Sustainable Creativity: A Process of Constant Change

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ABSTRACT: Creativity is widely viewed as the antecedent to innovation, which in turn is often held up as the hallmark of forward-thinking organizations. And yet the organizational sciences lack a conceptual consensus as to what creativity is, and how it may be operationalized or measured. Rather than attempting to generate such a universally acceptable definition of creativity, the following paper seeks to ground the term in Intentional Change Theory (ICT); a framework for promoting sustained, desired change. ICT is proposed as a means of unifying these existing, disparate conceptualizations under the banner of *sustainable creativity*. Sustainable creativity is proposed as a meta-state, through which creativity may be understood as a process of constant change that can be sustained over the course of an individual's lifetime —as opposed to the single, discrete acts of creation for which creativity in the organizational sciences is normally understood —and which is predicated upon an individual's cycling through the five discovery phases of the Intentional Change Theory framework.

"Creativity is about more than imagining or making something that has not previously existed. Though most of us perceive of the concept of creativity actualized as creation, *creativity is really much broader—it is that force in each of us that begins with a yearning to answer an unanswered (or ill-answered) question by imagining more than one correct new answer. Being comprehensively creative then concludes when an answer is realized. Often this concluded answer has to do with changing something that was true before we thought and acted creatively, in order to make a new or additional truth. In such cases, being creative is most fundamentally about advancing* change *in or about something."* (Harding, 2010, in abstract).

The study of creativity has represented a veritable cottage industry of scholarly enquiry within the organizational sciences. In terms of publication output, this research area enjoyed steady growth from the early 1970's into the early 21st century, before undergoing a substantial spike in the last decade (Anderson et al., 2014). Key to this recent upswing has been a widely-subscribed view – cutting across the scholar and practitioner divide – that promoting creativity in organizations provides the fertile ground from which innovation may emerge (Alves et al., 2007). In a global business environment routinely characterized as being in a state of perpetual flux, innovation and adaptation represent for many the gold standard through which successful, enduring business may flourish, and creativity the core antecedent which enables this flourishing. Due to the continual nature of the demand for innovation adaptation, and therefore creativity, this paper seeks to address an area on which little has been written or studied: how certain people be creative repeatedly and over time. That is, how can creativity be sustainable? This paper will address both of these challenges.

The Challenge of Defining Creativity

Whole tomes and calls for papers among the wider field's leading journals showcase just what value the organizational and industrial sciences have placed on getting to the theoretical bedrock of what creativity is, and what practices, behaviors, systems and policies most fulsomely conceptualize it and allow it to be operationalized within organizations. It has been analyzed across multiple strata, including at the individual, dyadic, team and organizational levels. Within each, myriad of proposed variables have been used to anchor creativity to a particular construct at some level of analysis. Canvassing the full extent of this work in any significant detail is a

project beyond the scope of the present paper. It is sufficient to note that creativity has been studied across multiple theoretical angles, and has produced a stockpile of empirical findings from which a number of provisional, domain-dependent conclusions can be drawn.

Yet despite the inevitable cross-pollination of much of the existing scholarly work, there has been a glaring absence of consistency in both how creativity is theorized, and then subsequently borne out under empirical examination. From one paper to the next, authors in this area seldom appear committed to a working definition of creativity that will hold steadfastly throughout different scholarly undertakings, nor does the literature evince a sense of "piggybacking" upon previous literature in a concerted march toward a consensus of terms. Moreover, the methods and experimental designs used differ often markedly; with figural, literal, numerical and visual tests of creativity employed across a multitude of dimensions measuring fluency, flexibility, originality, elaboration, combination and variation (Csikszentmihalyi & Wolfe, 2014), and with discrete, "one shot" acts of creation under strictly controlled experimental conditions often extrapolated to infer something about the state or process of creativity more generally.

While all empirical work dedicated to better understanding the factors underpinning such circumscribed actions of creation should be applauded for making some contribution to the canon upon which the overall research area is built, each of these research efforts has largely failed to capture the nature of creativity in a more holistic sense. However, rather than focusing squarely on trying to reconcile the disparate and often conflicting definitions of the term currently in usage, the present paper submits that there remains an opportunity to more fulsomely conceptualize creativity as an enduring psychological *meta-state* (Gennaro, 2005)—a higher order form of consciousness which takes together several overlapping mental models or

operations of cognition— under which individual, discrete acts of creation–of the sort explored within the organizational science literature – may be subsumed; essentially as sub-variables loading on to a latent factorial structure. Further, such a meta-state, rather than being temporally transient, is here proposed to be enduring over time, and a means by which an individual can continue to exhibit creativity over the course of their lifetime. These considerations represent the thrust of what this paper terms *sustainable creativity*; a new construct by which creativity may be understood as such an enduring phenomenon.

The following sections will use Intentional Change Theory (ICT), a model for promoting sustained, desired change, as a way to conceptually unify creativity as such a dynamic, ongoing process of change; under this theoretical banner of sustainable creativity. The theoretical basis of ICT will be outlined briefly, before being discussed more fully in terms of its purported relationship to creativity.

Intentional Change Theory

ICT (Boyatzis, 2008) is a framework for assessing how individuals and their social groups may achieve desired, sustainable change. At the individual level, ICT is used to describe the factors that comprise the sustainable (in that it will endure over a substantial period of time) and desirable (in that it is something the individual wishes were so) change of one's behaviors, thoughts, and feelings, and their subsequent effect on one's actions, aspirations, competencies, and outlooks. It serves as a form of 'desired adaptation' (Boyatzis & Akrivou, 2006) – by which individuals, through a process of self-awareness and a pursuit of beneficial change, seek to improve themselves in a manner that is congruent with their *own* ambitions and ideals. The focus

on one's 'own' here is of particular import; intentional change emerges from behavioral and cognitive changes relative to one's own ideals and standards ("the ideal self"), and not the expectations of others (the so-called "ought self").

The process of intentional change is a punctuated shift through 'tipping points' or 'trigger points' – instances of personal effort whereby a small incremental increase in behavior produces a large increase in effectiveness or efficiency. Concomitantly, there are five distinct phases of learning or change called 'discoveries', which represent various discontinuous stages through which an individual cycles through their own unique tipping points in the pursuit of sustained, desirable change. The five discovery phases of the ICT framework are (1) discovering the ideal self (2) assessing the real self (3) setting a learning agenda (4) experimentation and practice with new behaviors or modes of thinking (5) developing resonant relationships that allow one to better aspire toward their ideal self. The triggering mechanism by which one cycles through these discovery phases is explored in the next section, and in each the sections that follow, the discovery phases of the ICT framework will be explored as a means to understanding creativity as a process of sustainably promoting change.

The Ideal Creative Self

By the lights of ICT, The ideal self is "an evolving, motivational core within the self, focusing a person's desires and hope, aspirations and dreams, purpose and calling" and which "serves a mechanism linked to self-regulation; it helps to organize the will to change and direct it, with positive affect from within the person." (Boyatzis & Akrivou, 2006:625). In essence, the ideal self functions as a way post to signal the endgame of the current suite of changes one

wishes to enact in one's life. It highlights the disconnect – in a neutral and not pessimistic sense - between the optimization of oneself and the existing realization of it, and focuses one toward the former. Both cognitive and affective processes are implicated in driving and substantiating the ideal self, and allowing one to successfully articulate it. Positive affect in particular, however, is of significant import in ensuring that an individual accurately captures their ideal self. The affective dimension provides the barometer by which one's own emotional valence can be used to assess the congruence of some future state of being with one's core values and personal standards (Gilbert & Wilson, 2007).

Cycling Between Emotional Attractors

At opposing ends of the affective spectrum are states that are either characteristically positive or negative in their emotional valence, and are known as the *positive emotional attractor* (PEA) and *negative emotional attractor* (NEA) (Boyatzis, Rochford & Taylor, 2015). These are the states that are the tipping points to allow a person to move from one stage of ICT to another, and to be open to new ideas while in one state. The PEA and NEA represent some sum total of positive or negative aspects of cognition, emotions and behaviors that are mutually reinforcing, and being in the hormonal state of arousal called the Parasympathetic Nervous System and in the neural activation of the Default Mode Network, and have such strength of cognizance so as to be a trigger or tipping point which cycles away from one state toward the other. It should be noted, however, that negative emotions are stronger and more salient than positive emotions (Baumeister et al., 2001), and so the ballast demanded of positive triggers to move an individual from the NEA to the PEA is usually considerable greater.

While the nature of the relationships are probably not linear in correspondence, and involve some degree of overlap, physiologically speaking the PEA is physiologically grounded in activity in the brain's default mode network (DMN) and the arousal of the parasympathetic nervous system (PNS), while the NEA is driven by activity in the brain's task-positive network (TPN) and arousal of the sympathetic nervous system (SNS). The DMN is activated when the brain is in a state of awareness, and is also the neural network involved in processing Theory of Mind, social and moral reasoning, episodic memory, future envisioning, and narrative interpretation. It exhibits concurrent activation of the prefrontal cortex, the medial parietal cortex, posterior cingulate cortex, and the right temparo-parietal junction. The TPN, is involved in analytical and systemic thinking, task-based reasoning, deliberated attention, working memory, and so forth, and recruits the dorsal attention system, dorsolateral and ventrolateral prefrontal regions, and the insular cortical and supplementary motor areas. The PNS and SNS are subsystems within the autonomic nervous system that variably interact with the body's endocrine system to trigger hormonal responses that govern baseline immunity, cardiovascular health and sociality (PNS) and threat and stress management (SNS) (Boyatzis, Rochford & Taylor, 2015).

A growing body of converging empirical evidence has began to attest to the idea that creativity requires some degree of interplay between both the DMN and TPN (see Barbot & Tinio, 2014; Beaty et al., 2014); whereby the DMN allows the brain's rested state and defocused attention to be more receptive to novelty and divergence (the "inspiration" which guides much creative insight), and the TPN can effectively analyze the incoming novelty in the data stream, assess it for salience, and transform it into some tangible output (such as a creative product of some kind). The exact nature of this interplay, and the functional dynamism that gives rise to it, remain an open empirical question at this juncture. However, if creativity can be understood as a

process of change, then it seems reasonable to hypothesize, *prima facie*, that many of the same underlying cognitive, affective, neurological and behavioural mechanisms that give rise to the shift from the PEA to the NEA may also represent the factors that shift an individual from being uncreative to creative, and that the same root causes that lead to the sustained change that is characteristic of ICT may also lend themselves toward sustained creativity.

The Real Creative Self

The real self reflects who and what a person currently is, and the overall circumstances of which they themselves are a feature: the totality of matter-of-fact assessments about their strengths and weaknesses; achievements and failures; knowledge bases and ignorance gaps; number and kinds of relationships; and so forth. Should one reason honestly and critically about themselves, and be reasoned about honestly and critically by others, the real self should represent a veritable "state of the union" about what constitutes oneself; a cataloguing of the various constituent factors that characterize and give rise to one's current position in life. In the domain of leadership, for example, an understanding of the real self (as it relates to one's standing or abilities as a leader) might be arrived at by some combination of feedback modalities (such as 360-degree feedback, psychometric tests, etc.) and personal strengths inventories that provide a view of how others see and experience us (Boyatzis, 2008).

Creativity as a Meta-Phenomenon

Creativity, however, is almost certainly a much more complex domain to unpack as it regards understanding one's real self with any meaningful precision. Given the aforementioned lack of agreement on a usefully generalizable definition of the term itself, what constitutes one's real standing as a creative is likely prone to even more ambiguity; particularly when complicated further by the nuances of one's own creative enterprise, the often ethereal nature of that which one draws upon for creative inspiration, and so forth.

The present paper proposes that to both present creativity as a more tractable phenomenon, and to make it more amenable to the change dimensions of ICT, an analogy can be usefully drawn between creativity and athleticism. Athleticism, like creativity, is not a unitary phenomenon, but an effective total of some combination of traits that can be effectively marshaled in the service of facilitating expertise and/or performance in a specific, directed domain. Both kickboxers and golfers can be reasonably considered "athletes", and yet they differ markedly in the optimal combination of athletic traits – cardio-respiratory capacity, muscle strength, nutrition, game psychology, and so forth - required for desirable performance; though there are often degrees of overlap (both golfing and kickboxing require considerable joint flexibility and manual dexterity, for example). The particularities of an athletic pursuit allow an individual to assess, with considerable precision, their own relative strengths and weaknesses vis-à-vis an optimal state or form of those particularities; a golfer can adjust his swing based on establishing that he has an incorrect posture, a kickboxer can account for in-ring fatigue by improving her overall endurance levels, and all other athletic pursuits similarly have their own variants of this calibration process. This is thanks largely to the marriage of the sports sciences, as highly developed scholarly endeavors with strong theoretical accounts of the multitude of inputs required to drive human anatomy and physiology to peak performance levels, and

professional sport, which provides the resources and experimental manpower to fine-tune these accounts. Indeed sport, in many senses, epitomizes the theoretical bedrock of ICT, with high performance pursued by tweaking certain micro-factors in a real self in the service of aspiring toward an ideal self. Moreover, this process, as it is operationalized in athletic domains, is centered on making athleticism *sustainable* over as long a period as possible in one's lifetime (Teramoto & Bungum, 2010).

And so it may be theorized with creativity. The painter and the musician can be thought of as engaging in pursuits that differ in terms of both creative output *and* requirements of inputs, even though there may be some degree of homophily in the latter. If in creativity, as with athleticism, certain inputs lend themselves to certain micro-factors of creativity that have a particular efficacy within a chosen creative domain, then these features can be reasonably considered constitutive of the real self. Theorizing along these lines may also help to reconcile the many disparate conceptions of creativity that abound through the literature, and the various conduits that have been mooted to predict or promote them. That is, these may instead be understood as micro-factors subsumed within a meta-conceptualization of creativity, in the same way that muscular strength, endurance, and so forth are seen as a constituent parts of the meta-phenomenon of athleticism more generally.

Taken together, these various micro-influences represent a suite of indicators that load on to a latent factor; that of the meta-state of creativity. Understood this way, there are various aspects of oneself and one's circumstances – all that comprises their real self – that can be catalogued and assessed as being pertinent to their current state of creativity, as well as improved upon to advance toward the creative aspects of their ideal self. The ongoing and dynamic shift

between the real and ideal selves over time, in a process of constant changing, embodies what is meant here by sustainable creativity as an enduring meta-state.

The following sub-sections provide a partial list of some of the physical and psychological factors which represent some of the micro-influences which may have implications for fostering creativity, and which can be assessed by an individual in the pursuit of establishing the creative aspects of their real self in the service of sustaining creativity long-term:

Chronotype

Chronotype refers to the behavioural propensity of an individual to sleep at a certain time within a 24 hour cycle; relative to both the individual's own circadian cycle and myriad of other biophysical processes anchored to this cycle (Roenneberg, 2012). While the developmental and regulatory factors underlying chronotype remain yet to be fully determined, so-called 'clock genes' are widely believed to be implicated in physiologically regulating an organism's sleep patterns. Such genes are subject to significant differentiation in expression, and synchronize an individual to both solar and lunar cycles, depending on specific trigger cues within the organism's environment known as *zeitgebers* (Panda, Hogenesch & Kay, 2002). Among humans, these cues may include light exposure, thermoregulatory stressors, nutrition load and cycles, frequency and intensity of social interaction, and work and rest schedules (Roenneberg, Wirz-Justice & Merrow, 2003).

All told, there is substantial variability among humans in both genotypic coding for candidate clock genes, and their subsequent epigenetic expression relative to the individual's environment. In spite of this, the field of chronobiology – the science of periodic phenomena and

biological rhythms among living organisms – has generally cleaved humans into two distinct chronotypes: morningness ("early birds") and eveningness ("night owls"). Most subsequent empirical and theoretical work in the field has proceeded from the establishment of this dichotomy (Adan & Almirall, 1991; Horne & Ostberg, 1975). The establishment of an individual's chronotype is usually based on a subjective evaluation of their peak alertness relative to the time of day; a phenomenon closely correlated with their peak body temperature.

Cavallera et al. (2011), defining creativity as "the ability to become sensitive to new solutions, and to grasp aspects of problems, enabling the restructuring of elements" (p. 506), and using a sample of recreational youth sportspeople, found a small and statistically insignificant advantage in creative thinking for people of a morningness chronotype; with these findings mediated by both gender and extraversion. Interestingly, these findings ran counter to one of the author's earlier papers (Giampietro & Cavallera, 2007), which concluded that eveningness dispositions were positively correlated with the ability to strategically deploy novel thinking styles to visual content. Such findings appear consistent with other literature attesting to greater cognitive fluidity and flexibility among night owls, as well as a greater inclination to break with convention where possible (see e.g. Cimbalo & Hughey, 1986). The earlier study additionally found no gender differences in either chronotype or resultant creative thinking prowess, in contrast to the latter study's observation that men exhibited a greater propensity toward eveningness and a concomitant disadvantage in creative thinking.

In a more recent study, Roeser et al. (2015), using the Berlin Model of Intelligence Structure Test (a psychometric test of intellectual fluidity and crystallization; Jager, 1984), established advantages in both fluidity (response frequency) and flexibility (response diversity) for individuals with a morningness chronotype; though the latter was not statistically significant.

The significance of the fluidity findings was achieved irrespective of the time of day the testing took place; indicating that any asynchrony between chronotype and temporal considerations did not influence results. However, the authors admonished against drawing inferences from this absence of a statistical effect in asynchrony, noting that a larger sample and a more comprehensive and diverse test of creativity may produce differing results. The study additionally established advantages in fluidity for both females (consistent with Cavallera et al., 2011) and those in an advanced age bracket (inconsistent with Cavallera et al., 2011, which observed an advantage in creative thinking for those in younger to middle age ranges).

In each of the foregoing studies, appropriate cautions as to the universal veracity and applicability of the results were noted; particularly given each study's relatively small and discrete sample size and characteristics. Furthermore, the tests and indicators employed to determine creativity in each study were manifestly different and lacked conceptual uniformity. In sum, any purported relationship between chronotype and creativity remains very much an unresolved empirical question. As each study has concluded, much more large scale experimental testing with more wide-ranging and consistent benchmarks of creative thinking must be conducted before any such relationship can be established or meaningfully inferred.

Diet and Nutrition

The effects of diet and specific nutritional composition and patterns on brain structure and function (including cognitive ability) are now well-established in the fields of nutritional science, health science and biochemistry (see Kretchmer, Beard & Carlson, 1996). Food, primarily as a source of glucose, provides energy for the brain, as well as lipids and acids to

stimulate neural growth and plasticity, and a range of micronutrient-based psychoactive molecules which can substantially influence brain-relevant actions (Schmitt, 2010). Factors such as general malnutrition, deficiencies in organoiodine compounds (such as iodine), inadequate intake of healthy fats and vitamins, and inconsistency in eating patterns, have all been implicated in the misdevelopment and malformation of the human nervous system, with consequent deleterious effects on cognition (LaRue et al., 1997; Schmitt, 2010). Of particular significance are the impact of nutritional patterns on the cognitive development of children; with both inadequate or inappropriately structured diet and the sustained absence of crucial micronutrients exhibiting potentially enduring effects on cognition over the individual's lifespan (Bellisle, 2004; Burkhalter & Hillman, 2011). Both malnutrition (Bryan et al., 2004) and over-nutrition/excess eating (Vaynman et al., 2006) have been identified as having an explicit causal relationship to diminished cognitive capacity throughout childhood and adolescence, and often sustained well into adulthood.

Empirical evidence linking specific nutritional components and behaviors with discrete instances of creativity remains sparse in the extant literature, in spite of abundant anecdotal evidence attesting to the efficacy of particular food types and eating patterns as they relate to overcoming mental blocks and promoting inspiration in creative activity. Furthermore, such empirical pursuits have been hamstrung, as with many other experimental endeavours involving creativity, by the absence of a universally agreed-upon operational definition of the term itself (Runco, 2007). To date, the limited empirical work that has been pursued in this area has been anchored to the relationship between creativity and the production of the neurotransmitter dopamine (Chermahini & Hommel, 2010; Mayseless et al., 2013). Colzato, De Haan & Hommel (2014), in a first-of-its-kind study, found a positive relationship between ingestion of a

supplemental version of the amino acid tyrosine (a biochemical precursor of dopamine found in many high-protein foods including nuts, poultry, seafood and dairy) and the promotion of convergent ("deep") thinking, based on a verbal creativity-based test of remote associations (Mednick, 1962; Slamecka, 1964). While admonishing that there exist individual differences in genetic predisposition to the uptake of and reactivity to tyrosine, the authors nevertheless provided a modicum of evidence that this amino acid may serve as a form of cognitive enhancer capable of modulating deep thought processes generally and creativity specifically.

Despite the current dearth of scholarly work attempting to explicitly link nutrition and creativity, other existing work relating nutrition to cognition more generally may nonetheless have a theoretical bearing on potential such relationships – as well as serving as a guiding post to stimulate future research efforts in this area. The neurotransmitter histamine, for example, which is found in rich quantities in a range of fermented and acid-rich foods, has been implicated in aiding the thalamic regions of the brain in processing sensory integration (Craig, 2002). Sensory integration, in turn, has been identified as a crucial aspect of the underlying neurobiological mechanisms giving rise to creativity (Cotterill, 2001; Gruzelier, 2009). Dimethylaminoethanol, a precursor to acetylcholine (a neurotransmitter involved in responsiveness to sensory stimuli), is found in certain species of fish produced and consumed by humans, including salmon and sardines. Responsiveness to sensory stimuli has in turn been demonstrated to have an influence on creativity (Fink et al., 2010). The aforementioned relationship between dopamine and creativity may also admit of additional food-based precursory influences, with high-protein, amino acid-rich foods such as eggs, fish, poultry and red meat all identified as known triggers of dopamine production.

Of additional potential associative significance to any purported relationship between diet and nutrition with creativity is the presence of gut microbiota; the reservoir of intestinal microorganisms which inhabit the digestive tracts of host organisms, including humans – for whom such flora outnumber host cell bodies tenfold and possess 150 times the genetic material of the host's genome (Sears, 2005). Gut microbiota have a generally mutualistic and beneficial relationship with their host; converting undigested carbohydrates into bio-available energy, synthesizing key vitamins, and metabolizing acids and sterols (ibid.).

A swathe of recent empirical work (though primarily derived from animal studies) has additionally identified a number of relationships between the presence of gut microbiota and aspects of cognition, behavior and affect; based on what has been termed the *microbiota-gut-brain axis* (Collins, Surette & Bercik, 2012; Cryan & Dinan, 2012). Heijtz et al. (2011) demonstrated that normal functionality in gut microbiota modulated normal brain development, with subsequent implications for healthy cognitive development and function. The exogenous introduction of antibiotic stimuli has been shown to have marked effects of brain signaling (Duerkop, Vaishnava & Hooper, 2009), which in turn can significantly alter discrete aspects of cognition. The vagus nerve, the major nerve of the parasympathetic nervous system, and which carries axons related to sensory activation and interpretation, has been shown to be influenced by microfloral factors, although the nature of the relationship remains unclear (Wang et al., 2002).

While there has been, to date, no empirical work seeking to establish an explicit causal linkage between the presence and influence of gut microbiota on creativity, such microfloral influences on cognition more broadly seem to suggest that they could be more specifically implicated in creative thinking. This conceptual linkage may provide fertile ground for future experimental endeavours.

Exercise

A growing body of empirical work, particularly generated in the past decade, has attested to the widespread cognitive benefits afforded to an individual when a regular and appropriately coordinated physical exercise regime is folded into their lifestyle structure. Though the specificities of the evidence differ in terms of the modality, intensity, duration and frequency of the exercise in question, exercise in general has been demonstrated to be critical in supporting overall brain health and subsequent cognitive functioning (Cotman, Berchtold & Christie, 2007; Ploughman, 2008). Regular, sustained physical exercise has been shown to positively contribute to learning and memory enhancement (Erickson et al., 2011); executive function (Best, 2010; Bixby et al., 2007); spatial learning and memory (Anderson et al., 2000; Schweitzer et al., 2006); counteraction of cognitive decline in old age (Sofi et al., 2011); synaptic plasticity (Farmer et al., 2004); and overall neuroprotectiveness (Ding et al., 2004), as well as providing therapeutic benefits to counter the deleterious effects of mental disorders such as depression and anxiety (Jayakody, Gundasa & Hosker, 2013). Of particular import in this area have been studies which have determined the facilitation of ongoing cognitive function among members of elderly clinical populations who engage in some form of regular exercise, and for whom the accumulative end results of life-long psycho-physical processes inherent in the ageing process result in a natural baseline degradation of cognitive functionality. Physical exercise has additionally been demonstrated to assist with cycling an individual into the PEA (Petersen et al., 2015).

Creativity, as a discrete aspect of cognition has, as with the relative absence of studies linking it to diet and nutrition, received less attention in recent times in terms of explicit linkages to physical exercise and activity. While a number of second order theoretical inferences could almost certainly be made (and have been made – see Etnier et al., 1997) between the influence of exercise on specific elements of cognition, and how these elements of cognition causally and functionally relate to creativity, the empirical literature proposing and predicating first order relationships between physical exercise and creativity has become sparse in the last decade.

Colzato et al. (2011) found that, among non-athletes, acute moderate and intense physical exercise resulted in a *decrease* in performance in both convergent and divergent thinking tasks; hypothesizing that this curious result may have been due to the exhausting of limited cognitive-control resources. In other words, the cognitive load demanded by concentrating on such physically exertive activity may have depleted the neuro-availability of the resources required to facilitate both modes of creative thinking. Conversely, this effect did not hold for athletes in convergent thinking tasks; with acute exercise actually benefiting such individuals in this creative mode. Further hypothesizing, the authors note that this may be due to either possessing the requisite cognitive-control reserves that non-athletes, as aforementioned, did not, or else had engaged in such sufficient frequency of exercise previously that they benefited from an increase in oxygenation and glucose boosting in frontal brain regions associated with higher order cognitive functioning. Moreover, the authors of this study observed that the intensity of the exercise impaired and enhanced the creative output of non-athletes and athletes respectively, and further surmised that the absence of exercise may serve to impair creativity among athletes. One potential upshot of this research, though speculative, is that those individuals who are currently *non*-athletes could eventually be afforded the same advantages in creativity derived from

physical exercise as athletes should they be sufficiently inclined to increase their own level of physical activity.

Among earlier studies seeking to explicate a relationship between exercise and creativity, Blanchette et al. (2005) demonstrated that aerobic exercise was positively correlated with creative output, and further observed a residual effect whereby creative output could be effectively sustained for a two hour period following engagement in such physical exercise. This study was, however, limited to college-age students who self-identified as physically fit; limiting the generalizability of the findings, though adding a veneer of support to the Colzato et al. (2011) study and its conclusions regarding the beneficial effects on creativity for athletic individuals. Steinberg et al. (1997) found that physical exercise slightly enhanced creativity thinking (again among already fit individuals) and also enhanced mood, but that creativity and mood were independent of and did not predict each other, and exhibited no covariance. The effect size for physical exercise as a predictor of creative thinking in this study was modest.

Hormones

Hormones represent a clade of signaling molecules that operate in the service of regulating organismic behaviour and physiology. The precise mechanisms involved in hormone signaling are steeped in detail that is considerably beyond the scope of this paper (see Nelson, 2005 for an overview). It should be sufficient for present purposes to note that, among humans and other mammals, hormones operate in a tri-partite relationship with both the organism's overall endocrine architecture and influences in the external environment: the relay, recognition and amplification of hormones both cause behaviour and are caused by behaviour, forming a

recurrent feedback loop (Neave, 2007). The endocrine system, which regulates the activity of hormones, is divided into distinct systems which, among a vast number of other functions, stimulate growth and sexual reproduction, and maintain stress levels, blood pressure and fluid and nutrient retention.

The relationship between hormones and cognition is complex and multi-faceted, and subject to an enormous amount of variability between and within individuals; based on characteristics such as gender (Kimura, 2002); age (Driscoll et al., 2005); stress levels (Lupien et al., 2007); stage in the menstrual cycle (Sacher, Okon-Singer & Villringer, 2013); body mass index (Dahl et al., 2013); and pathogen load (Navarette, 2012), in addition to myriad other micro-level features that may further sculpt the specific phenotypic attributes of this relationship in an individual. Furthermore, the particularities of the environment in which an individual's hormones are expressed may vary widely; such that hormonal factors that may produce effects upon cognition for one individual in one environment which may not hold for the same person in another environment – much less another person in the same environment.

Nevertheless, a growing body of empirical work suggests that hormonal and endocrine factors may influence aspects of cognition that are directly or indirectly related to creativity. Wassell et al. (2015), using a combination of self-reports and objective measures, demonstrated that fluctuations in progesterone – a hormone involved in regulating the menstrual cycle, pregnancy, and sexuality of mammalian females, including humans – were predictive of the strength and vividness of visual imagery; with greater progesterone concentrations predictive of greater vividness and strength in such imagery. The interpretation of visual imagery has

previously been significantly correlated with creative thinking generally (Gonzales, Campos & Perez, 1997). The authors hypothesized that the upswing in vividness in imagery might be attributable to the comparatively enhanced attention enjoyed by women during the mid-luteal phase of the menstrual cycle, where progesterone is at peak or near-peak levels. An alternative hypothesis suggested that a greater concentration of progesterone may be responsible for modulating sensory activity in the visual context, in turn boosting sensory load and subsequent mental imaging. The study is broadly, though not precisely, consistent with the work of Krug et al. (1994) writing some two decades earlier. The authors in that study observed that when serum concentrations of the sex hormones estrogen and lutropin were highest, during the pre-ovulatory and mid-luteal phases of the menstrual cycle, test participants exhibited greater creative abilities during tests of semantic and figural divergent thinking when compared to controls (who were using oral contraceptives to retard sex hormone expression).

In a separate study from the same year, Yeh et al. (2015), using a game-based experimental framework, observed that increased concentrations of the stress regulation hormone cortisol served to enhance creativity up to a certain attentional threshold, as modulated by working memory. These effects, however, were reversed when subjects were provoked into a negative emotional state; with creative capacity diminishing while cortisol levels remained high – suggesting a U-shaped relationship, with the authors further noting that stress is not a unitary process, and is variably shaped by the nature and intensity of the stress provoker in question. This is consistent with the work of Joels et al. (2006), which posited a similar U-shaped relationship between the release of stress hormones and working memory.

In an earlier study, Reuter et al. (2005) demonstrated that, independent of gender, the sex hormone testosterone was predictive of sensation-seeking behaviour, which in turn was highly

predictive of figural, verbal and numeric creativity. Earlier still, Hassler (1990) observed that an excess of testosterone (i.e. above a gender-typical threshold) was beneficial to girls, yet detrimental to boys, in a study of musical creativity; suggesting there may be an optimal sex-specific range of testosterone which is conducive to creativity. It should be noted that in each of the foregoing studies presented here, appropriate admonitions were made by the authors regarding the generalizability of their findings and the multitude of other, non-endocrine factors which may have substantially influenced their results. This is consistent with the notion, referred to earlier, that the interplay between hormones and cognition, including creativity, is of such complexity as to make general conclusions difficult.

Finally, returning to the notion of emotional attractors explored earlier, cycling into the PEA is contingent, with its concomitant arousal of the parasympathetic nervous system, on triggering the release of several hormones into the blood, including oxytocin and vasopressin (primarily in women and men, respectively). Both hormones have been implicated in a range of physiological, psychological and social benefits, including reduction of anxiety and promotion of pro-social behaviors. Conversely, cycling into the NEA, and arousing the sympathetic nervous system, facilitates a suite of stress and defensve responses characterized by the release of the stress hormone cortisol, as well as epinephrine and norepinephrine into the bloodstream. This neuroendocrine response is often translated into negative outward emotionality, including fear and anxiety (DeQuattro & Feng, 2002; Dickerson & Kemeny, 2004; Insel, 1997). Though any relationship between the PEA and NEA and creativity remains unexplored as yet, it seems reasonable to hypothesize that any such potential appositeness has some grounding in endocrine factors.

Thermoregulation

Internal thermoregulation is a homeostatic process, by which an organism is able to maintain its body temperature within certain temperature parameters irrespective of temperature changes in the external environment. In humans, this process is regulated by the hypothalamic region of the brain, which bridges the nervous and hormone systems (Fiala, Lomas & Stohrer, 1999). Thermoregulation, among all mammals, is of particular import to humans, given the vast diversity of climactic environments in which our species inhabits.

Although a review of the literature has not revealed any express experimental work seeking to link changes in temperature with creativity specifically, relationships between temperature and other aspects of cognition have been so empirically determined. Lan et al. (2009) found that exposure to mild warmth (27 degrees celsius) in ambient room temperature was negatively associated with performance in tests of conditional reasoning, picture recognition and number calculation when compared to performance in the same tests at 32 degrees celsius. The authors surmised that the lower level of warmth made the study participants relaxed and comfortable, and thus under-motivated to perform the tasks at an optimal level. Conversely, the heightened temperature condition seemed to spur people into action, and the authors further noted that motivated people were capable of maintaining high performance for brief periods under adverse (both hot and cold) environmental conditions; although the quality of performance was found to be task-dependent.

Makinen et al. (2006), seeking to establish the potential effects of repeated exposure to cold on cognitive performance, found that cold exposure was a significant predictor of longer response times and decreased efficiency across a number of tasks. The authors were able to

directly link changes in thermoregulation with the observed decreases in cognitive performance in both simple and complex cognitive activity. Furthermore, a learning effect was found whereby reaction times and efficiency improved as participants became acclimated to the cold environs.

It is perhaps not unreasonable to propose that such experimental changes in thermoregulation may produce effects on creativity, positive or negative. Appropriately designed empirical testing in this area would provide an interesting and potentially fruitful avenue for future research efforts.

Olfaction

Olfaction is the sense of smell among vertebrates, including humans. It is a chemosensory process whereby odor molecules in the external environment are bound to sensory receptors post-inhalation, in turn triggering the brain's olfactory systems and producing the detection of an odor; a dynamic combination of volatile chemical compounds (Zelano & Sobel, 2005). The mechanisms of olfaction in humans have a direct to the amygdalae and hippocampal systems, which represent the neural substrates of affect-based learning and memory (Cahill et al., 1995) and are also thought to be recruited in creative activity (Cotterill, 2001). The olfactory system is also directly connected to the evolutionarily ancient limbic system, which is central to deep, reflexive emotional responses.

A laboratory study conducted by Knasko (1992), using the continuous deployment of lavender, lemon and dimethyl sulfide odorants of weak to moderate intensity, found no significant effect of odors on creativity apart from a modest gender advantage for women in originality in figural

thinking. This study was limited, by the author's own admission, as it did not test for the effects of odor intensity and patterns of intermittence, which may have yielded more informative results.

A review of the extant literature has not yielded any further empirical efforts to link creativity and stimulation of the olfactory system. A number of studies have established the effects of odor on other aspects of cognition, including goal-directedness (Holland, Hendriks & Aarts, 2005) and decision making (Mitchell, Khan & Knasko, 1995). Given the foregoing, and the regional proximity of the neural substrates underlying both olfaction and creativity, further research efforts may yet reveal a relationship between the two faculties.

Visual Perception

Visual perception is the process of converting information found in visible light, through the sensory system, into sensory signals in the central nervous system. It is roughly analogous to the sense of sight among vertebrates, including humans. The human visual sensory system interprets and relays details such as colour, texture, distance, edge-detection, motion, proximity, and so forth through a suite of processes including visual phototransduction, motion perception and depth perception (Marr, 1982).

Steidle and Worth (2013), using six separate studies which utilized darkness priming and various forms of room lighting, found that darkness and dim lighting promoted performance across a range of creativity tasks (including insight problem solving, imaginative originality, and generation of creative uses) which were sensitive to visual contextual changes. The authors in this study concluded that the mutually supportive results across their experiments were

suggestive of the effect darkness has in reducing inhibition, eliciting feelings of freedom and self-determination, and promoting an explorative task processing style.

Lichtenfeld et al. (2012), building on prior empirical work which linked exposure to specific colours with aspects of psychological functioning and analytical performance (e.g. Elliot & Maier, 2007; Mehta & Zhu, 2009), found that even brief exposure to glimpses of the colour green facilitated creative performance on a well-established assessment measure of creativity. While the experiments used in this study were enacted in tightly controlled laboratory settings, the authors posited a theoretical consistency with their own study and a range of prior field work (e.g. Berman, Jonides & Kaplan, 2008) which has demonstrated a host of cognitive benefits that accrue when humans are exposed to natural settings; for which greenness is a reliable visual cue of flora, and may have been encoded into the human genome over deep evolutionary time.

Table 1.0 – Summary of Proposed Micro-Influences on The Real Creative Self

FACTOR	**VARIABLES**
Chronotype	Advantage for morningness chronotype (Cavallera et al., 2011; Roeser et al., 2015); advantage for eveningness chronotype (Cimbalo & Hughey, 1986; Giampietro & Cavallera, 2007).
Diet & Nutrition	Ingestion of tyrosine (Colzato et al., 2014); ingestion of histamine (Craig, 2002); influence of gut microbiota (Duerkop et al., 2009; Wang et al., 2002).
Exercise	Acute exercise among athletes (Colzato et al., 2011; Steinberg et al., 1997); aerobic exercise in general population (Blanchette et al., 2005).
Hormones	Influence of progesterone, estrogen and lutropin (Krug et al., 1994; Wassell et al., 2015); influence of cortisol (Joels et al., 2006; Yeh et al., 2015); influence of testosterone (Hassler, 1990; Reuter et al., 2005).
Thermoregulation	Exposure to warmth (Lan et al., 2009); acclimation to cold (Makinen et al., 2006)
Olfaction	Exposure to scents/odors (Knasko, 1992)
Visual perception	Exposure to darkness (Steidle & Worth, 2013); exposure to priming colours (Lichtenfeld et al., 2012)

The Creative Agenda

Though the foregoing list of factors that can be assessed with regard to creativity in the real self is neither exhaustive nor universally applicable, it nevertheless serves to highlight a number of identifiable elements that one can both determine within themselves and, if necessary, mobilize intention to change. This dovetails appropriately into the third discovery of the ICT model: developing a learning agenda. This phase is about recognizing the gaps that exist between various aspects of the ideal and real selves, and resolving a commitment to close these gaps by engaging in practices and behaviors that move oneself closer to the ideal self. In more general self-development terms, this may take the form of a personal learning agenda or action plan, which explicitly details the steps one must take to prompt effective, sustained change.

A critical component within this discovery phase is practicing *mindfulness* (Boyatzis & Akrivou, 2006). In this context, mindfulness refers to having an ongoing cognizance of the effects of the practices and behaviors that move one toward the ideal self and those that do not, and doing what one can to ensure that anything that moves one away from the ideal self is appropriately addressed or mitigated. Mindfulness promotes an ongoing awareness of where one's real self lies relative to the beaconing effect produced by their ideal self and, positively applied in day-to-day action, both firms up the resolve to change and explicates the course required to effect such change. This needn't necessitate stability and structure, per se, and the next discovery phase will explore the necessity of experimentation and practice

In the context of creativity, a learning agenda will likely be most effective when structured as a multi-faceted plan that "sets the dials" which calibrate the current positioning of the ideal and real selves relative to each other (the next section, on experimentation and practice, is based on "tweaking the dials" as demanded by shifts in the gaps between the ideal and real selves). This reflects the openness to ideas (that is, the openness to *learn* new ideas and *learn*

from new ideas) which, in a core sense, epitomizes the nature of creativity. Based on the evidence covered in the foregoing sections, this process may include some combination of changing one's diet, sleep habits, thermal conditions, exposures to various colors and smells, etc., to better stimulate creativity at a micro-processing level. Additionally, the domain-specific creative demands of one's own particular pursuit will be steeped in myriad of different potential gaps between the ideal and real selves: a musician currently lacking songwriting inspiration might resolve to play his chosen instrument more frequently in the hopes of yielding new song-craft material in the process; an author currently suffering from writer's block might make a commitment to write some pre-determined amount of material, irrespective of perceived quality, on the basis that the act of writing alone might serve to stimulate novel plot ideas. The specific levers in question will differ both between individual creative people, and across the creative fields of which they are a part, but the act of setting a learning agenda for creativity can be meaningfully pursued by anyone that has correctly developed a sense of their real self, and the relative proximity it has to their ideal self.

Experimentation and Practice

If we accept the premise that creativity is fundamentally centered on advancing change, then the fourth discovery of the ICT model is perhaps of the greatest significance in the quest to promote creativity sustainably over the course of an individual's life time. This juncture of the change process provides the scope and rationale for "tweaking the dials": making incremental or wholesale adjustments to aspects of one's learning agenda. Creativity itself is, almost by sheer definition, inextricable from this process: if one's learning agenda is static, and their real and

ideal selves are perfectly aligned, then there is no possibility of stimulating novelty. The act of creating something necessitates a change in one's data stream - the sum state of incoming sensory signals, language processing, recalled memories, etc. – that guide human action and behavior. Stimulating novelty by making a change in the data stream requires thoughtful experimentation, and refinement of practices that have proven successful in yielding creative insights.

As with the learning agenda that it seeks to refresh, the exact nature and potential benefits of the experimentation and practice process will be idiosyncratic; contingent on both the individual doing the experimentation, and the domain for which they are attempting to facilitate a change in perspective and insight. The heightened self-awareness that one can derive from reasoning honestly and critically about themselves in establishing their real self can also be steered toward better recognition of practices and behaviors that work for *them*. Popular literature abounds with accounts of the rituals and individualistic tinkering that many of history's great creative minds undertook in the service of generating their own unique *muse* (Currey, 2013). It stands to reason that no single approach to prompting creative insight is going to work the same for all people, all of the time. Experimentation, with oneself as the participant, and practical refinement, with oneself as the arbiter of what constitutes best practice, can be a life-long process, whereby one's increased self-awareness acts as an antecedent to ongoing creative expansivity. With the horizon of the ideal self ever hovering in view, experimentation provides the thrust of continuous change needed to generate creativity sustainably over more than a fleeting period.

Trial and error is at the core of creativity (Simon, 1967), and one's fluctuation between states of being creative and uncreative hinges squarely on pumping novelty into the data stream

of their own consciousness, and the associated risk orientation or tolerance for ambiguity that enables one to have failures and not be felled by them. This might sometimes demand stepping outside the bounds of one's conventional comforts and beginning to intuit where one's personal boundaries are. But as with the analogy with athleticism explored earlier, sustained growth comes from a willingness to pursue peak performance by pushing the ideal self further away from immediate reach, and setting the real self the task of closing an ever more challenging gap. In the domain of creativity, this dynamic process of intentional change is the machinery by which novel creative output may flourish.

The Relationships That Enable Creativity

The social contexts in which discrete instances of creativity occur have been the focus of a long-term avenue of scholarly enquiry across a number of fields in the social and organizational sciences (see e.g. Perry-Smith, 2006; Perry-Smith & Shalley, 2003; Tierney et al., 1999). Given the aforementioned difficulties with sealing an agreed-upon working definition of the term itself that can be operationalized meaningfully across multiple domains, however, it is perhaps not surprising that the extant literature in this area has struggled to identify theoretical consistencies about the kinds of social relationships, structures and behaviors that are conducive to fostering creativity; particularly over the long term and across domains. The literature has largely been characterized by drawing conclusions from discrete, highly circumscribed instances of creative acts that lack the cross-domain generalizability that, this paper argues, the ICT approach to understanding creativity through change possesses. The discussion sections of

academic papers devoted to this topic are often replete with caveats cautioning against the universal validity of the paper's own findings.

On the whole, humans are inherently social, and our lives are embedded in a host of different social structures. Each of these structures has particular cognitive and affective dimensions that determine its interpersonal characteristics, and subsequently influence an individual's behavioral responses to its nuances. Furthermore, the aspects of an individual's personality that govern socially-relevant behavior differ in many ways across the general population, and reflect some combination of genetic, environmental and other factors that have uniquely sculpted any one individual's social makeup (Adolphs, 2001; Brewer, 1991).

Consequently, it is probably more prudent to avoid prescribing a one size fits all approach to the kinds of social practices and relationships that lend themselves to fostering creativity. Consistent with the ICT framework's fifth discovery phase, it is the *resonant* qualities of one's social relationships, and not other quantifiable characteristics such as their size or personal proximity, that determine their efficacy in facilitating the change process from which creativity emerges. The qualities that make any one relationship resonant for any one individual are almost certainly as unique as the individuals themselves. They will be based on some combination of the dyad's history, familiarity, levels of authority and influence, and so on.

Resonant relationships are united only in their ability to help steer one or more people in the relationship toward their ideal self; the specific interpersonal mechanisms by which this occur will vary widely. To this end, any relationship that cycles an individual into the PEA, and into the intentional change mindset, should be most effective in spurring creativity into action. Reflecting honestly about one's real self will reveal the kinds of relationships that one feels will

best help them adopt a personal learning plan for change, and give them the freedom to experiment and refine the change practices that help stimulate creative insight. Indeed, the social structures in which humans are embedded remain one of the most potent wellsprings of information in our data streams; a goldmine of raw material upon which the DMN, and its associated functions of both social exchange and receptiveness to novelty, can act upon to trigger creative insights.

Table 2.0: Overview of Creativity as a Process of Change (Adapted from Boyatzis, 2008)

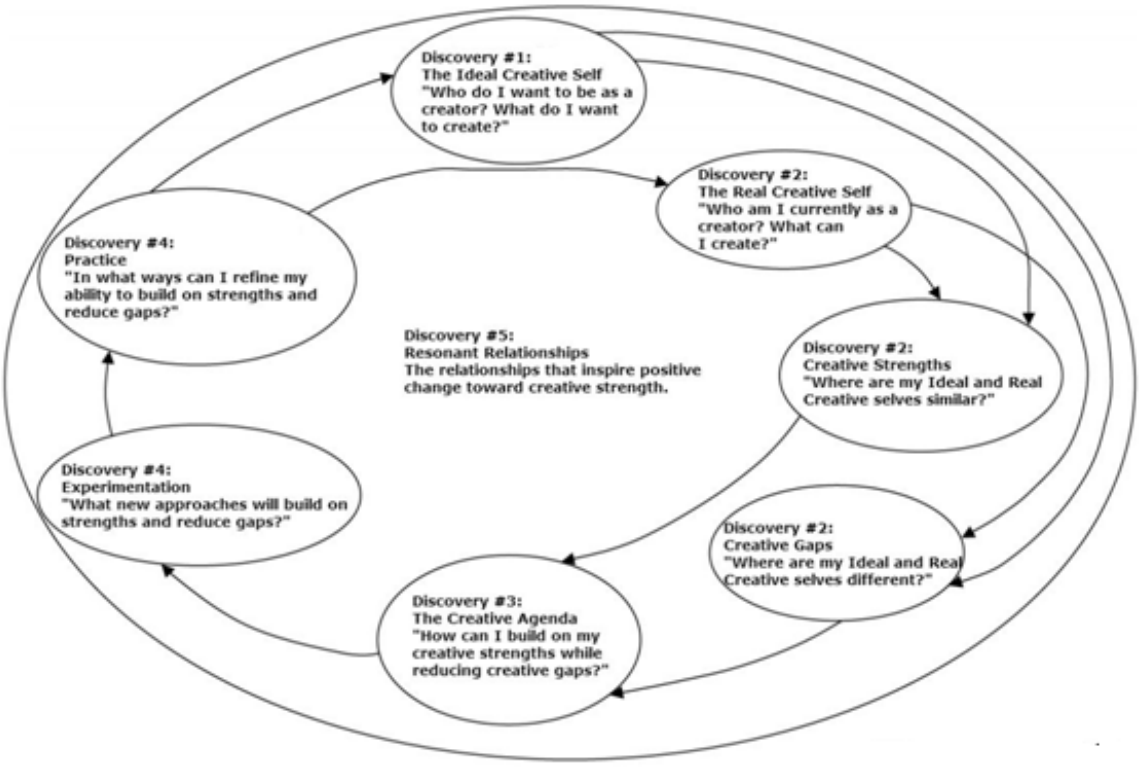

Table 3.0: Summary of the Intentional Change Framework in Creativity

ICT Discovery Phase	Essence of the Discovery	Characteristics/ Practices of the Discovery
#1 The Ideal Creative Self	A state of desired creativity in some particular domain.	Interplay between PEA/NEA and DMN/TPN; greater focus on PEA/DMN; receptivity to novelty.
#2 The Real Creative Self	An existing state of creativity in some particular domain.	Recognition of existing creativity abilities and constituent micro-influences which give rise to creativity.
#3 The Creative Agenda	"Setting the dials"; formulating a plan to close the gap between the ideal and real creative selves.	Mindfulness practices; openness to ideas; cataloguing of effects of micro-influences on real creative self.
#4 Experimentation and Practice	"Tweaking the dials"; experimenting with aspects of the creative agenda to better close the gap between the ideal and real selves	Experimentation with current practices and refinement of those practices; ritualism; increased self-awareness.
#5 Relationships That Enable Creativity	Resonant relationships which steer the individual toward their ideal creative self.	Establishment and development of which serve to foster and stimulate creativity.

Concluding Remarks

The foregoing sections have attempted to reconcile different conceptions of creativity under the banner of Intentional Change Theory; a framework for driving sustained, desired change, in an effort to understand creativity as a more holistic phenomenon – specifically, that of a meta-state - based on a dynamic and ongoing process of change at the individual level. In so doing, each discovery phase of the framework has been explored in terms of its relationship to creativity, and the implications it has for fostering the sort of enduring change upon which this understanding of creativity is predicated. In the first discovery, the ideal self, and its position relative to the real self, are held up as being analogous to the relative positioning of states of creativity and uncreativity; with a similar interplay of underlying neural networks (the DMN and TPN) posited as characteristic in both relationships. Under this conceptualization, the ideal self represents the state of creativity one *wishes* to be in, and the real self the state of creativity one is

currently in. The latter, explored in the assessment of the second discovery phase, represents a detailed cataloguing, based on honest and critical self-assessment, of the various micro-factors which comprise one's creative self. Chronotype, diet and nutrition, exercise, hormones, thermoregulation, olfaction and visual perception, were explored in detail as an inexhaustive list of factors variously and empirically implicated in stimulating and nurturing creativity, and which may, along with a deep personal understanding of the specificities of one's chosen creative domain, might serve as a useful benchmark as to what constitutes an individual's real creative self. A relational analogy was drawn between creativity and athleticism; with the latter identified as a useful conceptual tool to identify existing gaps between the ideal and real selves, and ways in which these gaps can be closed in the service of fostering creativity.

The third and fourth discovery phases of the framework, setting a learning agenda and engaging in experimentation and practice, cover how an individual might mindfully develop and enact an overall plan for driving themselves from their real to ideal self in the context of fostering creativity ("setting the dials"), before using experimentation and ongoing refinement of practices and behaviors to modify this plan so as to dynamically re-chart a course of ongoing creativity that is sustained over time ("tweaking the dials"). Finally, resonant relationships, for which the specific interpersonal characteristics will be peculiar to an individual's own social capacities, and the particular social structures in which they are embedded, was posited as a means of consolidating disparate accounts of the social dimensions which best lend themselves to unearthing creativity, and providing a platform through which it might be sustained over the long run.

This paper has been, in sum, a short order attempt to understand creativity through the lens of *change*, and to propose that sustainable creativity can be both understood and most

effectively realized when such change is embraced as a dynamic, ongoing process throughout the course of one's life. While the literature concerning creativity in the organizational sciences has borne much fruit in terms of discrete instances of creativity through particular modalities and circumscriptions; it has lacked an overarching theoretical framework through which creativity may be understood more holistically, and through which creativity as a sustainable phenomenon may be comprehended. ICT has thus been proposed as a coherent model under which creativity can be understood as a meta-state; under which more discrete aspects and exemplars of creativity can be meaningfully subsumed.

As noted in the quote that opened the paper, creativity is fundamentally a process of changing; of moving from one state of being into one which has been subject to change. ICT provides a comprehensive, validated model by which intentional change on the part of an individual may lead to sustainable creativity over the course of their lifetime. Carefully constructed empirical tests will be required to evidentially bear many of the claims within this paper out, and given the vindication ICT has received in the extant literature in the organizational sciences to date, such empirical pursuits would appear a sensible a potentially revealing undertaking scholarly undertaking indeed.

References

Adan, A., & Almirall, H. (1991). Horne & Östberg morningness-eveningness questionnaire: A reduced scale. *Personality and Individual differences*, *12*(3), 241-253.

Adolphs, R. (2001). The neurobiology of social cognition. *Current opinion in neurobiology*, *11*(2), 231-239.

Alves, J., Marques, M. J., Saur, I., & Marques, P. (2007). Creativity and innovation through multidisciplinary and multisectoral cooperation. *Creativity and Innovation Management*, *16*(1), 27-34.

Amabile, T. M. (1997). Motivating creativity in organizations: On doing what you love and loving what you do. *California management review*, *40*(1), 39-58.

Amabile, T. M., Barsade, S. G., Mueller, J. S., & Staw, B. M. (2005). Affect and creativity at work. *Administrative science quarterly*, *50*(3), 367-403.

Amabile, T. M., Schatzel, E. A., Moneta, G. B., & Kramer, S. J. (2004). Leader behaviors and the work environment for creativity: Perceived leader support. *The Leadership Quarterly*, *15*(1), 5-32.

Anderson, B. J., Rapp, D. N., Baek, D. H., McCloskey, D. P., Coburn-Litvak, P. S., & Robinson, J. K. (2000). Exercise influences spatial learning in the radial arm maze. *Physiology & behavior*, *70*(5), 425-429.

Anderson, N., Potočnik, K., & Zhou, J. (2014). Innovation and creativity in organizations a state-of-the-science review, prospective commentary, and guiding framework. *Journal of Management*, *40*(5), 1297-1333.

Baer, M. (2010). The strength-of-weak-ties perspective on creativity: a comprehensive examination and extension. *Journal of applied psychology*,*95*(3), 592.

Barbot, B., & Tinio, P. P. (2014). Where is the "g" in creativity? A specialization–differentiation hypothesis. *Frontiers in human neuroscience*,*8*.

Baumeister, R. F., Bratslavsky, E., Finkenauer, C., & Vohs, K. D. (2001). Bad is stronger than good. *Review of general psychology*, *5*(4), 323.

Beaty, R. E., Benedek, M., Wilkins, R. W., Jauk, E., Fink, A., Silvia, P. J., & Neubauer, A. C. (2014). Creativity and the default network: a functional connectivity analysis of the creative brain at rest. *Neuropsychologia*, *64*, 92-98.

Bellisle, F. (2004). Effects of diet on behaviour and cognition in children.*British Journal of Nutrition*, *92*(2),227-232.

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological science*, *19*(12), 1207-1212.

Best, J. R. (2010). Effects of physical activity on children's executive function: Contributions of experimental research on aerobic exercise.*Developmental Review*, *30*(4), 331-351.

Bixby, W. R., Spalding, T. W., Haufler, A. J., Deeny, S. P., Mahlow, P. T., Zimmerman, J. B., & Hatfield, B. D. (2007). The unique relation of physical activity to executive function in older men and women. *Medicine and science in sports and exercise*, *39*(8), 1408-1416.

Blanchette, D. M., Ramocki, S. P., O'del, J. N., & Casey, M. S. (2005). Aerobic exercise and creative potential: Immediate and residual effects.*Creativity Research Journal*, *17*(2-3), 257-264.

Boyatzis, R. E. (2006). An overview of intentional change from a complexity perspective. *Journal of Management Development*, *25*(7), 607-623.

Boyatzis, R. E. (2008). Leadership development from a complexity perspective. *Consulting Psychology Journal: Practice and Research*, *60*(4), 298.

Boyatzis, R. E. (2008). Leadership development from a complexity perspective. *Consulting Psychology Journal: Practice and Research*, *60*(4), 298.

Boyatzis, R., & McKee, A. (2006). Intentional change. *Journal of Organizational Excellence*, *25*(3), 49-60.

Boyatzis, R. E., & Akrivou, K. (2006). The ideal self as the driver of intentional change. *Journal of Management Development*, *25*(7), 624-642.

Boyatzis, R. E., Rochford, K., & Taylor, S. N. (2015). The role of the positive emotional attractor in vision and shared vision: toward effective leadership, relationships, and engagement. *Frontiers in psychology*, *6*.

Brewer, M. B. (1991). The social self: On being the same and different at the same time. *Personality and social psychology bulletin*, *17*(5), 475-482.

Bryan, J., Osendarp, S., Hughes, D., Calvaresi, E., Baghurst, K., & van Klinken, J. W. (2004). Nutrients for cognitive development in school-aged children. *Nutrition reviews*, *62*(8), 295-306.

Burkhalter, T. M., & Hillman, C. H. (2011). A narrative review of physical activity, nutrition, and obesity to cognition and scholastic performance across the human lifespan. *Advances in Nutrition: An International Review Journal*, *2*(2), 201S-206S.

Cahill, L., Babinsky, R., Markowilsch, H. J., & McGaugh, J. (1995). Amygdala and emotional memory. *Nature*, 377, 295-6.

Cavallera, G. M., Boari, G., Labbrozzi, D., & Bello, E. D. (2011). Morningness-eveningness personality and creative thinking among young people who play recreational sport. *Social Behavior and Personality: an international journal*, *39*(4), 503-518.

Chermahini, S. A., & Hommel, B. (2010). The (b) link between creativity and dopamine: spontaneous eye blink rates predict and dissociate divergent and convergent thinking. *Cognition*, *115*(3), 458-465.

Cimbalo, R. S., & Hughey, A. M. (1986). Preferences and behaviors of morning and night people: self-report. *Psychological reports*, *59*(2), 502-502.

Collins, S. M., Surette, M., & Bercik, P. (2012). The interplay between the intestinal microbiota and the brain. *Nature Reviews Microbiology*, *10*(11), 735-742.

Colzato, L. S., Szapora, A., Pannekoek, J. N., & Hommel, B. (2013). The impact of physical exercise on convergent and divergent thinking. *Frontiers in human neuroscience*, *7*.

Colzato, L. S., de Haan, A. M., & Hommel, B. (2014). Food for creativity: tyrosine promotes deep thinking. *Psychological research*, 1-6.

Cotman, C. W., Berchtold, N. C., & Christie, L. A. (2007). Exercise builds brain health: key roles of growth factor cascades and inflammation. *Trends in neurosciences*, *30*(9), 464-472.

Cotterill, R. M. (2001). Cooperation of the basal ganglia, cerebellum, sensory cerebrum and hippocampus: possible implications for cognition, consciousness, intelligence and creativity. *Progress in Neurobiology*, *64*(1), 1-33.

Craig, A. D. (2002). How do you feel? Interoception: the sense of the physiological condition of the body. *Nature reviews neuroscience*, *3*(8), 655-666.

Cryan, J. F., & Dinan, T. G. (2012). Mind-altering microorganisms: the impact of the gut microbiota on brain and behaviour. *Nature reviews neuroscience*, *13*(10), 701-712.

Csikszentmihalyi, M., & Wolfe, R. (2014). New conceptions and research approaches to creativity: Implications of a systems perspective for creativity in education. In *The Systems Model of Creativity* (pp. 161-184). Springer Netherlands.

Currey, M. (Ed.). (2013). *Daily rituals: How artists work*. Knopf.

Dahl, A. K., Hassing, L. B., Fransson, E. I., Gatz, M., Reynolds, C. A., & Pedersen, N. L. (2013). Body mass index across midlife and cognitive change in late life. *International journal of obesity*, *37*(2), 296-302.

DeQuattro, V., & Feng, M. (2002). The sympathetic nervous system: The muse of primary hypertension. Journal of Human Hypertension, 16(Suppl 1), S64-S69.

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. Psychological Bulletin, 130, 355-391.

Duerkop, B. A., Vaishnava, S., & Hooper, L. V. (2009). Immune responses to the microbiota at the intestinal mucosal surface. *Immunity*, *31*(3), 368-376.

Ding, Y., Li, J., Luan, X., Ding, Y. H., Lai, Q., Rafols, J. A., Diaz, F. G. (2004). Exercise pre-conditioning reduces brain damage in ischemic rats that may be associated with regional angiogenesis and cellular overexpression of neurotrophin. *Neuroscience*, *124*(3), 583-591.

Driscoll, I., Hamilton, D. A., Yeo, R. A., Brooks, W. M., & Sutherland, R. J. (2005). Virtual navigation in humans: the impact of age, sex, and hormones on place learning. *Hormones and behavior*, *47*(3), 326-335.

Elliot, A. J., & Maier, M. A. (2007). Color and psychological functioning.*Current Directions in Psychological Science*, *16*(5), 250-254.

Erickson, K. I., Voss, M. W., Prakash, R. S., Basak, C., Szabo, A., Chaddock, L., Wojcicki, T. R. (2011). Exercise training increases size of hippocampus and improves memory. *Proceedings of the National Academy of Sciences*, *108*(7), 3017-3022.

Etnier, J. L., Salazar, W., Landers, D. M., Petruzzello, S. J., Han, M., & Nowell, P. (1997). The influence of physical fitness and exercise upon cognitive functioning: A meta-analysis. *Journal of Sport & Exercise Psychology*, *19*, 249-277.

Farmer, J., Zhao, X., Van Praag, H., Wodtke, K., Gage, F. H., & Christie, B. R. (2004). Effects of voluntary exercise on synaptic plasticity and gene expression in the dentate gyrus of adult male Sprague–Dawley rats in vivo.*Neuroscience*, *124*(1), 71-79.

Fink, A., Grabner, R. H., Gebauer, D., Reishofer, G., Koschutnig, K., & Ebner, F. (2010). Enhancing creativity by means of cognitive stimulation: evidence from an fMRI study. *Neuroimage*, *52*(4), 1687-1695.

Fiala, D., Lomas, K. J., & Stohrer, M. (1999). A computer model of human thermoregulation for a wide range of environmental conditions: the passive system. *Journal of Applied Physiology*, *87*(5), 1957-1972.

Gennaro, R. (2005). The HOT theory of consciousness: between a rock and a hard place?. *Journal of Consciousness Studies, 12*(2), 3-21.

Giampietro, M., & Cavallera, G. M. (2007). Morning and evening types and creative thinking. *Personality and Individual Differences*, *42*(3), 453-463.

Gilbert, D. T., & Wilson, T. D. (2007). Prospection: Experiencing the future.*Science*, *317*(5843), 1351-1354.

González, M. A., Campos, A., & Pérez, M. J. (1997). Mental imagery and creative thinking. *The Journal of psychology*, *131*(4), 357-364.

Gruzelier, J. (2009). A theory of alpha/theta neurofeedback, creative performance enhancement, long distance functional connectivity and psychological integration. *Cognitive processing*, *10*(1), 101-109.

Harding, T. (2010). Fostering creativity for leadership and leading change.*Arts Education Policy Review*, *111*(2), 51-53.

Hassler, M. (1990). Testosterone and musical talent.*Experimental and clinical endocrinology*, *98*(2), 89-98.

Heijtz, R. D., Wang, S., Anuar, F., Qian, Y., Björkholm, B., Samuelsson, A., Pettersson, S. (2011). Normal gut microbiota modulates brain development and behavior. *Proceedings of the National Academy of Sciences*, *108*(7), 3047-3052.

Holland, R. W., Hendriks, M., & Aarts, H. (2005). Smells Like Clean Spirit Nonconscious Effects of Scent on Cognition and Behavior. *Psychological Science*, *16*(9), 689-693.

Horne, J. A., & Ostberg, O. (1975). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms.*International journal of chronobiology*, *4*(2), 97-110.

Insel, T. R. (1997). A neurobiological basis of social attachment. American Journal of Psychiatry, 154, 726-735.

Jäger, A. O. (1984). Intelligenzstrukturforschung: Konkurrierende Modelle, neue Entwicklungen, Perspektiven. *Psychologische Rundschau*.

Jayakody, K., Gunadasa, S., & Hosker, C. (2013). Exercise for anxiety disorders: systematic review. *British journal of sports medicine*, bjsports-2012.

Joëls, M., Pu, Z., Wiegert, O., Oitzl, M. S., & Krugers, H. J. (2006). Learning under stress: how does it work?. *Trends in cognitive sciences*, *10*(4), 152-158.

Kimura, D. (2002). Sex hormones influence human cognitive pattern. *Neuro endocrinology letters*, *23*, 67-77.

Knasko, S. C. (1992). Ambient odor's effect on creativity, mood, and perceived health. *Chemical Senses*, *17*(1), 27-35.

Kretchmer, N., Beard, J. L., & Carlson, S. (1996). The role of nutrition in the development of normal cognition. *The American journal of clinical nutrition*,*63*(6), 997S-1001S.

Krug, R., Stamm, U., Pietrowsky, R., Fehm, H. L., & Born, J. (1994). Effects of menstrual cycle on creativity. *Psychoneuroendocrinology*, *19*(1), 21-31.

La Rue, A., Koehler, K. M., Wayne, S. J., Chiulli, S. J., Haaland, K. Y., & Garry, P. J. (1997). Nutritional status and cognitive functioning in a normally aging sample: a 6-y reassessment. *The American journal of clinical nutrition*,*65*(1), 20-29.

Lan, L., Lian, Z., Pan, L., & Ye, Q. (2009). Neurobehavioral approach for evaluation of office workers' productivity: The effects of room temperature.*Building and Environment*, *44*(8), 1578-1588.

Lichtenfeld, S., Elliot, A. J., Maier, M. A., & Pekrun, R. (2012). Fertile green green facilitates creative performance. *Personality and Social Psychology Bulletin*, *38*(6), 784-797.

Lupien, S. J., Maheu, F., Tu, M., Fiocco, A., & Schramek, T. E. (2007). The effects of stress and stress hormones on human cognition: Implications for the field of brain and cognition. *Brain and cognition*, *65*(3), 209-237.

Mäkinen, T. M., Palinkas, L. A., Reeves, D. L., Pääkkönen, T., Rintamäki, H., Leppäluoto, J., & Hassi, J. (2006). Effect of repeated exposures to cold on cognitive performance in humans. *Physiology & behavior*, *87*(1), 166-176

Marr, D., & Vision, A. (1982). *A computational investigation into the human representation and processing of visual information*. Freeman and Company. San Francisco

Mayseless, N., Uzefovsky, F., Shalev, I., Ebstein, R. P., & Shamay-Tsoory, S. G. (2013). The association between creativity and 7R polymorphism in the dopamine receptor D4 gene (DRD4). *Frontiers in human neuroscience*, *7*.

Mednick, S. (1962). The associative basis of the creative process.*Psychological review*, *69*(3), 220.

Nelson, R. J. (2005). *An introduction to behavioral endocrinology*. Sinauer Associates.

Mehta, R., & Zhu, R. J. (2009). Blue or red? Exploring the effect of color on cognitive task performances. *Science, 323*(5918), 1226-1229.

Mitchell, D. J., Kahn, B. E., & Knasko, S. C. (1995). There's something in the air: effects of congruent or incongruent ambient odor on consumer decision making. *Journal of Consumer Research*, 229-238.

Neave, N. (2007). *Hormones and behaviour: a psychological approach*. Cambridge University Press.

Panda, S., Hogenesch, J. B., & Kay, S. A. (2002). Circadian rhythms from flies to human. *Nature, 417*(6886), 329-335.

Perry-Smith, J. E. (2006). Social yet creative: The role of social relationships in facilitating individual creativity. *Academy of Management journal, 49*(1), 85-101.

Petersen, R. B., Lissemore, F. M., Appleby, B., Aggarwal, N., Boyatzis, R., Casadesus, G. & Sajatovic, M. (2015). From Neurodegeneration to Brain Health: An Integrated Approach. *Journal of Alzheimer's Disease, 46*(1), 271-283.

Perry-Smith, J. E., & Shalley, C. E. (2003). The social side of creativity: A static and dynamic social network perspective. *Academy of management review, 28*(1), 89-106.

Ploughman, M. (2008). Exercise is brain food: the effects of physical activity on cognitive function. *Developmental neurorehabilitation, 11*(3), 236-240.

Roenneberg, T. (2012). What is chronotype?. *Sleep and biological rhythms,10*(2), 75-76.

Roenneberg, T., Wirz-Justice, A., & Merrow, M. (2003). Life between clocks: daily temporal patterns of human chronotypes. *Journal of biological rhythms*,*18*(1), 80-90.

Roeser, K., Riepl, K., Randler, C., & Kübler, A. (2015). Effects of chronotype and synchrony/asynchrony on creativity. *Journal of Individual Differences*.

Reuter, M., Panksepp, J., Schnabel, N., Kellerhoff, N., Kempel, P., & Hennig, J. (2005). Personality and biological markers of creativity. *European Journal of Personality*, *19*(2), 83-95.

Runco, M. (2007). *Creativity theories and themes: research, development and practice.* Burlington: Elsevier Academic Press.

Sacher, J., Okon-Singer, H., & Villringer, A. (2013). Evidence from neuroimaging for the role of the menstrual cycle in the interplay of emotion and cognition. *Frontiers in human neuroscience*, *7*.

Sears, C. L. (2005). A dynamic partnership: celebrating our gut flora.*Anaerobe*, *11*(5), 247-251.

Schmitt, J. A. (2010). Nutrition and cognition: meeting the challenge to obtain credible and evidence-based facts. *Nutrition Reviews*, *68*(suppl 1), S2-S5.

Schweitzer, N. B., Alessio, H. M., Berry, S. D., Roeske, K., & Hagerman, A. E. (2006). Exercise-induced changes in cardiac gene expression and its relation to spatial maze performance. *Neurochemistry international*, *48*(1), 9-16.

Simon, H. A. (1967). Understanding creativity. *Creativity: Its educational implications. New York: Wiley*.

Slamecka, N. J. (1964). An inquiry into the doctrine of remote associations. *Psychological Review*, *71*(1), 61.

Sofi, F., Valecchi, D., Bacci, D., Abbate, R., Gensini, G. F., Casini, A., & Macchi, C. (2011). Physical activity and risk of cognitive decline: a meta-analysis of prospective studies. *Journal of internal medicine*, *269*(1), 107-117.

Steidle, A., & Werth, L. (2013). Freedom from constraints: Darkness and dim illumination promote creativity. *Journal of Environmental Psychology*, *35*, 67-80.

Steinberg, H., Sykes, E. A., Moss, T., Lowery, S., LeBoutillier, N., & Dewey, A. (1997). Exercise enhances creativity independently of mood. *British Journal of Sports Medicine*, *31*(3), 240-245.

Teramoto, M., & Bungum, T. J. (2010). Mortality and longevity of elite athletes. *Journal of Science and Medicine in Sport*, *13*(4), 410-416.

Tierney, P., Farmer, S. M., & Graen, G. B. (1999). An examination of leadership and employee creativity: The relevance of traits and relationships. *Personnel psychology*, *52*(3), 591-620.

Vaynman, S., Ying, Z., Wu, A., & Gomez-Pinilla, F. (2006). Coupling energy metabolism with a mechanism to support brain-derived neurotrophic factor-mediated synaptic plasticity. *Neuroscience*, *139*(4), 1221-1234.

Wang, X., Wang, B. R., Zhang, X. J., Xu, Z., Ding, Y. Q., & Ju, G. (2002). Evidences for vagus nerve in maintenance of immune balance and transmission of immune information from gut to brain in STM-infected rats. *World Journal of Gastroenterology*, *8*(3), 540-545.

Yeh, Y. C., Lai, G. J., Lin, C. F., Lin, C. W., & Sun, H. C. (2015). How stress influences creativity in game-based situations: Analysis of stress hormones, negative emotions, and working memory. *Computers & Education*, *81*, 143-153.

Zelano, C., & Sobel, N. (2005). Humans as an animal model for systems-level organization of olfaction. *Neuron*, *48*(3), 431-454.