Creativity, the flow state and brain function

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There are various concepts of optimal human functioning such as creativity, flow, peak experience and self-actualization. With suggestions that creativity and flow are interrelated, and possibly even interchangeable, at first glance the metaphor of flow and the concept of creativity seem to be entangled. Rich descriptions of creativity and the flow experience exist, especially in psychological literature, yet very little is understood of the brain mechanisms that govern such human functioning. This article investigates flow, creativity, and the brain mechanisms that elicit such unusual human functioning, and what brain processes ground these psychological constructs. The intention is to distinguish the concept of flow from creativity, and expand the heuristic understanding and value of flow within the creative disciplines.
Key words: creativity, flow, brain function, prefrontal cortex, implicit and explicit systems

Kreatiwiteit, die vloeistaat en breinfunksie
Kreatiwiteit, vloei, uitstekbelewenis en selfaktualisering kan beskou word as konsepte van optimale menslike ervaring. Oppervlakkig beskou, kan die suggestie dat kreatiwiteit en vloei verwant is, en moontlik ook verruilbaar is, wel voorkom asof die twee konsepte eens is. Die sielkundige literatuur beskik oor ryk beskrywings van kreatiwiteit en die vloei-ervaring, dog word bitter min verstaan van die brein meganismes wat sulke menslike optrede beheer. Hierdie artikel ondersoek vloei, kreatiwiteit, sowel as die breinmeganismes waaruit sulke ongewone menslike funksionering voortspruit, sowel as die breinprosesse wat hierdie sielkundige konstrukte gewig gee. Die doel is om die twee konsepte te onderskei, sowel as om die heuristiese verstaan en waarde daarvan te verbreed binne-in die kreatiwe dissiplines.
Sleutelwoorde: kreatiwiteit, vloei, breinfunksie, prefrontale korteks, implisiete en eksplisiete stelsels

Csikszentmihalyi (1990) states that researchers of positive psychology have made the discovery that flow and creativity contribute to a fulfilling life. Sawyer (2006: 5) suggests that "[d]uring peak experiences known as *flow*, people are at their most creative". Burzik (2004), referring to reports by sports people, artists and scientists, claims that "...[flow] is closely related to creative high-performance in whatever area it is being experienced ". Statements such as these suggest that creativity and flow are interrelated, and possibly even interchangeable, and have the potential to lead to a life of fulfillment. As a lecturer and art practitioner, my interest in this topic initially started as curiosity about creative practice and then developed into frustration at the lack of information available to me beyond the theories pertaining to a concept so important and germane to the fine and applied arts. I needed to understand what phenomenological dimensions relate to best practice in fine and applied arts. The advent of flow hugely enriched this quest. This article aims to explain the concepts of creativity and flow through the eyes of a non-scientist, largely through a literature survey, in order to expand the heuristic understanding and value of flow and also to encourage research on this topic in the arts domain.

The roots of creativity

Anecdotal and ever expanding descriptions of creativity abound in populist literature. Opportunistic workshop presenters tout methods for accessing the creative beast within. The wealth of definitions of creativity could fuel endless debates, yet

> ...there is a certain consensus that creativity yields something partly or entirely new; gives existing objects new properties or characteristics; allows one to imagine new potentialities not conceived of before and to see or perform something in a manner different from what was thought possible or normal previously (Bechtereva *et al*, 2007).

As yet, however, creativity cannot be considered as being rigorously defined in the scholarly or academic domain - Bechtereva *et al* (2007) refer to the current psychophysiological literature containing more than 60 different definitions of creativity, referred to by them as the highest form of human mental activity. Ultimately it is due to the integration of cognitive psychology, neuropsychology and cognitive neuro- physiology achieved during the last decade that rapid progress has been made in studying creativity and creative activity.

Psychology is the discipline that pioneered the research and initiated descriptions of creativity: between 1950 and 1970 personality psychology, in terms of creativity, attempted to explain the creative personality. Even though this era included an important first wave of creativity research, personality psychologists did not establish what personality traits distinguish creative people from ordinary people - and had yet to design educational techniques that could improve a student's creativity.[1]

Cognitive psychology replaced personality psychology with regard to creativity research - it analyses creative mental processes and examines the representational structures of the mind, their interconnections, and the mental processes that transform them. Regardless of its major advances, cognitive psychology on its own is also found to be limited with regard to questions about creativity. Biopsychology (which developed from physiology) seeks to describe and explain creative behaviour (and even personality) in terms of nerves and chemicals in the body, especially in the brain (also referred to as localisation of function). Its progress can be traced to technological advances in measuring and observing the body. In terms of biology, Sawyer (2006: 78) states that most scientists believe that there is no creativity gene.[2]

From this initial groundwork two competing theories developed over the last century about the creative process - idealist theory, which argues that once the creative idea has been attained, the creative process is done; and action theory, which argues that the execution of the creative work is essential for the creative process (Sawyer, 2006: 58). The latter has proven to be the preferred way to explain creativity, as the medium or material with which the creator works, is often a source of idea generation.

Furthermore, by observing the creative process, scientists are better equipped to explain it. Csikszentmihalyi (1997b) identified five basic steps that characterise the creative process: preparation; incubation; insight; evaluation; elaboration.

Creativity research has been progressing in areas such as sociology and psychology, but laboratory-based science aimed at uncovering the fundamental processes, cognitive or neural, that give rise to creative information-processing in the brain, has not progressed in tandem. Despite great advancements in brain science vis-a-vis creativity, it alone cannot explain creativity. It appears that a combination of qualitative and quantitative research yields results with the best heuristic value with regard to creativity.

Brief exposition of brain function during creativity

Recall that neither cognitive psychology nor laboratory-based science, in other words direct empirical evidence, aimed at uncovering the fundamental processes, cognitive or neural, that give rise to creative information processing in the brain, have been able to explain creativity or flow satisfactorily. Models and theoretical information about creativity need to be combined with and substantiated through recent scientific information and empirical research. In other words, outdated information about creativity is not appropriate as the basis for observation and empirical research experiments.

An example of an outdated concept of creativity is 'divergent thinking' (Mölle *et al*, 1996). Divergent thinking was developed by Guildford in 1967, who grouped together several sub-skills of thinking, and referred to "the capacity to produce ideas that *diverge* from the ordinary, on the assumption that divergent thinking produces creative ideas" (Weisberg, 2006: 453). Sawyer (2006: 44) further compounds the debate by stating that one of the obvious differences between intelligence and creativity is that intelligence requires convergent thinking, coming up with a single right answer, while creativity requires divergent thinking, coming up with many potential answers. To conduct experiments for creativity based on divergent thinking which is associated with problem finding, i.e. coming up with many potential answers, would offer an incomplete picture of creativity, as creativity is also associated with problem solving, associated with convergent thinking, i.e. coming up with a single right answer. Sawyer (2006: 83) states:

> Some researchers have suggested that convergent thinking is a left-brain strength, with divergent thinking in the right brain (Springer & Deutsch, 1981). And because for decades creativity was associated with divergent thinking (although we now know that's not accurate), this may have contributed to the myth about right-brain activity.

Another example of an outdated idea is that creativity resides in the right brain, an outflow of the field of hemispheric specialisation (Sperry, 1968).

With regard to brain architecture, it emerges that creativity requires a constant dialogue between the two hemispheres where "the imagery and symbols generated by the right hemisphere require the left hemisphere to translate them into creative verbalizations" [Restak, (1993), in Sawyer (2006: 83)]. Hoppe and Neville (1990) refer to researchers hypothesizing that creative people have enriched communication between their hemispheres with freer access to mutual interaction of both hemispheres. Clearly creativity involves both hemispheres.

Estes and Ward (2002) suggest that our understanding of creativity cannot be complete without an understanding of the cognitive processes from which novel ideas emerge. In this regard Dietrich (2004a, 2004b) suggests that creativity results from the factorial combination of four kinds of mechanisms. Neural computation that generates novelty can occur during two modes of thought (deliberate and spontaneous) and for two types of information (emotional and cognitive). Dietrich (2004a) continues:

> Regardless of how novelty is generated initially, circuits in the prefrontal cortex perform the computation that transforms the novelty into creative behavior. To that end, prefrontal circuits are involved in making novelty fully conscious, evaluating its appropriateness, and ultimately implementing its creative expression.

Based on the assumption that creativity is both novel and appropriate, the cognitive flexibility germane to the prefrontal cortex is instrumental in assessing whether a particular new behaviour is creative, as opposed to merely new. "According to this view, the implicit system can only contribute to generating novelty, which may or may not be creative" (Dietrich, 2004a). The same author (2004a) found that creativity is enabled by the cognitive capabilities provided primarily by the dorsolateral prefrontal cortex (DLPFC), which is involved in executive function. He explains that this executive function of the DLPFC further integrates already highly processed information to enable still higher cognitive functions such as self-construct, self-reflective consciousness, abstract thinking, cognitive flexibility, planning, and willed action. "It formulates plans and strategies for appropriate behavior in a given situation and instructs the adjacent motor cortices to execute its computational product" (Dietrich, 2004a).

Christoff *et al* (2008) refer to three types of thought: goal-directed, spontaneous and creative. Goal-directed thought is associated with cognitive control, and found to reside in the prefrontal cortex - the DLPFC and the rostolateral PFC (or RLPFC). Spontaneous thought, (also referred to as mind wandering) is found to reside along the midline of the brain, including the medial prefrontal cortex, the anterior and posterior cingulate cortices, the precuneus and the posterior parietal lobule. Spontaneous thought is found to increase as cognitive demands decrease, and is thus further associated with diminished prefrontal recruitment - this descriptor could as easily describe flow. "Between these two extreme ends of a possible thought continuum lies yet another form of thinking, *creative thought*, which appears to share commonalities with both goal-directed and spontaneous thought" (Christoff *et al*, 2008). My understanding is thus that creativity and flow are indeed related, but not interchangeable.

Information and evidence emerging from empirical research will develop in tandem with the development of technology and also the accessibility of measuring instruments. Such experiments must be based on what Dietrich (2007) and Sawyer (2006) refer to as the creative cognition approach. The creative cognition approach explains creativity by examining how the mind combines concepts. Mental processes most relevant to creativity, studied by cognitive psychologists, are conceptual combination, metaphor and analogy. In other words, a combination of two concepts is employed in order to make a new one. Sawyer (2006: 65) states that creative cognition theorists hypothesize that a cluster of basic cognitive processes is used in creativity. For example, generative processes,[3] filtering processes,[4] and exploratory processes.[5] In this sense, creativity is accepted to emerge, rather to 'arrive in a flash'. In short, this approach "...breaks down creativity into its cognitive subcomponents and distributes them, right at the outset, throughout the information-processing system. Only when creativity is parceled out into its various operations can neuroscience get a handle on the issue" (Dietrich, 2007). In turn, fields such as psychology and philosophy, are required to unify with neuroscience to build on current cognitive science with regard to creativity and flow. There is no reason why the creative disciplines cannot play a role here too.

The roots of the flow state

During the 1970s Csikszentmihalyi studied hundreds of 'expert' artists, athletes, musicians, chess masters and surgeons - people who spend their time in activities they prefer, and he developed a theory of optimal experience based on the concept of *flow* - a cognitive/emotive state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it. Athletes refer to it as 'being in the zone', religious mystics as being in 'ecstasy' and musicians as 'aesthetic rapture' (Csikszentmihalyi, 1997a). The concept of state of flow is associated with optimal experience, and is also synonymous with optimal performance, when a person's mental or physical ability is "... stretched to its limits in a voluntary effort to accomplish something difficult and worthwhile" (Csikszentmihalyi, 2002: 3). References to creative endeavours producing flow are abundant, yet research on flow and art making and design (including architecture) has a long way yet to go.

Flow is a psychological state, characterised by nine specific phenomenological dimensions, some of which are prerequisites, and some of which relate to subjective experiences. Typical prerequisites are a balance of challenge and skill; clear perceived goals; unambiguous feedback; and total concentration on the task at hand. Subjective experiences include a sense of control; a merging of action and awareness; a loss of consciousness of self; a speeding up or slowing down of time; and a sense that one is engaged in an autotelic, (or a self-directed, intrinsic and rewarding) experience. (Csikszentmihalyi, 1978, 1985, 2002, 2004).

Flow researchers Whitmore and Borrie (2005) note that a flow state is theorised to occur when these nine dimensions co-occur at high levels. It comes as no surprise then, that they observe that for most people, achieving flow is a rare occurrence and is an elusive phenomenon. It may be elusive and rare, yet most experienced practicing artists with whom I have discussed the phenomenon of flow recognised many, if not all, of these phenomenological dimensions as occurring during their art making *modus operandi.*

As with creativity, rich descriptions of flow appear in psychological literature. Humanistic and health psychology has long focused on the subject of optimal human functioning. Carl Rogers[6] (during the 1940s) and Victor Maslow (during the 1950s), both humanistic psychologists, initiated the study of peak experiences and underscored the concept of self-actualisation (Benson, 2004: 112-113; Maslow, 1959; Rogers, 1977). Csikszentmihalyi (1999) refers to recent psychological approaches to happiness that focus on processes in which human consciousness uses its self-organising ability to achieve a positive internal state through its own efforts. These include Block and Block's *ego-resiliency*, Diener's *positive emotionality*, Antonovsky's *salutogenic approach*, Seeman's *personality integration*, Deci and Ryan's *autonomy*, Schneier and Carver's *dispositional optimism*, and Seligman's *learned optimism*. Csikszentmihalyi's concept of the *autotelic experience*, or *flow*, can rightfully be added to this list.

Csikszentmihalyi's concept of flow was predicated on studies on happiness, motivation, self-determination and peak experiences. Csikszentmihalyi (1999) equates the flow experience with happiness and states that happiness is the only intrinsic goal that people seek for its own sake - the bottom line of all desire. With regard to happiness, during the flow experience individuals are not necessarily aware of being happy, as they are involved in the task at hand and do not naturally reflect on their subjective states. It is after the flow experience that people report having been in *as positive a state as they could possibly feel*. This could explain why people repeatedly pursue the positive and even addictive effects (Csikszentmihalyi, 1985) of the flow experience.

A salient theoretical basis for the study of motivation (as in physical activity) is Self-Determination Theory (SDT), (Deci & Ryan, 1985; Deci *et al*, 1991; Deci & Ryan, 2000), the tenets of which were extended with the formation of Vallerand's Hierarchical Model of Intrinsic and Extrinsic Motivation (HMIEM) in 1997 (Kowal & Fortier, 2000). Vallerand proposed three hierarchical levels of motivation - global (or personality level motivation), contextual,[7] and situational[8]. Global motivation, the most stable of the three orientations, refers to "...relatively enduring individual differences with respect to people's motivations" (Guay *et al* (2003). Vallerand found that individuals with a self-determined motivational profile engage in physical activity out of personal choice or for the pleasure and satisfaction derived from the experience. Conversely, individuals with a nonself-determined motivational profile participate in physical activity as a result of internal controls, external pressures, or have no motivation to do so. Deci & Ryan (1985) refer to three motivational mediators that positively influence self-determined motivation: perceptions of autonomy, competence, and relatedness. Such perceptions are not unrelated to flow. Flow was incorporated into a new motivational model as a positive affective consequence of situational self-determined motivation. Past studies have suggested and demonstrated that intrinsic motivation is positively associated with the flow state in sport (Kowal & Fortier, 2000; Crews, 2004); physical recreational activity (Whitmore & Borrie, 2005); and music (Burzik, 2004) . In turn, flow has a direct and positive impact on contextual motivation. Such research has expanded understanding of what brings about self-determined motivation and how flow states occur (Kowal & Fortier, 2000). Much research has been conducted to identify and describe exceptional human functioning such as flow, yet next to nothing is known about its brain mechanisms. Like any other mental experience, a state of flow must be grounded in ordinary brain processes.

Brief exposition of brain function during flow

Flow is associated with creativity, and even accredited with eliciting the most heightened creativity. Therefore, one could assume that there would be an increase in the arousal of brain and neural circuitry during flow. However, equally, one could assume that due to increased challenges experienced in flow, such challenges would be serviced by skills that are already well practiced. One could imagine action potentials firing only when required.[9] Creativity is enabled by the cognitive capabilities provided primarily by the dorsolateral prefrontal cortex (DLPFC), which is involved in executive function. Dietrich (2004a) explains that it is imperative to recognize that flow and creativity recruit *different* brain circuits. Flow necessitates a state of transient (short of duration) hypo- (unusually low) frontality (anterior part of each cerebral hemisphere, in front of the central sulcus) that empowers the implicit system to execute a task at maximum skill level with maximum efficiency. Here information is computed in a nonalgorithmic, skill-based manner. This action enables the temporary suppression of the analytical and meta-conscious capacities of the explicit system. In order to appreciate Dietrich's hypothesis some explanations relating to cognitive science and neuroscience are necessary.[10] The same author (2004a) explains that modern brain research conceptualises cognitive function as hierarchically ordered:

> Evolutionary pressures forced the development of ever more integrative neural structures able to process increasingly complex information. This in turn led to increased behavioral flexibility and adaptability. The cerebral cortex, and in particular the prefrontal cortex, is at the top of the hierarchy, representing the neural basis of higher cognitive functions.

In addition to the development of the cerebral cortex, two neural systems developed, each designed to extract different types of information from the environment. One is emotional and seemingly designed "...to evaluate the biological significance of a given event. The other constructs representations that function as the basis for cognitive processing" (Dietrich, 2004a). Progressively more sophisticated computations are performed by increasingly higher-order structures. These two systems can be differentiated anatomically as well as in the way that they process information.

> Unlike the computational mode of cognitive system, the emotional system appears to compute information in a non-algorithmic, skill-based manner... Each system keeps a record of its activity so that emotional memory is part of the emotional circuitry and perceptual and conceptual memory is part of the cognitive circuitry (Dietrich, 2004).

Although these two systems have multiple connections between the two information processing systems, emotional and cognitive information seems only to fully reintegrate when both types of computations (emotional and conceptual) converge back on the dorsolateral prefrontal cortex (DLPFC). Dietrich emphasizes (2004a) that the DLPFC does not receive direct sensory input, is not involved in emotional computations, and does not store long-term memory.

I was fascinated by the notion that very sophisticated and complex activities, such as composing music, playing chess, or art making, can be executed 'intuitively', spontaneously, as 'second nature', in a state of flow, as it were. One would be drawn to conclude that the prefrontal cortex, the "most zenithal higher-order brain structure" (Dietrich, 2004a), must be engaged. In order to understand this phenomenon, the explicit and implicit systems need to be examined. In addition to the type of knowledge (emotional and cognitive), the brain also operates two distinct information processing systems to acquire, memorise and represent knowledge. Dietrich (2004a) explains:

> The explicit system is rule-based, its content can be expressed by verbal communication, and it is tied to conscious awareness. In contrast, the implicit system is skill or experience-based, its content is not verbalizable and can only be conveyed through task performance, and it is inaccessible to conscious awareness.

Thus, tasks that have fewer salient rules are more easily imprinted on the implicit system. Most scientific knowledge is not intuitive. For example the implicit system would not have acquired the learning that the earth rotates at fifteen degrees per hour, let alone why the sky is dark at night. Learning typically engages both systems simultaneously, even though information can be acquired exclusively by either system. Typical learning situations result in the formation of two distinct mental representations. However, the learned tasks would not be a complete characterisation of either system, as each sub-serves different functions. "The degree to which either system has a complete representation depends on the amount of practice and the nature of the task" (Dietrich, 2004a). Knowledge, thus, can be explicit and/or implicit. It is mostly represented in partially overlapping and in varying degrees of speciality required of each system. As I understand it the propensity for experiencing flow increases as explicit knowledge and skills in a field such as architecture or art become embedded, and therefore, more implicit.

A clearer picture emerges when integrating these two systems with brain architecture: The explicit system is dependent on prefrontal regions - especially the prefrontal cortex. Thus, the explicit system can be considered to be evolutionarily

> ...more recent and best developed in animals with a highly developed prefrontal cortex. This hypothesis is consistent with the view that information processing is hierarchically structured and that such a functional hierarchy localizes the most sophisticated mental abilities, and thus explicit knowledge representation, in the highest-order structure, the prefrontal cortex...The neural substrates of the implicit system are less clear (Dietrich, 2004a).

A critical issue for understanding the effortlessness characteristic of the flow experience, and its significance to highly skilled human performance, is a type of trade-off between the explicit and implicit systems. 'Internalising' or tapping into intuitive knowledge is in fact the result of building a representation in the implicit system, only through the circuitous route involving actual behaviour (often engaging motor skills). The explicit system is bypassed as it were - being denied the ability to 'micro manage' the skill through, for example, salient rules relating to the action being performed. If, however, due to the trade-off between the two systems, the implicit system transfers any amount of the skill to the explicit system control, the quality of the action will be affected. Actors or divers, for example, are often able to pin-point the exact moment when their performance was compromised due to the transfer from the implicit to the explicit system of control. This confirms on a neural level what has been known on a psychological level for some time: to do two things simultaneously, one has to be automatic or implicit - this is in effect a highly efficient use of skills. Thus, the flow experience must occur during a state of transient hypofrontality that can bring about the inhibition of the explicit system.

Crews (2004)[11] conducted a study on golfers to measure anxiety levels, and inadvertently contributed to the ongoing research on flow. Golfers were asked to rate their own anxiety levels; heart rate was monitored throughout; and electroencephalograms (EEG) were taken to measure brain activity throughout. The successful golfers (50% of participants) produced symmetrical left-right brain scans. Burzik (2004) attributes this to visualisations, by activating one's senses, by focusing on the smooth quality of the action. The other golfers produced scans predominantly active in the left brain, which indicated high cognitive activity - typically also true of sequential thinking, intellect, logic, sense of time, analysis, and focus on details, measurement, and quantity. The 'balanced' scan incorporates right hemisphere attributes such as association, images, intuition, synthesis, timelessness, holistic feelings, quality and aesthetic sense.

Further research was conducted by Anna Wise (in Burzik, 2004), a neurofeedback trainer and therapist, who developed a so-called Mind Mirror EEG which simultaneously measures the four frequency bands of beta, alpha, theta and delta brain waves. Fast frequencies such as beta are related to an aroused mind (very high beta combined with a highly aroused body is panic); alpha are related to physical and mental relaxation (otherwise put - alpha could be the bridge between the conscious and the unconscious); theta suggests drowsiness, early sleep stages, meditative states, memories; delta are associated with deep, dreamless sleep, deep meditation, suggested by Burzik (2004) to be the deep unconscious mind. Wise apparently found that during periods of peak mental awareness and creative inspiration, individuals exhibit a specific brain wave pattern in which the four waves - beta to delta - are combined in a distinct configuration, which she calls "the awakened mind". Burzik (2004) comments that in this configuration, you have it all - thought processes represented by beta - being connected through high alpha - with the creative unconscious of theta and delta. And here possibly lies the connection between creativity and flow, displaying perfect harmony, or trade-off, between the explicit and implicit systems of the brain.

Research of flow in the creative disciplines

Jackson & Marsh (1995) argue that a multi-method approach is needed to understand flow, incorporating both qualitative and quantitative research. Sawyer (2006: 83) suggests that the domain (such as fine art painting) determines the location of creativity in the brain, as do different subcomponents of ability in a single domain. In other words, the location of these subcomponents appears to differ in trained and untrained individuals. It follows that laboratory based research on creativity and flow is domain specific, and previous findings pertaining to research of flow in, for example, music, sport, may point the way, but will not substitute for research on flow in design or art making.

Latterly, the process of creativity (Bond, 2006; Dietrich, 2000, 2004b) is increasingly being coupled with theoretical and empirical work in cognitive science and neuroscience, as is the concept of flow (Burzik, 2004; Dietrich, 2004a; Jackson *et al*, 2001; Jackson *et al*, 2008: Kramer, 2007; Tenenbaum *et al*, 1999; Whitmore & Borrie, 2005; Christoff *et al*, 2008). Contemporary methodologies in cognitive neuro-science facilitate research about the psychophysiology of mental performance and psychometric measures are being used in combination with functional neuroimaging (fMRI) tools, optical imaging tools, transcranial magnetic stimulation, or electroencephalography (EEG) equipment. One must bear in mind that with creativity and flow, cognition as well as emotions are being studied. Various measuring instruments, based on Csikszentmihalyi's nine-dimension descriptor of flow, have been designed towards this end (Jackson & Marsh, 1995; Tenenbaum *et al*, 1999; Jackson *et al*, 2001; Mallett *et al*, 2007; Jackson *et al*, 2008). New methods of brain imaging have been developed "...either non-invasive or nearly non-invasive..." (Rose, 2003: 147), which offer a way of looking inside a person's head at an intact brain, whilst the subject is fully conscious and/or even engaged in some activities. Whereas fMRI would possibly indicate the exact location of flow, this method is currently not practicable. Currently, fMRI subjects may not exceed head motion of more than 3 millimeters for usable data, and this restriction will not accommodate typical physical movement during art making.[12]

As a precursor to my own experiments on flow, an individual's perceived disposition to experience flow will be ascertained through a questionnaire, thereafter, dispositional tendency to experience flow can be measured by the Dispositional Flow Scale (DFS), and the Flow State Scale (FSS). Thereafter, selected artists, active in the art making process, will be tested through EEG and heart-rate variability in order to establish physiological states during the art making process, and to record any changes in brain wave activity that could possibly point to the creative and/or flow brain states. In addition the artist will be recorded by video camera in order to corroborate art making activity with physiological changes and brain activity. Furthermore, interviews with independent observers of the recorded data will be conducted as further measures to corroborate data and to test assumptions.

Previous research on flow has lead to the development of a science of optimal performance with golfers, athletes, and swimmers. Whereas sport psychology may have lead the way, flow has also inspired educational and pedagogic methods for enhancing and making learning a joyful experience and has expanded the phenomenon of entrepreneurship and peak performance. Flow has been employed as grounded theory in research on self-concept, psychological skills and performance; has been employed in various aspects of health; has been used in art practices in the rehabilitation of cancer patients; and has complemented the modalities of meditation and mindfulness. Not only has flow been useful in a rehabilitative sense, but it has also been found to enhance information-seeking activities with Web and Internet users, and its usage has been instrumental in information technology applications and interactive experience associated with end-user technology and video game design. Lastly, it has been researched and employed to enhance language and writing skills, and has contributed significantly to teaching methods in music and performance. Far less research has been conducted in relation to architecture and art, yet the benefits to the disciplines, in the broadest sense, as well as to individuals, are obvious. Designers and artists need not wait to be defined by other disciplines. I contend that it is pertinent to contribute to the knowledge and applications of flow from art and design practitioners' perspectives - research on flow will contribute to the context of a growing science; alternatively, artists will learn more of their own, often instinctive, *modus operandi*, and be able to exercise control, and explore further applications thereof. I conclude with Arthur Koestler's words: "All decisive advances in the history of scientific thought can be described in terms of mental cross-fertilization between different disciplines"(in Sawyer, 2006: 64).

Notes

1. This first wave of creativity research in the discipline of personality psychology was pioneered by Taylor, Torrence, Stein, Terman, Getzels, Jackson, MacKinnon, Barron and Treffinger (Sawyer, 2006: 39-47, 54, 55).
2. With the exception of anthropologist Richard Klein, who argues that the discovery of the FOXP2 gene demonstrates that creativity may have evolved 200,000 years ago (Wade, 2003).

3. Generative processes produce ideas and include information retrieval, association, and combination (Sawyer, 2006:65).

4. Filtering processes select among the ideas.

5. Exploratory processes expand on the potential of each idea, by modifying and elaborating the idea, considering its implications, assessing its limitations, and may even transform the idea (Sawyer, 2006: 65).

6. Rogers developed a theory of self-actualization, similar to Maslow's. It emphasises an innate drive towards achieving one's potential. As he regarded the process as being ongoing, he preferred the term self-actualizing, rather than Maslow's self-actualization (Benson, 2004:112-113).

7. Contextual motivation is characterised by a general orientation toward a specific context or life domain (Kowal & Fortier, 2000).

8. Situational motivation is a state-specific measure that refers to motivation while currently engaged in a particular activity (e.g. a specific practice) and is considered relatively unstable (Kowal & Fortier, 2000).

9. Brains are metabolically demanding tissues, and neural signalling consumes much of this metabolic energy. Cortical energy budgets suggest that the rate at which cortical circuits consume energy increases with firing rate. Most of this energy is used to drive action potentials along axon collaterals and to generate postsynaptic potentials. Thus the high metabolic rate of cortical gray matter is a direct consequence of its ability to integrate information from many sources. Because these energy demands place a severe limitation on the rate at which a population of neurons can fire, the cortex uses energy-efficient circuits and codes (Laughlin, 2004:187).

10. Cognitive science is an interdisciplinary study drawing from various fields, which include psychology, philosophy, neuroscience, linguistics, anthropology, computer science and biology. Neuroscience refers to the nervous system and its functional or organic disorders, the brain, spinal cord, nerves (Britannica, 2008:73-74).

11. Crews first published this paper in 2001.

12. However, a variety of cognitive tasks may be performed whilst the fMRI is being conducted (such as viewing films, memorising or imagining). Specific cognitive tasks related to creative states, activity and state of flow may be designed in conjunction with the radiologist or fMRI practitioner. This will indicate and illustrate active brain sites and construct 3-dimensional images of *active brain sites,* however, this will not substitute for brain activity during the art making process.

Works cited

Bechtereva, N.P., Danko, S.G. and Medvedev, S.V. 2007. Current methodology and methods in psychophysiological studies of creative thinking. *Methods* 42 : 100-108.

Benson, N.C. 2004. *Introducing Psychology*. United Kingdom: Icon Books.

Bond, A.H. 2006. Brain mechanisms for interleaving routine and creative action. *Neurocomputing* 69 (10-12): 1348-1353.

Britannica guide to the brain. 2008. London: Constable & Robinson Ltd.

Burzik, A. 2004. On the neurophysiology of flow. *2nd Conference on Positive Psychology*, Verbania Pallanza, Italy, 5-8 July.

Christoff, K., Gordon,.A. & Smith, R**.** 2008. The role of spontaneous thought in human cognition. In Vartanian, O. & Mandel, R.(eds), *Neuroscience of decision making*, University of B.C: Psychology Press.

Crews, D.J. 2004. On the neurophysiology of flow. In Burzik, A. (ed), *2nd Conference on Positive Psychology*, Verbania Pallanza, Italy, 5-8 July.

Csikszentmihalyi, M. 1978. Attention and the wholistic approach to behavior. In Pope, K.S. & Singer, J.L. (eds), *The stream of consciousness*. New York: Plenum: 335-358.

Csikszentmihalyi, M. 1985. Reflections on enjoyment. *Perspectives in Biology and Medicine* 28 (4): 469-497.

Csikszentmihalyi, M. 1990. *Flow: The psychology of optimal experience.* New York: HarperCollins.

Csikszentmihalyi, M. 1997a. Finding flow. *Psychology Today,* July/August.

Csikszentmihalyi, M. 1997b. *Flow and the psychology of discovery and invention*. New York: HarperPerennial.

Csikszentmihalyi, M. 1999. If we are so rich, why aren't we happy? *American Psychologist*. October: 821 - 827.

Csikszentmihalyi, M. 2002. *Flow.* USA: Rider.

Csikszentmihalyi, M. 2004. *Good business.* USA: Penguin.

Deci, E.L. and & Ryan, M.R. 1985. The general causality orientations scale: self-determination in personality. *Journal of Research in Personality* 19 (2): 109-134.

Deci, E.L., Vallerand, R.J., Pelletier, L.G. and Ryan, R.M. 1991. Motivation and education: the self-determination perspective. *Educational Psychologist* 26 (3 & 4): 325-346.

Deci, E.L. and Ryan, R.M. 2000. The "what" and "why" of goal pursuits: human needs and the self-determination of behavior. *Psychological Inquiry* 11 (4): 227-268.

Dietrich, A. 2004a. *Neurocognitive mechanisms underlying the experience of flow.* Department of Behavioral and

Social Sciences, American University of Beirut, Lebanon.
Dietrich, A. 2004b. The cognitive neuroscience of creativity. *Psychonomic Bulletin and Review* 11 (6): 1011-1026.
Dietrich, A. 2007. Who's afraid of a cognitive neuroscience of creativity? *Neurocognitive Mechanisms of Creativity: a Toolkit* 42 (1): 22-27.
Guay, F.,Mageau, G.A., Vallerand, R.J. 2003. On the hierarchical structure of self-determined motivation: A test of top-down, bottom-up, reciprocal, and horizontal effects. *Personality and Social Psychology Bulletin* 29 (8): 992-1004.
Hoppe, K.D. and Neville, K.L. 1990. Dual brain, creativity, and health*. Creativity Research Journal* 3 (2): 150-157.
Jackson, S.A., & Marsh, H.W. 1995. Development and validation of a scale to measure optimal experience: The Flow State Scale. *Journal of Sport and Exercise Psychology* 18: 17-35.
Jackson, S.A., Thomas, P.R., Marsh, H.W. & Smethurst, C.J. 2001. Relationships between flow, self-concept, psychological skills, and performance. *Journal of Applied Sports Psychology* 13 (2): 129-153.
Jackson, S.A., Martin, A.J. & Eklund, R.C. 2008. Long and short measures of flow: The construct validity of the FSS-2, DFS-2, and New Brief Counterparts. *Journal of Sport and Exercise Psychology* 30: 561-587.
Kowal, J. and Fortier, M.S. 2000. Testing relationships from the hierarchical model of intrinsic and extrinsic motivation using flow as a motivational consequence. *Research Quarterly for Exercise and Sport* 71 (2): 171-181.
Kramer, D. 2007. Predictions of performance by EEG and skin conductance. *Cognitive Science and Philosophy*, Weinberg College of Arts and Science, Northwestern University.
Laughlin, S.B. 2004. The implications of metabolic energy requirements for the representation of information in neurons, in Gazzaniga, M.S. (ed*) The cognitive neurosciences III.* USA: MIT Press.
Maslow, A.H. 1959. Cognition of being in the peak experience. *Journal of Genetic Psychology* 94: 43-66.
Mölle, M., Marshall, L., Lutzenberger, W., Pietrowsky,R., Fehm, H.L. and Born, J. 1996. Enhanced dynamic complexity in the human EEG during creative thinking. *Neuroscience Letters* 208: 61-64.
Rogers, C.R. 1977. *On becoming a person*. Great Britain: RedwoodBurn Limited.
Rose, S. 2003. *The making of memory*. London: Vintage
Sawyer, R.K. 2006. *Explaining creativity*. New York: Oxford University Press.
Sperry, R.W. Hemispheric deconnection and unity in conscious awareness. *American Psychologist* 23 (10): 723-294.
Tenenbaum, G., Fogarty, G.J. and Jackson, S.A. 1999. The Flow Experience: A Rasch Analysis of Jackson's Flow State Scale.

Journal of Outcome Measurement 3 (3): 278-294.

Wade, N. 2003. Early voices: the leap to language. *The New York Times,* July 15.

Whitmore, J.G. & Borrie, W.T. 2005. Exploring the usefulness of the dispositional flow scale for outdoor recreation activities. *Proceedings of the 2005 Northeastern Recreation Research Symposium:* 371-378.