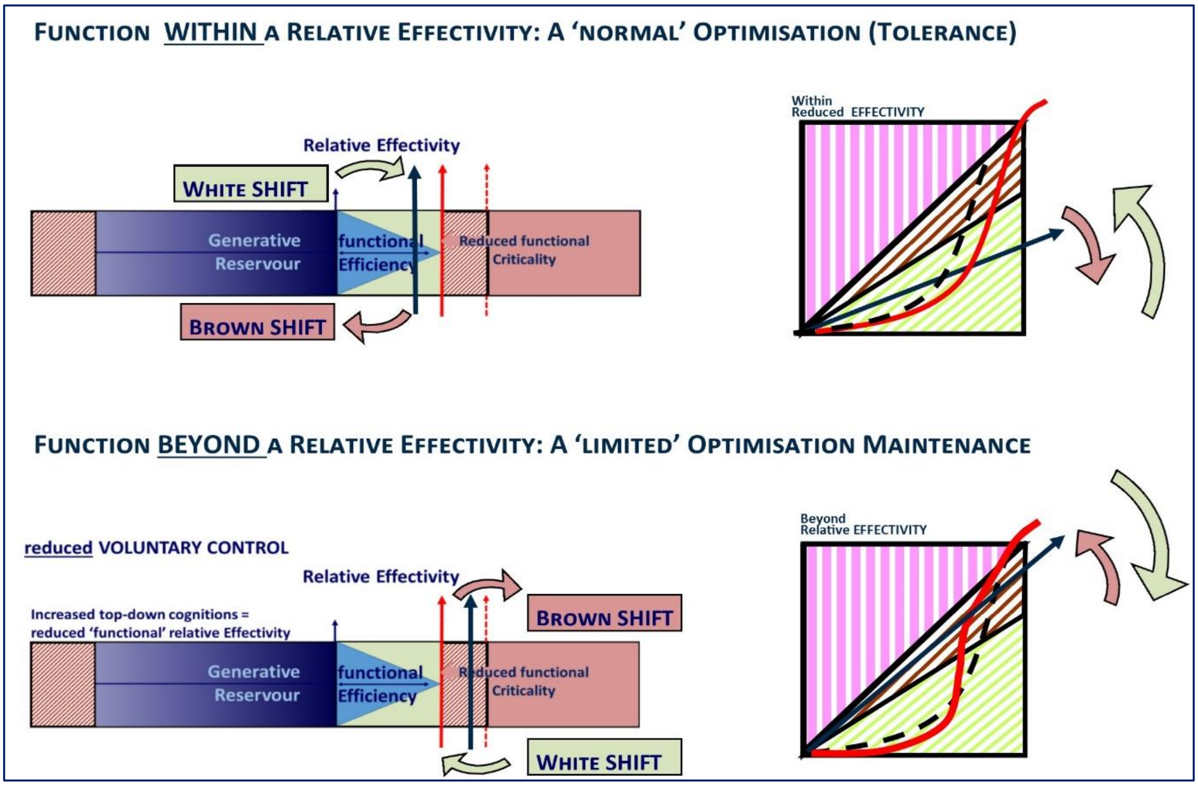

Figure 47 – Brown Shift within Relative Effectivity and beyond Relative Effectivity rVC

Though White-shift as an affective behavioural function takes the system towards Tolerance Optimisation in the 'normal' function, it is in the going 'beyond' or more correctly 'maintaining' Tolerance Optimisation at cusp, that a Brown-shift signature emerges, with reduced Voluntary Control indicative of a continued volition (beyond) the normal form of Tolerance Optimisation. Whereas White-shift has to consider that all agency, intentionality and ecological determinants may be in effect, Brown-shift in a Divergent Criticality hypothesis, however, must be of goal-oriented planning and forethought and evident as rVC behaviour as 'dominant' over affective behaviour – that can only be the signature of intentionality.

It is proposed here, that Divergent Criticality in a reduced Voluntary Control function provides a fractal-signature for intentionality as a 'Brown-shift', addressing Van Orden's *et al.* 'goal' of a "*reliable consequence of reduced voluntary control, then we have naturalized intentionality."* (2011, pg 658).

A clear distinction for intentionality in a Divergent Criticality model of Tolerance Optimisation is proposed: that of intentionality as defined by Cusp-Hopf bifurcation (Catastrophe Theory, see, 8.4.3 – Divergent Criticality: Contributions to Cusp Catastrophe Theory, p229). This can be considered as the 'maintenance' of Tolerance Optimisation, through 'effort-full' cognitive reallocation of resources when a relative Cusp-Criticality is exceeded (top-down cognitive effort, exerts intentional control over the other 'affective' dimensions, a 'limited'[111] dissipative-temporal proposition (Harlim & Langford, 2007). Such seemingly 'counter-affective' behaviour cannot be considered an 'innate' agential drive, but a "temporal extension" of 'conscious' intentionality (Bandura, 2001, p3). As a reduced Voluntary Control, this proposition of intentionality-effect over agential-affect, allows a criticality-function to emerge as an intentionality with a signature of 'Brown-shift' in fractal scaling, as the system is taken away from 'normal' Tolerance Optimisation. Brown-shift therefore is able to infer 'intentionality' in the Divergent Criticality hypothesis. The Divergent Criticality theory proposes brown-shift as an intentionality signature – a dissipating[112] entropy-function of agential 'cusp' mediation.

8.5.3 Considerations of Habituation and Expertise

Much of the research into 1/f signalling (associated White-shift) might be considered to have had an experimental-confounding in utilising learnt behaviours with a high-degree of habituation or expertise-bias in observation (e.g. walking and deliberate practice experiments where we are at our 'most' practiced). This expertise-bias is a confounding of neural functioning 'within' a relative Effectivity where additional cognitive-demands are accommodated easily within the efficiency of an expert Effectivity of function. If considering the examples from morbidity and ageing (Glass & Mackey, 1988; Schmit *et al.*, 2006) Divergent Criticality is in a White-shift which does not represent an optimal 'learning' proposition for Tolerance Optimisation (as able to still functioning 'within'

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[111] 'Normal' and 'Limited' denote Tolerance Optimisation function of 'normal' affective-attractor and 'limited' effective-attractor in Catastrophe Theory (Cusp Hopf bifurcation).

[112] There is no such thing as a 'free lunch': any stability away from one equilibrium-attractor (of Tolerance Optimisation) to another (Tolerance Maintenance) must be paid for in entropy, a reduced Voluntary Control and a dissipating relative Effectivity.

cusp). Brown-shift, however, represents the system working at the 'limits of its capability' in a Tolerance Optimisation, a maintenance proposition – as agency mediates Effectivity at a cusp of criticality.

If expertise is considered as 'just another' relative Effectivity, though end-goals may well be intentional in 'expert practice' (such as gait control) this adaptive behaviour as White-shift does not reflect a system at a learning-optimal. This offers an exciting prospect for Divergent Criticality in learning: We should expect to see White-shift become Brown-shift as relative expertise is taken into an optimal learning function and then maintains a cusp of learning criticality. This not only offers opportunities for 'skill-acquisition' in expert performers where the 'edge of criticality' (a maximal Self-Organising emergence as optimal system learning) is parameterised where white-shift changes to brown-shift, but also an approach to understanding criticality function in regards to situative and contextual learning (learning gain or learning potential) as functions of Tolerance Optimisation and Maintenance. This application of Divergent Criticality to expertise is discussed further in relation to Tolerance Optimisation as a learning function (see, 8.6.1 – The Optimisation in Learning, p244). It is that learning behaviours (such as shifting and switching) may be extrapolated towards further predicated or desired 'learning' outcomes, that the fundamental underpinning in Dynamical Systems Theory allows the application of Divergent Criticality to better understand and intervene in expertise acquisition, through a balance of affective constraint and reward towards desired end-goals (learning goals). Importantly, it is in the agential-mediation of a Divergent Criticality learning function, that consideration of the relative agential proclivities of the individual must be foundational in the shaping of this learning composite of agential determinants towards (expertise) end-goals.

As such, though expertise speaks of a 'learning-gain' and a contextual-function (of Brown-shift), the functional-refining of a neural-network's capability; it is in the 'bottom-up' situative-bias for learning that expertise, as a structural increase in neural capacity (the building of new neural pathways), reflects the entropic duality of criticality behaviour in habituation and expertise. This requirement in expertise for constraint-defined Tolerance Optimisation (the neural efficiency in ecological or perception-action coupling), is an optimal learning proposition for both the emergence of new neural-networks and in the refinement of existing neural-complexity, what Kello *et al.* (2012) have parsed into functional and structural Self-Organisation. This is a composite of Divergent Criticality function and agential mediation towards expertise that is discussed further in its pragmatic application (see, 8.10 – Application 4: Developing Expertise, p263).

Such agential functioning and mediation in learning has been explored in Attentional Control Theory where the role of an 'Executive Function' in working memory has directed much research into neural function and efficiency (Baddeley, 2007; Eysenck *et al.*, 2007; Miyake *et al.*, 2000). Therefore, Divergent Criticality is now considered in relation to these theories and its application towards such functionally differentiated learning.

8.6 The Functioning of Divergent Criticality: A Learning Mechanism

Illeris (2009) suggests that learning may be defined by two pivotal processes those of 'interaction' and 'acquisition' for the 'making meaning from experience'. When approached through a Divergent Criticality hypothesis, these processes may now be aligned to the agential mediation of Tolerance Optimisation in relation to a 'neural' state of ecological function. This confers an agential-prerogative to learning, that, in addition to the accommodation of ecological-demands of a situated-engagement (Chemero, 2013; Gibson, 1977; Greeno, Collins & Resnick, 1996; Thompson & Varela, 2001; Varela *et al.*, 1991), is the need to accommodate an agential-intentionality as we learn to resonate with our environments experientially (an ecology of the self, the social and the situated). It is in such agential-ecological learning, that Lakoff's *"abstract thought is largely metaphorical, making use of the same sensory-motor system that runs the body"* (2003, p3), sees relative Effectivity propagate top-down cognitions as agential 'mediated' bottom-up processes in neural function. Divergent Criticality (hypothesised as a drive towards a 'relative' Tolerance Optimisation), is seen as conferring a 'learning moment' through the emergent properties of a composite of top-down and bottom-up cognitive-processes (attentional) in neural function. It is in the essence of an attentional-awareness (to cognitive processes) as reflecting neural efficiency in function, that a perception of functional Affordance is a perception of the 'state' of learning function. The Divergent Criticality hypothesis allows learning to be considered as a continual-constructivist process of action and thoughts; rather than the delineation of experiential and transformative learning as separate processes (Illeris, 2009), it suggests that 'all learning' as being driven towards Tolerance Optimisation in a composite of Tolerance Optimisation and Tolerance Maintenance function. This accommodates Kello's *et al.* (2012) neural-complexity requirements of i) a situated optimisation (neural or structural criticality); and ii) 'contextual' optimisation (intentionality). Divergent Criticality functions around a Tolerance Optimisation for a perception of learning.

"Adaptive human behavior should be bursty appearing unstable, as it was always at the "edge of failure". Life-long learning continuously "raises the bar" to more challenging tasks, making performance critical as well." (Chialvo, 2010, p7)

8.6.1 The Optimisation in Learning

Divergent Criticality supports Chialvo (2010), in presenting neural functionality from both a contextual ‘raising the bar’ and a situative ‘ecological engagement’ in optimising learning as a ‘relative’ Effectivity. This optimal function as an optimal Tolerance state functional Affordance (Tolerance Optimisation) is affective in two ways: 1) an affective ‘drive’ of cognitive behaviour (as determined by the functional Affordance state in relation to a relative Effectivity, see, Hypothesis (H2, p200) and Hypothesis (H3, p209); or 2) as a ‘maintenance’ function (see SEM hypothesis – p206 and Hypothesis (H1, p207). In such an affective drive for Tolerance Optimisation through the associated behaviours of affective-drive and agential-maintenance, the Divergent Criticality hypothesis, as a selectionist proposition, is as much a theory of agential ‘learning’ as it is of ecological perception. Divergent Criticality as a learning hypothesis manifests itself in a perception for ecological engagement and in this regard, is an attentional awareness of the ‘state of learning’. We might more accurately describe perception as an attentional-awareness of the ‘state of neural learning’. Therefore, perception as a functional Affordance (neural state of attentional function) is an awareness of the functional determinants of learning, a ‘learning-moment’ of a flow of functional and structural – Criticality.

As a ‘relative’ function, such criticality(s) are different in their functional-composite and learning-behaviour(s), learning determined by agential mediation of top-down ‘reduced’ Voluntary Control). Tolerance Optimisation, therefore, as a unique ‘agential’ Effectivity, will be subject to different functional situative and contextual determinants in defining a learning optimisation. An agential functional landscape (of criticality), requiring the consideration that any learning optimisation will be ‘unique’ as a composite of situative and contextual criticality in any learning-moment. The application of such an agential composite is discussed in 8.8 – Application 2: Learning Centred on the Learner (p259).

8.6.2 A Learning-Moment as a Composite of Function

The Divergent Criticality hypothesis as a learning-moment is able to accommodate and inform a composite of function: i) At one extreme it provides an optimal-learning function for ecological engagement as a situated optimisation (bottom-up attentional processes bias) reflecting an ‘absolute’ of Voluntary Control (see, functional State-A, Figure 48, over); this is a proposition for the brain’s resources (neural networks) totally dedicated to being in the now and responding and adapting to the present; Conversely, ii) functional State-B, (Figure 48, over), shows an extreme reduced Voluntary Control (rVC) of relative Effectivity. This is an Affordance State beyond relative Effectivity (a contextual top-down and ‘intentionality’ proposition), and though still an optimisation, is an internal generative capability (requiring neural resources) and a reduced state of Complexity function (rVC) in order to accommodate a Cusp-Hopf function of 'beyond' function for the maintenance of Tolerance Optimisation.

8.6.3 A Learning Potential

Though both states (A) and (B) represent a Tolerance Optimisation or learning optimisation, it is in 'situated learning' State (A), that there is greater emergence of new learning structure that increases the 'learning-potential' of the complexity system (neural).

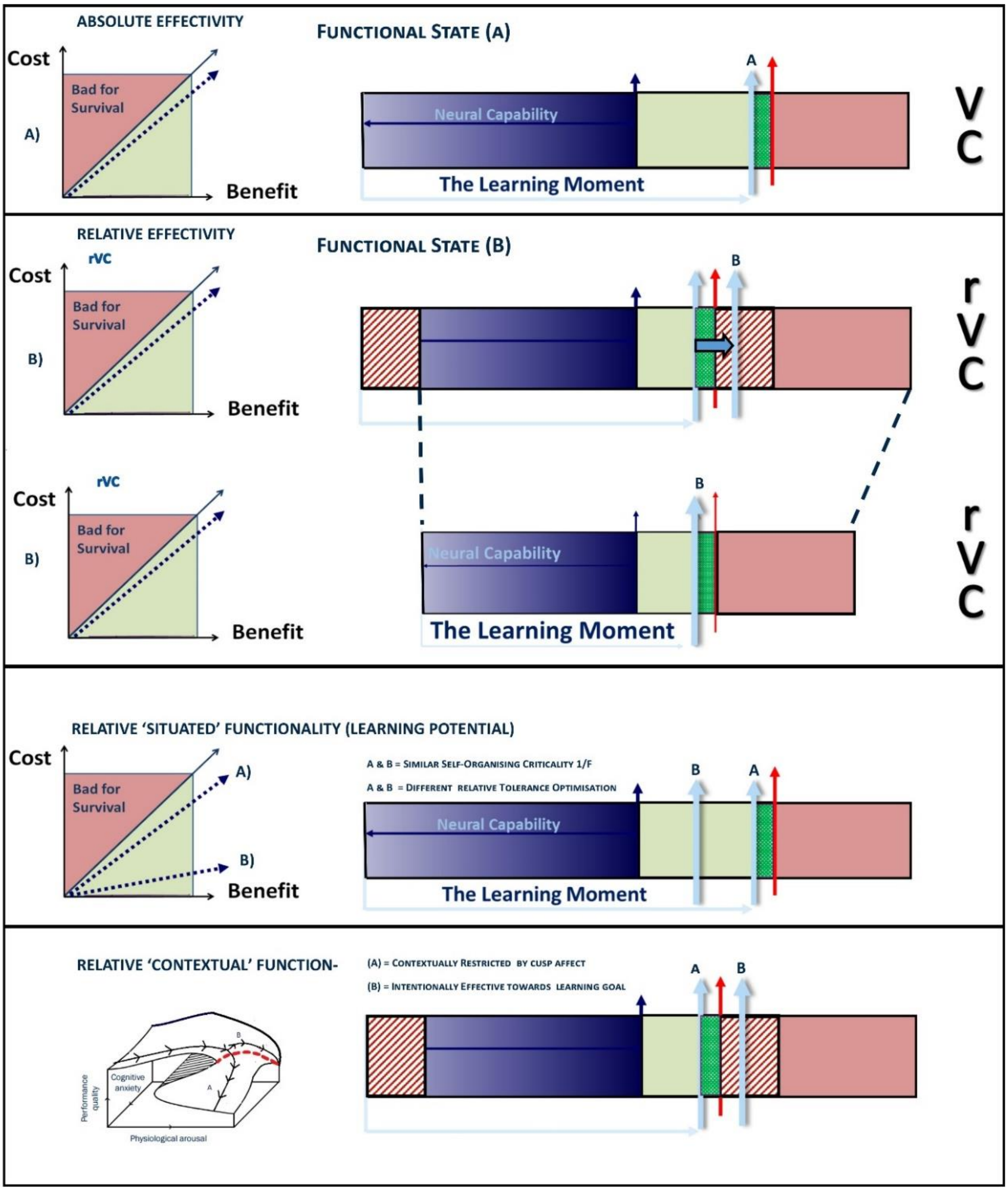

Figure 48 – The Learning Moment

It is tempting here to suggest that such a situated-function offers the greatest ‘learning potential’ and is primary in terms of learning value, however, though functionally correct, ecologically, this might provide for a less ‘dynamically-oriented’ proposition for forward-facing learning in a changing or dynamic world.

Such a situated ‘absolute’ function[113] (State A) is a ‘disposition to the situated now’ and not able to fulfil the selectionist criteria of frugality in ecological-engagement (there will be times of low and high entropic-function in such learning states of function, resulting in times of ‘less than efficiency function’ in a systems Tolerance Optimisation). If purely a dispositional ‘flow’ of experience and entropy, a situative function represents a poor selectionist proposition as there is a ‘void’ to fulfil in Tolerance Optimisation[114].

8.6.4 A Learning Gain

Van Orden *et al.* (2011, p658) proffers that *“Volition picks up the slack”.* If bottom-up demands or ecological ‘surprise’ do not fulfil the requirements for Tolerance Optimisation or utilise the capacity and complexity of the entropy system (brain), then an agential drive of not only ‘affective’ but agential-mediated ‘top-down’ behaviour towards optimisation ‘fills this void’ (*ibid*). Now, in terms of optimisation, a ‘maintenance’ State-B (above) presents the greatest contextual refining of learning, a

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[113] Though no true ‘absolute’ is possible in a dynamic system. Absolute here reflects a minimal top-down (reduced) Voluntary Control function, that of bottom-up dominance in attentional processes.

[114] However, such absolute ‘situative’ optimisation ‘is’ seen in some learning and cognitive development: e.g. Brown-noise has been observed in infant walking (Hausdorff *et al.*, 1999) where, the Affordance ‘exceeds’ relative Effectivity (Tolerance Optimisation) and the system goes into Brown-shift. It is questionable what intentionality there is in such infant ‘innate behaviour’, and therefore a White-shift of ‘affective’ agency might have been expected. This infant-anomaly might be explained in the behaviour as a naive ‘disinhibition’; an affective-bias in behaviour driven towards ‘normal’ Tolerance Optimisation rather than intentionality end-goals. This naïve ‘self-organisation’ takes the individual beyond Tolerance Optimisation (hence Brown-shift), though this is not prescient of a ‘limited’ cusp-maintenance, but an affective ‘normal’ self-organising regulation around optimisation. It seems that there are other processes in ‘affect’ at crucial developmental-periods in our learning, affective-biases which may exhibit extremes of function in behaviour for building learning-potential over learning-gain (Castillo, Kloos, Holden & Richardson, 2015; Kiefer, Wallot, Gresham, Kloos, Riley, Shockley & Van Orden, 2014; Kloos *et al.*, 2009). Learning as a contextual functional, needs to be grounded on a situative-structural platform. Karmiloff-Smith (2012) assertion of functionality over modularity and developmental times of greater, bottom-up functioning (the applications of this as addressed in APP 1, p267).

'learning-gain' (see State (B), Learning-Gain, Figure 48, above). Though seemingly a 'lesser' learning 'moment' from a reduced Voluntary Control state of criticality, such rVC provides a contextual richness and a 'temporal facilitation' towards optimisation, therefore, greater optimisation or 'maintenance' in regards to temporal end-points such as agential goals or motivations.

It is in this unique agential function and the need to accommodate the proposition of contextual volition or intentionality as well as a situated learning, that learning and its optimisation needs to be considered in terms of its composite of Tolerance Optimisation function: Not all learning function is the same and not all Tolerance Optimisations are 'edges of' the same criticality functioning. Divergent Criticality provides a functional explanation for this composite of agential learning: Situative affect and contextual intentionality are accommodated and naturalised in an affective 'drive' (Divergent Criticality) and the Cusp-Hopf (maintenance) of Tolerance Optimisation. An agency to maximise Tolerance and therefore learning optimisation is a proposition that learning will be subject to differing criticality-landscapes of agential affect and intentionality a unique situational and contextual 'optimisation' (the application of learning gain is discussed in, 8.7 – Application 1: Increasing Learning Potential, p258).

In this study's findings, it was seen that contextually dominant learning-gain was affectively favoured (selected for) with the greatest adherence to Tolerance Optimisation being achieved by 'top-down' functionally dominant states being reported as high functional Affordance states (see, 6.16 – p194). This concurred with triangulation analysis with 'contextual' learning domains correlating self-concept with functional Affordance states positively biased towards Tolerance Optimisation: A bias seen across learning domains where; developmental 'experiential contextual' learning was rewarded over experiential learning (e.g. 'team building' sampling reported higher in affective perceptions of self-concept than 'team challenge' sample domains: see, 6.22 – p203). That contextual and developmental determinants of learning were found to be positively biased over situative affective cognitions (more 'experiential' challenge activities), does not necessarily infer that a contextual bias is selectively preferred over situative experience, but concurs with intentionality (top-down function) in that it fills the functional 'void' in achieving and/or maintaining Tolerance Optimisation.

This presents interesting questions with regards to motivational theories, learning interest and pedagogy: i) What is the Divergent Criticality functioning for an agential 'drive or motivation for learning' beyond the necessities and optimisation of Effectivity – a 'wanting' rather than hedonic 'liking'; ii) How is agential volition in learning, functionally grounded in Divergent Criticality – agential capabilities and control in cognitive processes and; iii) finally, when is learning-gain optimal and when is learning-potential optimal? – These questions are now addressed in relation to Divergent Criticality:

8.6.5 A Drive or Motivation for Learning

The concept of an agential cognition suggests that we perceive and 'feel' our ecological experiences as functional states, and this requires the consideration of an awareness as cognitions of affective-emotional functioning (Damasio & Carvalho, 2013; Panksepp, 2017; Pessoa, 2013). Such affective cognitions have been explored as to how they might function, in a perception (functional Affordance) and in neurological function (Baddeley, 2007; Berridge & Kringelbach, 2013; Csikszentmihalyi, 1990; Damasio & Carvalho, 2013; Deci & Ryan, 2008; Derakshan & Eysenck, 2009; Eysenck, 1992; Hanin, 2003).

Affective cognitions as action-programmes are seen as 'encoded' by emotions, offering hedonic 'approach' cognitions of liking in an agent-environment Tolerance Optimisation, and such 'operant' feelings mediated towards an intentionally of 'wanting'.

"action programme and the respective feeling are often referred to by the same name, although they are distinct phenomena. Thus 'fear' can refer to either an emotion [the set of programmed physiological actions triggered by a fear-inducing stimulus] or a feeling [the conscious experience of fear]" (Damasio & Carvalho, 2013, p144).

It is in the functioning of Divergent Criticality around Tolerance Optimisation of relative Effectivity, that the iterations of criticality-behaviour provide better explanations towards situated and contextual agency in ecological engagement (and therefore, learning) – the mediation by the agent on 'affective' cognitions for biological-value (via top-down contextual cognitions). To be robust, these must not only be theoretically described, but Universality situated in functionality.

The Divergent Criticality hypothesis provides the criticality-function for such biasing of top-down contextual behaviours in learning (a 'beyond' relative Effectively of function). Importantly this does not compromise a selectionist hypothesis; an 'apex of affective behaviour' is still operant as a Tolerance Optimisation within agential Effectivity. It is in the re-appropriation of neural (generative) resources from a relative Effectivity (in a reduced Voluntary Control for intentionality), that top-down biasing is parameterised within a 'limited' phase of Cusp-Hopf function. This is still a Tolerance Optimisation 'zone' that is affectively rewarded. This was tested in the SEM hypothesis which concurred with functional Affordance state affectively biased for contextual 'top-down' functioning found to be significantly supported (see, 6.17 – An Agential-Mediation of Tolerance Optimisation, p194). In addition, this contextual bias in affective function is significantly supported in all correlation and difference tests conducted in the triangulation hypothesis (H1 – H3), a situative contextual (top-down) dominance over a bottom-up processes (see, Findings, p206).

The parameters of Tolerance Optimisation and support for the Divergent Criticality hypothesis are resonant with much motivational theory and it is possible to align the Divergent Criticality optimal 'zone of function' within the literature on Attribution, Goal Orientation, Attentional Focus, Self-Determination, Zone of Optimal Performance, etc. (Ames, 1995; Bandura, 1997; Csikszentmihalyi, 1990; Deci & Ryan, 1985; Eysenck *et al.*, 2007; Hanin, 1980; Levesque *et al.*, 2008; Roberts, Treasure & Balague, 1998; Vallerand, 1997). As a unique 'temporal' composite of situational and contextual functioning, this agential 'zone of optimisation', this requires the consideration as to 'how' these motivational drives are agential-mediated and/or ecologically-determined. Previous motivational literature might be critiqued in that affective cognitions have not been comprehensively defined theoretically; again, much theory of 'optimisation' in agential motivation (Catastrophe/Dynamic) needs to absolve itself from the criticism of reporting on behaviourism rather than causality.

As no two functional Affordance states are the same (as Effectivity composites), no two learning optimisations or motivational moments are the same, but instead, are defined in a 'dynamic' neural-landscape of ecological flux. Guided by agential-mediation within a zone of Tolerance Optimisation, the Divergent Criticality hypothesis allows the adherence of neural-function through an ecological learning or value-optimisation mechanism, to these complexity prerogatives. Divergent Criticality parameterises motivation in cognitive-function, as an efficiency and effort towards ecologically informed but agential mediated – perception end-points or functional goals. The pragmatic application of such agential motivations and end-point 'drives' are discussed in (8.9 – Application 3: Motivating Long-Term Learning, p261)

The concept of cognitive effort and an efficiency in neural processes (e.g. such as attentional processes) is of a goal-oriented agency and mediation. Perceptions as 'awareness of attention' are seen as directed attentional processes or neural resources in response to stimulatory cues (Corbetta & Shulman, 2002; Posner & Petersen, 1990). Attention therefore becomes subject to 'agency and control' facilitated through an 'Executive Function' (Baddeley, 2007; Derakshan & Eysenck, 2009; Eysenck *et al.*, 2007; Miyake & Friedman, 2012; Yantis, 1998). Such mediation of affective behaviour become attentional top-down cognitive functions, hence, any attention and 'awareness of attention' is agential and of 'some' top-down effect, and may be considered in a dynamic Divergent Criticality landscape as a capability mediated by a 'reduced Voluntary Control'.

8.6.6 Agential Capabilities and Control in Cognitive Processes

The observation of agential motivations, control and efficiency towards outcome-behaviours (of learning), manifests itself within Miyake *et al.* (2000) in the identifying of three central capabilities (neural beahviours) associated with an agential mediated cognitive-control or 'Executive Function' (Baddeley & Hitch, 1974):

"Updating – constant monitoring and rapid addition/deletion of working memory contents;
Shifting – switching flexibly between tasks or mental sets; and
Inhibition -deliberate overriding of dominant or prepotent responses" (Miyake & Friedman, 2012, p9)

This is observed as two operant 'diversity outcomes', seen as operationalised by an Executive 'Unity' on the function of three neural 'Abilities' as illustrated (Figure 49, below).

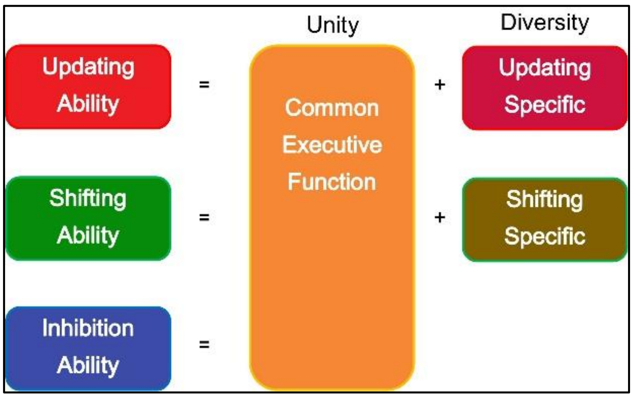

Figure 49 – Attentional behaviour in Executive Function (taken from, Miyake & Friedman, 2012, p11)

It is in the 'behavioural-diversity' when this model is applied that we see deviations from the expected functioning of the three 'Ability' determinants, with only Shifting and Updating (Switching) emergent as outcome 'Diversity' behaviours. This behavioural duality is seen across agent-environment studies (for example, Derakshan & Eysenck, 2009; Humphries *et al.*, 2016; Miyake & Friedman, 2012; Wilson, 2008; Zanone *et al.*, 2010), and therefore, a theoretical inadequacy critiqued within 'executive' unity models in their failing to develop 'Inhibition' function towards 'outcome' diversity.

Rather than question 'Inhibition' (a ubiquitous agential-capability observation), this speaks more of 'model-inadequacies' in formulating correct function, resulting in only Updating and Shifting as outcome-Diversity. The Executive Function (EF) seems a 'catch-all' to operationalise observed behavioural Diversity (in 'attempting' to accommodate a functional mechanism through a Unity mechanism (Baddeley, 2007; Miyake & Friedman, 2012). However, it might be argued that such a Common EF does not theoretically or adequately address the functional imperative of where such agential 'inhibition' ability comes from. It is in the very nomenclature of 'Ability' (in suggesting an agential neural-capacity), that function is given a behavioural-like capability and therefore, subject to a behaviourist critique of observation rather than functional explanation – What might be questioned is how inhibition is affective and why is inhibition subsumed within the Central Executive Function?

The Divergent Criticality hypothesis offers a better explanation to the observed diversity: Divergent Criticality in an agential 'relative' Effectivity, proposed Tolerance Optimisation as the 'Unity' function, where Tolerance Optimisation incorporates Inhibition as a cusp-phase of agential-mediation and intentionality. In re-defining the Common EF 'Unity' function through Divergent Criticality, Shifting and Switching become the expected diversity of an agential-mediated goal attribution and control function, resonating with the 'shifting' and 'switching' (Updating) found within Dynamical Theory observations (Kelso, 2012; Zanone *et al.*, 2010) as discussed (see, 8.4 – Setting Divergent Criticality within Dynamical Theory, p224). If considered through Tolerance Optimisation, an agential Unity is able to accommodate determinants of executive function as described in Miyake and Friedman (Figure 50, below).

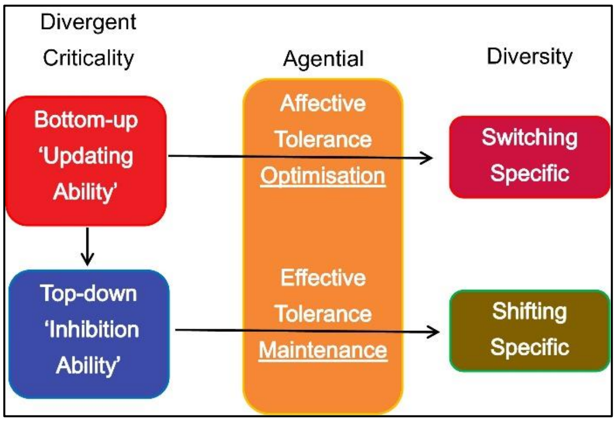

Figure 50 – Executive Function: as a Divergent Criticality Function
(adapted from, Miyake & Friedman, 2012, p11)

Updating (Switching) Specific – Diversity

Updating represents Divergent Criticality observed directly through local phase behaviour. Divergent Criticality takes the system through nested Criticalities and new stability(s) emerge (intensive and extensive). Rather than the linear function of an Executive Function of 'Unity', Divergent Criticality incorporates 'Updating' at all emergent levels in a phase of function, but observed as at a local-level of criticality (or 'Switch/Update' in phase)

Shifting Specific – Diversity

Shifting, then, as a Divergent Criticality 'Unity', becomes an intentional mediation of Cusp-Hopf behaviour on an Updating-Criticality, mediated by agential-effort (for the maintaining of a phase of optimal function).

Here, at a 'limited' Tolerance Optimisation, top-down cognitive resources are 'shifted' to bottom-up function (at an entropic cost[115]) and a 'shifting diversity' manifests itself in the maintenance of stability. Such 'shifting' might be considered as an agential moderation to Updating via an intentional Inhibition 'effect'.

Inhibition Subsumed Diversity

What emerges is that 'Inhibition' is not observed, but its effects on Updating are in effect. Inhibition is not lost in Divergent Criticality (as it is in the Unity of Executive Function), but made functional in a Shifting behaviour of agential-mediated Tolerance Optimisation. In defining Updating and Shifting within Divergent Criticality theory, behaviour may be hypothesised as; functionality in accordance with relative Effectivity and Tolerance Optimisation, therefore, may be used to investigate such agential 'mediated' behaviour – a diversity of a composite complexity and a conscious agential awareness from Divergent Criticality function.

Agential Mediation and Regulation Shifting and Switching Behaviour

As overt 'morbidity' behaviours exposed the base-functioning of intentionality (see, 8.5.2 – Determining Intentionality Through a Divergent Criticality Hypothesis, p237), similarly, a focus on the observations of 'overt' EF inhibition dis-function help expose the functional determinants of agential-mediation in a Unity – Executive Function. Such overt behaviour in agential regulation is observed in clinically termed 'Attention Deficit Hyperactivity' (ADHA). As such, ADHA as outcome-behaviour (of neural function) has been considered as either a hereditary dis-inhibition or the untrained suppression of a moderating ability (inhibition), displaying itself in overt situative behaviour such as novelty seeking and risk taking[116], etc. (Friedman, Miyake, Robinson & Hewitt, 2011; Miyake & Friedman, 2012; Young, Friedman, Miyake, Willcutt, Corley, Haberstick & Hewitt, 2009). If considered through the model of Divergent Criticality functioning rather than an Executive

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[115] Stability or phase proposition as a temporal-flux in energy potential is a non-stable equilibrium, and must pay a price to 'entropy' (the dissipation of entropy in free energy) in maintaining that stability. This price is exacted as an entropic dissipation is maintaining equilibrium. At a local phase boundary, such dissipation is observed as either an extreme entropic-flux of catastrophic change (new intensive stabilities emerge as local phase collapses – as 'switching/updating'), or a graduated 'limited' dissipation, permitted through a 'shifting' of the local phase-stability properties, a limited entropic decline within phase function. Switching and shifting represent then, the functioning of entropy within complexity structures or systems of stability; an agential re-payment route for entropy, as either a one-off payment (catastrophe) and/or a limited 'local-decline' and decreasing phase-inefficiency as entropy loss is tolerated within local-phase.

[116] As Divergent Criticality engages with overt challenge and surprise (entropic).

Function (EF), then such behaviour would be an outcome expectation from poor top-down or agential effect, therefore of 'cognitive dis-inhibition'. These behaviours would be expected to display as an absolute relative Effectivity in functioning and as an affective behavioural outcome, a 'switching' operant around criticality (Tolerance Optimisation), with little agential mediation or 'shifting' (see, 8.4.3 – Divergent Criticality: Contributions to Cusp Catastrophe Theory, p229). This may be due to neural capability, or a 'not yet learnt' Inhibition ability (dis-inhibition). Such extremes of outcome behaviour are seen by Miyake and Friedman (2012), as a reduced 'shifting -diversity', one that correlates with externally-oriented outcome driven attentional or bottom-up cognitive function, rather internal agential mediated goal-orientations:

"…. recent research has yielded substantial evidence that links individual differences in EFs to diverse self-regulatory behaviors, such as the expression and control of implicit racial biases and prejudice (e.g., Klauer, Schmitz, TeigeMocigemba, & Voss, 2010; Stewart, von Hippel, & Radvansky, 2009), staying faithful to romantic partners (e.g., Pronk, Karremans, & Wigboldus, 2011), and successfully implementing dieting and exercising intentions (e.g., Hall, Fong, Epp, Elias, 2008)".

Using a delayed gratification design to test the longitudinal stability in dis-inhibition behaviours (Friedman *et al.*, 2011), such Shifting inability was seen to be genetically-biased (a seeming hereditary 'trait'), displaying a dis-inhibition bias or 'trait', despite learning and maturation effects. This is the recognition of inhibition, rather than being only agential dependant, is moderated by a hereditary-bias (a fixed neural-trait as opposed to the flexibility of a functional state, such as agential mediation). Divergent Criticality, therefore, surmises that Inhibition as learnt or a trained-maturation is an agential mediation, though, one moderated by hereditary bias[117] .

As Inhibition functions in attentional behaviour (by goal-focused top-down agential mediations on value decisions), alternatively, a dis-inhibited bias provides a greater environmental resonance but exhibiting greater risk and instability (Goschke, 2000). These behaviours might be speculated to offer different selectionist benefits (and risks) to the individual as any trait must be considered as genetically retained, therefore must offer selectionist opportunities over and above agential mediation of ecological determinants. This very different perspective to a 'homogeneity of Inhibition' we educate for, the biasing of learning for inhibited behaviour. This requires that we

[117] There have been shown to be hereditary antecedents that limit any trained or learnt Inhibition, possibly explaining some of the seemingly extreme hedonistic and external behaviours displayed in 'attention deficit hyperactivity' (Young *et al.*, 2009).

reconsider not only the efficacy of our education methodologies (learnt and maturation), but also the Inhibition-bias(es) of agential hereditary (as considered in Application 2 and Application 3 – p259). It is in this Inhibition function that agential proclivities to learning presents themselves: how attentional process are operant as top-down dominant or bottom-up dominant in what McGilchrist (2009) describes as the balance and dominance of a continuum between a 'focus on the present', and a 'future oriented' attention. This is a composite of attentional (agential) processes towards biological-value, therefore, Divergent Criticality enables such behaviour to be explained through its simple functional mechanism (the mechanism is simple, not the outcome-complexity). When viewed through Divergent Criticality, Inhibition is easily subsumed in a composite function of contextual agential mediation (Cusp-Hopf) over situated biological drives.

8.6.7 Optimising Learning-Potential or Learning-Gain

Such functional learning in Divergent Criticality asks what is be prioritised, selected for as an optimal composite of bottom-up 'situative' and top-down 'contextual' processes:

1) A bottom-up dominance or dis-inhibition in functioning, through providing increased structural optimisation in building new neural structure and networks, increases capability (Effectivity) and learning-potential (Chialvo, 2010; Kello, 2013; Kello *et al.*, 2012) [118]. However, this learning is dispositional and contextually-restricted.
2) Or, top-down cognitions of an agential-mediated Effectivity, a bias towards maintaining Tolerance Optimisation towards contextual end-points and a goal-oriented learning function, reinforcing of the existing network. This is a 'temporal extension' of optimal function as predictive-processing (Clark, 2013) and refining efficient function, does so within the parameters of learning-potential.

Such a composite is reflected in the behavioural-outcomes accommodated within the Divergent Criticality hypothesis: An affective behavioural platform (Panksepp, 1998; Panksepp & Biven, 2012) drives the system towards Tolerance Optimisation (situative dis-inhibition) then a reduced Voluntary Control or 'maintenance' function, extends behaviour towards future-oriented 'contextual' value. It might therefore be argued that it is in the individuality of the agent-environment relationship, that requires learning to be 'functionally considered' rather than 'outcome considered' if achievable

[118] Experience and mistake contingent learning is rewarded, in the supporting glutamate and dopamine neurotransmitters we see reinforcing salient functionality and neural re-generation (plasticity) of new structure, with increased affective behaviour and structural – functionality.

learning gains are to be realised. Such functionality recognises a proposition that learning need be considered as an individual capability and potential (situative and contextual); the agential-learning proclivities directing individual goal optimisation, rather than a homogony of societal-goal oriented education.

8.6.8 Overt Contextual Behaviours

It might be considered that in a goal-oriented society (one that favours contextual focus and effort), an overt dis-inhibition bias would present a negative perspective; indeed, such proclivities have found themselves medicalised and labelled as 'disorder' (e.g. as with ADHD). Conversely, overt inhibition and contextual functioning presents similar 'non-normal' considerations: An Inhibition 'suppression' of affective behaviour is associated with Brown-shift (see, 8.6.6 – p249), this may be associated with avoid-affective cognitions (e.g. adverse psychological cognitive-emotional disorders such as depression and anxiety). Tolerance Optimisation as a self-organisation regulating mechanism, provides a Goldilocks-like proposition where overt neural function provides 'disorder' avoid cognitions (as any self-organising proposition should).

It is in the appreciation of the Divergent Criticality hypothesis representing a spectrum of agential function around a relative Tolerance Optimisation, that the recognition of a hereditary bias mediated by agential maturation (contextual and situational) would allow the accommodation of the individual's proclivities towards learning goals (whatever the 'desired' goals may be). In doing so, realistic interventions utilising Divergent Criticality theory might better direct educational and learning experiences to best achieve such behavioural outcomes[119] in consideration of the individual (these are discussed in APP2, p259).

This is from the perspective of neural functionality and the value of learning (as societal, ethical and philosophical); a 'value' constructed within opportunities 'of' the individual, not society dictating opportunities 'for' the individual which would seem to favour top-down intentionality as a selectionist proposition for social environments and the prioritising of contextual learning. It may be speculated that such contextual prerogatives have dominated in western culture, driving the appraisal of a quantitative learning-gain towards pre-specified linearly measures (Black & Wiliam, 1998; Harlen & Deakin Crick, 2003), however, such contextual learning-gain is restrictive in terms of neural learning-potential.

[119] 'Desired' outcomes may be as much self-oriented as societal-oriented.

Building Learning Potential

A bias towards top-down appraisal in learning does not accurately reflect the multiple learning potentials possible across a composite multiple-functionality. Though student centred learning has addressed this somewhat (e.g. Gardner, 2008; Garner, 1983; Nijhuis, Segers & Gijselaers, 2007), learning as a contextual function, needs to be grounded on a structural-optimisation or flexibility: the situational realigning of neural behaviour, accommodating the experiential unknown, in a neural-constructivism. This is supported by Karmiloff-Smith (2012) in her assertion of functionality over modularity, providing a neo-constructivism emphasis for times of greater, bottom-up 'structural' functionality in learning, the building of a knowledge 'pool' (see, 8.7 – Application 1: Increasing Learning Potential, p258). Observed as periods of seemingly 'restricted' Inhibition or unrestricted learning behaviours, developmental extremes as situative-bias functional states of learning become evident (e.g., Castillo *et al.*, 2015; Hausdorff *et al.*, 1999; Jessor, 1991; Kiefer *et al.*, 2014, ; Hollis, G., 2008, in Van Orden, *et al*. 2011; Kloos *et al.*, 2009). This bottom-up dominance in functioning might be considered as exhibiting enhanced 'dis-inhibition' (Miyake *et al.*, 2000), and might be speculated to represent a structuralism prerogative in developmental learning.

This emphasises a situative platform on which contextual learning may be constructed, and requires that the composite of Tolerance Optimisation function in relative Effectives be addressed. Here, both situative and contextual function are operational, where 'situative' structures are 'contextually' refined in functionality, increasing neural-efficiency and 'Effectivity' (towards Tolerance and ecological-resilience (Blake, Heiser, Caywood & Merzenich, 2006; Plunkett *et al.*, 2006; Wise, 2004)). Inhibition as primarily a learnt (top-down) behaviour, sees behaviours of contextual goal-orientation emerge. Such agential-function in Divergent Criticality, together with the ecological and societal prerogatives (a perception from the self, situation and society), can be abstracted further to explain the complexity and richness of our psychological experiences. Perception, naturalised as a selectionist proposition of agential-mediation, accommodates the iterations of agency, habitation, flow, self-concept, self-determination, intentionality and the many value-drives of motivation (e.g.,Bandura, 2001; Deci & Ryan, 1985; Deci & Ryan, 2008; Dweck, 1999; Graziano, 2013). Such a composite of agential function and affect in ecological engagement can be seen across species – from the increased dopamine release in 'playing' rats in interesting 'environments' (Panksepp & Biven, 2012), to the leaps of imagination and 'contextualisation' of bored children dreaming themselves out of classrooms, agential goal-orientation(s) towards increased Tolerance and future biological-value.

The fundamental simplicity of a Divergent Criticality mechanism when mediated through a composite of function, provides for a complexity in perceptual awareness and conscious behaviour.

It could be said that Divergent Criticality provides a ‘space for consciousness’ and may be used to parametrise ‘some’ of its behavioural outcomes. Though the mechanism may be simple, the outcomes can be infinitely complex.

The exploratory testing of the Divergent Criticality hypothesis of Tolerance Optimisation found significant results across all its research-designs supporting a Divergent Criticality entropic-mechanism for a cognitive drive and maintenance of Tolerance Optimisation through agential mediation. This supports the naturalistic hypothesis that we are truly ‘ecology defined’, and that creativity, intentionality and agential belief and desire, can only ever be borrowed from the potential of our biological functioning: a ‘limited’ function of reduced Voluntary Control and Effectivity. Therefore, the greater the Effectivity of the agent, the greater the potential for such contextual gain and a resilience and Tolerance to define a ‘spectrum of learning-function’ for the demands and learning-outcomes is required to tolerate the dynamic diversity and complexity in life. The practical application of this to learning is discussed in (Application 5: Healthy Learning and Wellbeing, p265). In considering the Divergent Criticality hypothesis, it suggests that education methodologies and policies may need to define more clearly the value concepts that will not only benefit society but will also utilise and benefit the optimisation of the individual’s abilities and capabilities.

Discussion Part Three: The Application to Learning of the Divergent Criticality Hypothesis

We learn innately, but how and what we learn are determined by our ecological engagement; an attentional-composite of situational and contextual neural-function influencing learning and perception processes. The functioning of Divergent Criticality self-organises to a state of Tolerance Optimisation, a learning state that may be considered as optimal in ecological function. Therefore, Divergent Criticality hypothesis has been presented as, primarily, an optimal learning theory – Tolerance Optimisation as an awareness and purposeful agency towards engaging with the opportunities available to the individual.

The findings from this study have inferred that there is the opportunity to enhance learning outcomes through a better understanding and application of Tolerance Optimisation. How the brain functions and responds to the learning environment, and how learning for the individual could be enhanced is discussed through five distinct applications:

Application 1: Increasing Learning Potential
Application 2: Learning Centred on the Learner
Application 3: Motivating Long-Term Learning
Application 4: Developing Expertise
Application 5: Healthy Learning and Wellbeing

8.7 Application 1: Increasing Learning Potential

Learning in Divergent Criticality is the refinement of the individual's learning-potential – Developmental interventions in education should therefore look to increase learning-potential.

There is a natural 'drive' to engage, experience and learn from the world, which, as a situative or dispositional proposition might be considered as the developing of neural 'structures' and building a learning potential (see, 8.6.2 – A Learning-Moment as a Composite of Function, p244). Divergent Criticality in a self-organising Tolerance Optimisation, sees affective behaviour oriented towards an 'experience contingent learning'. Though addressing a 'structural optimisation' (the building of neural structures of complexity), if only ever situationally-responsive, this would be a 'dynamically inefficient' proposition for learning in a changing world of unknown challenges (see, 8.6.3 – A Learning Potential, p245). However, such 'situative' function does provide a 'learning platform' on which to develop further ‘refined understanding’ through the learner’s contextualising of their experiences – a dynamic ‘optimisation’ of both situational and contextual determinates. Education, in this regard, might consider not only learning interventions attuned for an ‘optimisation’ of learning-potential, but also be able to align this to greater effect by considering the learning-proclivities and capabilities of the learner (see, Application 2: Learning Centred on the Learner, below).

Example: In building a learning-potential as a ‘learning platform’, it might be considered that an experiential ‘situative’ learning approach (see, Building Learning Potential, p256), favours a ‘developmental’ period in educational induction and introduction processes. Higher Education (HE) would favour times of student exploration and academic uncertainty (such as first year students getting to ‘explore’ the University’s systems and complexity before specific directed learning.

Here, the focus on experiential and exploratory learning over overt (top-down) contextualising, would favour motivation and attribution for learning and not detrimentally affect intentionality through non-essential cognitive distractions (specific academic-gain and specialisation are eschewed in favour of a generic exploration of the HE learning environment by the learner). Such an experientially biased learning approach might allow the student to develop agential ‘interest’ that though initially, situational, may later become mediated (agential or educator-guided) towards more ‘contextual’ curriculum or specific end-goals. In this way, biasing a student potential, in turn provides a functional platform for developing student capability (Tolerance) and learning gain.

8.8 Application 2: Learning Centred on the Learner

Divergent Criticality sets the student at the centre an optimal-learning methodology, individualised learning engagement informing learning-gain.

At the crux of Divergent Criticality is an embodied constructivism for the implementation of situative and contextual end-points in learning. This prerogative considers the individual’s ‘learning functioning’, over and above pre-determined aims and goals when developing learning interventions – interventions which at the very least, should operate within the learner’s Tolerance Optimisation.

In order to develop long term learning as an agential behaviour (a learning motivation), requires focusing on the student mediation of Tolerance Optimisation: the developing of Interest and hedonic-biases towards learning skills (see, 8.6.5 – A Drive or Motivation, p248). Thus, in defining learning-gain (a contextual bias in the functional composite of learning: 8.6.2, p244), education-methodologies might look to the relative Effectivity of the student and their agential-mediating of Tolerance Optimisation as learning proclivities and intentionality. It is in Divergent Criticality's recognition of the learner's neural functionality, that learning is not tailored only to the 'required' end-points, but also to the individual's functional capabilities. This is not a stating of the obvious in re-describing, good teaching and methodological practice, but a 'teaching' that concurs with Tolerance Optimisation, a recognition of an individualised functionality requiring an individualised 'pedagogical' approach to learning. – Rather than the differentiation of teaching practice, different pedagogical learning journeys are required for each learner, so that learning-gain is achieved and maintained at an optimal function.

Learning-gain may be guided through experiential and contextual interventions, continually adapted to the learner's 'functional' optimisation – a resonance with learner's capabilities and motivations.

Example: where there is 'contextual' paucity (learnt or hereditary dis-inhibition), then a more situative/ experiential grounding to learning would bias learning-potential as a platform on which to refine future contextual depth (building learning potential before refining learning gain). Conversely, where a contextual focus is detrimental to the learner's wellbeing (inducing anxiety from overt top-down cognitions), then a more experiential or 'situative' intervention might help 'reset' normal function within learner Tolerance (see, 8.6.7 – Optimising Learning-Potential or Learning-Gain, p254).

Divergent Criticality and Tolerance Optimisation do not advocate 'situative learning' over 'contextual learning' – both are necessary in a 'composite of function' for learning-gain. It is not that education should be parsed into experientially-biased or contextually-refined pedagogies, but using Divergent Criticality functionality (for Tolerance Optimisation), traditional 'Classroom Education' and its contextual focus might better inform 'Learning outside the Classroom', and 'Learning outside the Classroom' provide a greater situative guidance for Classroom Education.

This is the recognition of the 'functional prerogative' in any agent/environment learning engagement, over and above goal-oriented or specific end-points (academic or skill acquisition). Functionally, in response to what might be considered predominately, 'contextual' post-industrial end-points for education, Divergent Criticality suggests that a greater 'situative' application for education methodologies and pedagogy, would better address the learner's capabilities and proclivities towards learning as central and foremost (see, Building Learning Potential, p256). As a 'developmental-learning' approach, this may also offer opportunities for learner capabilities (hereditary and/or learnt-ability to contextualise) to be recognised and education be better aligned to the student and not the system (see, Agential Mediation and Regulation Shifting and Switching Behaviour, p252).

Example: such 'student centred learning', might offer multi-assessment criteria that accommodates 'flexible' achievement goals (student centred), rather than a 'conformity towards assessment'. Subsequently, it might be critiqued that, many 'Learning Support Plans' in attempting to accommodate the student's learning needs, actually 'manipulate' the student's learning-weaknesses towards 'too-ridged' end-point assessments. A Divergent Criticality functional approach would look to accentuate the learning-strengths of the student in an individualised learning optimisation – personalised end-points and assessment criteria, made fungible in achievement and learning-gain.

As learning becomes a habitualised behaviour, it may be contextualised by the student as a 'learnt skill' – a learning capability that reflects the functional determinants applied to the individual. This offers a spectrum of educator influence and functional guidance that can be aligned and applied to the learner, a 'guided learning' that ranges from the more traditional contextual-interventions, to less-guided experiential environments of exploration, surprise and adventure. This enables an attentional-continuum to be tailored to the learner's cognitive resources and learning demands guided through: i) cognitively-engaging with experientially 'wide' (situative) experiences; ii) to a more 'narrow', contextually-focused attention. Both these wide and narrow attentional-states are intrinsically interwoven in the Divergent Criticality hypothesis as a 'composite' of cognitive functioning, which can be manipulated to favour building learning-potential and/or learning-gain (see, 8.6.2 – A Learning-Moment as a Composite of Function, p244).

8.9 Application 3: Motivating Long-Term Learning

Tolerance Optimisation as a 'functional' learning-state, informs perceptions of self-belief, self-control and of agency. Such cognitive-emotional 'states' perpetuate behavioural 'traits' that may motivate long term learning.

If we consider the student at the centre of learning, then learning that is accessible to the student's functional capability becomes a learner-perception of cause and consequence, attributions that emerge as end-point motivations or learner mediated Tolerance Optimisation towards learner salient-goals (Bandura, 2001; Bandura & Locke, 2003; Dickinson & Balleine, 2000; Honicke & Broadbent, 2016; Vancouver, Thompson & Williams, 2001). In a 'reciprocal determinism' (a resonance between agent and environment), these goal-oriented 'beliefs' develop an agency for future achievements and self-determination. It is in how the educator helps to shape the functional landscape (the composite of situative and contextual learning) as a unique optimisation, that learning motivations may be guided and determined by Divergent Criticality and learner mediated Tolerance Optimisation (see, 8.6.5 – A Drive or Motivation, p248).

As such, motivation is an attentional 'dynamic' state, a 'learning moment' mediated by attentional processes (situative and contextual). Divergent Criticality allows the manipulation of situative and contextual bias in learning interventions (e.g. guided and experientially less-guided learning, see, Barrows & Tamblyn, 1980; Greeno *et al.*, 1996; Guay, Ratelle & Chanal, 2008; Kirschner, Sweller & Clark, 2006; Noë, 2008; Schmidt *et al.*, 2007). What emerges is a continuum of 'guided learning' towards maintaining an optimal learning-moment, learning interventions continually oriented towards the relative Effectivity 'state' of the learner (their self-attributions and relatedness learning end-points). This individualising of learning is a proposition considered "germane" to a learning-constructivism (Schmidt *et al.*, 2007, p93); a 'level of guidance' that puts the learner at the locus of a self-regulating, self-directed learning experience, but a learning-experience constrained to the learners capabilities, acceptance and mediation of – Tolerance Optimisation.

Education policies that have predominately focused on specific-goals as societal/cultural end-points (such as academic-examination and deliberate/repetitive practice), are contextual-biased learning methodologies that may exclude the individual's relatedness, intentionality and Effectivity therefore, restricting the optimising of learning-potential and future learning-gain. Therefore, a situative learning-approach of 'experiential' education has been suggested as a more student-centred approach, than that of the traditional classroom-learning environments (Cason & Gillis, 1994; Dillon et al., 2005; Hans, 2002; Hattie et al., 1997; Malone, 2008; 2004).

This experiential 'situative-bias' for student relatedness and mediation, was supported in this study's hypothesis H2 and H3, with greater learner-interest and 'intrinsic' motivation being reported (perception measures of self-concept), over more traditional 'contextual' classroom learning (see, 7.3 – Difference Tests between High and Low states of functional Affordance, p208). Here, positive self-concept was reported in learning environments that maximised Tolerance Optimisation through a learning-moment or 'composite', of situative and contextual attentional demands. It is in maintaining the 'relatedness' of the learning-moment to the end-point or goals of education, that learning traits become affective as learning-motivations through situational interest and hedonic-bias – the long-term functional regulation (situative/contextual) and learner motivation(s) for learning goals. The educator therefore should look to both short and long term learning goals of agential-relatedness, to develop for long term learning capabilities and learning motivation.

Example: Long term educational goals are known to illicit student 'amotivation', be it mid-module or mid-course phenomena such as 'second year drop-out' of HE students (e.g. Jacobs & Newstead, *2000; Lieberman & Remedios, 2007; Thompson, Milsom, Zaitseva, Stewart, Darwent & Yorke, 2013). Divergent Criticality allows greater attention to the 'learning moment' as a functional-state needing to be attended towards agential goals; the mediation of Tolerance Optimisation in maintaining an agential 'relatedness' state, therefore, a long term learning-trait (as a key motivational drive). This requires a collaborative and continuous communication between learner, the educator and the curricula as discussed in (Cook-Sather, Bovill & Felten, 2014; Murphy, Nixon, Brooman & Fearon, 2017). This is a student/educator collaboration, relating student capabilities to motivational goals (informed from experience and understanding of 'previous' learning behaviours), developing an optimal 'learning function' related to student proclivities.*

Such continual 'attention to learning' allows long-term learning-gains to be functionally guided and contextually grounded – the 'how' underpinning the student being 'enabled' to achieve their best. Importantly, this must not be an expectancy (student or educator) of 'success or restriction', but an optimisation of the unique learning-functioning in each student – a learning-composite with many different learning-routes to 'optimal' learner-specific goals.

Divergent Criticality suggests that there may be many different 'Learning Moments' for a learner across a continuum of learning function. Using Tolerance Optimisation to guide a 'functional state' might help identify and parameterise learning-goals as accessible to the capabilities of the learner. These learning-states can then become long term traits, a meta-cognition where learning-gain is contextualised beyond short term gratification – A learning-moment focusing on salient goals, becomes internalised as 'agential-attributions' of learning motivation, autonomy and relatedness to educational end-points. Divergent Criticality provides a functional approach for long-term learning through optimising learner-interest and motivation, the functional determinants of learnt-behaviour (Chen *et al.*, 2001a; Deci & Ryan, 1985; Hidi & Anderson, 1992; Rotgans & Schmidt, 2011).

8.10 Application 4: Developing Expertise

Expertise may be considered as a 'deliberate-habituation' – an efficient resonance between the agent and the ecological demands of 'the expertise'.

A Tolerance Optimisation represents the individual's optimal (neural) functioning for learning; however, not all Tolerance Optimisation states are the same learning-composite; they encompass a spectrum of optimisation-function from situative skill-acquisition through to contextual theorising. This allows the manipulation of this composite of learning function in two ways: for either greater situational interventions grounding learning in action to optimise skill-acquisition; or an agential-mediation (cognitive focus) towards contextual goals (see, 8.6.4 – A Learning Gain, p246). Thus to optimise a deliberate expertise, we need to consider the specific demands (ecological) of a directed expertise and the optimal learning interventions in achieving that expertise.

As an ecological function, expertise is ‘represented’ as a neural-efficiency in relation to the ecological (expertise) demands. Such ‘efficiency’ relates cognitive-effort to expertise – the greater the habituation towards a ‘specific’ expertise interaction, the less cognitive-effort required and less attention given to that interaction. If the agent is able to dedicate their neural resources to the engagement in the ‘here and now’, what has been documented as an optimal affective behaviour (e.g. 'flow', Csikszentmihalyi, 1990; Hanin, 1980, etc.), then such optimising of a functional habituation as a neural-efficiency proposition sees expertise-habituation represent an automatic, non-attentive state of Voluntary Control.

Educating to ‘maximise efficiency’ might then be considered as a priority in coaching and learning; however, ‘neural efficiency’ in Divergent Criticality terms, does not build neural-potential or increase agent Effectivity, it instead, focuses existing neural-capability towards agential (mediated) expertise end-goals. There is an expertise dichotomy, therefore, that in deliberately focusing learning function for expertise (the contextual refining of expertise as specific learning-gain), the learner’s potential ‘capability’ may be limited through too restrictive a focus. It might, therefore, be argued, that there has been an overt focus on expertise as a niche’ optimisation through deliberate practice (e.g. Ericsson, 1993). This approach restricts learning-potential when considered within Divergent Criticality functionality; if we educate for only a ‘niche’ of potential (a deliberate expertise), this misses the opportunity of our more expansive, dynamic capability for increasing learning-potential[120]. Though we need to consider the determinants of the expertise required for specific end-points (the need to match desired-goal characteristics with the resonate learning engaged in by the learner, i.e. skill acquisition will ultimately require contextual skill learning), there is also a need to build a situated ‘platform of experience’ from which to contextually refine ‘acquisition in learning-gain’. It is in the optimising of a learning-potential that educators and coaches of expertise could consider generalise learning (experientially novel and new) – especially in the developmental stages of expertise.

[120] Complexity function in Divergent Criticality provides a fundamental perspective to expertise potential, in that contextual learning moments are analogous to that of the agent, therefore optimising the complexity potential of the agent that will allow greater contextual (expertise) and future focus.

The Divergent Criticality hypothesis guides strategies for optimising function (situative and contextual) towards the desired end-goals of expertise (either physical skill or knowledge acquisition). Though skill acquisition should be 'deliberately' educated for, it should be part of a learning composite that aims to optimised the situative 'potential' as well as the contextual expertise-focus of the individual. The optimising of a 'situative' Tolerance Optimisation (increasing learning-potential), provides a greater neural base on which to develop future contextual skill or learning gain.

Example: In practical terms, to optimise expertise, learning-potential should first be promoted, then learning-gain expertly refined – First, to achieve a maximal learning potential learners should be taken to the limits of their capabilities, but functioning 'at the edge' of their comfort zone (Tolerance Optimisation), not the limit 'beyond' Tolerance Optimisation (which favours the deliberate, intentional learning-gain). This emphasises expansive engagement with a 'wide' approach to ecological dynamics (rather than the constraint and specificity in a learning-engagement directed for expertise). This is a 'learning for expertise', a Tolerance Optimisation that is parameterised by functioning at a state where affective behaviour becomes effortful, a learning state that has been parameterised in Divergent Criticality as where White-shift becomes a Brown-Shift in entropic flux (see, 8.5.3 – Considerations of Habituation and Expertise, p241). In concert with learning-potential, deliberate practice focused on expertise may be integrated by taking learning 'function' to the edge of Tolerance, as parameterised in Divergent Criticality as a Brown-Shift in entropic flux taken to the limits of Tolerance Optimisation (i.e. before performance collapse).

8.11 Application 5: Healthy Learning and Wellbeing

Divergent Criticality is a self-organising (learning) mechanism where cognitive-behaviour is affectively regulated to optimal 'Tolerance' function and emotionally rewarded for. Learning function, therefore, may be associated with cognitive-emotional behaviour and wellbeing.

Affective emotion-regulation as a perception affects an innate and goal-oriented drive for a Tolerance Optimisation (a composite balance of situative and contextual function), the learning-mechanism driven by Divergent Criticality. When learning function is emotionally aligned to affective cognitions at a 'cusp' of Tolerance Optimisation (see, 3.10 – How the Brain Knows: Tolerance Optimisation, p113), as a self-regulating mechanism around an 'optimal-cusp', Criticality 'affects' both positive cognitive-emotions when close to cusp, and negative cognitions when or far 'beyond' cusp (adverse affective-cognitions of boredom and deprivation anxiety, or fear and overt anxiety – see, 2.14 – Cognitive Processes of Attention, p44).

It could be argued that modern world and western education structures have become overtly 'contextualised' in their delivery and assessment, with a focus on technological and academic minutiae (such as exam end-points and overtly contextual – Information Technology); a bias excluding the 'situative' balance from an expansive, ecological engagement (a human 'nature' evolved into the demands of the self, the social and physical environments). Such 'overt' academic methodologies {Robinson, 2010 #1801}, with an 'attention to contextual learning' function (see, 8.6.8 – Overt Contextual Behaviours, p255), risks affective-cognitions functioning far from a cusp of Tolerance Optimisation – a 'less than optimal' state of functional Affordance (and negative perception). Here, a relative cusp-collapse ensues as function is taken beyond Tolerance Optimisation and elicits adverse behavioural and cognitive effects.

Such states of functional Affordance represent increasing distraction[121] and anxiety, 'less than optimal' function that may well manifest as abnormal or dis-functional goal-directed behaviours and detachment cognitions. If education is able to accommodate a functional approach to learning methodologies, it might look to implement greater situative demand (especially in formative teaching and coaching periods of learning-development), in balancing the functional composite of situative and contextual demand. This greater adherence to the functioning composite necessary for Tolerance Optimisation, results in a greater functional resilience to a learner's contextual-mediations and greater emotional regulation – states of function inducing affective cognitive behaviours of less anxiety in learning.

Example: The encouraging of grade-boundaries as end-point metrics in education represents an exaggerated 'contextual-demand' on the learning-function, one that may lead to learning dis-function (e.g. study obsessive 'top-down' cognitions and behaviours – Tolerance Optimisation is compromised at the cost of affective-behavioural and psychological wellbeing); thus being counter-productive to achieving the very contextual 'optimisation' end-points it seeks.

In addition, learning, if overtly contextually-biased in its functional demands towards non-salient end-points (not related to agential goals), may also deliver dysfunction in learning behaviour as affective-cognitions realise a 'lesser' functional Affordance state – affective-cognitive behaviours of 'amotivation' may result, i.e. boredom, dis-engagement and eventually, learning drop-out (as seen in

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[121] Distracting, as in taking neural resources 'away' from ecological representation and action/perception efficiency (Voluntary Control) – a reduced Voluntary Control (rVC).

the sampling of some theoretically-obtuse sampling domains (see functional Affordance states (IP7), 0 – APPENDIX XV: Sample Interdependence Profiles, p363). In this study, most of the education domains sampled 'did not' reflect such overt contextual-demands. It is in addressing the balance of situative and contextual learning demands, that a composite of learning-function might be promoted for student well-being and health.

Example: In overtly contextually-demanding learning environment, re-balancing the learning function through increasing 'situative' or experiential activities may be applied. This is evident in a resurgence of experiential activity and therapy interventions – be it cognitive-behaviour or 'mindfulness' techniques of attentional mediation (an attention to the 'now', of being in the moment), to the restorative benefits of physical exercise and green spaces (for education, anxiety and recuperation). Using Divergent Criticality and the Tolerance Optimisation hypothesis allows a 'taught' capability to be emotionally-regulated, the situative and the contextual demands on attention to be varied and compartmentalised, and allows not only a functional grounding of cognitive-emotional behaviours (and a wellbeing through Tolerance Optimisation), but also increases the learning-potential (see, 8.7, p258) increasing Tolerance and resilience of the learner towards future contextual demand.

Throughout the application of the Divergent Criticality, it is in this 'functional balance', that we are reminded that we are products of our evolution – an evolution of social-engagement and situative-demands. This study does not advocate that one approach to learning is necessarily better than another, rather it requires us to consider all the determinants of learning, both the situational and contextual functional demands. These are set within the needs and context of a 'dynamic' methodology: a learning function directed towards achievement goals, but guided by hereditary and agential proclivities. This is an educational proposition that optimises agential well-being, but also accommodates the contextual and learning values and gains society determines.

9 CHAPTER NINE – Conclusion

9.1 Divergent Criticality: A Radical Ecological Psychology

The Divergent Criticality hypothesis has been presented as a theory of ecological perception. When set within the self-organising processes of non-linear physics, biology emerges as a self-replicating autopoiesis, and Dynamical Theory is able to be formulated for perceptions and cognitions resonating with ecological demand. In doing so, a hypothesis of agential-mediation of affective behaviour is formulated and tested in the Divergent Criticality Hypothesis. Here, cognition and behaviour, rather than being ecologically bound, become conscious as an agential-mediated function. Such agential mediation of neural 'entropic' processes can then be considered as a functional imperative for learning in dynamic environments of surprise and change. The Divergent Criticality hypothesis, therefore, is proposed here as a fundamental mechanism for perception and learning.

Chemero (2003) has argued that although an ecological approach to perception is an agential concept, it cannot be considered as selectionist since in its animal-environment autonomy, it is individual and niche-limited rather than species-oriented. Chemero (2008, 2013), though justifiably sceptical in attaching a selectionist label to perception, does, however, recognise the beginnings of agent-environment 'agency' in having affective-behavioural (biological) value:

"Combining Affordances 2.0 with enactivist studies of the organism makes for a fully dynamical science of the entire brain-body-environment system: non-representational neuro-dynamic studies of the nervous system and sensorimotor *abilities (Cosmelli, Lachaux, & Thompson, 2007; Thompson & Varela, 2001) match up with ecological psychological studies of affordances and sensorimotor abilities"* (Chemero, 2008, p267).

In suggesting that perception (as an Affordance) might be naturalised and aligned with biological-value, though parsimonious in his attaching a selectionist function to Ecological Psychology, Chemero, does bring together the functionalism of Ecological Psychology with the structuralism of Cognitive Science in a 'Radical Embodied Cognitive Science' (see over, Chemero, 2013).

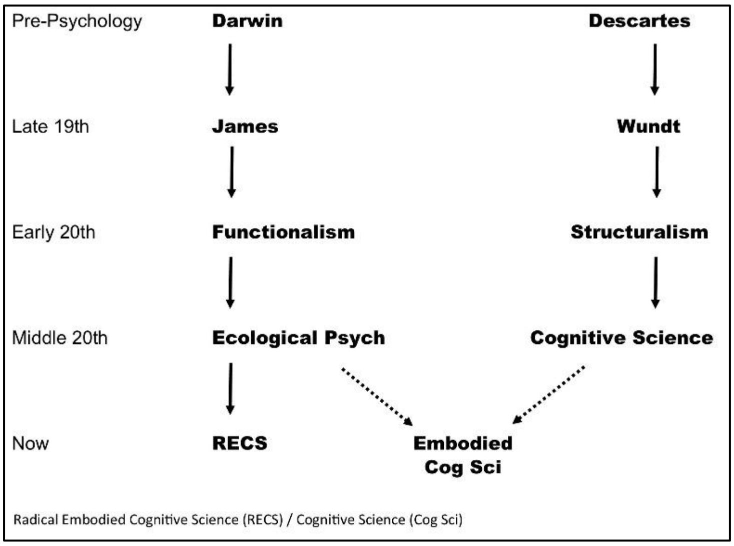

Figure 51 – Intellectual lineage of modern psychological traditions (from, Chemero, 2013, p147)

Radical Embodied Cognitive Science (Chemero, 2009; Kaufer & Chemero, 2015; Thompson, 2007), sets perception within a Darwinian/Jameson 'functionalism', but, as grounded in Dynamical theory, provides an objectivity and structuralism to agent-environment autonomy: As such, agential subjectivity is able to be ecologically-coordinated in a 'naturalised' neural-function. This permits the Divergent Criticality theory to be set 'within' a Radical Functionalism, and can be aligned with the Phenomenological and Cognitive Science traditions. This enables Darwinian principles (of biological-value in perception) to be fulfilled and the selectionist definition applied to the Divergent Criticality hypothesis as a perception of and from, dynamic entropic-function. Divergent Criticality may be considered, therefore, as a selectionist hypothesis.

9.2 Developing a Theory of Divergent Criticality and Tolerance Optimisation

This study set out to explore the functioning of a Divergent Criticality hypothesis through perception measures as inferring the functioning of the processes which drive learning. The research developed a fundamental concept for explaining perception and understanding learning, that of a Self-Organising Tolerance Optimisation – a mechanism for ecological adaptation and learning.

The literature review explored perception from a phenomenological and neuro-psychological perspective, enabling a relationship between attentional processes and affective behaviour to be proposed. Entropic behaviour (formulated in Free Energy principles), was then applied to an ecological framework for biological-value, providing a coordinating-definition of 'Tolerance' with which subjective perceptions may be empirically observed. Awareness of attentional processes was hypothesised as a neural state of Tolerance and a 'perception' of a functional Affordance state. This 'state' of functioning represents neural-efficiency in a landscape of neural (entropic) function, and perception measures, therefore, can be modelled on agential mediated Affordance in terms of Tolerance Optimisation.

Divergent Criticality, in developing a functional imperative for neural processes towards biological-value, proposes that learning is optimised at a point of maximum entropic-dissipation and that cognitions and behaviours are driven to this threshold by Divergent Criticality as a fundamental entropy-mechanism. By utilising a biological-value model and formulating function as a 'relative' Effectivity, the Divergent Criticality hypothesis is able to parameterise a Tolerance Optimisation, and coordinate observation of perceptions as 'awareness of attentional-processes', the neural processes of situative and contextual adaptation in neural complexity and Self-Organising Criticality.

9.3 The Testing of the Divergent Criticality hypothesis

Structural Equation Modelling (SEM) of perception measures, as a situational-awareness of a state of neural-function, allowed an inductive 'Interdependence Profile' to be derived as a 'state' of functional Affordance. These 'states' of functional Affordance not only correlated with the Divergent Criticality hypothesis predicted 'affective behaviour', but were able to differentiate between relative high and low (Effectivity) states. When set within the 'agential' functioning of relative-Effectivity, the Divergent Criticality hypothesis was significantly supported in the SEM modelling of affective cognitions inferring Tolerance Optimisation.

The Triangulation of the Interdependence Profile

Further support for the hypothesis was conducted in the triangulation of the Interdependence Profile (as a 'state of functional Affordance'), with a measure of 'self-concept'; correlation and difference testing were seen to concur significantly with the Divergent Criticality hypothesis of Tolerance Optimisation.

A Repeat Mixed-Measures Design

The repeat measures study (Two-Way Mixed ANOVA) exhibited significant inference in a difference test for the Divergent Criticality hypothesis. The differentiation here was of a qualitative-split of 'Traditional Classroom Learning' vs 'Learning Outside the Classroom' (LoTC). The findings significantly supported the hypothesis of LoTC eliciting greater affective cognitions for 'high' functional Affordance states (function near or at the cusp of Optimisation). These results were further supported with post-hoc triangulation with an Interdependence Profile. The Interdependence Profile for the two sample groups concurred with the hypothesised high/low states of functional Affordance, further supporting the Divergent Criticality hypothesis.

9.4 Further Directions for the Divergent Criticality Hypothesis

It is in the composite of ecologically-determined demands on cognitive function, that there is the opportunity to better define and manipulate the functional determinants of learning optimisation, a Tolerance Optimisation of affective-behaviour towards goal-oriented outcomes. This study, in suggesting Divergent Criticality as a functional mechanism, provides empirical support for its function and application. The ideas presented, are the early foundations of a Divergent Criticality Theory and further research is necessary to substantiate the hypothesis of Tolerance Optimisation. In defining a 'Universality' of neural-functioning for perception and learning, Divergent Criticality provides an opportunity for understanding not only how the brain learns, but the process that effect and shape that learning.

This study has in some small way, addressed Chalmers (1995) 'Hard Problem' of naturalising perception and conscious intentionality through an objective definition of Tolerance and relative Effectivity – functional Affordance. If accepted as a working hypothesis, a Divergent Criticality of Tolerance Optimisation has the potential to be applied to the exploration of neural function and aligned to nomothetic research (e.g. dynamical coupling paradigms and fractal-scaling research in ever more reductive-scanning of neural behaviour). If such observations are able to be situated within a mixed-methodology of enquiry, then it has the potential to provide the functional-holism demanded for the enquiry of brain and body function, a functional imperative to underpin perception-research with a Universality and to naturalise the explanations of the human condition – an Ecological Psychology.

9.5 Concluding thoughts

The Divergent Criticality hypothesis has presented a fundamental theory for neural function, in particular, the functioning of perception and learning in dynamic environments. By naturalising perception and behaviour within Universal principles, a model of learning as ecological adaptation, contributes to our understanding of the functioning of the brain and more pertinently, 'how' we learn. The results of this study provide support for the Divergent Criticality hypothesis and offer an exciting prospect, not only in the informed exploration of learning, but also the unravelling and understanding of how a perception of agency and intentionality in neural function inform our conscious experience. If substantiated, since all life is dynamic, Divergent Criticality may be applied more widely to encompass greater biological and ethological function.

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APPENDICES

APPENDIX I: Initial Pathway Analysis

Pathway guidance using original authors methodology (Chen *et al.*, 2001a): Correlation – Partial Correlation and Regression inform the 'Apriori' SEM Assumptions

Table 37 – Correlations – 2 tailed – df (37)

				InsEn	Nov	Att	Chall	SitIn
Exploratory Interest	-	Eng	Pearson	.655**	.583**	.415*	.496**	.672**
			Sig	.000	.000	.011	.002	.000
Instant Enjoyment	-	InsEn	Pearson	1	.582**	.805**	.409**	.929**
			Sig		.000	.000	.012	.000
Novelty	-	Nov	Pearson		1	.485**	.621**	.637**
			Sig			.002	.000	.000
Attention Demand	-	Att	Pearson			1	.326*	.831**
			Sig				.049	.000
Challenge	-	Chall	Pearson				1	.457**
			Sig					.004

** Correlation is significant at the 0.01 (2-tailed)

* Correlation is significant at the 0.05 (2-tailed)

Table 38 – Partial Correlations

Partial Correlations Of Interest (Instant Enjoyment Controlled – 2

Control Variables			Eng	Nov	Att	Chall	Sitin
InsEn	Eng	Corr	1.000	.328	-.251	.331	.226
		Sig		.051	.14	.049	.185
	Nov	Corr		1.000	.033	.516	.320
		Sig			.850	.001	.057
	Att	Corr			1.000	-.007	.376
		Sig				.970	.024
	Chall	Corr				1.000	.227
		Sig					.182

Partial Correlations Of Interest (Instant Enjoyment –

Control Variables			Eng	Nov	Chall	Sitin
Att	Eng	Corr	1.000	.480	.419	.645
		Sig		.003	.011	.000
	Nov	Corr		1.000	.560	.482
		Sig			.000	.003
	Chall	Corr			1.000	.354
		Sig				.034
	InsEn	Corr				.788
		Sig				.000

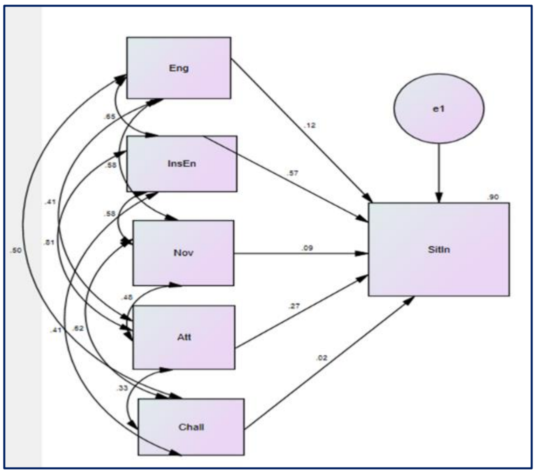
Table 39 – Regressions of Model 1

Model		R	R Square	Adjusted	Std. Error	
1		.951	.904	.888	1.1606	
Unstandardized			Estimate	S.E.	C.R.	P
SitIn	<---	Eng	.134	.083	1.622	.105
SitIn	<---	InsEn	.679	.130	5.207	***
SitIn	<---	Nov	.095	.080	1.198	.231
SitIn	<---	Att	.249	.084	2.975	.003
SitIn	<---	Chall	.021	.085	.253	.800

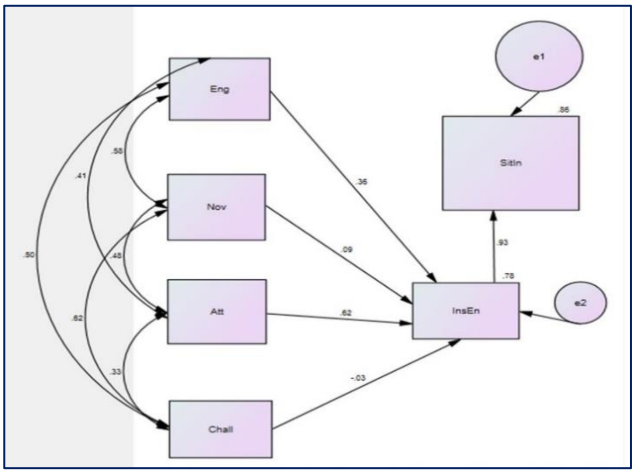
a. Dependent Variable: SitIn

Apriori – Situational Interest Path Analysis

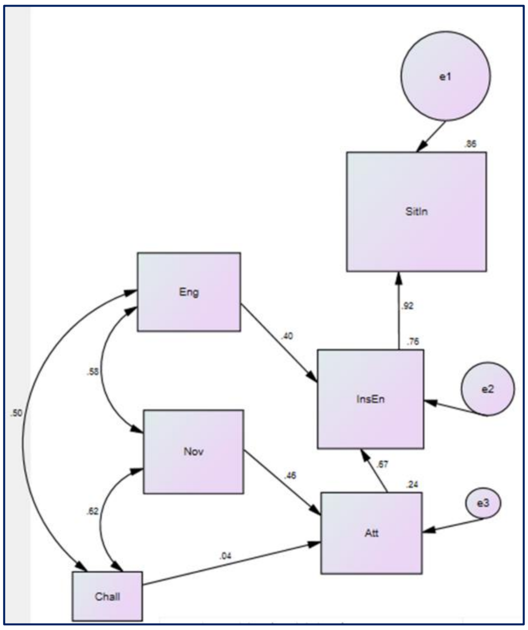
MODEL 1



MODEL 2



MODEL 3



Twin Pathway MODEL 4

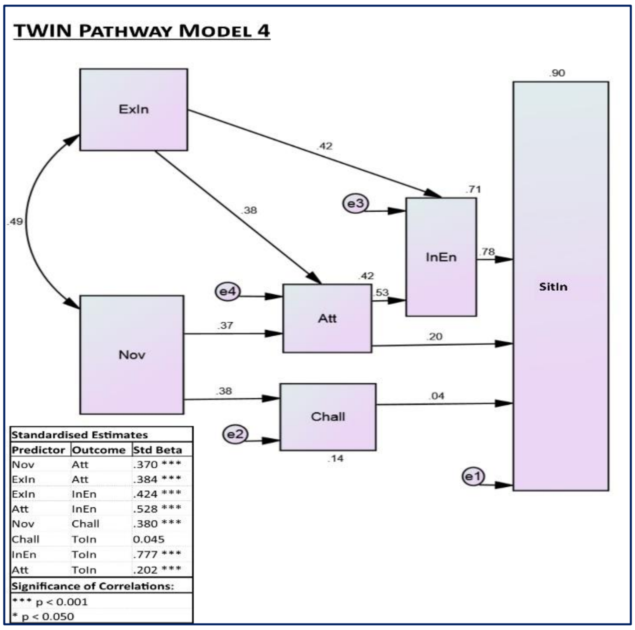


Figure 52 - Initial Pathway Assumptions (AMOS$_{IBM24}$)

Table 40 – Model Fit Thresholds for Twin Pathway Model 4

Recommended Threshold	Twin Pathway Model
Chi-square/df (cmin/df) <3-5	2.834 good
p-value for the model <.05	.0001 *
CFI >.95	.981 good
GFI >.95	.958 good
IFI >.95	.981 good
SRMR <.08	.0533 good
RMSEA <.06	.121 poor
PCLOSE >.05	.040 poor

Note: Thresholds from Hu and Bentler's "Cutoff Criteria and Fit Indexes" (1999)

APPENDIX II: Questionnaire Development and Providence

Pilot Study One: MK 1 – ORIGINAL SITUATIONAL INTEREST

Self-Concept and Cognitive Functioning: A Perception Study

Research request:

You are being invited to take part in a research study. Before you decide it is important that you understand why the research is being done and what it involves. Please take time to read the following information. Ask us if there is anything that is not clear or if you would like more information. Take time to decide if you want to take part or not.

What is the purpose of the study?

This research considers the effects of Experiential Learning on the ability of the brain to process new and challenging experiences and how this might affect your perceptions and self-concept. It is based on the premise that neural-efficiency may be assessed by measuring factors such as; interest, confidence, self-esteem, satisfaction, awareness, etc.

Do I have to take part?

No. It is up to you to decide whether to take part or not. You are free to withdraw at any time and without giving any reason.

What will happen to me if I take part?

You will be asked to complete a two-page questionnaire on Interest and Self-Concept, this should take no longer that 10 minutes.

You should only consider the activity or lesson you have just done when answering.

How do I complete this?

Please read the statements and circle the answer that indicates to what extent you AGREE or DISAGREE with that statement; e.g.

I don't agree **I Strongly Agree**

1	2	3	4	5	6	7	8

6 = I agree, but not too strongly!

Are there any risks / benefits involved?

Knowing what interests you and makes you feel good about yourself lets us design great teaching that you hopefully enjoy and learn from.

As with all psychological studies: some of the questions ask you to think about how you feel towards a situation, or about yourself. If any question causes you concern, please do not answer that question. If you are upset by any question, then please talk to your teacher, other pastoral care, or Head.

Will my taking part in the study be kept confidential?

This type of questionnaire does not show the final answer in your statement answers. Any personal information collected during the study will be anonymised and remain confidential. Personal data is requested on the questionnaire, you do not have to give this if you do not want to. All results are presented as a population statistic – there will be no way to identify your information.

David Larkin: c/o/LJMU, I M Marsh, Barkhill House, Aigburth, Liverpool , L17 6BD email-d.larkin@ljmu.ac.uk

If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Appendix II

NAME ____________________ AGE:_____(years) _____(mths) TODAY'S DATE:___ /___ /____

MALE ☐ FEMALE ☐ ACTIVITY / EVENT DESCRIPTION:_______________________

Part 1

This activity is exciting. InEn121	1	2	3	4	5	6	7	8
This is a difficult activity. Chal252	1	2	3	4	5	6	7	8
This activity is complicated. Chal152	1	2	3	4	5	6	7	8
My attention needed to be high. Att141	1	2	3	4	5	6	7	8
This activity is interesting. ToIn161	1	2	3	4	5	6	7	8
I was very attentive all the time. Att242		2	3	4	5	6	7	8
I like to find out more about how to do it. ExIn212	1	2	3	4	5	6	7	8
This is a unique type of activity. Nov434	1	2	3	4	5	6	7	8
I want to analyse it, to have a grasp on it. ExIn313	1	2	3	4	5	6	7	8
This activity is appealing to me. InEn414	1	2	3	4	5	6	7	8
The activity look fun to me. ToIn262	1	2	3	4	5	6	7	8
This was a new-fashioned activity for me to do. Nov333	1	2	3	4	5	6	7	8
It is an enjoyable activity to me. InEn222	1	2	3	4	5	6	7	8
I want to discover all the tricks in this activity. ExIn111	1	2	3	4	5	6	7	8
This activity is fresh. Nov232	1	2	3	4	5	6	7	8
This activity is new to me. Nov 131	1	2	3	4	5	6	7	8
I was focused. Att343	1	2	3	4	5	6	7	8
I was concentrated Att444	1	2	3	4	5	6	7	8
Its fun to try this activity. ToIn363	1	2	3	4	5	6	7	8
This activity is a demanding task. Chal353	1	2	3	4	5	6	7	8
This is an interesting activity. ToIn161	1	2	3	4	5	6	7	8
The activity inspires me to participate. ToIn323	1	2	3	4	5	6	7	8
It is hard for me to do this activity. Chall454	1	2	3	4	5	6	7	8
I like to inquire into details of how to do it. ExIn414								

Situational Interest Scale: Chen, A., Darst, P.W. & Pangrazi, R.P. (1999).

STUDY ONE - ORIGINAL ROPELOC QUESTIONNAIRE

GER20/9/00

PLEASE READ THESE INSTRUCTIONS FIRST

This is not a test - there are no right or wrong answers.

This is a chance for you to look at how you think and feel about yourself. It is important that you:

- are honest
- give your own views about yourself, without talking to others
- report how you feel NOW (not how you felt at another time in your life, or how you might feel tomorrow)

Your answers are confidential and will only be used for research or program development. Your answers will not be used in any way to refer to you as an individual.

Use the eight point scale to indicate how true (like you) or how false (unlike you), each statement over the page is as a description of you. Please do not leave any statements blank.

FALSE NOT LIKE ME							TRUE LIKE ME
1	2	3	4	5	6	7	8
This statement doesn't describe me at all; it isn't like me at all			More false than true		More true than false	This statement describes me very well; it is very much like me.	

SOME EXAMPLES

A. I am a creative person.	1	2	3	4	5	6	7	8

(The 6 has been circled because the person answering believes the statement "I am a creative person" is sometimes true. That is, the statement is sometimes like him/her.)

B. I am good at writing poetry.	1	2	3	4	5	6	7	8

(The 2 has been circled because the person answering believes that the statement is mostly false as far as he/she is concerned. That is, he/she feels he/she does not write good poetry.)

C I enjoy playing with pets.	1	2	3	4	5	6	~~7~~	8

(The 6 has been circled because at first the person thought that the statement was mostly true but then the person corrected it to 7 to show that the statement was very true about him/her.)

If still unsure about what to do, ASK FOR HELP.

Review of Personal Effectiveness and Locus of Control Instrument (ROPELOC), Richards, G. E., Ellis, L. A. & Neill, J. T. (2002).

STATEMENT	FALSE not like me - TRUE like me							
01. When I have spare time I always use it to paint. CI101	1	2	3	4	5	6	7	8
02. I like cooperating in a team. CT102	1	2	3	4	5	6	7	8
03. No matter what the situation is I can handle it SF103	1	2	3	4	5	6	7	8
04. I can be a good leader. LA104	1	2	3	4	5	6	7	8
05. My own efforts and actions are what will determine my future IL105	1	2	3	4	5	6	7	8
06. I prefer to be actively involved in things. AI106	1	2	3	4	5	6	7	8
07. I am open to different thinking if there is a better idea. OT107	1	2	3	4	5	6	7	8
08. In everything I do I try my best to get the details right. QS108	1	2	3	4	5	6	7	8
09. Luck, other people and events control most of my life. EL109	1	2	3	4	5	6	7	8
10. I am confident I have the ability to succeed anything I want to do. SC110	1	2	3	4	5	6	7	8
11. I am effective in social situations. SE111	1	2	3	4	5	6	7	8
12. I am calm in stressful situations. SM112	1	2	3	4	5	6	7	8
13. My overall effectiveness in life is very high. OE113	1	2	3	4	5	6	7	8
14. I plan and use my time efficiently. TE114	1	2	3	4	5	6	7	8
15. I cope well with changing situations. CH115	1	2	3	4	5	6	7	8
16. I cooperate well when working in a team. CT216	1	2	3	4	5	6	7	8
17. I prefer things that taste sweet instead of bitter. CI217	1	2	3	4	5	6	7	8
18. No matter what happens I can handle it. SF218	1	2	3	4	5	6	7	8
19. I am capable of being a good leader. LA219	1	2	3	4	5	6	7	8
20. I like being active and energetic. AI220	1	2	3	4	5	6	7	8
21. What I do and how I do it will determine my successes in life. IL221	1	2	3	4	5	6	7	8
22. I am open to new thoughts and ideas. OT222	1	2	3	4	5	6	7	8
23. I try to get the best possible results when I do things. QS223	1	2	3	4	5	6	7	8
24. When I apply myself to something I am confident I will succeed. SC224	1	2	3	4	5	6	7	8
25. My future is mostly in the hands of other people. EL225	1	2	3	4	5	6	7	8
26. I am competent and effective in social situations. SE226	1	2	3	4	5	6	7	8
27. I can stay calm and overcome anxiety in almost all situations. SM227	1	2	3	4	5	6	7	8
28. I am efficient and do not waste time. TE228	1	2	3	4	5	6	7	8
29. Overall, in all things in life, I am effective. OE229	1	2	3	4	5	6	7	8
30. When things around me change I cope well. CH230	1	2	3	4	5	6	7	8
31. I am good at cooperating with team members. CT331	1	2	3	4	5	6	7	8
32. I can handle things no matter what happens. SF332	1	2	3	4	5	6	7	8
33. I solve all mathematics problems easily. CI333	1	2	3	4	5	6	7	8
34. I am seen as a capable leader. LA334	1	2	3	4	5	6	7	8
35. I like to get into things and make action. AI335	1	2	3	4	5	6	7	8
36. I can adapt my thinking and ideas. OT336	1	2	3	4	5	6	7	8
37. If I succeed in life it will be because of my efforts. IL337	1	2	3	4	5	6	7	8
38. I try to get the very best results in everything I do. QS338	1	2	3	4	5	6	7	8
39. I am confident in my ability to be successful. SC339	1	2	3	4	5	6	7	8
40. I communicate effectively in social situations. SE340	1	2	3	4	5	6	7	8
41. My life is mostly controlled by external things. EL341	1	2	3	4	5	6	7	8
42. I am calm when things go wrong. SM342	1	2	3	4	5	6	7	8
43. I am efficient in the way I use my time. TE343	1	2	3	4	5	6	7	8
44. I cope well when things change. CH344	1	2	3	4	5	6	7	8
45. Overall, in my life I am a very effective person. OE345	1	2	3	4	5	6	7	8

Questionnaire and Providence Study Two: Mk 2

Self-Concept and Cognitive Functioning: A Perception Study

Research request:

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This research considers the effects of Experiential Learning on the ability of the brain to process new and challenging experiences and how this might affect your perceptions and self-concept. It is based on the premise that neural-efficiency may be assessed by measuring factors such as; interest, confidence, self-esteem, satisfaction, awareness, etc.

Do I have to take part?

No. It is up to you to decide whether to take part or not. You are free to withdraw at any time and without giving any reason.

What will happen to me if I take part?

You will be asked to complete a two-page questionnaire on Interest and Self-Concept, this should take no longer that 10 minutes.

You should only consider the activity or lesson you have just done when answering.

How do I complete this?

Please read the statements and circle the answer that indicates to what extent you AGREE or DISAGREE with that statement; e.g.

I don't agree **I Strongly Agree**

1	2	3	4	5	6	7	8

6 = I agree, but not too strongly!

Are there any risks / benefits involved?

Knowing what interests you and makes you feel good about yourself lets us design great teaching that you hopefully enjoy and learn from.

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Will my taking part in the study be kept confidential?

This type of questionnaire does not show the final answer in your statement answers. Any personal information collected during the study will be anonymised and remain confidential. Personal data is requested on the questionnaire, you do not have to give this if you do not want to. All results are presented as a population statistic – there will be no way to identify your information.

David Larkin: c/o/LJMU, I M Marsh, Barkhill House, Aigburth, Liverpool , L17 6BD email-d.larkin@ljmu.ac.uk

If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Appendix II

Situational Interest Mk 2

Part 1- (this is about what you have 'just' been doing – NOT your thoughts on this questionnaire)

This activity is exciting. **This activity is exciting. InEn121**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
This is a difficult activity. **This activity is complicated Chal252**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
This activity is complicated. **This activity is complicated Chal152**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
My attention needed to be high. **My attention was high Att141**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
This activity is interesting. **This activity is interesting ToIn161**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
I was very attentive all the time. **I was very attentive all the time Att242**		**2**	**3**	**4**	**5**	**6**	**7**	**8**
I like to find out more about how to do it. **I like to find out more about how to do it ExIn212**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
This is a unique type of activity. **This is an exceptional activity Nov434**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
I want to analyse it, to have a grasp on it. **I want to analyse it to have a grasp on it ExIn313**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
This activity is appealing to me. **This activity is appealing to me InEn414**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
The activity look fun to me. **The activity look fun to me ToIn262**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
This was a new-fashioned activity for me to do. **This is a new-fashioned activity for me to do Nov333**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
It is an enjoyable activity to me. **It is an enjoyable activity to me InEn222**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
I want to discover all the tricks in this activity. **I want to discover all the tricks in this activity ExIn111**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
This activity is fresh. **This activity is fresh Nov232**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
This activity is new to me. **This activity is new to me Nov 131**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
I was focused. **I was focused Att343**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
I was concentrated **I was concentrated Att444**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Its fun to try this activity. **Its fun to try this activity ToIn363**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
This activity is a demanding task. **This activity is a demanding task Chal353**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
This is an interesting activity. **This activity is interesting ToIn161**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
The activity inspires me to participate. **The activity inspires me to participate ToIn323**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
It is hard for me to do this activity. **It is hard for me to do this activity Chall454**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
I'd like more details of how to do this type of activity **I like to inquire into details of how to do it ExIn414**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

ROPELOC Mk 2

Part 2- what is your perception of yourself?

I Don't agree **I strongly Agree**

I enjoy working with others. **02. I like cooperating in a team. CT102**	1	2	3	4	5	6	7	8
I can handle things, whatever I might be asked to do. **03. No matter what the situation is I can handle it SF103**	1	2	3	4	5	6	7	8
I am open to new ideas. **22. I am open to new thoughts and ideas. OT222**	1	2	3	4	5	6	7	8
I try my best in everything I do. **23. I try to get the best possible results when I do things. QS223**	1	2	3	4	5	6	7	8
I know I have the ability to do anything I want to do. **10. I am confident that I have the ability to succeed in anything I want todo SC110**	1	2	3	4	5	6	7	8
I am calm when things go wrong. **12. I am calm in stressful situations. SM112**	1	2	3	4	5	6	7	8
I plan and use my time efficiently. **14. I plan and use my time efficiently. TE114**	1	2	3	4	5	6	7	8
I cope well with changing situations. **15 I cope well with changing situations. CH115**	1	2	3	4	5	6	7	8
I cooperate well with others. **16. I cooperate well when working in a team. CT216**	1	2	3	4	5	6	7	8
No matter what happens, I can handle it. **18. No matter what happens I can handle it. SF218**	1	2	3	4	5	6	7	8
I can change my mind easily if there is a better idea. **07. I am open to different thinking if there is a better idea. OT107**	1	2	3	4	5	6	7	8
I tried my possible best. **23. I try to get the best possible results when I do things. QS223**	1	2	3	4	5	6	7	8
When I really try, I believe I will succeed. **24. When I apply myself to something I am confident I will succeed. SC224**	1	2	3	4	5	6	7	8
I stay calm in almost all situations. **27. I can stay calm and overcome anxiety in almost all situations. SM227**	1	2	3	4	5	6	7	8
I do not waste time. **28. I am efficient and do not waste time. TE228**	1	2	3	4	5	6	7	8
I cope well when unexpected things happen. **30. When things around me change I cope well. CH230**	1	2	3	4	5	6	7	8
I communicate well with others. **31. I am good at cooperating with team members. CT331**	1	2	3	4	5	6	7	8
I can handle most things, no matter what. **32. I can handle things no matter what happens. SF332**	1	2	3	4	5	6	7	8
I like new ideas. **36. I can adapt my thinking and ideas. OT336**	1	2	3	4	5	6	7	8
I try to get the very best results in everything I do. **08. In everything I do I try my best to get the details right. QS108**	1	2	3	4	5	6	7	8
I believe I am confident and will be successful. **39. I am confident in my ability to be successful. SC339**	1	2	3	4	5	6	7	8
I am calm in stressful situations **42. I am calm when things go wrong. SM343**	1	2	3	4	5	6	7	8
I am efficient in the way I use my time. **43. I am efficient in the way I use my time. TE343**	1	2	3	4	5	6	7	8
I don't mind when things change. **44. I cope well when things change. CH344**	1	2	3	4	5	6	7	8

Situational Interest Questionnaire and Providence Study Three Mk 3

Part 1- what do you think about the activity you have 'just' been doing – NOT this questionnaire!

	I Don't agree							I strongly Agree
This activity is exciting This activity is exciting. InsEn121	1	2	3	4	5	6	7	8
It is hard for me to do this activity It is hard for me to do this activity Chall454	1	2	3	4	5	6	7	8
This activity is new to me This activity is new to me Nov 131	1	2	3	4	5	6	7	8
I was determined during this activity Att141 My attention was high Att141: now Toin 363	1	2	3	4	5	6	7	8
This activity looked an interesting activity This activity is interesting ToIn161	1	2	3	4	5	6	7	8
I'd like to find out more about how to do this sort of activity I like to find out more about how to do it ExIn212	1	2	3	4	5	6	7	8
This is an unique activity This is an Unique activity Nov434	1	2	3	4	5	6	7	8
I want to analyse it to have a grasp on it I want to analyse it to have a grasp on it ExIn313	1	2	3	4	5	6	7	8
This activity is appealing to me This activity is appealing to me InsEn414	1	2	3	4	5	6	7	8
I was curious to try this activity The activity looked fun to me ToIn262	1	2	3	4	5	6	7	8
This activity is fresh This activity is fresh Nov232	1	2	3	4	5	6	7	8
It was a tense activity Chall151 This is a complex activity Chall151 adapted to: I was determined during this activity Att141	1	2	3	4	5	6	7	8
This activity is an unusual activity for me to do This is a new-fashioned activity for me to do Nov333	1	2	3	4	5	6	7	8
It is an enjoyable activity to me It is an enjoyable activity to me InsEn222	1	2	3	4	5	6	7	8
I want to discover all the ways of doing this type of activity I want to discover all the tricks in this activity ExIn111	1	2	3	4	5	6	7	8
This activity was demanding This activity is a demanding task Chall353 Att242	1	2	3	4	5	6	7	8
I was nervous at times I was anxious during this activity InDis171 Chal252	1	2	3	4	5	6	7	8
I was focused I was focused Att343	1	2	3	4	5	6	7	8
My attention was high Its fun to try this activity ToIn363	1	2	3	4	5	6	7	8
The activity inspires me to participate The activity inspires me to participate InsEn323	1	2	3	4	5	6	7	8
I had to concentrate I was concentrated Att444	1	2	3	4	5	6	7	8
This can be considered a challenging activity This is an interesting activity for me to do ToIn464	1	2	3	4	5	6	7	8
I was uncertain at times This activity is a demanding task Chall353 now Att242 Chall353	1	2	3	4	5	6	7	8
I'd like more details of how to do this type of activity I like to inquire into details of how to do it ExIn414	1	2	3	4	5	6	7	8

ROPELOC Mk3

	I Don't agree							I strongly Agree
I enjoy working with others 02. I like cooperating in a team. CT102	1	2	3	4	5	6	7	8
I can handle things no matter what the situation is 03. No matter what the situation is I can handle it SF103	1	2	3	4	5	6	7	8
My own efforts and actions will determine my future 05. My own efforts and actions are what will determine my future. IL105	1	2	3	4	5	6	7	8
I can change my mind easily if there is a better idea 07. I am open to different thinking if there is a better idea. OT107	1	2	3	4	5	6	7	8
I try my best to get the details right in everything I do 08. In everything I do I try my best to get the details right. QS108	1	2	3	4	5	6	7	8
I know I have the ability to do anything I want to do 10. I am confident that I have the ability to succeed in anything I want to do. SC110	1	2	3	4	5	6	7	8
I cope well with changing situations. 15 I cope well with changing situations. CH115	1	2	3	4	5	6	7	8
I plan and use my time efficiently 14. I plan and use my time efficiently. TE114	1	2	3	4	5	6	7	8
I cooperate well with others 16. I cooperate well when working in a team. CT216	1	2	3	4	5	6	7	8
No matter what happens, I can handle it 18. No matter what happens I can handle it. SF218	1	2	3	4	5	6	7	8
What I do and how I do it will determine my success 21. What I do and how I do it will determine my successes in life. IL221	1	2	3	4	5	6	7	8
I am open to new thought and ideas 22. I am open to new thoughts and ideas. OT222	1	2	3	4	5	6	7	8
I tried to do my possible best 23. I try to get the best possible results when I do things. QS223	1	2	3	4	5	6	7	8
When I really try, I believe I will succeed 24. When I apply myself to something I am confident I will succeed. SC224	1	2	3	4	5	6	7	8
I do not waste time 28. I am efficient and do not waste time. TE228	1	2	3	4	5	6	7	8
I cope well when unexpected things happen. 30. When things around me change I cope well. CH230	1	2	3	4	5	6	7	8
I work well with others 31. I am good at cooperating with team members. CT331	1	2	3	4	5	6	7	8
I can handle most things no matter what 32. I can handle things no matter what happens. SF332	1	2	3	4	5	6	7	8
I like new ideas 36. I can adapt my thinking and ideas. OT336	1	2	3	4	5	6	7	8
If I succeed in life it will be because of my efforts 37. If I succeed in life it will be because of my efforts. IL337	1	2	3	4	5	6	7	8
I try to get the very best results in everything I do 38. I try to get the very best results in everything I do. QS338	1	2	3	4	5	6	7	8
I believe I am confident and will be successful 39. I am confident in my ability to be successful. SC339	1	2	3	4	5	6	7	8
I am efficient in the way I use my time 43. I am efficient in the way I use my time. TE343	1	2	3	4	5	6	7	8
I don't mind when things change. 44. I cope well when things change. CH344	1	2	3	4	5	6	7	8

APPENDIX III: Goodness of Fit Indices

Confounding Considerations of Chi-square (χ^2) tests in Absolute Fit Indices

This Chi-square (χ^2) test forms the bases of many 'fit indices' and is almost ubiquitously reported in SEM. However, χ^2 comes with inherent issues in relation to the data used (Newsom, 2012, p1):

1) It is confounded by large sample-size over 200 giving significance and possible Type I errors.
2) It can reject small sample models, Type II errors.
3) Chi-square is affected by skew and kurtoses, confounding multivariate normality.
4) Chi-square does not easily accommodate missing variables.
5) Complex models produce greater χ^2 confounding positive reporting (Kenny, 2015).

Where Chi-square forms the basis of other fit indices (transformations based on χ2), similar confounding must be considered, e.g. Goodness of Fit Index (GFI), adjusted Goodness of Fit Index (AGFI), root means residual (RMR) and standardised root means residual (SRMR).

Relative Fit Indices

It might therefore be advisable to look to test the 'assumed' model fit against an independent or null-model (all measured variables are un-correlated, i.e. no latent variables exist). When the assumed model is compared against the null model, a ratio or 'normed' relative measure of fit indices can then be produced such as Bollen's Incremental Fit Index (IFI) and the Tucker-Lewis Index (TLI). Of note is that Bollen (1990, in Newsom, 2018, p3) was able to show that IFI and TLI were relatively unaffected by sample size.

However, in acknowledging that any Chi-Square (χ^2) test is a normative distribution measure, there is a centrality to the null-hypothesis (no difference in model fit) causing concern in both Absolute parametric assumptions and Relative (alternative model) assumptions, as both are χ^2 fit generated. That is to say, that such multivariate 'normality' assumptions are not tested in both Absolute and Relative fit indices (Newsom, 2012). To accurately test normality, we need consider 'non-centrality':

Non-centrality fit indices aim to reject an 'alternative' hypothesis in a method where the χ^2 is given for a 'perfect fit' of non-centrality (1 rather than 0); if rejected, the multivariate data might be assumed 'normally distributed', obfuscating the χ^2 skew and kurtoses issues discussed above. Two such indices able to be considered normed-Relative fit indices (where ratios between 0 and 1 can be obtained), are the Bentler-Bonett Normed Fit Index (NFI) and Bentler's Comparative Fit Index (CFI). Such indices, then, are relative models and contemporary cut-off values for 'assumed fit' are accepted when the researcher-assumed model and the relative-alternative model (normed for non-centrality), are 'different' to a ratio measure of .95 (Hu & Bentler, 1999).

APPENDIX IV: Bias Considerations In Situational Domain Sampling

Expectation Bias

The possibility of an expectation-bias of ‘euphoric’ reporting, question the timing of the data collection (i.e. as at the beginning of a new phase of education, experience or life). The internal validity of such a measure is questionable in such instances, as it may represent ‘euphoric’ reporting (Marsh, Richards & Barnes, 1986). Rather than a measure of a current ‘state’, it may well be that an agential bias exists towards a percieved future state, one where an ‘emotional bias of expectation’ again informs a present cognition (Clark, 2013; Kahneman & Riis, 2005).

Frame of Reference Trait over State Bias

The positive reporting of cognitions of *Organisational Skills* (OS), saw *Time Effectiveness* (TE), provide more trait-like inference than ‘supposed’ appraisals of competence such as *Self-Confidence* (SC). These are seemingly more prevalent and might be considered to be trait-like cognitions of robust temporal effect. That some constructs of Self-Concept are more susceptible to a temporal ‘trait’ influence, and that their reporting might under-report the ‘state’ requirements of a Self-Concept perception measure. To this end, the duration of engagement might have a moderating effect on state reporting through a maturation ‘trait’ effect. Such a possible ‘duration’ effect on Self-Concept interventions has been reported in the literature (see, Rickinson *et al.*, 2004, meta-analysis), and might well be considered as a positive confounding of ‘state’ measurement. Therefore, constructs of Self-Concept that seemingly reflected more ‘state’ like perceptions were investigated in future studies.

Age, Activity and Gender

In addition to the maturation effect above, past reporting of Self-Concept has also reported the mediating effects of age, gender and environment (Dillon *et al.*, 2005; Hattie *et al.*, 1997; Malone, 2008). However, rather than a bias of non-homogeneity between sample groups, it is considered in Ecological Psychology that these effects as situational and mediating of a domain-effect on perception, present a supporting rather than confounding bias effect: If it is in ecologies of situation, self and environment that perception is formulated, sampling (if homogeneity ‘within’ group is maintained), statistical analysis of the ‘group’ will reflect a situational-bias effective on the functional state of individual’s perception. It is therefore in appropriate Divergent Criticality hypothesis to reflect such group-effect biasing as much a part of any individual perception effect and therefore, situationally valid in this studies ‘between’ groups (situational domains) hypothesis.

APPENDIX V: Study Two – ROPELOC Factor Analysis

Study Two: ROPELOC Factor Extraction

Table 41 – KMO and Bartlett's Test

Measure	Threshold		Test
Kaiser-Meyer-Olkin	**>.90**		.919
Bartlett's Test of Sphericity		Approx. Chi-Square	3769.863
		df	276
	p **<.05**	Sig.	.000

Table 42 – Initial Maximum Likelihood Components

Total Variance Explained

	Initial Eigenvalues				Parallel Analysis - Study 2		
Component	Total	% of Variance	Cumulative %		Mean	SD	95 percentile
1	**9.642**	40.173	40.173	F_1	1.559	0.0469	1.6364
2	**2.342**	9.759	49.932	F_2	1.4776	0.0397	1.5431
3	**1.543**	6.430	56.362	F_3	1.4116	0.0307	1.4622
4	1.231	5.129	61.492	F_4	1.3529	0.0304	1.403
5	1.064	4.433	65.925	F_5	1.297	0.027	1.3416
6	0.767	3.196	69.121	F_6	1.2494	0.0277	1.2952
7	0.743	3.097	72.218	F_7	1.1995	0.0239	1.2389
8	0.686	2.858	75.076	F_8	1.1526	0.0236	1.1916
9	0.647	2.696	77.772	F_9	1.1093	0.0213	1.1445
10	0.606	2.524	80.296	F_10	1.0696	0.0214	1.105
11	0.530	2.208	82.504	F_11	1.0302	0.0195	1.0623
12	0.506	2.109	84.613	F_12	0.9939	0.0223	1.0307
13	0.473	1.969	86.582	F_13	0.9536	0.02	0.9867
14	0.431	1.797	88.379	F_14	0.917	0.0212	0.952
15	0.362	1.507	89.886	F_15	0.8842	0.0206	0.9183
16	0.344	1.431	91.317	F_16	0.8479	0.0197	0.8804
17	0.321	1.337	92.654	F_17	0.8119	0.0207	0.846
18	0.298	1.242	93.895	F_18	0.7796	0.0215	0.815
19	0.285	1.188	95.083	F_19	0.7446	0.0214	0.7799
20	0.273	1.136	96.220	F_20	0.7119	0.019	0.7432
21	0.257	1.072	97.292	F_21	0.6735	0.0209	0.7079
22	0.236	0.982	98.274	F_22	0.6378	0.0223	0.6746
23	0.217	0.904	99.178	F_23	0.5926	0.0237	0.6318
24	0.197	0.822	100.000	F_24	0.5428	0.0344	0.5996

Note: Extraction Method: Maximum Likelihood Analysis.

Communalities

Table 43 – Communalities

CT102	0.626
SF103	0.480
OT107	0.452
QS108	0.525
SC110	0.587
SM112	0.646
TE114	0.292
CH115	0.505
CT216	0.583
SF218	0.653
OT222	0.286
QS223	0.398
SC224	0.435
SM227	0.606
TE288	0.339
CH230	0.665
CT331	0.534
SF332	0.605
OT336	0.408
QS338	0.478
SC339	0.554
SM342	0.680
TE343	0.365

Note: Extraction Method: Maximum Likelihood.

From this initial factor analysis, it was also possible to explore the Communalities between the variables; expecting variables that loaded sufficiently with a latent factor, to display reciprocal communality with other similar variables. In this instance, strong communalities suggested that communality above .30 would provide a guide to the initial investigation of variables, but a more stringent .40 could highlight variables less likely of causing potential validity problems further down the factor analysis.

(TE114 = .292), (OT222 **= .**286), (QS223 **= .**398), (TE288 = .339), (TE343 = .365) and (CH344 **= .**390) were highlighted as potential issues and though not removed at this stage, was monitored through the remainder of the EFA and future Confirmatory Factor Analysis.

A following Rotated Matrix (see, Table 44, below) was produced suppressed loadings less than (0.40).

Table 44 – Rotated- Matrix

FACTOR Variable	1	2	3
SM342	0.804		
CH230	0.795		
SM112	0.765		
SM227	0.738		
SF218	0.697		
SF332	0.684		
CH115	0.559		
CH344	0.495		
TE288	0.452		
TE114	0.446		
TE343	0.441		
CT102		0.770	
CT216		0.716	
CT331		0.613	
OT107		0.600	
QS108		0.534	0.488
OT336		0.512	
OT222		0.487	
QS223		0.467	0.425
SC110			0.694
QS338			0.618
SC339	0.402		0.607
SC224			0.566

Extraction Method: Maximum Likelihood.

Two cross-loadings were seen at this .40 threshold. Of concern were variables (QS108) and (QS223) as these did not express clear discriminatory loadings (r > .60) towards any one particular latent factor. These variables were not removed at this point, but was noted for future consideration (if there was a problem in later Confirmatory Factor Analysis). To help simplify the loading matrix further, a pattern matrix was now produced suppressing for discriminatory loadings.

Study Two - Confirmatory Factor Analysis: ROPELOC

Using the Rotated Factor Matrix, a basic model with all factors co-varied was built in AMOS$_{IBM24}$ (see below, Gaskin, 2016d), allowing the EFA to be taken forward for convergent and discriminatory validity within a model fit – a Confirmatory Factor Analysis CFA:

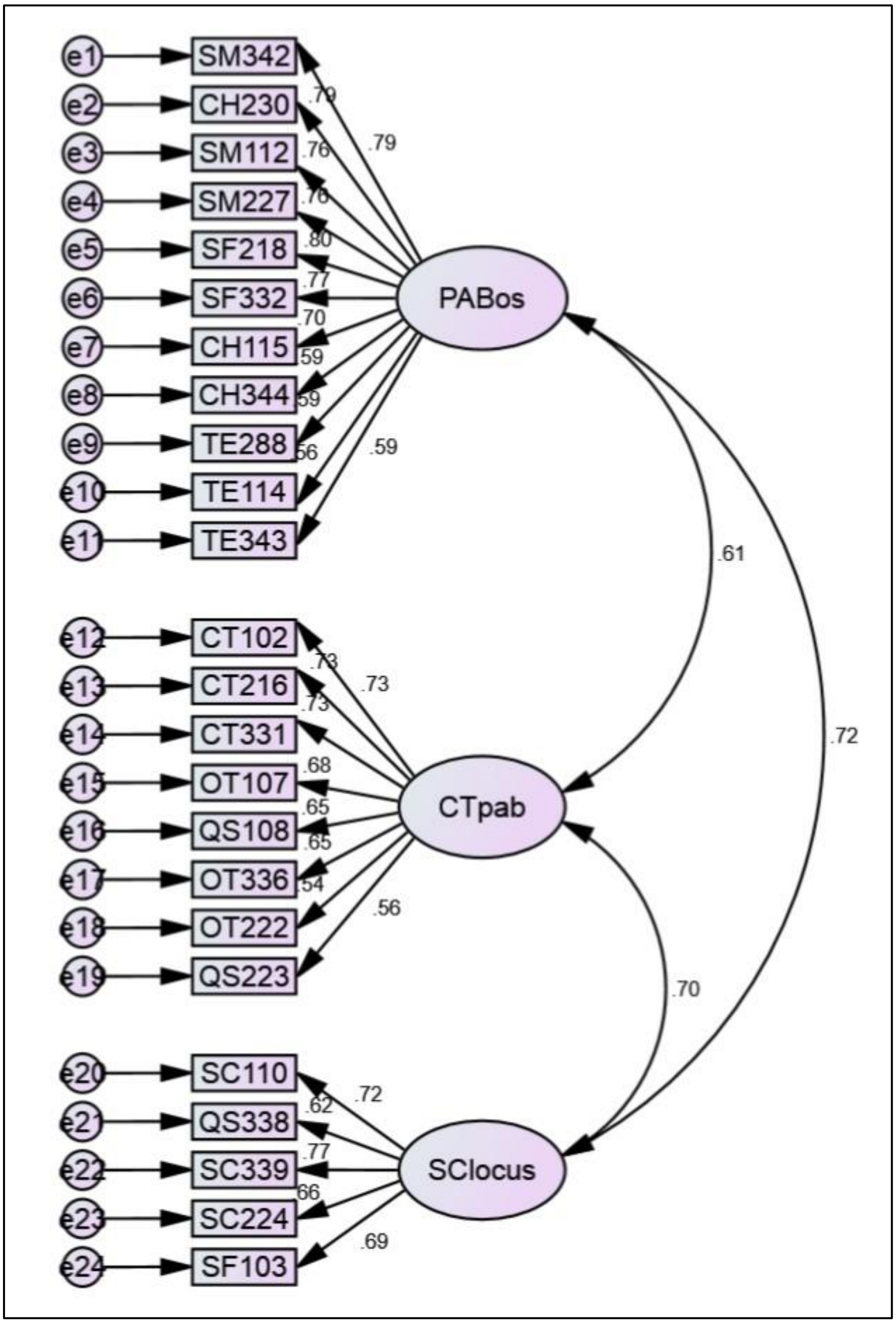

Figure 53 – EFA Suggested Factor Model (AMOS$_{IBM24}$)

Initially, no clear discrimination between the original ROPELOC Factors of Personal Abilities and Beliefs (PAB), Organisational Skills (OS) and Cooperative Teamwork. However, biased on the Study 1 correlations, nominal labels were applied to the factors in (Figure 53) representing the dominant bias. Of interest may the emergence of a self-confidence (SC) factor. As Study Two had identified 'Internal Locus' as a significant correlation, it was considered that such LOCUS might be in evidence.

Initial Confirmatory Model Analysis

The following guidance metrics were used in an initial-fit model to gauge validity.

Validity Issues

Time Effectiveness

Weak convergence validity was see across the Time Effectiveness variable ($r \leq .59$) (see, Figure 53, above). This was thought to indicate a lack of convergence on PAB from TE and the possibility of a latent factor not being adequately represented in a three factor model. However, Time Effectiveness was removed in this exploratory model to assess the modeling of the PAB factor, but noted for possible reintroduction in future analysis as TE had reported strongly in previous correlation analysis (see Study One).

Quality Seeking (QS223), Open Thinking (OT222) and Coping with Change (CH344)

CH344 and QS223 approached convergent validity ($r = .59$ and $r = .56$ respectively) and where retained though QS223 was subject to co-varying as per modification indices (below). Open Thinking (OT222) had displayed poor Communality and was therefore removed from the model.

Modification Indices

Available co-variances were applied to variables displaying high Modification Indices ($\text{AMOS}_{\text{IBM24}}$) where *a priori* knowledge (e.g., item similarity) provided enough face explanation for covariance:

QS223 and QS108 are thought to express the 'Quality Seeking' perceptions. QS223 and QS108 were therefore co-varied. This however did not improve the variables convergence ($r=.56$ reduced to $r=.50$) and therefore, QS223 was though eligible for removal.

A model with Time Effectiveness, QS223 and OT222 removed (Figure 54, below) was now taken forward to confirmatory factor analysis.

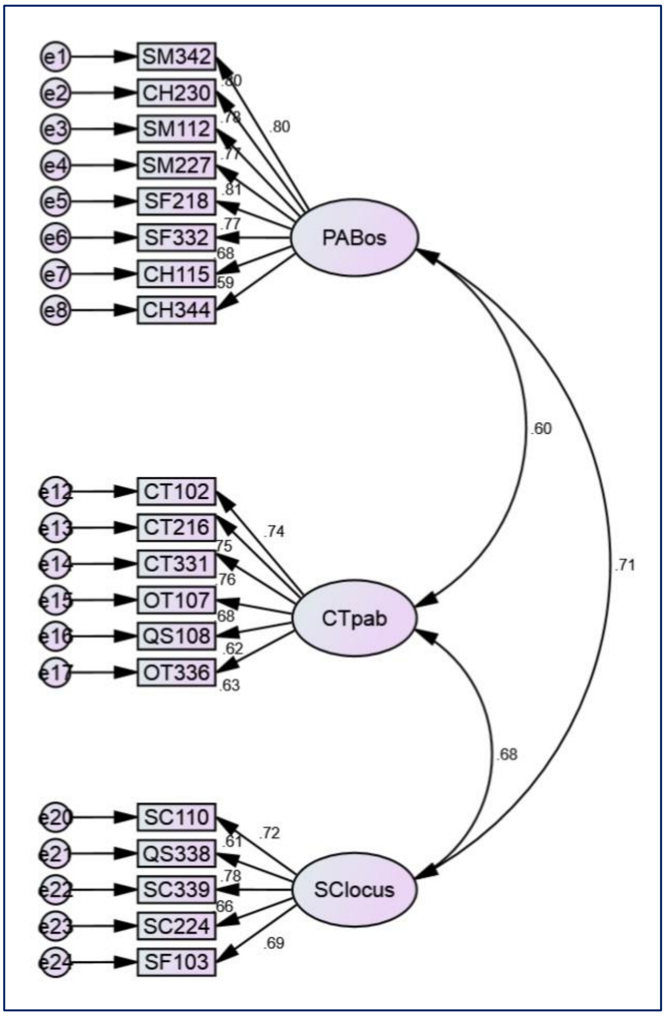

Figure 54 – Initial Confirmatory Analysis Model (AMOS$_{IBM24}$)

Model Fit

Using the model fit indices to test the validity of our model, the following was derived:

Table 45 – Model-Fit Thresholds

Recommended Threshold	Twin Pathway Model
Chi-square/df (cmin/df) <3-5	3.687
p-value for the model <.05	p<.0001
CFI >.95	.862
GFI >.95	.829
IFI >.95	.863
SRMR <.08	.0745
RMSEA <.06	.098
PCLOSE >.05	.000

Note: Taken from Hu and Bentler's "Cutoff Criteria and Fit Indexes" (1999, p.27)

Model fit was found not to achieve threshold's.

APPENDIX VI: Study Three – Situational Interest EFA and CFA

Study 3: Situational Interest Factor Extraction

Table 46 – KMO and Bartlett's Test

Measure	Threshold		Test
Kaiser-Meyer-Olkin	**>.90**		.934
Bartlett's Test of Sphericity		3769.863	3769.863
		276	276
	p **<.05**	.000	.000

Note: Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy

Table 47 – Initial Maximum Likelihood Components

	Initial Eigenvalues					
Component	Total	% of	Cumulative %		Mean	95
1	**9.246**	38.526	38.526	F_1	1.309	1.384
2	**2.825**	11.771	50.297	F_2	1.263	1.323
3	**1.682**	7.008	57.305	F_3	1.224	1.276
4	**1.469**	6.119	63.424	F_4	1.193	1.242
5	1.015	4.230	67.654	F_5	1.164	1.198
6	0.773	3.219	70.873	F_6	1.138	1.171
7	0.693	2.886	73.759	F_7	1.112	1.143
8	0.590	2.457	76.216	F_8	1.091	1.130
9	0.533	2.222	78.438	F_9	1.067	1.107
10	0.509	2.122	80.560	F_10	1.047	1.084
11	0.472	1.965	82.525	F_11	1.027	1.061
12	0.459	1.914	84.440	F_12	1.004	1.036
13	0.449	1.869	86.309	F_13	0.982	1.013
14	0.412	1.718	88.028	F_14	0.961	0.988
15	0.387	1.612	89.640	F_15	0.940	0.968
16	0.383	1.597	91.236	F_16	0.918	0.943
17	0.338	1.406	92.643	F_17	0.899	0.926
18	0.320	1.333	93.976	F_18	0.879	0.903
19	0.302	1.260	95.236	F_19	0.858	0.888
20	0.275	1.147	96.383	F_20	0.834	0.863
21	0.240	0.998	97.381	F_21	0.813	0.846
22	0.223	0.930	98.310	F_22	0.787	0.813
23	0.206	0.859	99.169	F_23	0.761	0.796
24	0.199	0.831	100.000	F_24	0.729	0.771

Factor extraction simplifies the matrix values from the linear transformations of correlation loading inherent in the analysis extraction. It provides an Eigenvalue for each variable, that signifies how much of the variance in all the data is explained by that single factor: Eigenvalue values greater than 1.0 (the default in SPSS) might now be used to indicate significant discrimination and compare how the latent variables load towards significant factors). Five factors displayed Eigenvalues greater than 1.0 using SPSS23. As a comparative, a parallel 'Random Data Eigenvalue' analysis was conducted using bootstrapped resampling (Vivek *et al.*, 2007). By comparing the Random Data Eigenvalue (Random-Factor Mean= Initial Eigenvalue) with the Maximum Likelihood Extraction (this should be equal to or higher than the 'comparative' means), only the first four of the factors accounting for 63.48% of the total variance was confirmed (see, Table 47)

However, in lieu of the '*a priori*' model from (Chen et al., 1999) suggesting Six factors. Therefore, rather than discard the 5th factor, the Eigenvalues above 1.0 were investigated with a Scree Plot. The Scree Plot was used to gauge the visual difference in the 5th factor when compared to the mean; if it was above the leveling-off of the scree-profile then some discriminatory validity in such a 5th factor is acceptable. This, in addition to the Eigenvalue being above 1.0, was considered to display sufficient face-validity in order for a 5th factor to be taken forward for further analysis. Five extracted factors were therefore taken forward.

Table 48 – Communalities

InEn121	0.681
Chall454	0.319
Nov131	0.512
Att141	0.631
Toin161	0.782
ExIn212	0.702
Nov434	0.612
Exin313	0.520
InEn424	0.742
ToIn262	0.620
Nov232	0.575
Chal151	0.500
Nov333	0.490
InEn222	0.735
ExIn111	0.682
Att242	0.543
Chal252	0.362
Att343	0.717
ToIn363	0.767
InEn323	0.631
Att444	0.398
ToIn464	0.540
Chal353	0.430

Note: Extraction Method: Maximum Likelihood.

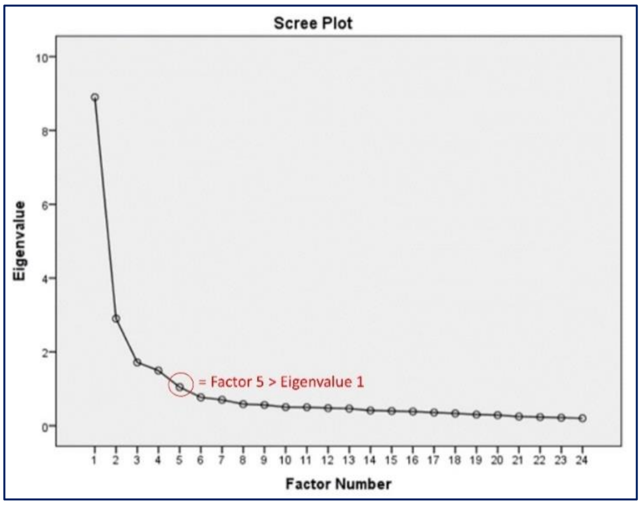

Figure 55 – Scree Plot Displaying Independence of Factor 5

Table 49 – Factor Correlation Matrix

Factor	1	2	3	4	5
1	1.000	0.129	-0.571	0.275	0.509
2	0.129	1.000	-0.276	0.305	0.238
3	**-0.571**	-0.276	1.000	-0.181	-0.419
4	0.275	0.305	-0.181	1.000	0.278
5	**0.509**	0.238	-0.419	0.278	1.000

Note: Extraction Method: Maximum Likelihood.

In Table 49 (above) correlations between factor 1 and factors 3 & 5 were greater than 0.5 (r = 0.509 & 0.571 – respectively), displaying a moderately oblique relationship. However, as these two were the only cases out of 10 pairwise correlations, no overall obliqueness was considered evident in the factors, therefore the factors were considered not obliquely related. The matrix was therefore investigated through an orthogonal rotation using Varimax to extract factor loadings from the variables. Using a cutoff of .40 could highlight variables less likely of causing potential validity problems further down the factor analysis.

Chall454 **=** .32, Chall252 **=**.36 and Att444 were highlighted as potential issues and though not removed at this stage (greater than .30 value is acceptable within the EFA), they were to be monitored through the remainder of the EFA and future Confirmatory Factor Analysis.

Table 50 —-Structural Matrix

FACTOR Variable	1	2	3	4	5
Toin161	0.808				
InEn222	0.782				
InEn121	0.761				
InEn424	0.758				
Att141	0.632				
ToIn262	0.630			0.421	
InEn323	0.574				
Nov232	0.509				0.493
Att242		0.680			
ToIn464		0.652			
Chal151		0.649			
Chal353		0.634			
Chal252		0.571			
Chall454		0.546			
ExIn414			0.772		
ExIn111	0.402		0.700		
ExIn212	0.454		0.669		
Exin313			0.645		
Att343				0.757	
ToIn363				0.752	
Att444				0.412	
Nov131					0.701
Nov333					0.615

Extraction Method: Maximum Likelihood.

Reliability of Factor Loading

As part of this initial analysis, factor-1 displayed oblique rotations with r>.50 across factors (3 & 5). As an 'a prior' assumption (based on the original questionnaire SEM in Study One) of the variables loading on factor-1 were thought to be indicative of Enjoyment and Total Interest constructs. This might highlight a possible confounding of these constructs or psychological-domains of emotion (Enjoyment), and attention (Interest) on one factor; alternatively, as convergent variables representing one dominant factor enjoyment and interest might indeed represent one cognitive emotional-construct. To this end, a further Factor Analysis was conducted using a 3 factor rotation to represent these construct possibilities on the variables loading to the original, single, factor-1.

As inference of oblique loadings might signify possible cross-loadings weakening this factor's items reliability, a further 3 factor orthogonal-rotation was performed using a Oblimin-rotation on factor-1 only (an initial rotation provided high correlations between two sub-factors in this sub-rotation = 0.828). This questioned the robustness of variables towards this dominant factor's convergence and an investigation to identify if secondary or sub-factors might be hidden within.

Table 51 – Sub-Factor Structure Matrix

	Factor 1		
	1	2	3
InEn222	0.876	0.688	
Toin161	0.873	0.772	-0.349
InEn424	0.840	0.766	
InEn121	0.819	0.678	
InEn323	0.752	0.660	
Att141	0.731	0.631	
ToIn262	0.744	0.897	
Nov232	0.597	0.684	

Extraction Method: Maximum Likelihood.
a. 3 factors extracted. 12 iterations required.

Cross-loading values of sub-factors that are similar (i.e. not greater than .2) require us to question their convergence validity towards the original factor-1 and the possibility that sub-influences might be in operation within the latent factor. Such questionable loadings are seen for all variables across two of the three sub-factors (Table 51), requiring us to assess the discriminatory validity of assigning variables to the original factor-1 Cronbach's Alpha (Cronbach, 1958).

Cronbach's (1958) as a 'reliability of factor loading', is a measure of internal-consistency of variables towards a loading a latent factor. It is a measure taken of the correlation between the variance (within item) and covariance across all items or variables thought to relate to that latent factor. This is able to provide a ratio measure of increasing reliability in consistency of item correlations (internal consistency reliability) as Crombach's Alpha (α) approaches 1. Therefore high Cronbach's α is essential internally, if a latent factor is to be considered valid to correlated against other measures[122]: *"reliabilities should ideally be high, around .9, especially for ability tests. Certainly alphas should never drop below .7" (Kline, 2013, p13)*

[122] It should be noted that Cronbach's Alpha has a positive relationship with large sample sizes and increasing degrees of freedom, therefore questioning its use as a true measure of (Hair *et al.*, 2013). However, there is no caveat for low Crombach's Alpha (α) and is therefore, is used at this Exploratory phase. More accurate measures of reliability are pursued in the Confirmatory Factor Analysis

Cronbach's Alpha Reliability

Cronbach's α test was applied on Latent factor-1 items. In addition, a sensitivity analysis or 'scale purification' framework applies statistical inference to which importantly, judgement criteria should be considered (Wieland, Durach, Kembro & Treiblmaier, 2017) a framework to consider item removal, or not.

Table 52 – Sub-Factor 1: Crombach's Alpha (α = .928)				
Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Toin161	36.8120	127.252	0.837	0.912
InEn222	36.7570	128.249	0.809	0.914
InEn121	36.9488	132.116	0.772	0.917
InEn424	37.1520	126.978	0.814	0.913
Att141	36.7922	136.151	0.701	0.922
ToIn262	37.0539	129.363	0.761	0.918
InEn323	37.0327	134.187	0.717	0.921
Nov232	37.2494	135.291	0.618	**0.929**

All factor-1 variables, displayed a consistency in their reporting on the latent variable factor-1 and were retained. However, Nov232 was noted from cross-loading on factor-5 in the Structural Factor Matrix (Table 50, p313) and resulted in little reliability loss to factor 1 if removed. Therefore a Cronbach's α was conducted on factor-5 including Nov232:

Table 53 – Sub-Factor 5: Crombach's Alpha (α =.769)				
Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Nov131	14.6569	27.313	0.571	0.717
Nov232	14.2737	31.809	0.560	**0.720**
Nov333	14.5870	30.602	0.521	0.739
Nov434	14.3259	29.809	0.643	0.678

Here, there is significant loss of reliability if Nov232 is removed, suggesting that it may have more discriminatory validity assigned to this factor 5 rather than factor 1. This is supported in the initial structure matrix where Nov232 reported strongly toward a second sub-factor. As latent factor-3 had also displayed oblique loading against factor-1 questioning the discriminatory adherence of that factor's items, Cronbach's α test was applied to factor-3:

Table 54 – Sub-Factor 3: Crombach's Alpha (α =.875)				
Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
ExIn414	12.7289	28.219	0.758	0.829
ExIn111	12.6129	28.228	0.755	0.830
ExIn212	12.3837	28.708	0.746	0.833
Exin313	12.7712	31.164	0.665	0.864

All factor-3 variables, displayed a consistency in their reporting on the latent variable factor-3 and were retained.

Table 55 – Rotated-Structural Matrix

FACTOR Variable	1	2	3	4	5
Cronbach Alpha	**α=.928**	**α=.805**	**α=.875**	**α=.785**	**α=.768**
Toin161	0.808				
InEn222	0.782				
InEn121	0.761				
InEn424	0.758				
Att141	0.632				
ToIn262	0.630				
InEn323	0.574				
Att242		0.680			
ToIn464		0.652			
Chal151		0.649			
Chal353		0.634			
Chal252		0.571			
Chall454		0.546			
ExIn414			0.772		
ExIn111			0.700		
ExIn212			0.669		
Exin313			0.645		
Att343				0.757	
ToIn363				0.752	
Att444				0.412	
Nov131					0.701
Nov333					0.615
Nov434					0.602

Extraction Method: Maximum Likelihood.

Using the Rotated Factor Matrix, a basic model with all factors co-varied was built in allowing the EFA to be taken forward for convergent and discriminatory validity within a model fit – a Confirmatory Factor Analysis CFA

Confirmatory Factor Analysis: Situational Interest

Using the Rotated Factor Matrix, a basic model with all factors co-varied was built in AMOS$_{IBM24}$ (see below, Gaskin, 2016d), allowing the EFA to be taken forward for convergent and discriminatory validity within a model fit – a Confirmatory Factor Analysis CFA. This EFA Pattern Matrix was taken forward for CFA:

Rotated Factor Matrix

	1	2	3	4	5
Cronbach	**α=.928**	**α=.805**	**α=.875**	**α=.785**	**α=.768**
Toin161	0.808				
InEn222	0.782				
InEn121	0.761				
InEn424	0.758				
Att141	0.632				
ToIn262	0.630				
InEn323	0.574				
Att242		0.680			
ToIn464		0.652			
Chal151		0.649			
Chal353		0.634			
Chal252		0.571			
Chall454		0.546			
ExIn414			0.772		
ExIn111			0.700		
ExIn212			0.669		
Exin313			0.645		
Att343				0.757	
ToIn363				0.752	
Att444				0.412	
Nov131					0.701
Nov333					0.615
Nov434					0.602
Nov232					0.509

Extraction Method: Maximum Likelihood.

Using this pattern matrix, a basic model with all factors co-varied was built in AMOS$_{IBM24}$ (Gaskin, 2016d), to use in a Confirmatory Factor Analysis (CFA) to test for Convergence and Discriminatory validity:

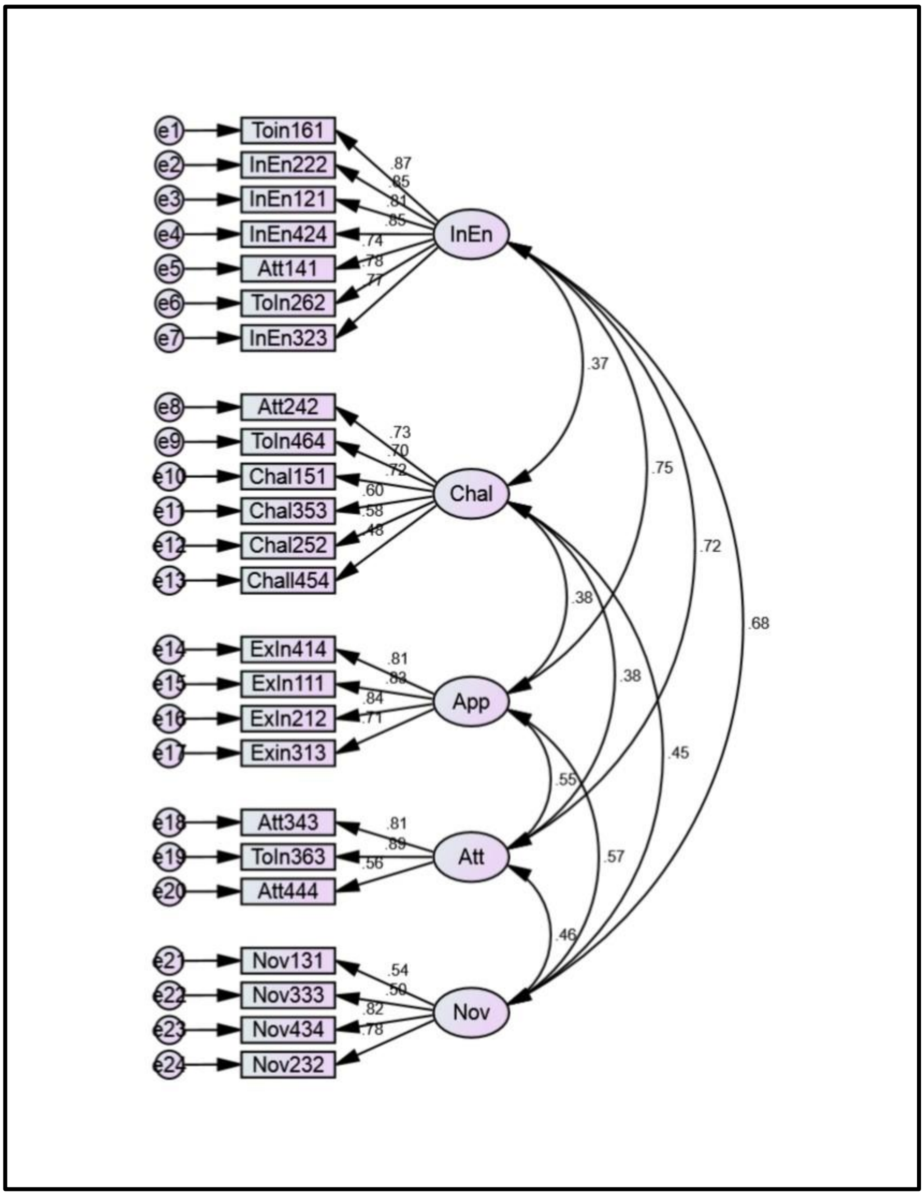

Figure 56 –Pattern Matrix for Taking Forward AMOS$_{IBM24}$

Confirmatory Factor Analysis: Study Three – Situational Interest

Convergence and Discriminatory Validity

The following guidance metrics were used in an initial-fit model to gauge validity.

High correlations on latent factor loading for convergence validity requires correlations greater than 0.7 (r >.70) for variables towards a factor, with an overall average above 0.60 towards a particular factor (Hair *et al.*, 2013).

Low factor co-variance for discriminatory validity requires correlations less than 0.8 (r <.80) between factors with strong discriminatory validity requiring loadings of below 0.70 (ibid).

CFA Validity Issues

Challenge 454

The initial convergence validity (Figure 56) required the variable (Chal454=.48) to be questioned. This is seen to provide a significant effect for 'poorer' overall convergence validity for Challenge, and needs consideration in light of its poor 'Communality' Analysis (Chal454 = .32). The variable Chal454 was therefore removed from this CFA model analysis.

Instant Enjoyment 323 and Total Interest 262

Discriminatory confounding from the *Instant Enjoyment* (InEn) latent factor (expressed in high discriminatory loadings (r>.7) to the *Approach* (App) factor and the Attention Demand (Att) factor when (r<.7) are required, might correspond to the confounding of cross-loading from InEn323 and ToIn262 seen in the EFA across these factors.

The Variables (InEn323 and ToIn262), when removed, improved the discriminatory loadings across one of these pathway (*Instant Enjoyment – Attention Demand*). To further address Convergence and Discriminatory validity, modification indices were applied to variables displaying high Modification Indices (MI >.40, $AMOS_{IBM24}$) where *apriori* similarity provided enough explanation for covariance: (Chal353 + Chal252) describe overtly negative aspects as affective emotions and were therefore co-varied.

Novelty 333

NOV333 displayed poor weighting of the CFA model, together with the cross-loading seen in the EFA and considering its co-variance with NOV131, it was considered acceptable to remove NOV333.

A model with Chal454, InEn323, ToIn262 and Nov333 removed and co-variances on (Chal353 &252) applied was now used for initial confirmatory analysis (Figure 57).

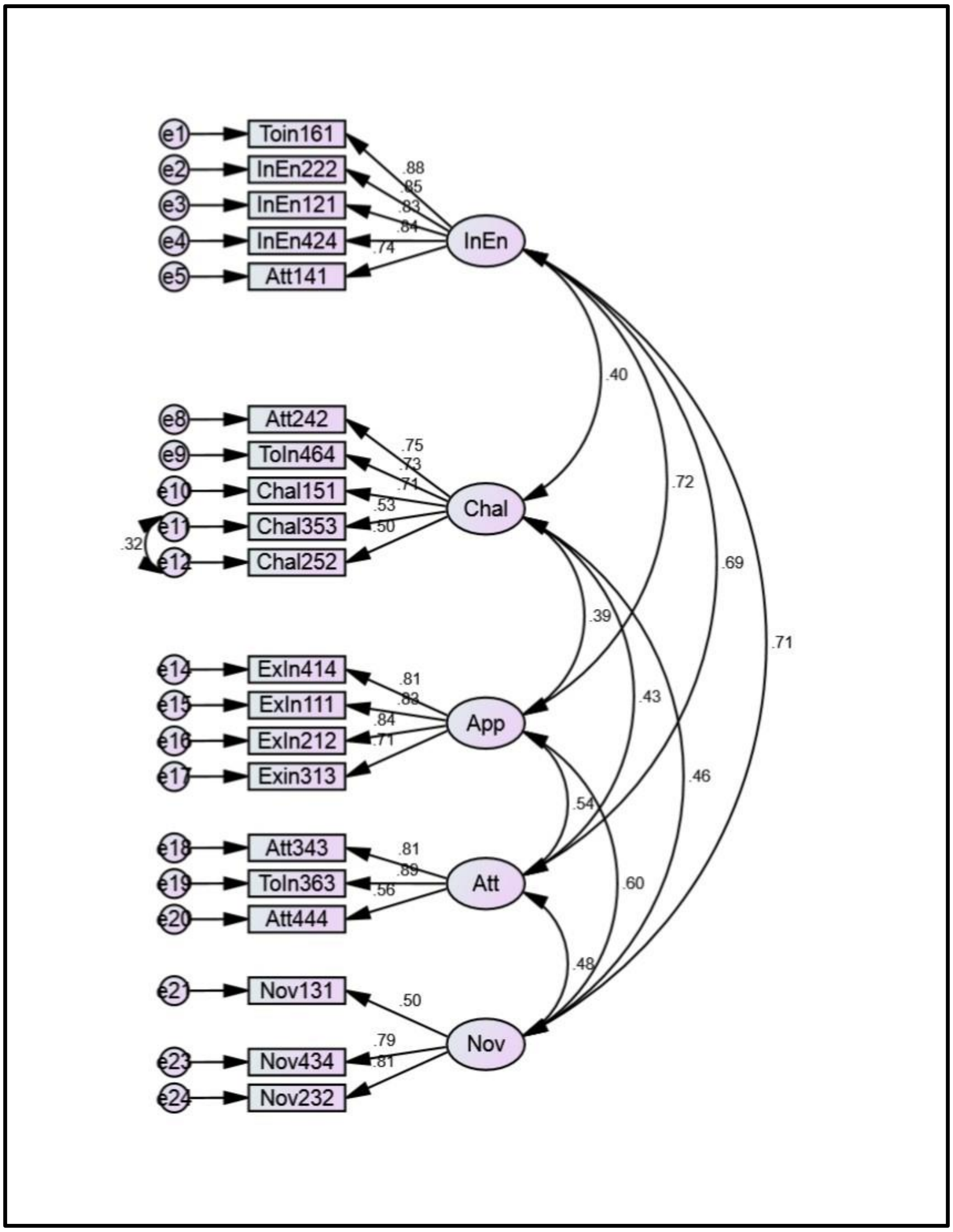

Figure 57 – Initial Confirmatory Analysis Model AMOS$_{IBM24}$

APPENDIX VII: Measurement Invariance Tests

Configurable Invariance for Gender

Adequate configurable-invariance was observed in model fit across gender groups when a freely-estimated model was run for two gender groups. A Chi-square (χ^2) test between groups looking for non-independence or non-variance in the goodness of model fit was run on $\text{AMOS}_{\text{IBM24}}$ (i.e. there is no significant difference between the groups in terms of data variance).

Model fit indices, CFI, SRMR, and RMSEA (Table 56), are considered acceptable using less restrictive thresholds for multivariate models in respect to sample size and item number (Byrne, 2008, p876).

Table 56 – Gender Configurable Invariance

Recommended Threshold	Invariance Pathway Model
Chi-square/df (cmin/df) <3-5	3.543
p-value for the model <.05	.0001
CFI >.92-.95	.920
SRMR <.06-.08	.067
RMSEA <.06-.08	.056

Note: Strict Thresholds (Hu & Bentler, 1999);
Acceptable Thresholds (Hair *et al.*, 2013; Lomax & Schumacker, 2004)

Result: Configurable Invariance (INTEREST) for gender grouping **was** found in the primary CFI model.

Metric Invariance for Gender

This next step in data validity explores how group data is invariant in respect of how the variable items load towards latent factors. Rather than an overall 'model equivalence', metric invariance requires that the item loadings towards a latent factor are also equivalent. This is achieved by constraining the factor loadings and letting the intercepts freely estimate in $\text{AMOS}_{\text{IBM24}}$ (Van de Schoot *et al.*, 2012). A Chi-square (χ^2) test between a constrained and a freely estimated group looking for non-invariance in the model fit was conducted in Microsoft Excel_{10} (Gaskin, 2017a), to test to see if the two models are found invariant (i.e. there is no significant difference between the groups in terms of data variance towards individual latent factors (Table 57).

Table 57 – Metric Invariance for gender

Overall Model	Chi-square	DF	P	Invariant?
Unconstrained	1119.6	316		
Fully constrained	1132.5	336		
Number of groups		2		
Difference		20	**0.882**	**YES**

Note: Chi-square Difference Measure (Gaskin, 2017a)

Result: Metric Invariance (INTEREST) for gender grouping **was** found in the primary CFI model.

Scalar Invariance for Gender

This tests invariance as to how individual items report to a particular latent factor – a 'similarity in item invariance' across the groupings. Scalar invariance for gender was performed by comparing the partially Constrained model (factor loadings) with a fully Constrained (loadings and Intercepts) using a χ^2test across gender groups in $AMOS_{IBM24}$ (Table 58).

Table 58 – Scalar Invariance 1) for gender

Model	DF	CMIN	P
Measurement intercepts	32	43.268	0.082

Note: Assuming model Unconstrained to be correct

Result: Scalar Invariance (INTEREST) for gender grouping **was** found in the primary CFI model.

Configurable Invariance for Age

Table 59 – Age Configurable Invariance

Recommended Threshold	Invariance Pathway Model
Chi-square/df (cmin/df) <3-5	2.578
p-value for the model <.05	.0001
CFI >.92-.95	.901
SRMR <.06-.08	.061
RMSEA <.06-.08	.043

Note: Strict Thresholds (Hu & Bentler, 1999);

Acceptable Thresholds (Hair *et al.*, 2013; Lomax & Schumacker, 2004)

Result: Though not quite achieving CFI fit, in consideration of reduced thresholds for 'multivariate' models (Byrne, 2008, p876). Configurable Invariance (INTEREST) for age was accepted here in order to further develop the CFI model. However, it was introduced as a possible extraneous factor in the final SEM to account possible variance (age grouping).

Metric Invariance for Age

Table 60 – Age Configurable Invariance

Overall Model	Chi-square	DF	P	Invariant?
Unconstrained	1618.7	628		
Fully constrained	1662.7	684		
Number of groups		4		
Difference	44	56	0.877	YES

Note: Chi-square Difference Measure (Gaskin, 2017a)

Result: Metric Invariance (of INTEREST above) for age grouping **was** found in the primary CFI model.

Scalar Invariance for Age

Individual items reporting to particular latent factors, are tested for 'similarity in variance' across the groupings (below).

Table 61 – Scalar invariance 1) for age

Model	DF	CMIN	P
Measurement intercepts	30	301	0.000

Note: Assuming model Unconstrained to be correct

Here, there is 'non-invariance' (a difference between models), therefore a difference in the way that age influences the reporting on certain items towards factors.

As with Gender invariance, the intercept-estimates were interrogated in the freely-estimated model using a pairwise analysis for items with the largest absolute value (regardless of positive/negative). From this, the following items were identified as possibly confounding scalar invariance in age: ToIn464, Nov434, Chal353, Att343 and Nov434. However, when set to freely estimate, still no scalar invariance was evident and it was considered detrimental to scalar invariance to further remove further intercept constraints.

However, if invariance is not found in scalar 'goodness of fit', but invariance is found in 1) configurable and 2) metric Invariance, partial measurement invariance across groups is still plausible (Steenkamp & Baumgartner, 1998). Therefore, the model was taken forward to Validity and Reliability testing.

Strict Invariance for Gender and Age

The final Measurement Invariance test is one of 'Strict Invariance', which compares the residuals or error reporting across items and factors. As only gender had reported scalar invariance, and age, no scalar invariance, it was not thought practicable to gain more validity inference from such a 'strict' and seldom used procedure in social science.

The initial Confirmatory Factor Analysis (CFA) Model (Figure 31, p171), is accepted for the further metrics to establish factor validity and reliability.

APPENDIX VIII: Tests for Multivariate Influence and Multi-Collinearity

Multivariate Influence: Outliers and Influence using Cooks Distances

Cook's distances (Cook, 1979) were calculated using liner regression to determine if there were any non-normal influential items. A Cook's Threshold of 3.0 (Gaskin, 2016b) is used to judge the adverse influence of Independent Variables (IV) on a Dependent variable (DV). DVs were assigned using the *a priori* hypothesised SEM model from Study One (see, APPENDIX I: Initial Pathway Analysis, p292). Here, though the *a priori* factor of Total Interest (ToIn) had been subsumed into the Study Three factors, pathways between *Novelty*, *Exploratory* Interest, *Instant Enjoyment*, *Challenge* and *Attentional Demand*, were still considered to be able to provide Dependent and Independent relationships for this test. We therefore entered pairwise IV on DV: Nov→InEn; Nov→Att; Nov→Chal; Att→InEn; Chal→InEn; InEn→App; ExIn→Att; ExIn→InEn.

Example: a calculated Cook's Distance (SSPS$_{IBM23}$) for *Novelty* on *Instant Enjoyment* (graphically represented in a simple scatter-plot to help identify outliers (Figure 58), displays clearly an outlier, data-point 469, but one that lies within tolerance (Cooks= .0366).

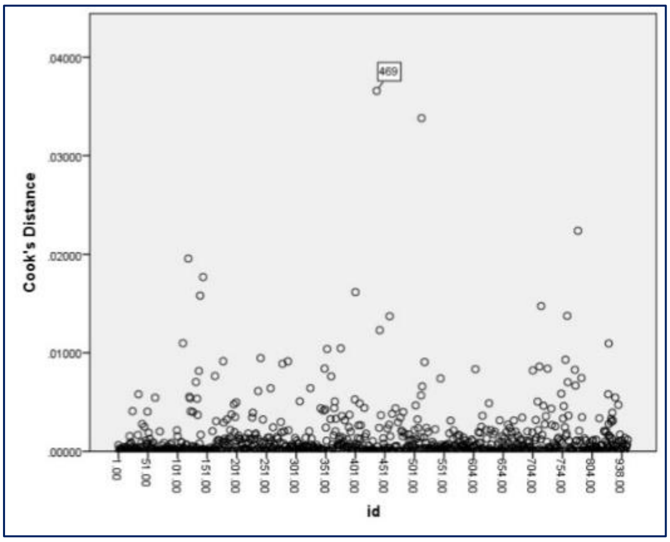

Figure 58 – Example of Cooks Distance Scatter Plot

Results: Cooks distances showed **no** significant values (Cooks < 1), indicating that no one case had undue or abnormal influence on the data set.

Tests of Multi-Collinearity

A Collinearity test is conducted to see if there is an acceptable 'degree of accuracy' in the *a priori* Independent Variables (IV) predicting a Dependent Variable (DV). This was conducted using liner regression and the collinearity-diagnostics (SSPS$_{IBM23}$) to produce a Tolerance Inflation Factor (TIF) and a Variable Inflation Factor (VIF). Again using the SEM pathway model from Phase II to determine *a priori* DVs (*Novelty* and *Exploratory Approach*) on IVs (*Instant Enjoyment*, *Challenge* and

Attentional Demand) are regressed. Ideally, collinearity is accepted across all DVs where: Tolerance (TIF) > 0.1 and (VIF) < 3 (Gaskin, 2016b). This would indicate that the pathway model could be considered collinear between factors. The proposed CFA was found to be collinear (Table 62, below).

Table 62 – Collinearity Coefficients: Tolerance (TIF) and Variable (VIF)

Novelty		**t**	**Sig.**	**TIF**	**VIF**
1	(Constant)	-0.187	0.852		
	Att	-1.737	0.083	0.711	1.406
	Chal	10.050	0.000	0.913	1.095
	InEn	19.050	0.000	0.727	1.376
Approach					
1	(Constant)	-0.542	0.588		
	Att	1.919	0.055	0.711	1.406
	Chal	11.590	0.000	0.913	1.095
	InEn	23.173	0.000	0.727	1.376

APPENDIX IX: Study Three ROPELOC EFA and CFA

With consideration to the use of a modified measure of Review of Personal Effectiveness and Locus of Control – ROPELOC (Neill, 2009) and the adaption of its constructs. As such changes had been made to the questionnaire to reflect feedback and descriptive statistical findings form the second phase of the study, An Exploratory Factor Analysis and Confirmatory Analysis was conducted:

Table 63 – Rotated Pattern Matrix for ROPELOC suppressed to (.30)

	1	2	3	**4**
Cronbach	**α=.887**	**α=.837**	**α=.866**	**α=.776**
QS223	0.720			
QS338	0.687			
IL221	0.644			
IL105	0.615			
QS108	0.600			
SC110	0.597			
SC224	0.584			
IL337	0.508			
SC339	0.505			
TE343		-0.811		
TE228		-0.769		
TE114		-0.732		
SF332			0.772	
CH230			0.749	
SF218			0.736	
CH115			0.642	
CH344			0.539	
OT222			0.527	
SF103			0.486	
OT336			0.376	
CT216				-0.836
CT331				-0.682
CT102				-0.555

Extraction Method: Maximum Likelihood.

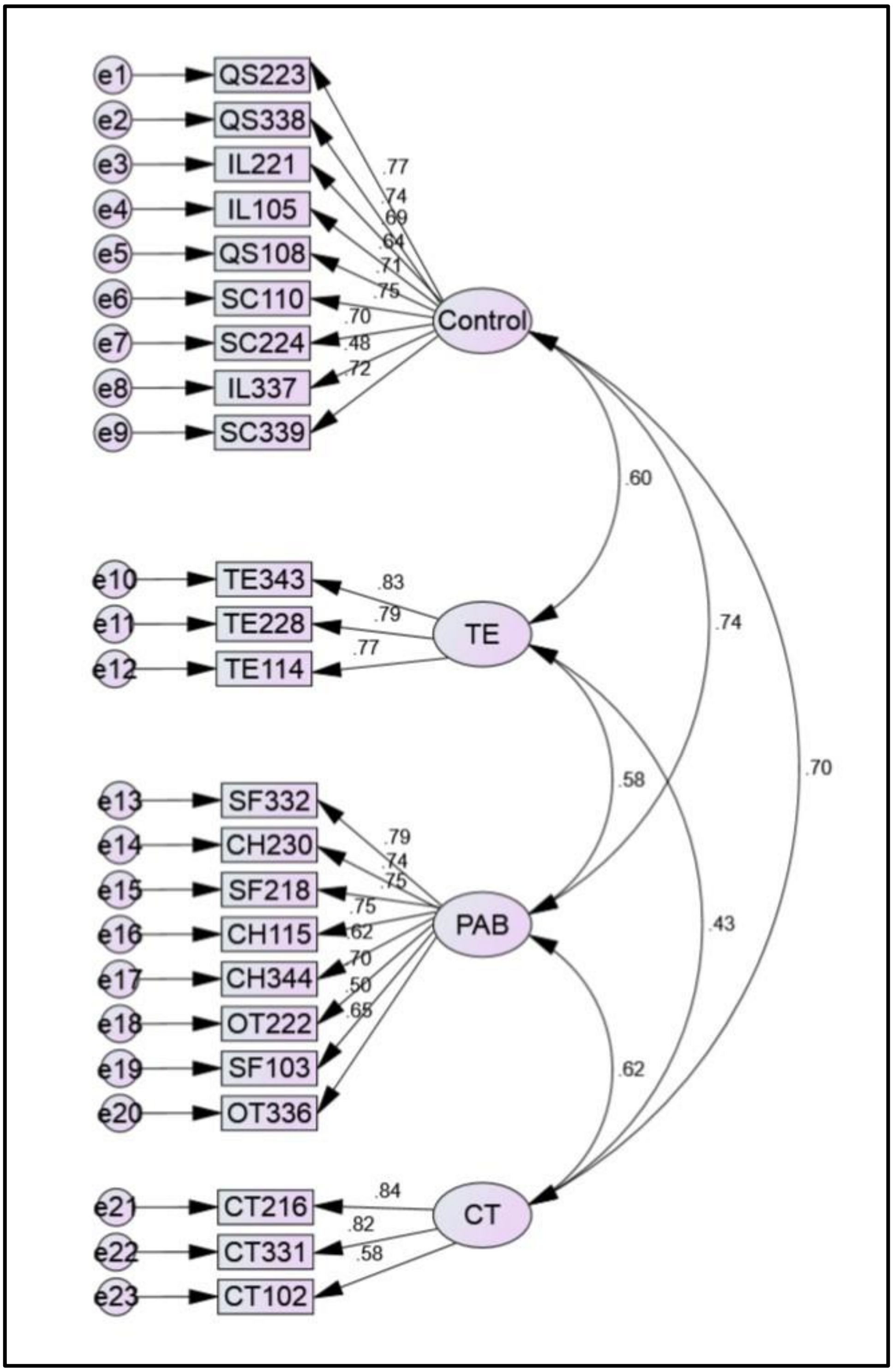

Figure 59 - EFA Factor Model (AMOS$_{IBM24}$)

Addressing CFA Model Fit Issues

Internal Locus (IL337)

The initial convergence validity (Figure 59) required the variable (IL337=.48) to be questioned. This is seen to provide a significant effect for ‘poorer’ overall convergence validity for Challenge, and needs consideration in light of its poor ‘Communality’ Analysis (IL337=.246) and it scale effect on Cronbach’s Alpha (an increase when removed). The variable IL337 was therefore removed from this CFA model analysis.

Self Confidence (SF103)

The initial convergence validity from required the variable (SF103=.50) to be questioned. This is seen to provide a significant effect for ‘poorer’ overall convergence validity for Challenge, and needs consideration in light of its poor ‘Communality’ Analysis (SF103=.50) and it scale effect on Cronbach’s Alpha (an increase when removed). The variable SF103 was therefore removed from this CFA model analysis.

Modification Indices

Modification indices recommended the following co-variances to be made to the model. A model with IL337 and SF103 removed and co-variances on error residuals (QS223 338; SC110-339; SF332-218) applied (Figure 60,below).

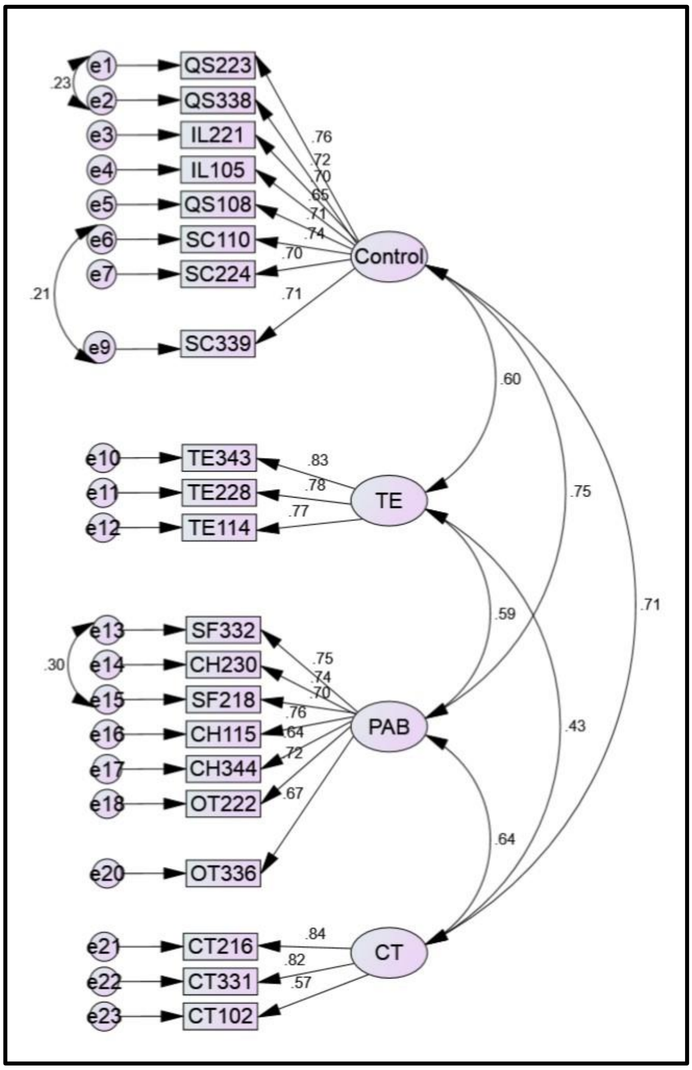

Figure 60 – Initial Confirmatory Analysis Model AMOS IBM24

Model Fit

Table 64 – Model-Fit Thresholds taken from, Hu & Bentler (1999)

Recommended Threshold	CFA Pathway Model
Chi-square/df (cmin/df) <3-5	5.731
p-value for the model <.05	.0001
CFI >.92-.95	.923
SRMR <.06-.08	.061
RMSEA <.06-.08	.074

Note: Strict Thresholds (Hu & Bentler, 1999);

Acceptable Thresholds (Hair *et al.*, 2013; Lomax & Schumacker, 2004)

*The model fit did not achieve ‘strict’ model-fit thresholds under Hu and Bentler (1999). However, Hair *et al.* (2013, p584) and Lomax and Schumacker (2004, p112) have suggested acceptable model-fit at lesser thresholds in consideration of sample size and the number of measure-items (e.g. RMSEA < .06 - .08) and therefore, this Initial CFA was thought to be acceptable in initial confirmatory analysis and able to continue the validity metrics.

Measurement Invariance: For Non-independence threats

Configurable Invariance for Gender

Adequate configurable-invariance was observed in model fit across gender groups when a freely-estimated model was run for two gender groups. A Chi-square (χ^2) test between groups looking for non-independence or non-variance in the goodness of model fit was run on $\text{AMOS}_{\text{IBM24}}$ (i.e. there is no significant difference between the groups in terms of data variance). Model fit indices, CFI, SRMR, and RMSEA (Table 65) were considered acceptable using less restrictive thresholds for multivariate models in respect to sample size and item number (Byrne, 2008, p876).

Table 65 – Gender Configurable Invariance

Recommended Threshold	Invariance Pathway Model
Chi-square/df (cmin/df) <3-5	2.821
p-value for the model <.05	.0001
CFI >.92-.95	.927
SRMR <.06-.08	.050
RMSEA <.06-.08	.048

Note: Strict Thresholds (Hu & Bentler, 1999);

Acceptable Thresholds (Hair *et al.*, 2013; Lomax & Schumacker, 2004)

Result: Configurable Invariance (ROPELOC) for gender grouping was found in the primary CFI model.

Metric Invariance for Gender

This next step in data validity is how group data is invariant in respect of how the variable items load towards latent factors. Rather than an overall ‘model equivalence’, metric invariance requires that the item loadings towards a latent factor are also equivalent. This is achieved by constraining the factor loadings and letting the intercepts freely estimate in $\text{AMOS}_{\text{IBM24}}$ (Van de Schoot *et al.*, 2012). A Chi-square (χ^2) test between a constrained and a freely estimated group looking for non-invariance in the model fit was conducted in Microsoft Excel_{10} (Gaskin, 2017a), to test to see if the two models are found invariant (i.e. there is no significant difference between the groups in terms of data variance towards individual latent factors (Table 66).

Table 66 – Metric Invariance for gender via Chi-square Difference

Overall Model	Chi-square	DF	P	Invariant?
Unconstrained	1119.6	316		
Fully constrained	1132.5	336		
Number of groups		2		
Difference		20	**0.882**	**YES**

Note: Chi-square Difference Measure (Gaskin, 2017a)

Result: Metric Invariance (ROPELOC) for gender grouping **was** found in the primary CFI model.

Scalar Invariance for Gender

This tests invariance to how individual items report to particular latent factor – a 'similarity in item invariance' across the groupings.

Table 67 – Scalar Invariance 1) for gender

Model	DF	CMIN	P
Measurement intercepts	35	87.6	0.000

Note: Assuming model Unconstrained to be correct

Scalar invariance for gender was performed by comparing the partially Constrained model (factor loadings) with a fully Constrained (loadings and Intercepts) using a Chi-square (χ^2) test across gender groups in $AMOS_{IBM23}$ (Table 67). Here, no-significance would show invariance.

There was variance found, suggesting a difference in the way that gender groupings influence the reporting on certain items towards one or more factor(s). This requires further consideration of possible issues with some of the items and their validity towards inferring similar reporting towards a latent factor across different groups.

To identify any possible items causing this variance, the two gender group's 'intercept-estimates' in the freely-estimated model are interrogated for outlier information (those with the largest 'absolute' value). From this, the following items were identified as possible confounding scalar invariance; Ch115, CT216 and CT102. These items were allowed to freely estimate to obfuscate their effect. When set to freely estimate, still no scalar invariance was evident and it was considered detrimental to scalar invariance to further remove further intercept constraints.

However, if invariance is <u>not</u> found in scalar 'goodness of fit', but invariance <u>is</u> found in 1) configurable and 2) metric Invariance, partial measurement invariance across groups is still plausible (Steenkamp & Baumgartner, 1998). Therefore, the model was taken forward to Validity and Reliability testing.

Configurable Invariance for Age

Table 68 – Age Configurable Invariance:

Recommended Threshold	Invariance Pathway Model
Chi-square/df (cmin/df) <3-5	2.244
p-value for the model <.05	.0001
CFI >.92-.95	.91
SRMR <.06-.08	.048
RMSEA <.06-.08	.038

Note: Strict Thresholds (Hu & Bentler, 1999);

Acceptable Thresholds (Hair *et al.*, 2013; Lomax & Schumacker, 2004)

Result: Using less restrictive thresholds for multivariate models (Byrne, 2008, p876). Configurable Invariance (INTEREST) for age was considered acceptable to further develop the primary CFI model.

Metric Invariance for Age

Table 69 – Age Configurable Invariance via Chi-square Difference

Overall Model	Chi-square	DF	P	Invariant?
Unconstrained	1615.4	720		
Fully constrained	1678.9	781		
Number of groups		4		
Difference		61	**0.388**	**YES**

Note: Chi-square Difference Measure (Gaskin, 2017a)

Result: Metric Invariance (of ROPELOC above) for age grouping **was** found in the primary CFI model.

Scalar Invariance for Age

Individual items reporting to particular latent factors, are tested for 'similarity in variance' across the groupings (Table 70).

Table 70 – Scalar invariance for age

Model	DF	CMIN	P
Measurement intercepts	38	67.9	0.002

Note: Assuming model Unconstrained to be correct

There was non-invariance, therefore a difference in the way that age influences the reporting on certain items towards factors.

As with Gender invariance, the intercept-estimates were interrogated in the freely-estimated model using a pairwise analysis for items with the largest absolute value (regardless of positive/negative). From this the following items were identified as possibly confounding scalar invariance in age: CH115, CH344 and OT336. However, when set to freely estimate, still no scalar invariance was evident and it was considered detrimental to scalar invariance to further remove further intercept constraints.

However, if invariance is not found in scalar 'goodness of fit', but invariance is found in 1) configurable and 2) metric Invariance, partial measurement invariance across groups is still plausible (Steenkamp & Baumgartner, 1998). Therefore, the model was taken forward to Validity and Reliability testing.

Validity and Reliability Tests

The initial Confirmatory Model Analysis above, now allows for the further validity metrics to establishing factor validity and reliability, such as Construct Reliability (CR). Though Cronbach's Alpha is often quoted for reliability, this does present problems for multi-construct models with large sample sizes as Cronbach has a positive relationship with increasing degrees of freedom, one that questions it as a reliability measure (Hair *et al.*, 2013). More accurate reliability may be found through Construct Reliability (CR) where reliability might be assumed if CR>.5 ideally CR>.7 (Hair *et al.*, 2013, pg 605). In addition we test:

Average Variance Extracted(AVE); Maximum Shared Variance(MSV); Average Shared Variance(ASV).

Construct Reliability – **CR** > .70

Convergent Validity – **AVE** > .50 explained variance is greater than residual variance (Bagozzi & Yi, 1988)

Discriminant Validity - **MSV** < **AVE** and ;

Discriminant Validity - Square root of **AVE** greater than inter-construct correlations (Hair *et al.*, 2013, pg 605)

Table 71 – Ropeloc Convergent and Discriminant Validity Metrics

	CR	AVE	MSV	MaxR(H)	PAB	Control	TE	CT
PAB	0.877	0.506	**0.569**	0.880	**0.711**			
Control	0.890	0.503	**0.569**	0.940	0.754	**0.710**		
TE	0.838	0.633	0.362	0.954	0.588	0.602	**0.796**	
CT	0.792	0.566	0.511	0.963	0.636	0.715	0.426	**0.752**

Perceptions of Ability and Beliefs (PAB) and Self-Confidence/Locus of Control (Control) clearly pose validity issues. To address these validity concerns a further factor analysis was conducted across only the variables convergent on a latent factors PAB and Locus, to see how reliable the variable converge on these factors (see, Table 72, below).

Table 72 – Factor Analysis of PAB and

	Factor		
	Factor		
	1	2	3
CH230	.734		
SF332	.728		
SF218	.688		
CH115	.663	.310	
OT222	.615	.348	
CH344	.607		
OT336	.504	.405	
QS223		.754	
QS108		.697	
QS338		.692	
IL221	.302	.623	
IL105		.620	
SC110	.405	.522	.329
SC224	.387	.493	.314
SC339	.342	.376	.860

Extraction Method: Maximum Likelihood.

a. 3 factors extracted. 6 iterations required.

In addition to the PAB and Locus factors, another latent variable provided some explanation to the validity issues observed in these primary factors: we see ALL the Self-Confidence variables in PAB, confounded in this latent variable[123].

As the purpose of the use of ROPELOC was to provide some perception reflecting 'emotional awareness' to correlate a differentiated model of Interest; this allows for the general constructs of ROPELOC (life effectiveness as an 'awareness' of a state neural function -Effectivity and the Divergent Criticality hypothesis). For that reason, rather than the need maintain the multi-construct structure of specific psychological variables (such as Self-Confidence), it was reasoned that the maintenance of main factor construct (PAB), would allow sub-constructs that caused discriminatory issues, such as Self-Confidence, to be removed.

In conjunction with the PAB and Locus factor analysis, the following variables where removed for displaying weak extraction communalities less than (0.4) and that cross-loaded with other factors; CH115; SC110; SC339; SC224.

[123] It should be remembered that this third factor does not display itself in the master model. It therefore is an effect specifically aligned to the factors of Locus and PAB.

Figure 61 – Metric Validity Assumed CFA ROPELOC Model (below), achieved the following validity metrics that were deemed acceptable to continue with the CFA

Table 73 – Convergent and Discriminant Validity Metrics

	CR	AVE	MSV	MaxR(H)	PAB	Control	TE	CT
PAB	0.853	0.**493**	0.468	0.856	0.**702**			
Control	0.847	0.526	0.510	0.921	0.684	0.**725**		
TE	0.838	0.633	0.360	0.944	0.600	0.593	0.**796**	
CT	0.792	0.565	0.510	0.956	0.647	0.714	0.426	0.**752**

Common Methods Bias

This is done by creating the Common Latent Factor for all variables (Gaskin, 2016a) and then run as; i) a freely estimated model and then ii) a model constrained to zero.

In such a 'Common Method' test, if there is significance using a Chi-square difference test between the: 1) freely estimated model, and 2) model constrained to zero across variables; this determines if there is enough shared variance with the CLF to warrant its inclusion in further analysis.

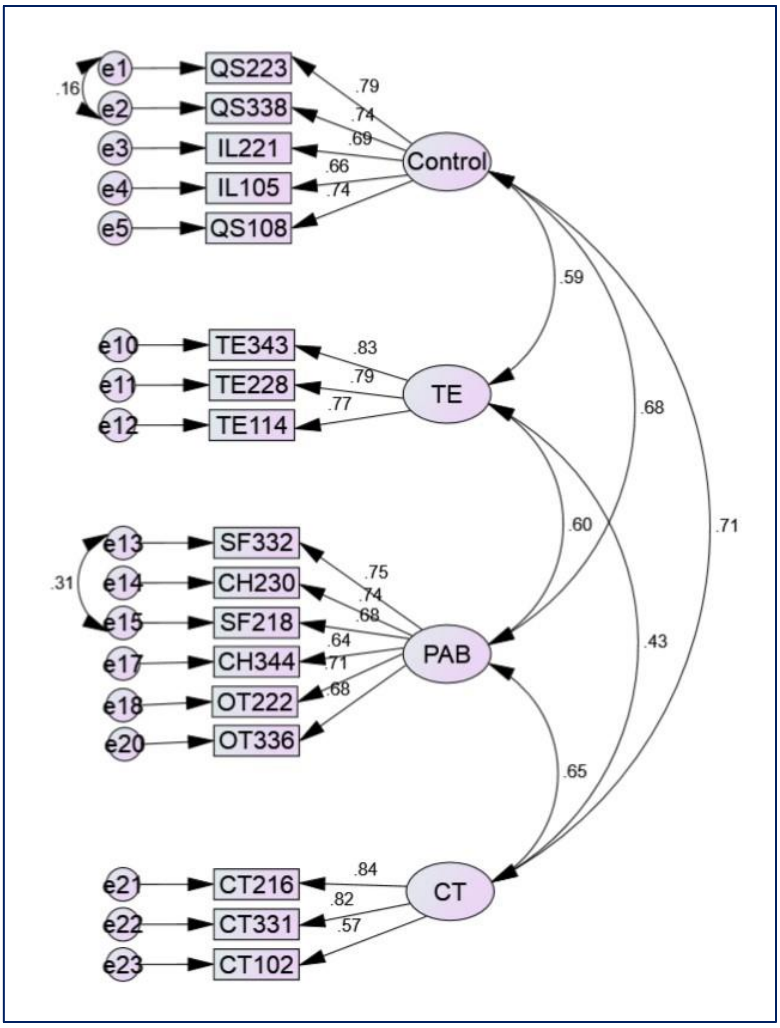

Figure 61 – Metric Validity Assumed CFA ROPELOC Model ($\text{AMOS}_{\text{IBM24}}$)

Table 74 – Chi-square Difference Test CLF

	Chi-square	DF	P	Invariant?
Unconstrained	317.9	96		
Fully constrained	423.0	111		
Number of groups		2		
Difference	105.1	15	**0.000**	**NO**

Note: Chi-square Difference Measure (Gaskin, 2017a)

There is significance (p<.05) therefore shared variance will need to be assumed.

As shared variance is significant (i.e. not significantly invariant), the model is was investigated for convergence and discriminatory validity now that the variables are seen to share variance between the CLF and their EFA latent factors. The final (see, Figure 62, below) acceptable model for imputing 'partialised' values for all the variables whilst considering a CLF effects.

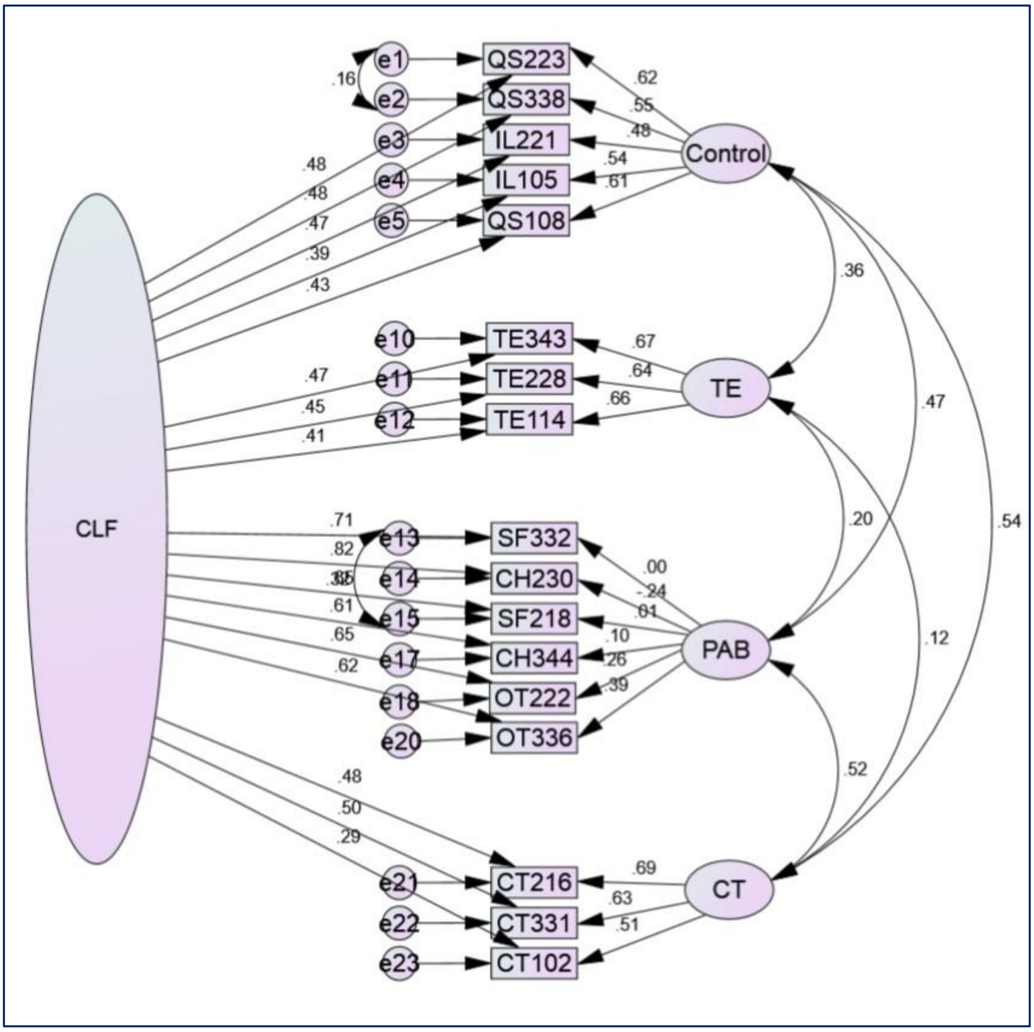

Figure 62 – Final CLF Model ($AMOS_{IBM24}$)

The CLF now acts as a covariant on all variables and therefore, partialised-values are applied in defining the weightings towards other latent variables. These values are now imputed onto the latent values. A final Model Fit was conducted on the unconstrained model with 4 latent variables (including a CLF). The following fit indices where achieved:

Table 75 – Final Model Fit	CLF Pathway Model
Chi-square/df (cmin/df) <3-5	2.734
p-value for the model <.05	p<.0001
CFI >.92-.95	.974
SRMR <.06-.08	.030
RMSEA <.06-.08	.078

Note: Strict Thresholds (Hu & Bentler, 1999);
Acceptable Thresholds (Hair *et al.*, 2013; Lomax & Schumacker, 2004)

Finally, the CLF was used to create factor values for future analysis by imputation allowing for the 'Common Method Bias' corrections. This is a partialization of the variables in accordance with the CLF. The variables are considered to covariate of the CLF and the latent factor, that is, they are produced by more than one pathway. Partialized 'standardised' betas now, will be reflections of the proportion of variance toward the latent factor.

If we take the above into consideration, when allowed to co-vary and predict the latent variable, imputed factor values, will now represent partialized measures for the dependent variables and enable the model correlations to reflect the covariance of the CLF.

As the ROPELOC questionnaire was not to be used for further SEM multi-variate assumptions for latent factors in such a model were not required. Multi- variate 'Influence' and 'Collinearity' assumptions were not necessary.

APPENDIX X: Conditional Independence

Conditional Independence (CI) provides a truly quantitative analysis and offers an alternative to interrogate possible qualitative confounding used in Structural Equation Modelling.

Conditional Independence was conducted in this study to provide some triangulation to the Structural Equation Modelling. It also provides some suggestion that such a CI approach to model building offers an efficient and more accurate approach to structural modelling in the face of large data sets and multi-step methodologies (Bacciu *et al.*, 2013).

Conditional Independence assumes the null hypothesis, i.e. that there are no relationships between variables and that they are independent. By comparing one variable's relationship to another – conditional on 'no relationships' with all the other measure variables; if any shared information is uniquely observed through this condition, then these 'paired' variables may be assumed to have a relationship (i.e. one variable's condition informs the others uniquely 'variable' condition, to some extent)[124]. This suggests the variables cannot be considered independent and the null-hypothesis is disproved, i.e. if there exists a relationship, we decide to what level of significance to weight that significance.

In multiple variables of CI, the conditional information is provided as a 'measure of probability', that of the probable state of shared information between variables based on an information-condition from multiple variables. This can be considered as a state of entropy of one variable's distribution in comparison with all other variable's condition, and is given as a property of information – the statistically expressed entropy of Shannon Theory (Shannon, 1948). This gives us an information-distribution of one variable reflecting all the other variables, a unique condition able then to be compared against another variable's unique 'conditional' state.

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[124] Rather than through direct correlation between pairwise variables (as in regression where such associations may be the result of associations with other, confounding, variables), CI requires that rather than a direct relationship, the variables are conditionally investigated via a third condition (e.g. via another measure variable[s]). These 'conditions' produce their own independent probability-distributions as a third condition. If and only if, there exists 'shared information' between these independent distributions, then a 'conditional dependence' or significant relationship exists. This significance is represented by the shared information between the two conditional, probability-distributions. This is the occurrence of one variable's probability distribution providing information on the probability of other variable's probability distribution.

What is in effect is a Chi-squared (χ2) probability-distribution, one able to calculate a goodness of fit between the 'actual' variable distribution and the expected 'information' distribution[125]. From this, a graphical model of Conditional Independence shows none biased, purely quantitative, statistical relationships between the variables presented as 'edge-minimum entropy' – A model of the shared information (true relationship) between variables.

Sorting and Preparation of Data for Conditional Independence

The raw Interest data was prepared and sorted in accordance with the EFA Phase. The only difference was the variable's (Likert) reporting scale was collapsed into 4 groups from the 8, in order to reduce the polynomial calculations needed:

Shannon information:

$$H = -\sum_{i} pi \log_2(pi)$$

(Shannon, 1948)

Is adapted for a mutual-measure of shared entropy (information) as:

$$\tilde{I}(i,j|A) = \sum_{x_i,x_j,x_A} p_{ijA}(x_i,x_j,x_A)\log_2 \frac{p_{ijA}(x_i,x_j|x_A)}{p_{i|A}(x_i|x_A)p_{j|A}(x_j|x_A)}$$

(taken from, Bacciu *et al.*, 2013, pg625)

The software used was CiMAp version 1 – MatLab (R2011a) 64-bit (win64) (Bacciu *et al.*, 2013).

[125] Variable A and B are considered Independent (no relation) if, joint probability equals the product of their probabilities – p(A n B) = p(A) + p(B) (Birnbaum, 1962).

From this, a graphical representation of the relationships between variables provides an entropy measure (Ĩ) as a measure of mutual information between variables, and allows the pairwise relationships to build a multivariable model.

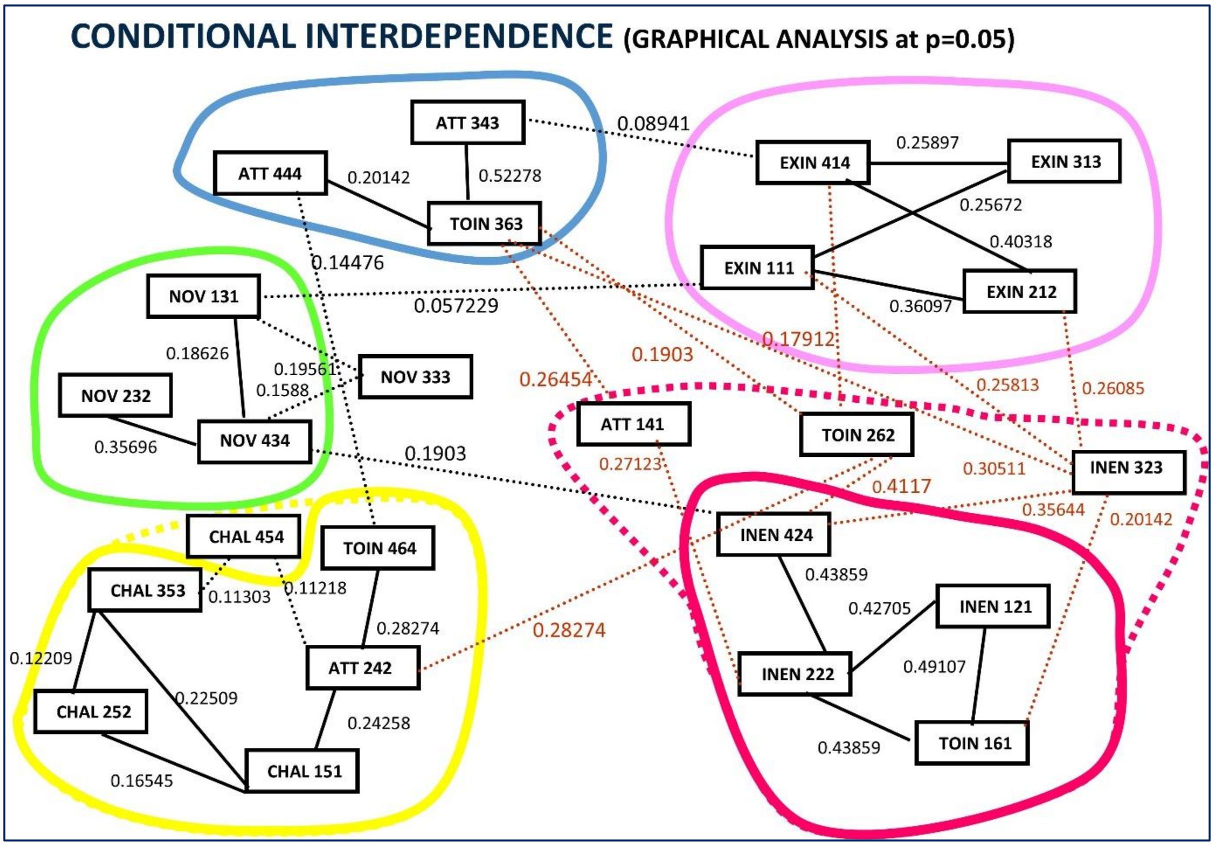


Figure 63 – Conditional Interdependence map (adapted from CiMAp version 1, Bacciu *et al*., 2013)

Interpreting the Multivariate Assumptions

The above (Figure 63) has been extrapolated from the raw graphical analysis (see, Figure 65, p343) to clearly display significant convergent relationships. The weightings are in megabits (mbits) of mutual 'shared' information.

Factor Analysis

Of interest here are the significant relationships within what might be considered, 'latent factor groupings' (see Figure 64, below). These generally display stronger grouped relationships. Shared inter-factor relationships (brown pathways) display cross-loading across grouping centres of shared variance. Here we see support for the 5 factor analysis from the EFA.

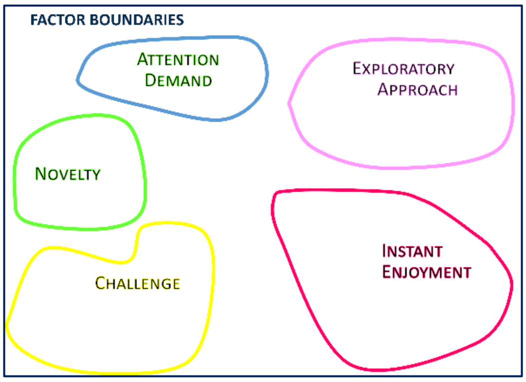


Figure 64 – Latent Factor Boundaries

Variables not obviously incorporated within a factor boundary: InEn323; Att141; Nov333; ToIn262 & Chal454 (Figure 63, above) can be seen to be cross-loaded with other factors through 'multiple' relationships. This again would support the confounding seen in the factor analysis tests, where it is these very variables are seen to be removed through CFA and SEM.

Though the a Conditional Independence approach would seem to offer a quick and efficient approach to model building when compared with CFA and SEM, the interpretation of the relationships benefited from some *a priori* guidance to help identify and understand the raw data provided. For example, the inclusion of Nov333 had the effect of Nov 232 becoming non-significant.[126]

[126] When Nov333 was removed in CFA iteration, Nov 232 was seen to provide one of the strongest predictors of Novelty). This removal of Nov 333 was a direct result from an iterated CFA approach using knowledge about the confounding effects on this variable in relation to an 'age group' effect. This and the constructivist approach to SEM from a working knowledge of the measures and the sampling.

Base Conditional Independence Analysis

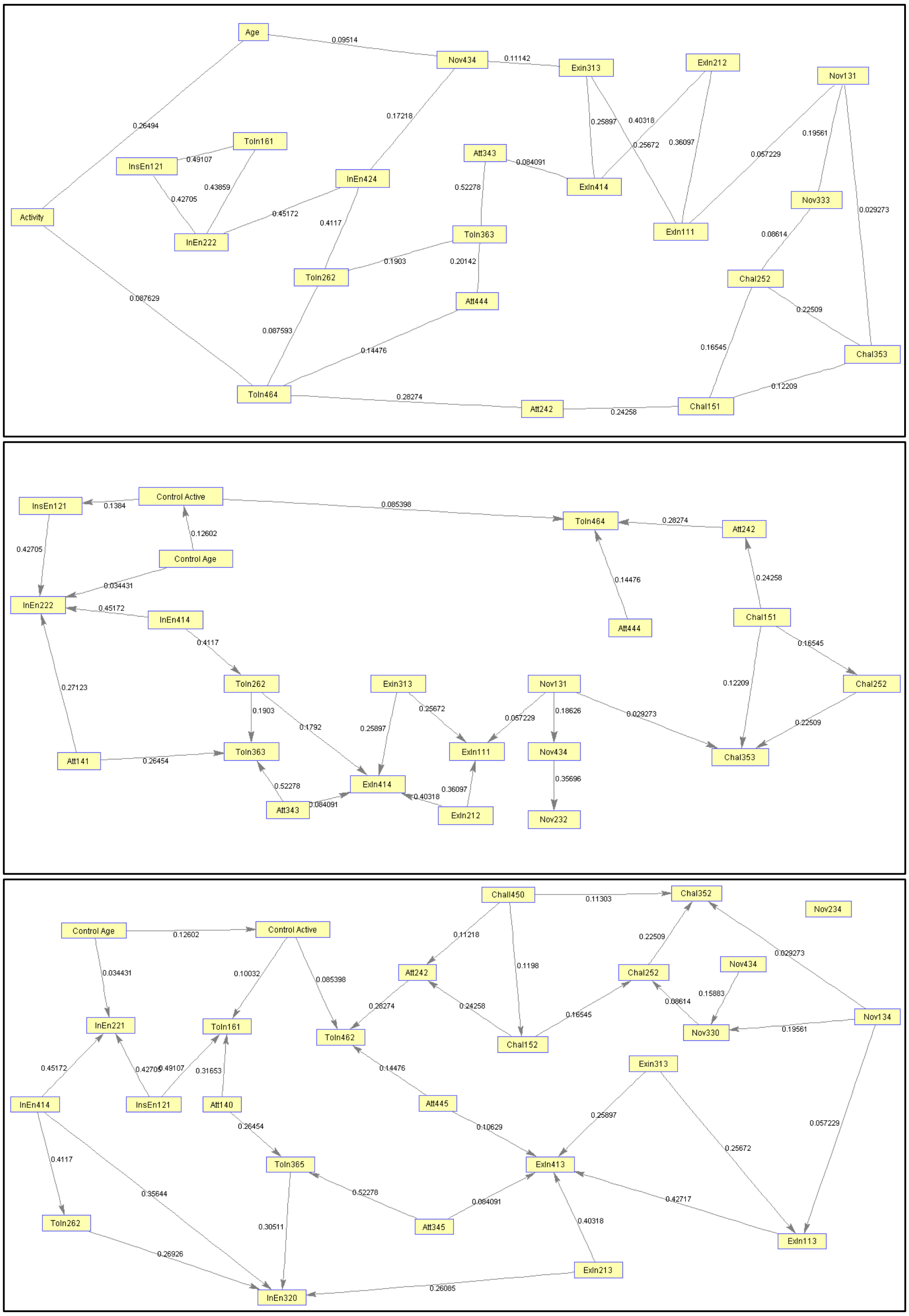


Figure 65 – Base Conditional Independence Analysis (CiMAp version 1) [127]

[127] NOTE: All the Conditional Independence analysis was conducted using a face differentiation of Activity Effectivity differentiation. Of interest would be further study of CI involving the Interdependence Profile .

APPENDIX XI: SEM Interdependence Profile – Congruence Assumptions

The following provides an inductive rationale for an Interdependence Profile representing a state of functional Affordance.

A. Within absolute Effectivity, an Approach cognition congruent with an agential learning assumption for Divergent Criticality (a learning motivation) will have a positive effect regardless of relative Effectivity (rVC). This allows an assumption that as an affective-behavioural construct for Divergent Criticality, Approach (as affective-agential), will be increasing in its relationships with all affective constructs in the Interest Model until absolute phase is exceeded.

B. Affective cognitions will function around a phase of relative-Effectivity. This is perception as a state of neural efficiency towards 'Tolerance Optimisation' that will be dependent on a composite effect of situative bottom-up and contextual top-down attentional processes. As such, perceptions of neural efficiency will be congruent with Tolerance Optimisation from such attentional cognitive processes. This is to say, increasing Challenge should be congruent with increasing Novelty and/or Attentional Demand, as both are extraneous variables providing contextual and situative Divergent Criticality.

C. A variable with multiple pathways will reflect a similar effect on these pathways. Approach cognition therefore will influence similar effect on its regressions from Attentional Demand and Novelty (i.e. both pathways will be subject to similar increasing or decreasing Approach effects).

Using these pathway assumptions, it is possible to accept or reject possible pathway effects towards informing an Interdependence Profile to suggest states of functional Affordance.

Effect Assumptions for developing an Interdependence Profile

As a Structural Equation Model, many direct pathways are mediated to a lesser or greater effect by indirect pathways. There exists then, direct and indirect effects to be considered before a total effect might be deconstructed[128]. In accordance with the Divergent Criticality hypothesis, the 'dependent' variable of 'Approach' is investigated to suggest possible 'indicator pathways' as to the functioning of a profile analysis, pathways 1,2, and 6 (see, Figure 66, below). It is here that it is possible to truly utilise the analysis power of SEM to deconstruct and decipher the covariance effects in an Interdependence Profile that we may then apply to a further causal hypothesis (e.g. providing ordinal-differentiation for a functional Affordance scale to test against other perception measures such as ROPELOC).

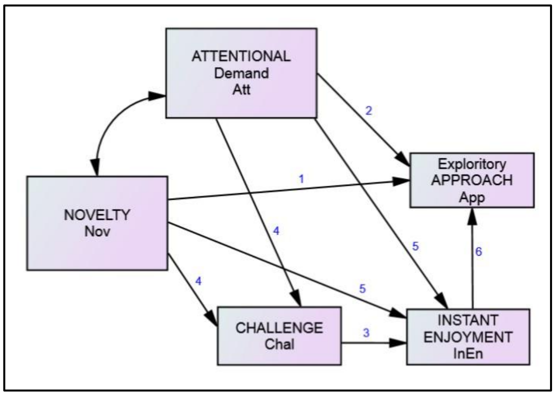


Figure 66 – Possible Pairwise Regression Pathways

Direct Pathway Regressions

Investigation of these 'direct' pathway assumptions lead to the selection of 'two' pathway regressions that were thought to offer the most useable information for an Interdependence Profile (Pathways- 1 & 2 (see, - Direct Pathway Regressions inferring Attentional Process Bias, below) were thought to infer the Effectivity landscape (relative Effectivity). Direct pathway (6) Instant Enjoyment → Approach, offered no slope-differentiation as Instant Enjoyment is mediated by all other constructs, conflating any effect assumptions. This guides now the mediating indirect-pathways towards Instant Enjoyment for future profile information.

Indirect Pathway Regressions

Instant Enjoyment is thought a primary mediating variable (such primacy is supported here and throughout the Interest literature (e.g., Chen *et al.*, 2001a; Chen, Sun, Zhu & Chen, 2014; Deci & Ryan, 2008; Harter, 1978; Hidi & Renninger, 2006; Rotgans & Schmidt, 2011), was investigated (in

[128] The primary analysis strength in SEM is in the deconstructing of the functional effects between related variables, not in making causal effect estimates.

their application towards an Interdependence Profile) in terms of its indirect pathways towards Approach. From this, only one indirect pathways through (3) Challenge → Instant Enjoyment→ Approach, seemed to offer viable functional information (see,

Challenge Indirect Pathway Regressions inferring a relative Effectivity State, below). Indirect pathways (4) (5) and (6) were not considered as offering differentiation information for any Interdependence Profile (see, Analysis and Rejection of 'Other' Regression Pathways, below).

Direct Pathway Regressions inferring Attentional Process Bias

Pathway 1) Novelty on Approach pathway as bottom-up dominance

Novelty → Approach is a 'direct' regression pathway. Congruence will see positive regressions reflecting increasing Approach (Exploratory Interest) in relation to increasing bottom-up Novelty on Approach as a relative Effectivity assumption.

Pathway 2) Attentional Demand on Approach pathway as top-down dominance

Attentional Demand effects on Approach are indicative of an 'attentional-awareness' that must infer top-down (attentional) processes. As co-varied with Novelty, it may be hypothesised to reflect top-down cognitive processes in relation towards surprise-appraisal. This composite awareness or co-variance of SEM can be extrapolated to a 'dominance' proposition between Attentional Demand and its co-relationship with Novelty on Approach as a relative Effectivity assumption.

The interdependence of pathways Novelty → Approach and Attentional Demand → Approach

As Novelty is considered an attention awareness of 'surprise' from the known, then if Attentional Demand → Approach is seen to regress positively (positive effect observed) and Novelty → Approach negatively, such opposed regressions (in accordance with pathway-congruence assumption 'C') infer a 'top-down' dominance in effect, as Novelty (sensory surprise) is perceived as declining whilst Approach is increasing. Alternatively, if a positive effect is observed in the Novelty → Approach pathway and Attentional Demand is regressed negatively, then bottom-up processes may be considered dominant. If both pathways are seen to be positively regressed, then dominance bias is difficult to determine and therefore a 'shared' composite-attention must be inferred[129].

[129] It should be remembered that all pathways as awareness-constructs are 'top-down' to some extent. Novelty and Attentional Demand will co-vary as all 'awareness' must have some top-down cognition on attentionly-aware. However, dominance-biasing may still be inferred from the interdependence of these pathways.

Through these pathway regressions (1 & 2) we may infer 'probable' cognitive bias in attentional processes and infer cognitive-function reflecting an Effectivity landscape, it does not however, provide information inferring the state of function within that landscape (functional Affordance either within or beyond relative cusp Effectivity).

To address this, Challenge as an antagonistic affective avoidance-cognition (dislike) is seen to meditate Novelty and Attentional Demand effects on Instant Enjoyment. It will illicit an antagonistic affective-cognition, on Instant Enjoyment mediated through Challenge indirect-pathway(s), Novelty → Challenge → Instant Enjoyment; and Attentional Demand → Challenge → Instant Enjoyment. As such, Challenge as affective

Challenge Indirect Pathway Regressions inferring a relative Effectivity State

Pathways 3) Challenge mediated on Instant Enjoyment inferring Affordance state

Challenge, importantly in this study, had been developed as a construct representing an avoid affective-emotional cognition. Challenge is observed as an emotional-cognition inferring states of phase-function within and beyond relative Effectivity. That is to say, increasing Challenge represents an increasingly negative or 'avoid' cognition aligned with cognitive emotions of anxiety and uncertainty in accordance with the Tolerance Optimisation hypothesis. As relative Effectivity is exceeded, the Challenge → Instant Enjoyment 'appraisal' pathway, represents the antagonistic 'avoid' mediations to hedonic 'enjoyment'. It is hypothesised that this Challenge → Instant Enjoyment mediation regulates the affective approach behaviours of surprise 'seeking' (the Novelty → Instant Enjoyment / Attentional Demand → Instant Enjoyment pathway) and such a proposition sees Challenge → Instant Enjoyment providing the self-regulation regulating 'affect' around a Tolerance Optimisation hypothesis and Divergent Criticality 'cusp inflection' Theory.

As a functional Affordance state, emergent either 'within' or 'beyond' a relative-Effectivity, the Challenge → Instant Enjoyment affectively rewarded 'within' rVC, but needs agential 'effort' if Affordance is taken 'beyond' relative Effectivity and Approach goal-oriented is to be positive.

As a state of Affordance determined by within or beyond relative Effectivity, cognitive function is able to be inferred from this Challenge → Instant Enjoyment pathway, dependent on the mediating surprise (Novelty) and Attentional Demands of the situated domain.

The inference from these affective pathways (1,2 &3) in an Interdependence Profile (IP), now informs how perceptions as attentional awareness (Interest measure), might reflect the state of functional Affordance in relative Effectivity from the SEM of it's attentional-antecedents and their inter-dependence.

Analysis and Rejection of 'Other' Regression Pathways

Pathway 4) Attentional Demand and Novelty on the Challenge pathway

Though these pathways would seem to offer inference as to the functioning of bottom up and top-down cognitions, as Challenge may always be seen of positive effect in Divergent Criticality, similar to that of the Approach assumption. However, Challenge had exhibited poor regression-power in the local tests of the model. This is possibly an issue with the accuracy of the questionnaire, and TYPE II errors missing Challenge effects. Therefore, it was considered that these pathways are better considered through their total-effects, a summation thought to offer greater validity in the effect of Novelty and Attentional Demand on → Approach (see 1) above.

Pathway 5) Attentional Demand and Novelty on Instant Enjoyment pathway

The pathways Attentional Demand → Instant Enjoyment and Novelty → Instant Enjoyment, are deemed to represent an affective inference (for life-regulation through cognitive-emotions). However, these pathways as direct effects on Instant Enjoyment reflect a paucity of agential affect as direct pathways and are better accommodated through the indirect Challenge → Instant Enjoyment pathway.

Pathway 6) Instant Enjoyment on Approach

The multi-relationship influences mediating Instant Enjoyment preclude inductive reasoning as the causal effects of this reporting pathway.

An Interdependence Profile

There exists, then, the possibility of interpreting pathway regressions in a profile that infers inter-dependence effects in relation to Tolerance Optimisation. It is in the interdependence between: Novelty → Exploratory Approach; Attentional Demand → Exploratory Approach; and Challenge →

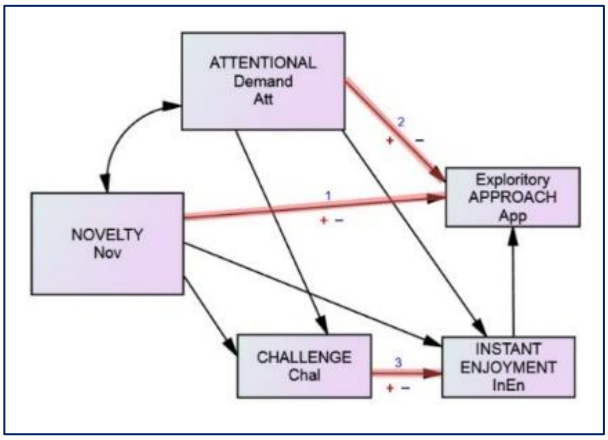


Figure 67 - Interdependence Profile

Instant Enjoyment), that an 'Interdependence Profile' might infer a composite of bottom-up and top-down attentional processes inferring a state of relative Effectivity and function.

The regression pathways seen in SEM Final Model 2 between the Interest's questionnaire constructs (Figure 67) provided many possible pathways that might be considered to offer inference for an Interdependence Profile (able to infer the possible functioning of an attention's cognitive processes in effect). Therefore, some *a priori* assumptions are necessary.

A State of Attentional Function in Direct and Indirect Effects

In the Pathway Final Model 2, the factor of Exploratory Approach (App) is seen as an affective cognitive behavioural construct mediated or 'dependent' on all other constructs within the model. This would seem to concur the hypothesised mechanism of Divergent Criticality for life regulation: Here a 'driving' or agential '*Approach'* is seen as influenced or mediated by the other 'Interest' constructs in a functional (cognitive) perception. This is supported in research on affective-behaviour, such as a motivational 'wanting' or 'cognitive-drive' over and above the hedonic 'liking'. Approach as dependent on, not only 'situated' cognitive demands (bottom-up) but also contextual 'top-down' agential processes, is seen as affective and agential (see, Berridge & Robinson, 2003; Northoff & Hayes, 2011; Panksepp, 2005).

From all the Interdependence Profiles possible, we can identify three pathways that may be considered as the 'most probable' in relation to construct-inferred, attentional processes (see, Figure 67, above) for identifying a 'state(s) of functional Affordance'. Voluntary Control Theory suggests criticality functioning in different relative landscapes (of Effectivity), and is able to be graphically represented through a model of Voluntary Control as 'reduced Voluntary Control' or the 'relative' functioning of criticality (see, Figure 68, over).

Criticality functioning as Voluntary Control sees internal top-down cognitions exact a cost and as 'limiting' of Voluntary Control 'reducing' of the generative reservoir available for criticality function. Increasing top-down attentional components not only reduce the functioning through their cognitive-demands, but reduce the functional phase of criticality (relative Effectivity). The effect is a steeper 'criticality' slope (the rate of temporal flux in neural efficiency) and such temporal flux behaviour is a signal of 'reduced Voluntary Control' indicative of relative Effectivity (Van Orden *et al.*, 2011). This provides the prospect of differentiating a state of Affordance objectively, when different 'Effectivity landscapes' (of criticality) are acknowledged (below) as relative Effectivity. A functional Affordance and Effectivity able to be inferred through the SEM Interdependence Profile.

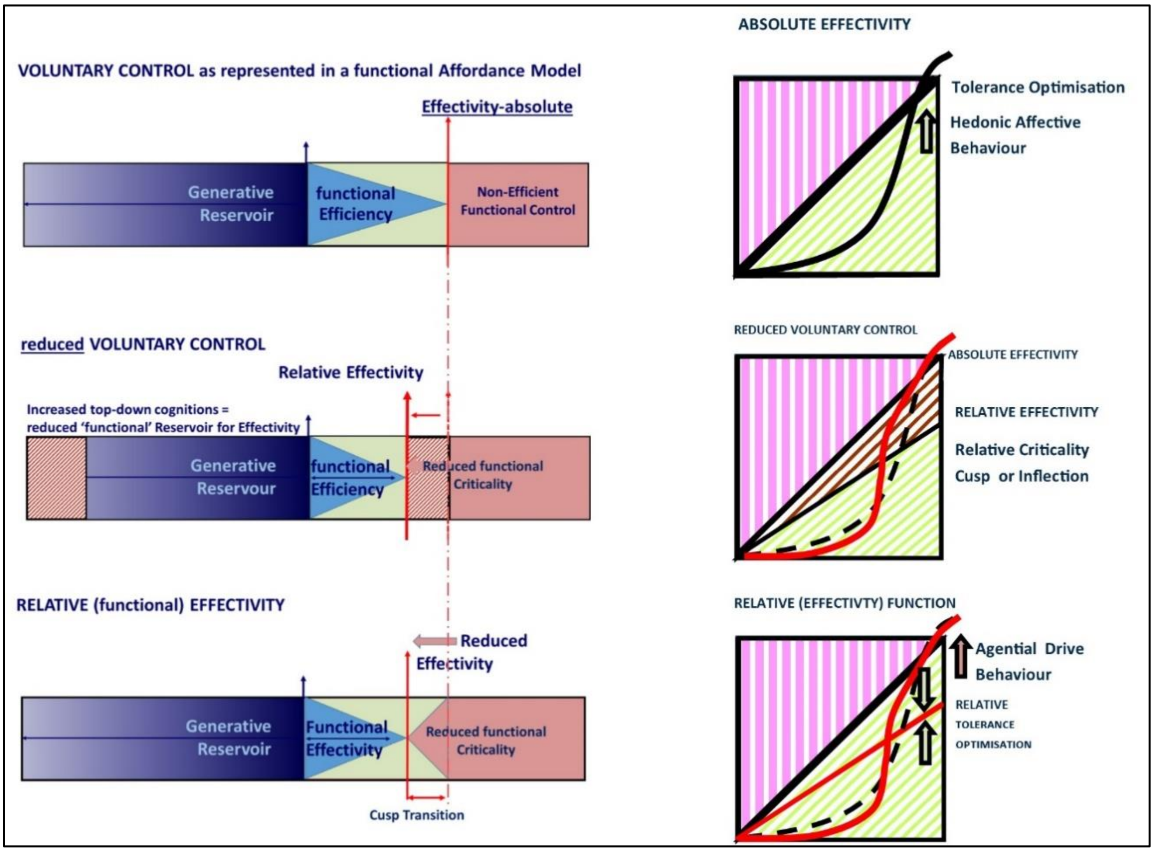


Figure 68 – Reduced Voluntary Control

Importantly, this 'reduced' Effectivity is not an 'absolute of function'. It is possible for a cusp-function in a rVC landscape to permit greater Effectivity as top-down attentional processes are diverted to bottom-up processing, in an agential-focus on sensory over contextual cognitions (Van Orden *et al.*, 2011). This, however, is not an easily realised cognitive capacity. Such a focus requires cognitive 'effort' (Eysenck *et al.*, 2007), and represents a 'lesser' optimal functioning proposition for Agential drive, tolerance and therefore function beyond relative cusp exerts an exponential cost of rVC. This 'beyond' relative Effectivity is seen as a transitional 'cusp' of function from a relative Effectivity towards an absolute parameter of possible function – absolute Effectivity. Once such an absolute is reached function will exhibit catastrophic functional collapse as compliant with Phase-criticality (Bak *et al.*, 1987; Van Orden *et al.*, 2011).

The *Approach* construct then, reflects an Agential capability or Effectivity due to reduced Voluntary Control. Here, as cognitive function goes through a relative cusp of Effectivity, there will be a reversal in hedonic-affect in accordance with the Tolerance Optimisation hypothesis. Though Divergent Criticality is still increasing within an 'absolute' of agential Effectivity, affective cognitions will display a correlation reversal with Instant Enjoyment as the systems moves beyond the relative

Tolerance Optimisation. *Approach* cognitions however, are able to remain positive through an agential motivation or goal-oriented 'drive' overriding hedonic cognitions. Goal directed behaviour will function at reduced efficiency until an absolute of phase (Effectivity) is reached. Here, catastrophic-collapse in is inevitable as parameters in phase-function are breached.

Pathway regressions as an awareness of cognitive criticality function, may therefore be expected to reflect such a relative Effectivity as either a 'WITHIN' relative Effectivity cognitions or 'BEYOND' relative Effectivity cognitions, a prerogative that allows us to make Congruence Assumptions on SEM pathway effects (congruence with a Tolerance Optimisation hypothesis). Such assumptions (see, APPENDIX XI) allow inference from the SEM 'effects' (Total, Direct and In-direct) to be applied in an Independence Profile, reflecting a state of function (functional Affordance) with which to investigate the Divergent Criticality hypothesis.

Even extracting only three pathways, eight-fold combinations and 64 different possible regressions exist. Using the Congruence Assumptions (APPENDIX XI), these regression possibilities may be reduced to one for each of the eight-fold combinations (see,Table 76).

Table 76 – Example of Regression Effects

Slope Profile	1) Nov→App	2) Att→App	3) Chal→ InEn	Relative Effectivity	Congruence Assumptions
+ + +					
+++	↑↑	↑↑	↑↑	WITHIN relative Effectivity	Okay
+++	↑↑	↑↑	↓↓		No A&B
+++	↑↑	↓↓	↑↑		No C
+++	↑↑	↓↓	↓↓		No B&C
+++	↓↓	↑↑	↑↑		No B&C
+++	↓↓	↑↑	↓↓		No B&C
+++	↓↓	↓↓	↑↑		No A
+++	↓↓	↓↓	↓↓	No	No A
+ + -					
++-	↑↑	↑↑	↑↓	BEYOND relative Effectivity	Okay
++-	↓↓	↓↓	↑↓		No B
++-	↑↑	↑↑	↓↑		No B
++-	↓↓	↓↓	↓↑		No A
++-	↑↑	↓↓	↑↓		No C
++-	↓↓	↑↑	↑↓		No C
++-	↓↓	↑↑	↓↑		No A
++-	↑↑	↓↓	↓↑		No A&C
+ - +					
+-+	↑↑	↑↓	↑↑		No A
+-+	↑↑	↓↑	↑↑	WITHIN relative Effectivity	Okay
+-+	↓↓	↑↓	↓↓		No A
+-+	↓↓	↓↑	↓↓		No A&B
+-+	↑↑	↑↓	↓↓		No B&C
+-+	↑↑	↓↑	↓↓		No A&C
+-+	↓↓	↑↓	↑↑		No A
+-+	↓↓	↓↑	↑↑		No B&C
+ - -					
+--	↑↑	↑↓	↑↓		No B
+--	↑↑	↓↑	↓↑		No A
+--	↓↓	↑↓	↑↓		No A
+--	↓↓	↓↑	↓↑		No A&B
+--	↑↑	↑↓	↓↑		No B&C
+--	↓↓	↑↓	↓↑		No A&C
+--	↓↓	↓↑	↑↓		No A&B
+--	↑↑	↓↑	↑↓	BEYOND relative Effectivity	Okay
- + -					
-+-	↑↓	↑↑	↓↑		No B&C
-+-	↓↑	↓↓	↑↓		No B&C
-+-	↓↑	↑↑	↑↓	BEYOND relative Effectivity	Okay
-+-	↑↓	↓↓	↓↑		No A
-+-	↑↓	↑↑	↑↓		No B
-+-	↓↑	↓↓	↓↑		No A&B
-+-	↓↑	↑↑	↓↑		No C
-+-	↑↓	↓↓	↑↓		No A
- + +					
-++	↑↓	↑↑	↑↑		No B
-++	↑↓	↑↑	↓↓		No B&C
-++	↓↑	↓↓	↑↑		No A&B
-++	↓↑	↓↓	↓↓		No A&B
-++	↑↓	↑↑	↓↓		No C
-++	↓↑	↑↑	↑↑	WITHIN relative Effectivity	Okay
-++	↓↑	↑↑	↓↓		No C
-++	↑↓	↓↓	↑↑		No A
- - +					
--+	↑↓	↑↓	↑↑		No A
--+	↑↓	↑↓	↓↓		No A&C
--+	↑↓	↓↑	↑↑		No B
--+	↑↓	↓↑	↓↓		No B&C
--+	↓↑	↑↓	↓↓		No B&C
--+	↓↑	↑↓	↑↑		No B
--+	↓↑	↓↑	↓↓		No A
--+	↓↑	↓↑	↑↑		No C
- - -					
---	↑↓	↑↓	↑↓	aMOTIVATION	No A
---	↑↓	↑↓	↓↑		No A
---	↑↓	↓↑	↑↓		No B
---	↑↓	↓↑	↓↑		No A&B
---	↓↑	↑↓	↑↓		No B
---	↓↑	↑↓	↓↑		No A&B
---	↓↑	↓↑	↑↓		No C
---	↓↑	↓↑	↓↑		No A

Using the regression and congruence assumptions, the following Interdependence Profiles emerge as congruent in an eight-fold possibility matrix for an Interdependence Profile (Table 77).

Table 77 – Base Interdependence Profiles

Slope Profile	1) Nov→App	2) Att →App	3) Chal→ InEn	Divergent Criticality	Congruence	Interdependence *(Dominance First)*
+ + +	↑↑	↑↑	↑↑	WITHIN relative Effectivity	Okay	Shared Dominance
+ + -	↑↑	↑↑	↑↓	BEYOND relative Effectivity	Okay	Shared Dominance
+ - +	↑↑	↓↑	↑↑	WITHIN relative Effectivity	Okay	Bottom-Up Dominance
+ - -	↑↑	↓↑	↑↓	BEYOND relative Effectivity	Okay	Bottom-Up Dominance
- + +	↓↑	↑↑	↑↑	WITHIN relative Effectivity	Okay	Top-Down Dominance
- + -	↓↑	↑↑	↑↓	BEYOND relative Effectivity	Okay	Top-Down Dominance
- - +	None	None	None	NO	NO	N/A
- - -	↑↓	↑↓	↑↓	WITHIN absolute Effectivity	NO	Top-Down Amotivation

Divergent Criticality and Congruence Assumptions – Notable Exceptions

There are congruence ‘issues’ with two Interdependence Profiles:

I. The Interdependence Profile IP = (- - +) did not provide for any Divergent Criticality within an absolute Effectivity.

Instant Enjoyment on Approach should, in a ‘within’ absolute phase of Effectivity, produce a positive Divergent Criticality effect from either increasing Novelty or Attentional Demand and a Positive Approach assumption (Congruence Assumption A & C). This effect is not seen in the profile for Interdependence Profile where either Nov→ App or Att→ App would be seen to report positive. That Instant Enjoyment reports a positive Divergent Criticality effect (as it must in its pathway with a positive Approach) this further confounds non Divergent Criticality observed in this profile. That such a profile (- - +) is ‘not’ reported in any of the 24 sampling domains (see , APPENDIX XV), its absence might be inferred as further support for the ethical sampling of Divergent Criticality ‘within’ absolute Effectivity (Methodological Considerations).

II. The Interdependence Profiles IP = (- - -) might similarly seem to challenge Divergent Criticality with Novelty and Attentional Demand reporting negative, however:

This profile either represents a negative Instant Enjoyment→ Approach pathway possible in a functional Affordance state beyond Effectivity (an unusual ‘absolute’ consideration given the sampling criteria but a possibility in a ‘beyond’ relative Effectivity). Such reporting of a lack of agential drive or motivation, is an ‘amotivational’ state causing relative Effectivity to report like absolute Effectivity. Such amotivation is well known within the motivational literature (Deci & Ryan, 1985).

APPENDIX XII: Interdependence Profile –Functional Affordance

The Interdependence Profile – IP 1 (+ – –): Bottom-up Attentional Dominant

Dominance – This is one where the interaction between attentional components is bottom-up dominant. In that, with any 'awareness of attention' there must be a top-down construct to even be aware of attending, therefore some 'reduced Voluntary Control' (rVC) is in effect. However, the perception of decreasing ATT in relation to increasing NOV suggests bottom-up dominance.

reduced Voluntary Control – The Interdependence profile of regression-betas (+ – –) is one that offers the most probable function for a **narrow** rVC cusp-effect (see, Figure 68, p350).

Effectivity – The negative Challenge → Enjoyment regression infers a relative Effectivity state BEYOND the rVC functional (tolerance) optimal (see Figure 69, below).

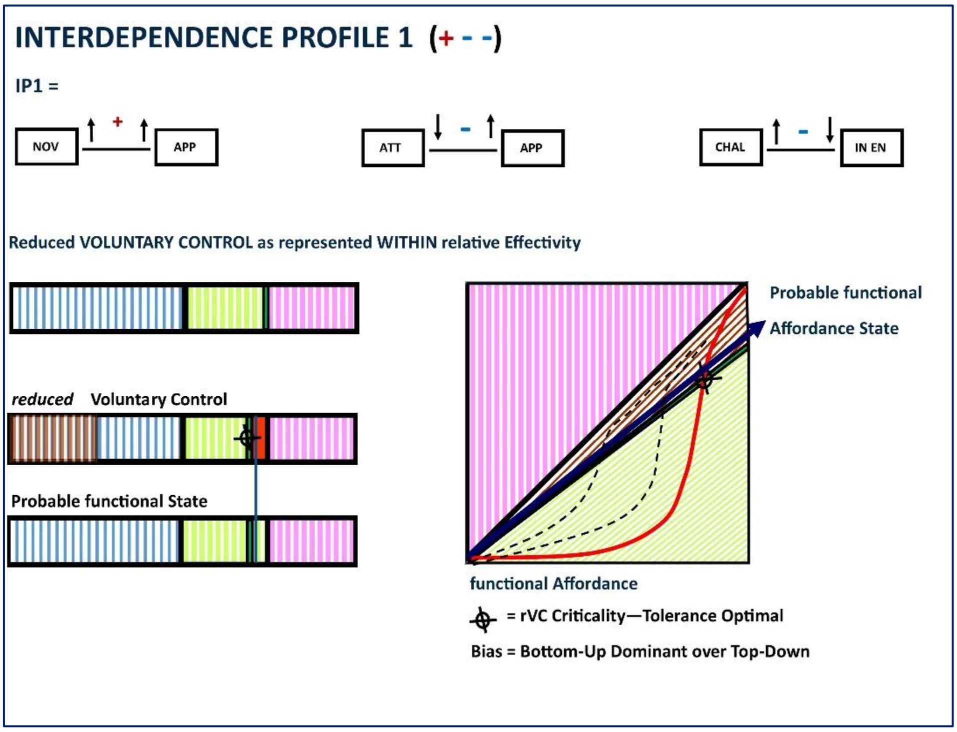


Figure 69 – Interdependence Profile 1 (+ – –)

<u>Slope</u> <u>Inference</u>

βeta = +

<u>**1 NOVELTY →Exploratory APPROACH**</u>

Here, a cognitive appraisal of Novelty is positively regressed with an Approach motivation. This is congruent with an increasing Divergent Criticality which, in the absence of a 'top-down' positive effect (Attentional Demand → Approach is negative) may infer a bottom-up attentional influence.

βeta = –

<u>**2 Attention DEMAND → Exploratory APPROACH**</u>

That awareness of Attentional Demand (cognitive-effort) is perceived as negative in its regression with Approach allows us to consider that, top-down effects on attentional cognition are limited.

βeta = –

<u>**3 CHALLENGE →Instant ENJOYMENT**</u>

Challenge, here, as a measure indicative of an inverse measure of anxiety and uncertainty, if found to be negatively regressed with an increasing Instant Enjoyment suggests a state within rVC criticality.

The Interdependence Profile – IP 2 (+ + –): Shared Attentional Processes

Dominance – This is one where the interaction between attentional components is shared, a composite of both bottom-up and top-down cognitions in affect.
Reduced Voluntary Control – The Interdependence Profile of regression-betas (+ + -) is one that offers the most probable function for a **medium** rVC cusp-effect (see, Figure 68, p350).
Effectivity – The negative Challenge → Enjoyment regression infers an Effectivity state BEYOND the rVC Tolerance optimal (see, below).

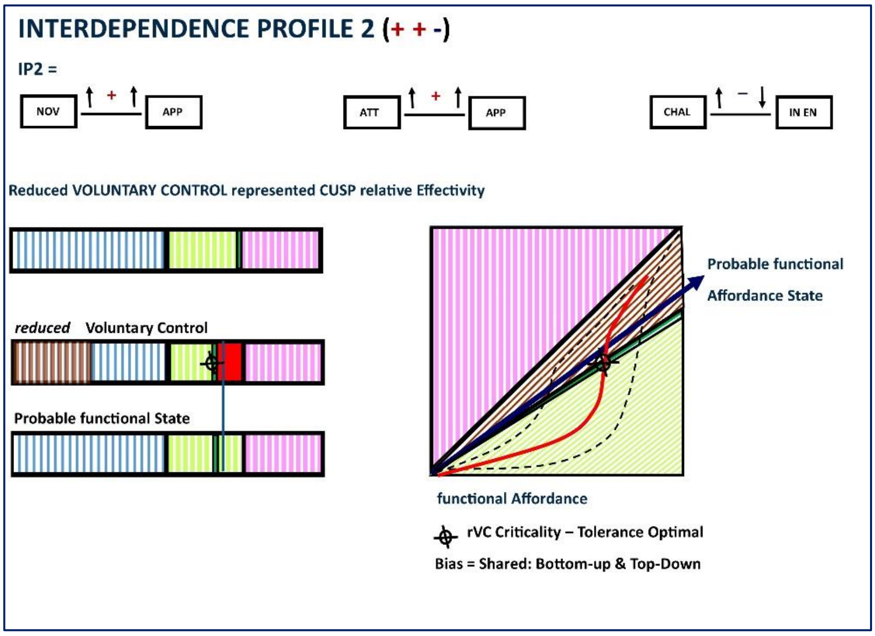


Figure 70 – Interdependence Profile 2 (+ + –)

<u>Slope</u>	<u>Inference</u>
βeta = +	<u>**1 NOVELTY →Exploratory APPROACH**</u> Here, a cognitive appraisal of Novelty is positively regressed with an Approach motivation. This is congruent with an increasing Divergent Criticality and infers a bottom-up influence on awareness cognitions of Interest.
βeta = +	<u>**2 Attention DEMAND → Exploratory APPROACH**</u> Cognitive effort as a top-down awareness of Attentional Demand, is perceived as positive in its regression with Approach. This is congruent with an increasing Divergent Criticality and infers a top-down influence on awareness cognitions of Interest.
βeta = –	<u>**3 CHALLENGE →Instant ENJOYMENT**</u> Challenge here, as a measure indicative of anxiety and uncertainty, if found to be negatively regressed with a decreasing Instant Enjoyment suggests a state within rVC criticality.

The Interdependence Profile – IP 3 (– + –): Top-down Attentional Dominance

Dominance – This is one that offers the most probable explanation for a reduced Voluntary Control of top-down bias.
Reduced Voluntary Control – The Interdependence Profile of regression-betas (– + –) is one that offers the most probable function within a **wide** rVC cusp-effect (see Figure 68, p350).
Effectivity – The negative Challenge → Enjoyment regression infers an Effectivity state BEYOND the rVC tolerance optimal (see, below).

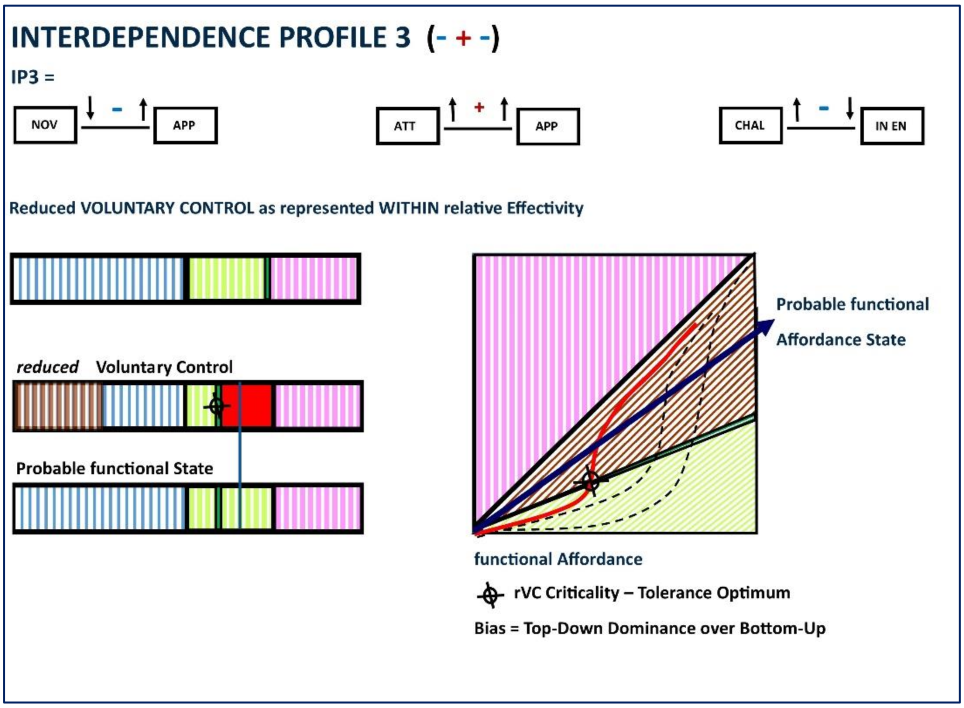


Figure 71 – Interdependence Profile 3 (– + –)

Slope	Inference
βeta = –	**1 NOVELTY →Exploratory APPROACH** Here, as Novelty is negatively regressed with a positive (congruent) Approach, inferring bottom-up cognitions of attention are of limited effect in view of top-down biased effect from ATT→APP.
βeta = +	**2 Attention DEMAND → Exploratory APPROACH** Cognitive effort as a top-down awareness of Attentional Demand is perceived as positive in its regression with Approach. This is congruent with an increasing Divergent Criticality and infers a top-down influence on awareness cognitions of Interest.
βeta = –	**3 CHALLENGE →Instant ENJOYMENT** Challenge, here, as a measure indicative of increasing anxiety and uncertainty, if found to be negatively regressed with an decreasing Instant Enjoyment suggests a state BEYOND rVC Criticality.

The Interdependence Profile – IP 4 (– + +): Top-down Attentional Processes

Dominance – This is one that offers the most probable explanation for a reduced Voluntary Control of top-down bias.
Reduced Voluntary Control – The Interdependence Profile of regression-betas (– + +) is one that offers the most probable function within a **wide** rVC cusp-effect (see, Figure 68, p350).
Effectivity – The positive Challenge → Enjoyment regression infers an Effectivity state WITHIN the rVC functional optimal (see, below).

The Interdependence Profile – IP 5 (+ + +): Shared Attentional Processes

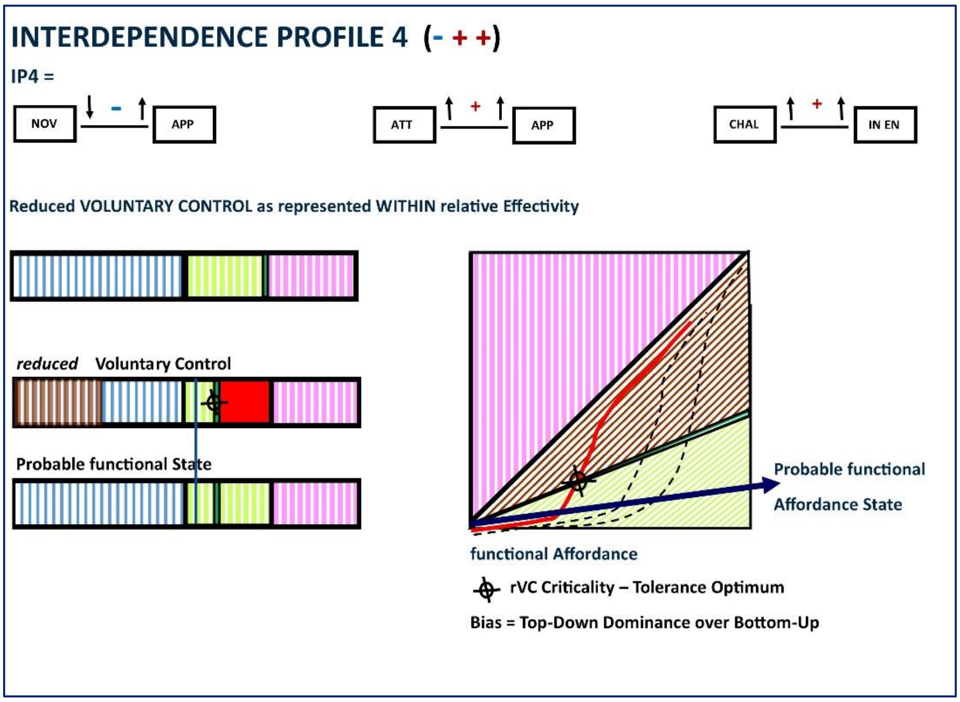


Figure 72 – Interdependence Profile 4 (– + +)

Slope	*Inference*
*β*eta = –	**1 NOVELTY → Exploratory APPROACH** Here, as Novelty is negatively regressed with a positive (congruent) Approach, and infers bottom-up cognitions of attention are of limited effect in view of top-down biased dominance.
*β*eta = +	**2 Attention DEMAND → Exploratory APPROACH** Cognitive effort as a top-down awareness of Attentional Demand, is perceived as positive in its regression with Approach. This is congruent with an increasing Divergent Criticality and infers a top-down influence on awareness cognitions of Interest.
*β*eta = +	***3 CHALLENGE → Instant ENJOYMENT*** Challenge, here as a measure of anxiety and control-uncertainty, if found to be positively regressed with Instant Enjoyment, suggests that such increasing anxiety is still able to be affective-positive (hedonic) instant enjoyment when congruent with Divergent Criticality, indicating an Effectivity state still WITHIN functional phase.

Dominance – This is one where the interaction between attentional components is shared, a composite of both bottom-up and top-down cognitions in affect.

The Interdependence Profile – IP 5 (+ + +): Top-down Attentional Processes

Reduced Voluntary Control – The Interdependence Profile of regression-betas (+ + +) is one that offers the most probable function for a **medium** rVC cusp-effect (see Figure 68, p350).

Effectivity – The positive-reporting congruent in Approach and Instant Enjoyment is indicative of functioning within absolute Effectivity – a probable rVC criticality still within relative Effectivity (see, below).

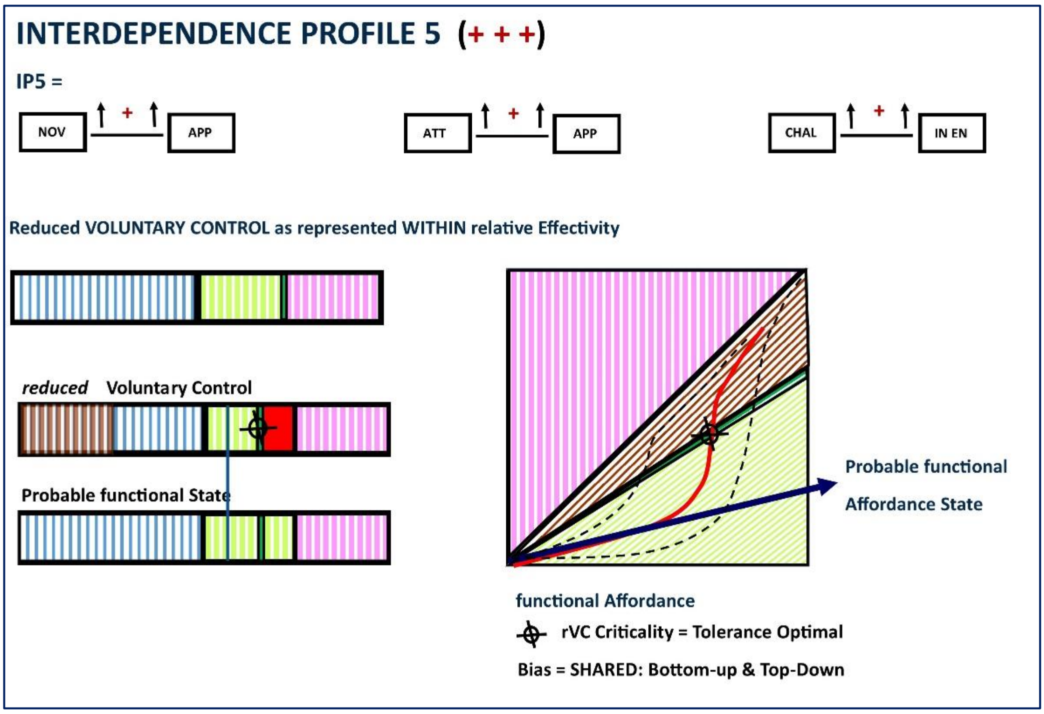


Figure 73 – Interdependence Profile 5 (+ + +)

Slope	Inference
βeta = +	**1 NOVELTY →Exploratory APPROACH** Here, a cognitive appraisal of Novelty is positively regressed with an Approach motivation. This is congruent with an increasing Divergent Criticality and infers a bottom-up influence on awareness cognitions of Interest.
βeta = +	**2 Attention DEMAND → Exploratory APPROACH** Cognitive effort as a top-down awareness of Attentional Demand, is perceived as positive in its regression with Approach. This is congruent with an increasing Divergent Criticality and infers a top-down influence on awareness cognitions of Interest.
βeta = +	**3 CHALLENGE →Instant ENJOYMENT** Challenge here, as a measure of anxiety and control-uncertainty can be considered as positively regressed with Instant Enjoyment. That such increasing anxiety is still able to be affective-positive hedonic reporting when congruent with Divergent Criticality, indicates an Effectivity state still within relative Effectivity.

The Interdependence Profile – IP 6 (+ – +): Bottom-up Attentional Dominance

Attentional Dominance – That in any 'awareness of attention' there must be a top-down construct to even be aware of attending, therefore some 'reduced Voluntary Control' (rVC) is in effect. However, the perception of decreasing ATT in relation to increasing NOV suggests bottom-up dominance.

reduced Voluntary Control – The Interdependence profile of regression-betas (+ – +) is one that offers the most probable function for a **narrow** rVC cusp-effect (see, Figure 68, p350).

Effectivity – The positive-reporting evident in Approach and Instant Enjoyment is indicative of probable functioning 'within' relative Effectivity – a state possible within a wide spectrum but able to be determined to a probable function by the Criticality slope of bottom-up attentional processes (see, below).

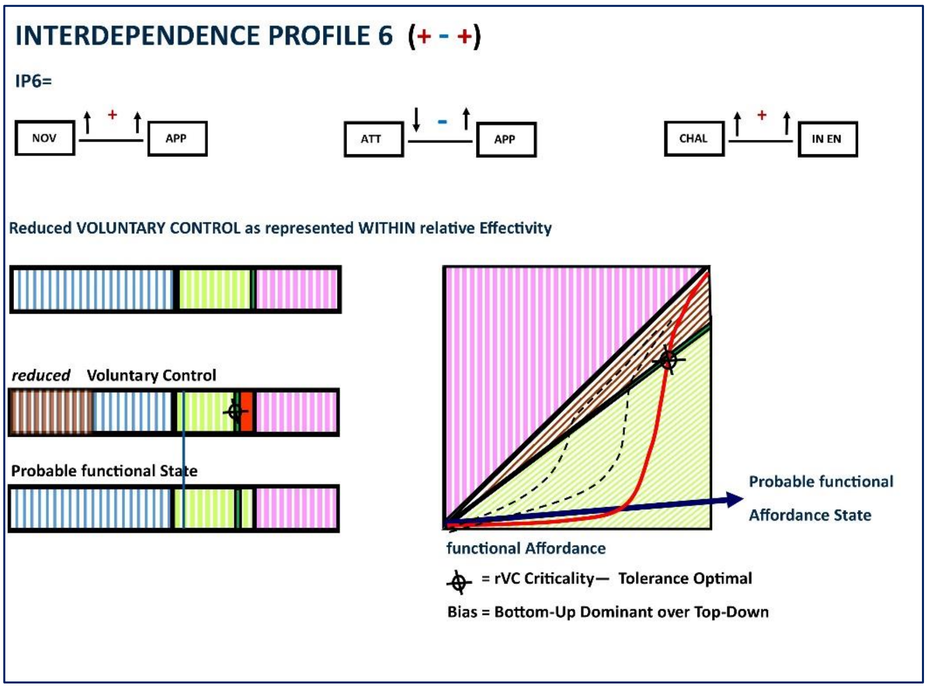


Figure 74 – Interdependence Profile 6 (+ – +)

βeta **<u>1 NOVELTY → Exploratory APPROACH</u>**

\+ Here, a cognitive appraisal of Novelty is positively regressed with an Approach motivation. This is congruent with an increasing Divergent Criticality which, in the absence of a 'top-down' positive effect (Attentional Demand → Approach is negative) may infer a bottom-up attentional influence.

βeta **<u>2 Attention DEMAND → Exploratory APPROACH</u>**

– That awareness of Attentional Demand (cognitive-effort) is perceived as negative in its regression with Approach allows the consideration that top-down perceptions on attentional cognition are limited.

βeta **<u>3 CHALLENGE → Instant ENJOYMENT</u>**

\+ Challenge here, as a measure of anxiety and control-uncertainty can be considered as positively regressed with Instant Enjoyment. That such increasing anxiety is still able to be affective-positive hedonic reporting when congruent with Divergent Criticality, indicates an Effectivity state still within relative Effectivity.

The Interdependence Profile – IP 7 (– – –): Amotivational Agency Effects

Dominance – This is one where the interaction between attentional components is shared, a composite of both bottom-up and top-down cognitions in affect.
Reduced Voluntary Control – The Interdependence Profile of regression-betas (- - -) is one that offers the most probable function for a **medium** rVC cusp-effect (see, Figure 68, p350).
Effectivity – The negative Challenge → Enjoyment regression infers an Effectivity state BEYOND the rVC Tolerance optimal (see, below).

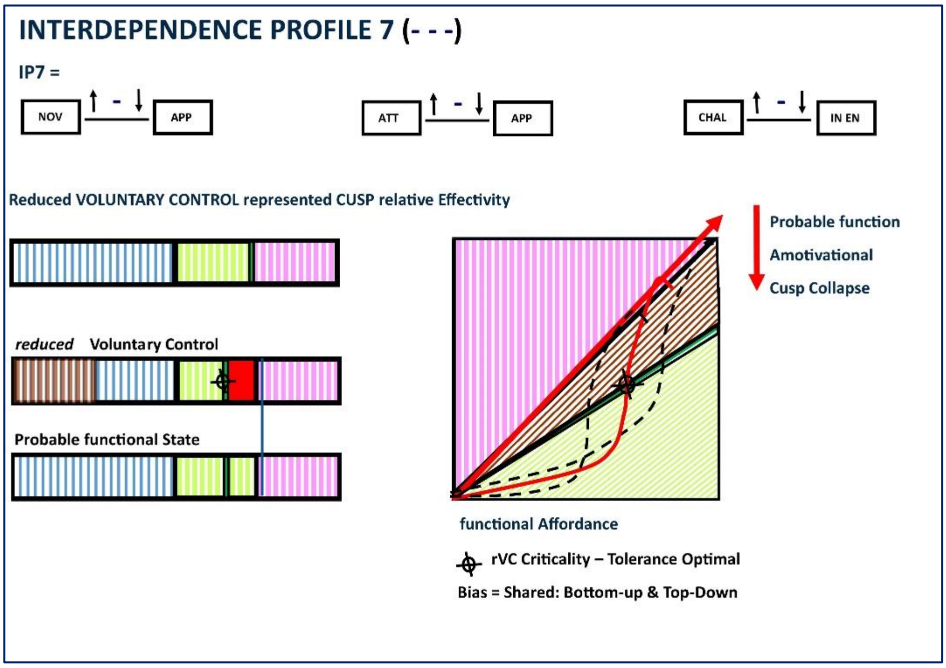


Figure 75 – Interdependence Profile 7 (– – –)

Slope	*Inference*
*β**eta* = –	**1 NOVELTY →Exploratory APPROACH** Here as Novelty is negatively regressed with Approach, but in a state of function 'beyond' relative Effectivity, such negative or decreasing Approach infers negative Agential effort to drive Approach cognitions (in effect focusing top-down attentional demand towards Agential goal-orientations) resulting in 'Amotivational' affective-cognitions and greater probability of relative criticality collapse, a cusp-collapse similar to absolute Effectivity collapse.
βeta = –	**2 Attention DEMAND → Exploratory APPROACH** As it is considered unlikely that bottom-up cognitions take Effectivity beyond phase collapse, it is therefore hypothesised that overt amotivation cognitions created a negative or decreasing Approach inferring negative Agential effort or drive resulting in 'Amotivational' affective-cognitions and greater probability of relative criticality collapse, a cusp-collapse similar to absolute Effectivity collapse.
βeta = –	***3 CHALLENGE →Instant ENJOYMENT*** Instant enjoyment, here, as an affective hedonic emotional-cognition will be seen to be decreasing as Challenge takes function beyond relative Tolerance Optimal into a 'beyond' or inflection point of phase transition, a cusp-collapse similar to absolute Effectivity collapse.

APPENDIX XIII: Hypothesis (H1) – Initial Correlation Analysis

H1 – Correlations of measures Self-Concept (ROPELOC) and functional Affordance, will report in accordance with agential-mediation of the Divergent Criticality hypothesis

If a Divergent Criticality hypothesis is in effect, then states of function as suggested by the Interdependence Profile, should correlate with perceptions of personal effectiveness. The following results were obtained through a Spearman's Rank Order One-tailed correlation (Table 78, above). The Divergent Criticality hypothesis predicted a positive correlation using $SPSS_{IBM24}$.

Table 78 – IP Spearman's rho Correlations

	IPcont	CT	Control	TE	PAB
Correlation	1.000	0.040	-0.018	**.089****	0.028
Coefficient	p	0.135	0.305	0.007	0.219
n	767	767	767	767	767

Note:**. Correlation is significant at the 0.01 level (1-tailed).

Before accepting such seemingly poor reporting, there is the need to account for the non- continuous 'IP' scale: That though ordinal in terms of functional Affordance state actually represents behaviour around an 'inflection of affect' (Tolerance Optimisation), the scale reverses at IP3 - IP1.

Applying a continuous scale with the 'beyond' Tolerance Optimisation IP-scale reversed and in orientation with the ROPELOC scales (1=low and 6= high), a further correlation was conducted.

Table 79 – Continuous IP Spearman's rho Correlations

	IPcont	CT	Control	TE	PAB
Correlation	1.000	0.037	-0.018	**-.087****	0.027
Coefficient	p	0.311	0.618	0.016	0.447
n	767	767	767	767	767

Note:**. Correlation is significant at the 0.01 level (1-tailed).

Though again finding limited correlation, what is interesting here is that the correlation is similar (though reversed as would be expected), emphasising the influence of the 'beyond' Tolerance Optimisation reporting. Such a result is in accordance with the Divergent Criticality hypothesis of Tolerance Optimisation: though recognising the rank-order of the data, Spearman's does not account for the non-linear functioning of Divergent Criticality and therefore the assumptions of similar 'non-normality' in non-parametric reporting, cannot be - assumed. However, this confounding would not be so prevalent 'beyond' Tolerance Optimisation as this represents a 'limited' (Cusp-Hopf function) of Tolerance Optimisation maintenance. We should therefore expect the negligible influence of the 'within' IP-scale as the Divergent Criticality hypothesis is a Tolerance Optimisation functioning hypothesis. Therefore it is appropriate to analyse the IP-scales (1-3) in isolation (see 6.20, Hypothesis Testing (H1,xiii p199).

APPENDIX XIV: Hypothesis H(3) Repeat Measures Two-Way Mixed ANOVA

Mixed box designs have received some criticism (such as baseline measurements, 'biasing' repeat-measures through carryover effects, questioning testing sequence validity (O'neill, 1977)). In order to accommodate for possible order confounding and to account for any intervention-expectancy that might be in effect (Matthews, 1988), the use of an alternated-intervention model and a two week 'wash-out' period to the sampling (see, Table 80), intended to accommodate such 'periodicity' and 'carry-over' effects in the data (Hedayat & Zhao, 1990).

Table 80 – Mixed Box Design (counter-balances measure-order and intervention)

Sample	ID	Description		Cross Order	Date	Activity	Activity	IP
TCL Sampling		TRADITIONAL CLASSROOM LEARNING						
10	3.12b	MHA1	School Classroom	1	20/11/2015	3	3	2
9	3.10b	LJMU CO 1	Coach Lecture	2	02/12/2015	3	3	2
13	3.142b	LJMU PE 1	Phys Ed - Lecture	1	02/11/2015	3	3	5
7	3.4b	LJMU TE 1	Teach Direct Lecture	2	23/05/2016	3	3	7
15	3.16b	LJMU OE 1	Developm' Lecture	1	03/11/2015	3	3	5
17	3.19a	CHS 1	School Classroom	2	03/03/2016	3	3	3
LoTC Sampling		LEARNING OUTSIDE THE CLASSROOM						
11	3.11a	MHA2	Outdoor Activity	1	25/11/2015	7	1	1
8	3.9b	LJMU CO 2	Coaching Activity	2	22/09/2015	7	1	2
12	3.13b	LJMU PE 2	Outdoor Activity	1	01/12/2015	7	1	1
5	3.3a	LJMU TE 2	Outdoor Walk	2	03/03/2015	7	1	1
14	3.15b	LJMU OE 2	Team Activity	1	02/12/2015	3	3	2
18	3.20b	CHS 2	Glacier Walk	2	12/02/2016	9	2	3

Note: Cross Order (1) = TCL sampled first; Cross Order (2) = LoTC sampled first

What would be a simple paired-means test now becomes factorial: a two- dependent variable (High and Low Situational Domain DV's), a between sampling-order of presentation (ORDER). The use of factorial ANOVA analysis of the data aims to avoid compound-probability problems (a validity issue of more simplistic, multiple paired t-tests analysis).The results are presented for the ROPELOC constructs: Cooperative Teamwork (CT), Time Effectiveness (TE), Locus of Control (Locus) and Personal Abilities and Beliefs (PAB).

Two sample groups where removed in the sorting for confounding the sampling criteria:

1) The paired samples 10 and 11 from (MHA) were sampled prior to the wash-out period of two weeks, negating the sampling criteria.
2) The sample 18 (CHS), on enquiry, was found to have been conducted as an evening review (residential-based), rather than the 'situated' sampling required for a 'state' measure. Paired samples 17 & 18 were also removed.

APPENDIX XV: Sample Interdependence Profiles

SAMPLE DOMAINS AND CODES

No	Sample code	Descrition—Domain	Domain	Domain Ordinal	IP
1	3.5A	Biology Trip	9	2	6
2	3.23A	Mountaineering Review	7	1	7
3	3.1A	Swanage Geography Field	9	2	2
4	3.2A	Canoe Award	7	1	3
5	3.3A	Moel-Fameau Hill Walk	7	1	1
6	3. 6 A	Team Building	9	2	2
7	3.4B	HE Lecture	3	3	7
8	3.9B	Team Building	7	1	2
9	3.10B	HE Lecture	3	3	2
10	3.11B	Secondary Lesson	3	3	2
11	3.12B	Outdoor Activity	7	1	1
12	3.13B	Outdoor Activity	7	1	1
13	3.142B	HE Lecture	3	3	5
14	3.15B	HE Workshop	3	3	2
15	3.16B	Team Challenge	7	1	5
16	3.17B	Skiing	7	1	5
17	3.19A	Secondary Lesson	3	3	3
18	3.20B	Glacier Walking	9	2	3
19	3.21B	Team Building	9	2	1
20	3.22B	Mountaineering	7	1	4
21	3.24 B	Paddlesport / Review	9	2	7
22	3.25B	DoE 2	10	4	2
23	3.26B	Geography Lesson	3	3	3
24	3.01A	DoE 4	10	4	3

Domain	Description
9	Half Day Team Build
9	Half Day Sport Activity
3	2 Hour min Theory Session
4	Recall of Past Activity
10	4 Plus Day OE Residential
10	2 Day Expo
7	OA Activities
7	1 Day Outdoor Activities
9	Field Day - Residential
10	4 Day Expo - Doe

KEY

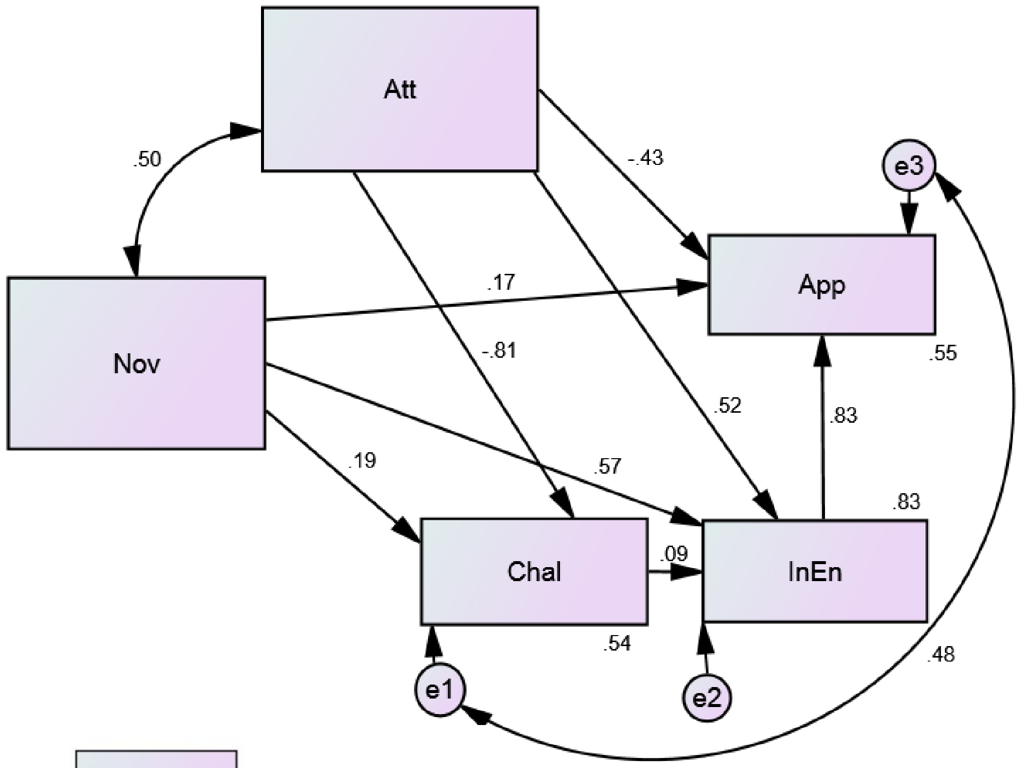
n=874

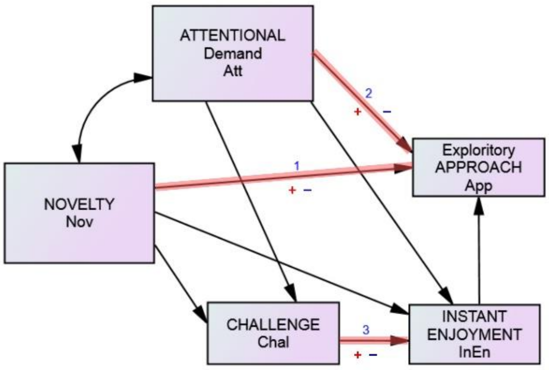
Domain = **Situational Sampling**

Domain Ordinal = **Domain Sorted**
(Used in Conditional Independence)

IP = **Interdependence Profile**
(SEM inferred functional Affordance)

Full Interdependent profile Example for Sample 1 – IP6 (+- - +); All samples overleaf.





	SAMPLE 1 - IP6 = (+ - +)		
	Predictor	**Outcome**	**Std Beta**
	Att	Chal	-.811 ***
	Nov	Chal	0.185
3	Chal	InEn	0.089
	Nov	InEn	.575 ***
	Att	InEn	.524 ***
2	Att	App	-.428 *
1	Nov	App	0.169
	InEn	App	.827 **

SAMPLE 2 - IP7 = (- - -)

	Predictor	Outcome	Std Beta
	Att	Chal	-0.424
	Nov	Chal	0.19
3	Chal	InEn	-0.144
	Nov	InEn	.605 **
	Att	InEn	0.306
2	Att	App	-0.026
1	Nov	App	-0.058
	InEn	App	.863 **

SAMPLE 3 - IP2 = (+ + -)

	Predictor	Outcome	Std Beta
	Att	Chal	-0.131
	Nov	Chal	.230 †
3	Chal	InEn	-.473 ***
	Nov	InEn	.457 ***
	Att	InEn	.306 **
2	Att	App	0.123
1	Nov	App	.194 †
	InEn	App	.721 ***

SAMPLE 4 - IP3 = (- + -)

	Predictor	Outcome	Std Beta
	Att	Chal	-0.04
	Nov	Chal	0.205
3	Chal	InEn	-.453 *
	Nov	InEn	0.155
	Att	InEn	.408 †
2	Att	App	0.274
1	Nov	App	-0.108
	InEn	App	0.246

SAMPLE 5 - IP1 = (+ - -)

	Predictor	Outcome	Std Beta
	Att	Chal	0.115
	Nov	Chal	.494 **
3	Chal	InEn	-0.226
	Nov	InEn	-.411 **
	Att	InEn	.580 ***
2	Att	App	-.369 †
1	Nov	App	.521 *
	InEn	App	.808 ***

SAMPLE 6 - IP2 = (+ + -)

	Predictor	Outcome	Std Beta
	Att	Chal	0.184
	Nov	Chal	.242 †
3	Chal	InEn	-0.189
	Nov	InEn	.324 *
	Att	InEn	.467 ***
2	Att	App	0.167
1	Nov	App	.257 †
	InEn	App	.269 *

SAMPLE 7 - IP7 = (- - -)

	Predictor	Outcome	Std Beta
	Att	Chal	0.039
	Nov	Chal	.310 *
3	Chal	InEn	-.417 ***
	Nov	InEn	.399 ***
	Att	InEn	.449 ***
2	Att	App	-0.083
1	Nov	App	-0.045
	InEn	App	.795 ***

SAMPLE 8 - IP2 = (+ + -)

	Predictor	Outcome	Std Beta
	Att	Chal	0.181
	Nov	Chal	0.145
3	Chal	InEn	-.220 *
	Nov	InEn	.237 *
	Att	InEn	.592 ***
2	Att	App	.189 †
1	Nov	App	.173 †
	InEn	App	.558 ***

SAMPLE 9 - IP2 = (+ + -)

	Predictor	Outcome	Std Beta
	Att	Chal	-0.033
	Nov	Chal	.425 **
3	Chal	InEn	-.316 **
	Nov	InEn	.716 ***
	Att	InEn	.485 ***
2	Att	App	.251 *
1	Nov	App	.580 ***
	InEn	App	.367 ***

SAMPLE 10 - IP2 = (+ + -)

	Predictor	Outcome	Std Beta
	Att	Chal	0.062
	Nov	Chal	0.239
3	Chal	InEn	-.354 ***
	Nov	InEn	.602 ***
	Att	InEn	.379 ***
2	Att	App	0.014
1	Nov	App	0.214
	InEn	App	.578 ***

SAMPLE 11 - IP1 = (+ - -)

	Predictor	Outcome	Std Beta
	Att	Chal	0
	Nov	Chal	0.213
3	Chal	InEn	-0.156
	Nov	InEn	.535 ***
	Att	InEn	0.172
2	Att	App	-0.005
1	Nov	App	.497 ***
	InEn	App	.352 *

SAMPLE 12 - IP1 = (+ - -)

	Predictor	Outcome	Std Beta
	Att	Chal	-0.031
	Nov	Chal	.428 ***
3	Chal	InEn	-.308 ***
	Nov	InEn	.340 ***
	Att	InEn	.547 ***
2	Att	App	-0.062
1	Nov	App	.285 ***
	InEn	App	.627 ***

SAMPLE 13 - IP5 = (+ + +)

	Predictor	Outcome	Std Beta
	Att	Chal	.269 †
	Nov	Chal	.321 *
3	Chal	InEn	0.091
	Nov	InEn	-0.112
	Att	InEn	.763 ***
2	Att	App	0.022
1	Nov	App	0.14
	InEn	App	.656 ***

SAMPLE 14 - IP2 = (+ + -)

	Predictor	Outcome	Std Beta
	Att	Chal	0
	Nov	Chal	0.217
3	Chal	InEn	-0.189
	Nov	InEn	-0.051
	Att	InEn	0.314
2	Att	App	0.109
1	Nov	App	0.182
	InEn	App	.443 *

SAMPLE 15 - IP5 = (+ + +)

	Predictor	Outcome	Std Beta
	Att	Chal	.584 *
	Nov	Chal	0.245
3	Chal	InEn	0.183
	Nov	InEn	0.129
	Att	InEn	.502 †
2	Att	App	0.077
1	Nov	App	0.071
	InEn	App	.643 *

SAMPLE 16 - IP5 = (+ + +)

	Predictor	Outcome	Std Beta
		Chal	.361 †
	Nov	Chal	0.212
3	Chal	InEn	0.065
	Nov	InEn	.477 *
	Att	InEn	0.009
2	Att	App	.524 **
1	Nov	App	0.185
	InEn	App	-0.042

	SAMPLE 17 - IP3 = (- + -)		
	Predictor	**Outcome**	**Std Beta**
	Att	Chal	-0.143
	Nov	Chal	-.267 *
3	Chal	InEn	-0.129
	Nov	InEn	.594 ***
	Att	InEn	.288 **
2	Att	App	0.073
1	Nov	App	-.331 *
	InEn	App	.812 ***

	SAMPLE 18 - IP3 = (- + -)		
	Predictor	**Outcome**	**Std Beta**
	Att	Chal	-0.065
	Nov	Chal	0.093
3	Chal	InEn	-.346 ***
	Nov	InEn	.562 ***
	Att	InEn	.432 ***
2	Att	App	0.178
1	Nov	App	-0.173
	InEn	App	.425 *

	SAMPLE 19 - IP1 = (+ - -)		
	Predictor	**Outcome**	**Std Beta**
	Att	Chal	-0.086
	Nov	Chal	0.127
3	Chal	InEn	-.443 **
	Nov	InEn	.308 *
	Att	InEn	.456 **
2	Att	App	-0.06
1	Nov	App	.479 **
	InEn	App	.520 **

	SAMPLE 20 - IP4 = (- + +)		
	Predictor	**Outcome**	**Std Beta**
	Att	Chal	0.193
	Nov	Chal	0.389
3	Chal	InEn	0.169
	Nov	InEn	-0.201
	Att	InEn	.523 *
2	Att	App	.290 †
1	Nov	App	-0.002
	InEn	App	.711 ***

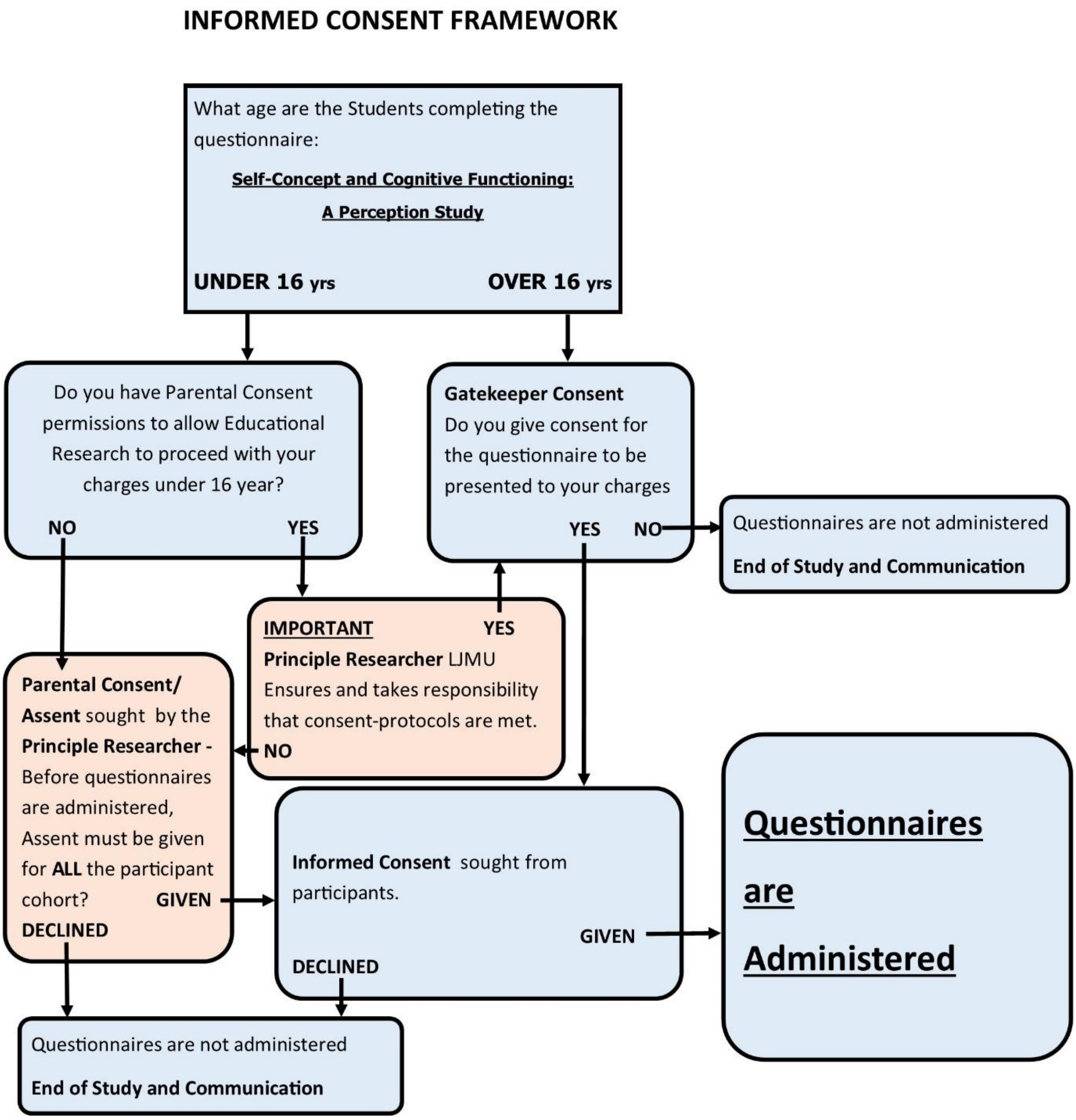
	SAMPLE 21 - IP7 = (- - -)		
	Predictor	**Outcome**	**Std Beta**
	Att	Chal	-0.127
	Nov	Chal	-0.232
3	Chal	InEn	-.426 **
	Nov	InEn	.632 ***
	Att	InEn	.264 †
2	Att	App	-0.099
1	Nov	App	-0.036
	InEn	App	.972 **

	SAMPLE 22 - IP2 = (+ + -)		
	Predictor	**Outcome**	**Std Beta**
	Att	Chal	0.164
	Nov	Chal	0.032
3	Chal	InEn	-.350 ***
	Nov	InEn	.553 ***
	Att	InEn	.221 *
2	Att	App	.228 **
1	Nov	App	.242 *
	InEn	App	.437 ***

	SAMPLE 23 - IP3 = (- + -)		
	Predictor	**Outcome**	**Std Beta**
	Att	Chal	0.472
	Nov	Chal	-0.332
3	Chal	InEn	-0.035
	Nov	InEn	0.34
	Att	InEn	-0.114
2	Att	App	0.1
1	Nov	App	-0.404
	InEn	App	.370 *

	SAMPLE 24 - IP3 = (- + -)		
	Predictor	**Outcome**	**Std Beta**
	Att	Chal	0.203
	Nov	Chal	.521 †
3	Chal	InEn	-0.161
	Nov	InEn	0.432
	Att	InEn	.572 *
2	Att	App	0.021
1	Nov	App	-.295 *
	InEn	App	.980 ***

APPENDIX XVI: Sampling and Sampling Protocols



APPENDIX XVII: Permission for Adaptations to Questionnaire Measures:

Situational Interest Scale (Chen et al., 1999)

I apologize for replying late due to my extensive overseas travel. Sure, you have my permission to use the situational interest scale. I appreciate you sharing the details of your study. These are fascinating findings. At the theoretical level, however, interest does distinguish from other similar constructs such as arousal; and enjoyment seems to be one important indicator distinguish between the two. Perceptions with negative emotions (e.g. fear) may be representing the arousing aspect of an event, not necessarily that of situational interest. I believe your adding avoidance items may help distinguish these constructs. I look forward to reading your findings.

Ang Chen

Review of Personal Effectiveness and Locus of Control instrument (ROPELOC) (Richards et al., 2002)

Thanks for your email and news about your research, much appreciated. Feel free to use a modified ROPELOC. We would be interested in a copy of your study when completed.

I'm not sure of Garry's current email, but he has previously indicated that he's happy for me to response to ROPELOC requests.
Let me know if I can do anything else.

James Neill