

Reference List

A Naturalistic Study of Insight

Author: Klein, Gary; Jarosz, Andrea

Journal of Cognitive Engineering and Decision Making 5 (4) 2011-12 p335

Although insight is often invoked as a phenomenon of problem solving and innovation, it has rarely been studied in a naturalistic fashion. The purpose of the study reported here was to learn more about insights as they occur in field settings as opposed to controlled laboratory conditions. The authors collected a set of 120 examples of insight taken from cognitive task analysis interviews, media accounts, and other sources and coded each incident using a set of 14 features. The results generated a descriptive model of insight that is different from the findings that emerge from research with puzzle problems. It posits multiple pathways for gaining insights. One pathway is triggered by detecting a contradiction. A second pathway is triggered by a need to break through an impasse. The third pathway gets triggered by seeing a connection.

"Aha!": The neural correlates of verbal insight solutions

Author: Iacoboni, Marco; Aziz-Zadeh, Lisa; ...

Human brain mapping 30 (3) 2009-03 p908

->What are the neural correlates of insight solutions? To explore this question we asked participants to perform an anagram task while in the fMRI scanner. Previous research indicates that anagrams are unique in that they can yield both insight and search solutions in expert subjects. Using a single-trial fMRI paradigm, we utilized the anagram methodology to explore the neural correlates of insight versus search solutions. We used both reaction time measures and subjective reports to classify each trial as a search or insight solution. Data indicate that verbal insight solutions activate a distributed neural network that includes bilateral activation in the insula, the right prefrontal cortex, and the anterior cingulate. These areas are discussed with their possible role in evaluation and metacognition of insight solutions, as well as attention and monitoring during insight.

Aha! Insight experience correlates with solution activation in the right hemisphere

Author: Jung-Beeman, Mark; Bowden, Edward M

Psychonomic bulletin & review 10 (3) 2003-09 p730

In one experiment, we tested for an association between semantic activation in the right hemisphere (RH) and left hemisphere (LH) and the Aha! experience when people recognize solutions to insight-like problems. The compound remote associate problems used in this experiment sometimes evoke an Aha! experience and sometimes do not. On each trial, participants (N = 44) attempted to solve these problems and, after 7 sec, named a target word, made a solution decision, and rated their insight experience of recognizing the solution. As in prior studies, the participants demonstrated more solution priming for solutions presented to the left visual field-RH (lvf-RH) than for solutions presented to the right visual field-LH (rvf-LH). As was predicted, following unsolved problems the participants showed greater priming for solutions that they rated as evoking an insight experience on the subsequent solution decision than for solutions that did not evoke an insight experience. This association was stronger for solutions presented to the lvf-RH than for those presented to the rvf-LH. These results tie the

subjective experience of insight to an objective measure—semantic priming—and suggest that people have an Aha! experience in part because they already had semantic activation that could lead them to recognize the solution quickly. We believe semantic activation in both hemispheres cooperatively contributes to problem solving, but weak solution activation that contributes to the Aha! experience is more likely to occur in the RH than in the LH.

Aha! Voila! Eureka! Bilingualism and insightful problem solving

Author: Cushen, Patrick J; Wiley, Jennifer

Learning and Individual Differences 21 (4) 2011 p458

What makes a person able to solve problems creatively? One interesting factor that may contribute is experience with multiple languages from an early age. Bilingual individuals who acquire two languages by the age of 6 have been shown to demonstrate superior performance on a number of thinking tasks that require flexibility. However, bilingual advantages have yet to be identified particularly on insight problems that are used as a model of creative problem solving following initial impasse. As such, the goal of the present study was to investigate the influence of language experience on problem solving performance on a matched set of insight and non-insight problems. Results demonstrate an interaction between type of problem (insight versus non-insight) and language status.

Climate for Creativity: A Quantitative Review

Author: Mumford, Michael D; Hunter, Samuel T; ...

Creativity Research Journal 19 (1) 2007-05 p69

Creativity is commonly held to emerge from an interaction of the person and the situation. In studies of creativity, situational influences are commonly assessed by using climate measures. In the present effort, a meta-analysis was conducted to examine 42 prior studies in which the relationships between climate dimensions, such as support and autonomy, and various indices of creative performance were assessed. These climate dimensions were found to be effective predictors of creative performance across criteria, samples, and settings. It was found, moreover, that these dimensions were especially effective predictors of creative performance in turbulent, high-pressure, competitive environments. The implications of these findings for understanding environmental influences on creativity and innovation are discussed.

Differentiating insight from non-insight problems

Author: Gilhooly, KJ; Murphy, P

Thinking & Reasoning 11 (3) 2005-08 p279

This study aimed to investigate whether a range of tasks that have been generally classed as requiring insight form an empirically separable group of tasks distinct from tasks generally classed as non-insight. In this study, 24 insight tasks, 10 non-insight tasks, and tests of individual differences in cognitive abilities and working memory were administered to 60 participants. Cluster analysis of the problem-solving tasks indicated that the presumed insight problems did tend to cluster with other presumed insight problems, and similarly the presumed non-insight problems tended to cluster with other presumed non-insight tasks. Performance on presumed insight problems was particularly linked to measures of ideational flexibility with a different pattern of results for the non-insight tasks. Spatial insight problems were linked to

spatial flexibility and verbal insight tasks were linked to vocabulary scores. The results are discussed in relation to recent developments of dual process theories of thinking.

Executive functions in insight versus non-insight problem solving: An individual differences approach

Author: Fioratou, E; Gilhooly, K. J

Thinking & Reasoning 15 (4) 2009-11 p355

This study investigated the roles of the executive functions of inhibition and switching, and of verbal and visuo-spatial working memory capacities, in insight and non-insight tasks. A total of 18 insight tasks, 10 non-insight tasks, and measures of individual differences in working memory capacities, switching, and inhibition were administered to 120 participants. Performance on insight problems was not linked with executive functions of inhibition or switching but was linked positively to measures of verbal and visuo-spatial working memory capacities. Non-insight task performance was positively linked to the executive function of switching (but not to inhibition) and to verbal and visuo-spatial working memory capacities. These patterns regarding executive functions were maintained when the insight and non-insight composites were split into verbal and spatial insight and non-insight composite scores. The results are discussed in relation to dual processing accounts of thinking.

Methods for investigating the neural components of insight

Author: Jung-Beeman, Mark; Bowden, Edward M

Methods (San Diego, Calif.) 42 (1) 2007-05 p87

The authors describe how they have used visual-hemifield and event-related neuroimaging approaches to study their theory specifying some of the neural components of insight. A set of problems developed by the authors, and the use of solvers' self reports of insight, are presented to argue that advances in our understanding of insight are being unnecessarily stifled by over reliance on traditional insight problems and a widespread failure to determine whether insight has occurred on a solution-by-solution basis.

Neural activity when people solve verbal problems with insight

Author: Haberman, Jason; Reber, Paul J; ...

PLoS biology 2 (4) 2004-04 pE97

People sometimes solve problems with a unique process called insight, accompanied by an "Aha!" experience. It has long been unclear whether different cognitive and neural processes lead to insight versus noninsight solutions, or if solutions differ only in subsequent subjective feeling. Recent behavioral studies indicate distinct patterns of performance and suggest differential hemispheric involvement for insight and noninsight solutions. Subjects solved verbal problems, and after each correct solution indicated whether they solved with or without insight. We observed two objective neural correlates of insight. Functional magnetic resonance imaging (fMRI) revealed increased activity in the right hemisphere anterior superior temporal gyrus for insight relative to noninsight solutions. The same region was active during initial solving efforts. Scalp electroencephalogram recordings (EEG) revealed a sudden burst of high-frequency (gamma-band) neural activity in the same area beginning 0.3 s prior to insight solutions. This right anterior temporal area is associated with making connections across distantly related information during

comprehension. Although all problem solving relies on a largely shared cortical network, the sudden flash of insight occurs when solvers engage distinct neural and cognitive processes that allow them to see connections that previously eluded them.

Neural correlates of mental preparation for successful insight problem solving

Author: Lv, J.Y; Wei, D.T; ...

Behavioural Brain Research 216 (2) 2011 p626

A distinct type of mental preparation (activity in medial frontal and temporal areas) had been found to facilitate insight problem solving independent of specific problems [25]. In order to explore whether neural activity during a preparatory interval (mental preparation) is associated with which insight problems would be solved or not, we developed a task that uses Chinese logogriphs (riddles) as materials. Blood oxygenation level-dependent fMRI contrasts between Successful and Unsuccessful mental preparation were measured. Results showed that mental preparation leading to successful problem solving involves heightened activity in the left middle/medial frontal gyrus, the left middle/superior temporal gyrus, the right cerebellum, the bilateral claustrum and the left postcentral gyrus. We discussed the role of these areas in mental preparation for successful insight problem solving.

Neural correlates of the “Aha” experiences: Evidence from an fMRI study of insight problem solving

Author: Zhang, Qinglin; Jou, Jerwen; Cortex 46 (3) 2010 p397

In the present study, we used learning–testing paradigm to examine brain activation of “Aha” effects with event-related functional magnetic resonance imaging (fMRI) during solving Chinese logogriphs. Blood oxygenation level-dependent fMRI contrasts between Aha and No-aha conditions were measured. Increased activities in the precuneus (BA 19/7), the left inferior/middle frontal gyrus (BA 9/6), the inferior occipital gyrus (BA 18), and the cerebellum were specifically associated with the “Aha” effects. The results indicate that (1) the precuneus might be involved in successful prototype events retrieval, (2) the left inferior frontal/middle frontal gyrus might be involved in forming novel association and breaking mental sets, (3) the inferior occipital gyrus and the cerebellum might be involved in re-arrangement of visual stimulus and deployment of attentional resources.

Studying insight problem solving with neuroscientific methods

Author: Luo, Jing; Knoblich, Guenther

Methods 42 (1) 2007 p77

Insights are sporadic, unpredictable, short-lived moments of exceptional thinking where unwarranted assumptions need to be discarded before solutions to problems can be obtained. Insight requires a restructuring of the problem situation that is relatively rare and hard to elicit in the laboratory. One way of dealing with this problem is to catalyze such restructuring processes using solution hints. This allows one to obtain multiple insight events and their accurate onset times, which are required for event-related designs in functional magnetic resonance imaging (fMRI) and Electroencephalogram (EEG), and to reliably record the activity associated with the restructuring component of insight. In this article, we discuss in detail the methodological

challenges that brain research on insight poses and describe how we dealt with these challenges in our recent studies on insight problem solving.

The Aha! Moment: The Cognitive Neuroscience of Insight

Author: John Kounios; Mark Beeman

Current Directions in Psychological Science 18 (4)2009-08-01 p210

A sudden comprehension that solves a problem, reinterprets a situation, explains a joke, or resolves an ambiguous percept is called an insight (i.e., the “Aha! moment”). Psychologists have studied insight using behavioral methods for nearly a century. Recently, the tools of cognitive neuroscience have been applied to this phenomenon. A series of studies have used electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) to study the neural correlates of the “Aha! moment” and its antecedents. Although the experience of insight is sudden and can seem disconnected from the immediately preceding thought, these studies show that insight is the culmination of a series of brain states and processes operating at different time scales. Elucidation of these precursors suggests interventional opportunities for the facilitation of insight.

The neural basis of insight problem solving: An event-related potential study

Author: Zhang, Qinglin; Luo, Yuejia; Brain and Cognition 68 (1) 2008 p100

The electrophysiological correlates of successful insight problem solving (Chinese logogriphs) were studied in 18 healthy subjects using high-density event-related potentials (ERPs). A new experimental paradigm (learning-testing model) was adopted in order to make subjects find a solution on their own initiative rather than receive an answer passively. Results showed that Successful guessed logogriphs elicited a more positive ERP deflection (P200–600) than did Unsuccessful guessed logogriphs in the time window from 200 to 600 ms after onset of the stimuli. Subsequently Successful logogriphs elicited a more negative ERP deflection than did Unsuccessful logogriphs in the time windows of 1500–2000 ms (N1500–2000) and 2000–2500 ms (N2000–2500). Maps of the P200–600 showed strong activity in the midline parieto-occipital scalp regions. Dipole analysis localized the generator of P200–600 in the left superior temporal gyrus and parietotemporo-occipital cortex areas. The N1500–2000 and N2000–2500 had a distinct activation over left frontal scalp regions. Dipole analysis localized the generator of the N1500–2000 in the anterior cingulate cortex (ACC) and the N2000–2500 in the posterior cingulate cortex (PCC). This result indicates that the parietotemporo-occipital cortex areas might be involved in forming rich associations in the early stage of successful logogriph solving. Then, the ACC might play an important role in the breaking mental set and the forming of novel associations. At last, “Aha” feeling might activate the PCC.

The AHA! experience: creativity through emergent binding in neural networks

Author: Stewart, Terrence C; Thagard, Paul

Cognitive science 35 (1) 2011-01 p1

Many kinds of creativity result from combination of mental representations. This paper provides a computational account of how creative thinking can arise from combining neural patterns into ones that are potentially novel and useful. We defend the hypothesis that such combinations arise from mechanisms that bind together neural activity by a process of convolution, a

mathematical operation that interweaves structures. We describe computer simulations that show the feasibility of using convolution to produce emergent patterns of neural activity that can support cognitive and emotional processes underlying human creativity.

Time of day effects on problem-solving: When the non-optimal is optimal

Wieth, Mareike B and Zacks, Rose T

Thinking & Reasoning, 11/2011, Volume 17, Issue 4, pp. 387 - 401

In a study examining the effects of time of day on problem solving, participants solved insight and analytic problems at their optimal or non-optimal time of day. Given the presumed differences in the cognitive processes involved in solving these two types of problems, it was expected that the reduced inhibitory control associated with non-optimal times of the day would differentially impact performance on the two types of problems. In accordance with this expectation, results showed consistently greater insight problem solving performance during non-optimal times of day compared to optimal times of day but no consistent time of day effects on analytic problem solving. The findings indicate that tasks involving creativity might benefit from a non-optimal time of day.

Intuition, Insight, Imagination and Creativity

Author: Duch, W

IEEE Computational Intelligence Magazine 2 (3) 2007p40

Can computers have intuition and insights, and be creative? Neurocognitive models inspired by the putative processes in the brain show that these mysterious features are a consequence of information processing in complex networks.

Intuition is manifested in categorization based on evaluation of similarity, when decision borders are too complex to be reduced to logical rules. It is also manifested in heuristic reasoning based on partial observations, where network activity selects only those paths that may lead to solution, excluding all bad moves. Insight results from reasoning at the higher, non-verbal level of abstraction that comes from involvement of the right hemisphere networks forming large "linguistic receptive fields." Three factors are essential for creativity in invention of novel words: knowledge of word morphology captured in network connections, imagination constrained by this knowledge, and filtering of results that selects the most interesting novel words.

These principles have been implemented using a simple correlation-based algorithm for auto-associative memory. Results are surprisingly similar to those created by humans.

Incubation, insight, and creative problem solving: a unified theory and a connectionist model

Author: Hélie, Sébastien; Sun, Ron

Psychological review 117 (3) 2010-07 p994

This article proposes a unified framework for understanding creative problem solving, namely, the explicit-implicit interaction theory. This new theory of creative problem solving constitutes an attempt at providing a more unified explanation of relevant phenomena (in part by reinterpreting/integrating various fragmentary existing theories of incubation and insight). The explicit-implicit interaction theory relies mainly on 5 basic principles, namely, (a) the coexistence of and the difference between explicit and implicit knowledge, (b) the simultaneous

involvement of implicit and explicit processes in most tasks, (c) the redundant representation of explicit and implicit knowledge, (d) the integration of the results of explicit and implicit processing, and (e) the iterative (and possibly bidirectional) processing. A computational implementation of the theory is developed based on the CLARION cognitive architecture and applied to the simulation of relevant human data. This work represents an initial step in the development of process-based theories of creativity encompassing incubation, insight, and various other related phenomena.

Sleep inspires insight

Ullrich Wagner, Steffen Gais, Hilde Haider, Rolf Verleger & Jan Born

Nature 427, 352-355 (22 January 2004)

Insight denotes a mental restructuring that leads to a sudden gain of explicit knowledge allowing qualitatively changed behaviour. Anecdotal reports on scientific discovery suggest that pivotal insights can be gained through sleep. Sleep consolidates recent memories and, concomitantly, could allow insight by changing their representational structure. Here we show a facilitating role of sleep in a process of insight. Subjects performed a cognitive task requiring the learning of stimulus–response sequences, in which they improved gradually by increasing response speed across task blocks. However, they could also improve abruptly after gaining insight into a hidden abstract rule underlying all sequences. Initial training establishing a task representation was followed by 8 h of nocturnal sleep, nocturnal wakefulness, or daytime wakefulness. At subsequent retesting, more than twice as many subjects gained insight into the hidden rule after sleep as after wakefulness, regardless of time of day. Sleep did not enhance insight in the absence of initial training. A characteristic antecedent of sleep-related insight was revealed in a slowing of reaction times across sleep. We conclude that sleep, by restructuring new memory representations, facilitates extraction of explicit knowledge and insightful behaviour.

Working Memory capacity, attentional focus, problem solving

Wiley, Jennifer, & Jarosz, Andrew F.

Current Directions in Psychological Science August 2012 21: 258-262,

Attentional focus is important for many cognitive processes, including problem solving. In this article, we discuss working memory capacity (WMC), a construct related to the ability to focus attention, and its differential effects on analytic and creative problem solving. One of the main ways in which WMC benefits analytic problem solving seems to be that it helps problem solvers to control their attention, resist distraction, and narrow their search through a problem space. Conversely, several lines of recent evidence have shown that too much focus can actually harm performance on creative problem-solving tasks.

Revenge of the 'neurds': Characterizing creative thought in terms of the structure and dynamics of human memory.

Gabora, L. (2007). *Creativity Research Journal*.

Empirical results suggest that defocusing attention results in primary process or *associative thought*, conducive to finding unusual connections, while focusing attention results in secondary process or *analytic thought*, conducive to rule-based operations. Creativity appears to involve both. It is widely believed that it is possible to escape mental fixation by spontaneously and

temporarily engaging in a more divergent or associative mode of thought. The resulting insight (if found) may be refined in a more analytic mode of thought. The question addressed here is: how does the architecture of memory support these two modes of thought, and what is happening at the neural level when one shifts between them? Recent advances in neuroscience shed light on this. It was demonstrated that activated cell assemblies are composed of multiple 'neural cliques', groups of neurons that respond differentially to general or context-specific aspects of a situation. I refer to neural cliques that *would not* be included in the assembly if one were in an analytic mode, but *would* be if one were in an associative mode, as 'neurds'. It is posited that the shift to a more associative mode of thought conducive to insight is accomplished by recruiting neurds that respond to abstract or atypical subsymbolic microfeatures of the problem or situation. Since memory is distributed and content-addressable this fosters reminders and the forging of creative connections to potentially relevant items previously encoded in those neurons. Thus it is proposed that creative thought involves neither randomness, nor search through a space of predefined alternatives, but emerges naturally through the recruitment of neurds. It is suggested this occurs when there is a need to resolve conceptual gaps in ones' internal model of the world, and resolution involves context-driven actualization of the potentiality afforded by its fine-grained associative structure.

The Philosophy of Creativity - Berys Gaut

Philosophy Compass 5/12 (2010): 1034–1046

This paper surveys some of the central issues in the philosophy of creativity and argues that an adequate treatment of them requires attention to the rich psychological literature on creativity. It also shows that the range of interesting philosophical questions to be raised about creativity is much wider than concerns its role in art. Issues covered include the definition of 'creativity'; the relation of creativity to imagination; whether the creative process is rational; whether it is teleological; the relation of creativity to knowledge; whether creativity can be explained; computational and Darwinian theories of creativity; whether creativity is a virtue; the relation of creativity to tradition; the aesthetic value of creativity; and whether creative activity is different in science and art.

How crosstalk creates vision-related eureka moments

George Terzis, *Philosophical Psychology* 14 (4):393 – 421 (2001)

The discussion begins with a familiar and defensible characterization of the eureka moment, according to which it is the unexpected product of separate and often seemingly incompatible perspectives. The principal aim of the discussion is to explain how, so characterized, vision-related eureka moments can occur. To fulfill this aim, the discussion employs a notion of crosstalk, in which cognitive interference slightly increases as a result of the creative thinker's considerable, albeit only partly successful, pre-eureka cognitive effort. Such crosstalk, it is suggested, is likely to occur when top-down visual imaging repeatedly stimulates pyramidal cells closely apposed to others that, although simultaneously active, are part of bottom-up visual perception that is initially cognitively unrelated to such imaging. It is further suggested that local circuitry, in the form of inhibitory interneurons, can synchronize cells associated with these initially separate processes, thus causing subsequent perceptual patterns to be subtly modified by pre-eureka problem-solving imagery. This modification, it is claimed, may help explain the

unexpected shift in visual perception that accompanies the creative thinker's eureka moment, a shift that can improve the thinker's subsequent understanding of the relevance of information to a problem's solution.

Incubated cognition and creativity

Dustin Stokes, *Journal of Consciousness Studies* 14 (3):83-100 (2007)

Many traditional theories of creativity put heavy emphasis on an incubation stage in creative cognitive processes. The basic phenomenon is a familiar one: we are working on a task or problem, we leave it aside for some period of time, and when we return attention to the task we have some new insight that services completion of the task. This feature, combined with other ostensibly mysterious features of creativity, has discouraged naturalists from theorizing creativity. This avoidance is misguided: we can maintain unconscious incubated cognition as (sometimes) part of the creative process and we can explain it in scientifically responsible ways. This paper, focusing on the effects of attention on the functional networking of the brain, attempts just such an explanation. It also serves to assuage the naturalist's scepticism about other features of creative cognition. The broad upshot, one would hope, is that philosophers of mind and cognitive scientists return some attention to the long neglected topic of creativity.

Creativity : method or magic?

Stevan Harnad

In Henri Cohen & Brigitte Stemmer (eds.), *Consciousness and Cognition: Fragments of Mind and Brain*. Elsevier Academic Press (2007)

Creativity may be a trait, a state or just a process defined by its products. It can be contrasted with certain cognitive activities that are not ordinarily creative, such as problem solving, deduction, induction, learning, imitation, trial and error, heuristics and "abduction," however, all of these can be done creatively too. There are four kinds of theories, attributing creativity respectively to (1) method, (2) "memory" (innate structure), (3) magic or (4) mutation. These theories variously emphasize the role of an unconscious mind, innate constraints, analogy, aesthetics, anomalies, formal constraints, serendipity, mental analogs, heuristic strategies, improvisatory performance and cumulative collaboration. There is some virtue in each, but the best model is still the one implicit in Pasteur's dictum: "Chance favors the prepared mind." And because the exercise and even the definition of creativity requires constraints, it is unlikely that "creativity training" or an emphasis on freedom in education can play a productive role in this preparation.

Creativity and the neural basis of qualia

Ken Mogi

Proceedings of Mind II conference, Dublin, Ireland, September 1997

In what computational aspect is the brain different from the computer? In what objective measures can the brain said to be "creative"? These are the fundamental questions that concerns the neural basis of human mental activity. Here we discuss several important aspects of the essential computational ingredients of human mind in order to understand the "creative" process going on in the brain. One of the key concepts is the nature of the source of "externality" that adds new ingredients to the system and its output. We argue that in addition to

information input and stochasticity, we need to consider a third possibility, namely "dynamics-embedded externality". We discuss how the neural origin of the subjective sensory qualities (qualia) is related to this aspect of creativity. The invariance of qualia under a certain class of transformation, and the mapping of discrete,

Minimally Creative Thought

Dustin Stokes

Metaphilosophy 42 (5):658-681 (2011)

Creativity has received, and continues to receive, comparatively little analysis in philosophy and the brain and behavioural sciences. This is in spite of the importance of creative thought and action, and the many and varied resources of theories of mind. Here an alternative approach to analyzing creativity is suggested: start from the bottom up with minimally creative thought. Minimally creative thought depends non-accidentally upon agency, is novel relative to the acting agent, and could not have been tokened before the time it is in fact tokened, relative to the agent in question. Thoughts that meet these three conditions—agency, psychological novelty, and modal—are what may be called cognitive breakthroughs. Even if such breakthroughs are not necessary to or definitive of richer creativity, they are indeed central to much of creativity. The minimal analysis provides a more workable explanandum for theories of creativity of varied motivation and method

Its Own Reward: A Phenomenological Study of Artistic Creativity

Barnaby Nelson & David Rawlings

Journal of Phenomenological Psychology 38 (2007) 217–255

Abstract The phenomenology of the creative process has been a neglected area of creativity research. The current study investigated the phenomenology of artistic creativity through semi-structured interviews with 11 artists. The findings consisted of 19 interlinked constituents, with 3 dynamics operating within these constituents: an intuition-analysis dynamic, a union-division dynamic, and a freedom-constraint dynamic. The findings are discussed in relation to the issues of creativity and spirituality, intuition and analysis, the creative synthesis, affective components, and flow. The findings display considerable overlap with previous research into the phenomenology of the artistic creative process, yet place particular emphasis on the shift in sense of self associated with creative experience and the energising effect of a synthesis of disparate elements.

Can clouds dance? Neural correlates of passive conceptual expansion using a metaphor processing task: Implications for creative cognition

Author: Barbara Rutter et al.

Brain & Cognition, 2012 Mar;78(2):114-22

Abstract

Creativity has emerged in the focus of neurocognitive research in the past decade. However, a heterogeneous pattern of brain areas has been implicated as underpinning the neural correlates of creativity. One explanation for these divergent findings lies in the fact that creativity is not usually investigated in terms of its many underlying cognitive processes. The present fMRI study focuses on the neural correlates of conceptual expansion, a central component of all creative processes. The study aims to avoid pitfalls of previous fMRI studies on creativity by employing a novel paradigm. Participants were presented with phrases and made judgments

regarding both the unusualness and the appropriateness of the stimuli, corresponding to the two defining criteria of creativity. According to their respective evaluation, three subject-determined experimental conditions were obtained. Phrases judged as both unusual and appropriate were classified as indicating conceptual expansion in participants. The findings reveal the involvement of frontal and temporal regions when engaging in passive conceptual expansion as opposed to the information processing of mere unusualness (novelty) or appropriateness (relevance). Taking this new experimental approach to uncover specific processes involved in creative cognition revealed that frontal and temporal regions known to be involved in semantic cognition and relational reasoning play a role in passive conceptual expansion. Adopting a different vantage point on the investigation of creativity would allow for critical advances in future research on this topic.

Neural Networks Involved in Artistic Creativity

Author: Yasuyuki Kowatari et al.

Human Brain Mapping, Volume 30, Issue 5, pages 1678–1690, May 2009

Creativity has been proposed to be either the result of solely right hemisphere processes or of interhemispheric interactions. Little information is available, however, concerning the neuronal foundations of creativity. In this study, we introduced a new artistic task, designing a new tool (a pen), which let us quantitatively evaluate creativity by three indices of originality. These scores were analyzed in combination with brain activities measured by functional magnetic resonance imaging (fMRI). The results were compared between subjects who had been formally trained in design (experts) and novice subjects. In the experts, creativity was quantitatively correlated with the degree of dominance of the right prefrontal cortex over that of the left, but not with that of the right or left prefrontal cortex alone. In contrast, in novice subjects, only a negative correlation with creativity was observed in the bilateral inferior parietal cortex. We introduced structure equation modeling to analyze the interactions among these four brain areas and originality indices. The results predicted that training exerts a direct effect on the left parietal cortex. Additionally, as a result of the indirect effects, the activity of the right prefrontal cortex was facilitated, and the left prefrontal and right parietal cortices were suppressed. Our results supported the hypothesis that training increases creativity via reorganized intercortical interactions.

Creativity and the brain: Uncovering the neural signature of conceptual expansion

Author: Anna Abraham et al.

Neuropsychologia. 2012 Jul;50(8):1906-17.

Neurophysiological studies of creativity thus far have not allowed for clear conclusions to be made regarding the specific neural underpinnings of such complex cognition due to overgeneralizations concerning the creativity construct, heterogeneity in the type of creativity tasks used, and the questionable efficacy of the employed comparison tasks. A novel experimental design was developed in the present fMRI study which rendered it possible to investigate a critical facet of creative cognition – that of conceptual expansion – as distinct from general divergent thinking, working memory, or cognitive load. Brain regions involved in the retention, retrieval and integration of conceptual knowledge such as the anterior inferior frontal gyrus, the temporal poles and the lateral frontopolar cortex were found to be selectively involved during conceptual expansion. The findings go against generic ideas that argue for the dominance of the right hemisphere during creative thinking and indicate the necessity to reconsider the functions of regions such as the anterior cingulate cortex to include more abstract facets of cognitive control. This study represents a new direction in the investigation of

creativity in that it highlights the necessity to adopt a process based perspective in which the multifaceted nature of creativity can be truly grasped.

Creative-Action Theory of Creativity

Author: Peter Carruthers

In *The Innate Mind*, Volume 3: Foundations and the Future

Most models of creative thought and creative activity assume that thought is normally the precursor of action: we think first, then we act. This chapter argues that creative action can't be reduced to creative thought, and that at least *some* forms of creative action aren't preceded by a creative thought. It then briefly argues that it is implausible that there should be two distinct and independent sources of creativity — one for action and one for thought. It shows how creative thought can be explained in terms of creative action, utilizing known mechanisms including a well-established system for the mental rehearsal of action, and a cognitive architecture for global broadcasting of sensory or quasi-sensory (imagistic) states. It is argued that act-first accounts of creativity have evolutionary precursors, some of them quite ancient. It is shown that thought-first accounts of creativity, in contrast, face problems of evolvability, and that they need to assume a heavy explanatory burden in comparison with the act-first account. Some of the costs and benefits of accepting an act-first account of creativity are outlined.

Creative Action in Mind

Author: Peter Carruthers

Philosophical Psychology, Volume 24, Issue 4, p. 437

The goal of this article is to display the attractiveness of a novel account of the place of creativity in the human mind. This is designed to supplement (and perhaps replace) the widespread assumption that creativity is thought-based, involving novel combinations of concepts to form creative thoughts, with the creativity of action being parasitic upon prior creative thinking. According to the proposed account, an additional (or perhaps alternative) locus of creativity lies in the assembly and activation of action-schemata, with creative thoughts arising subsequently from the mental rehearsal of those actions, normally resulting in either visual imagery or inner speech.

Creative People Use Nonconscious Processes to Their Advantage

Jason Gallate, Cara Wong, Sophie Ellwood, R.W. Roring, Allan Snyder

Creativity Research Journal, Volume 24, Issue 2-3, pp. 146 - 151

Although contentious, there is evidence to suggest that nonconscious processes contribute to creative output, particularly during refractory periods. However, no one has examined whether this break benefit differs as a function of creative ability. To address these issues, this investigation examined Wallas's (1926) seminal theoretical framework of creativity. More specifically, the most controversial stage postulated by Wallas, the incubation phase, was empirically tested. A regression analysis demonstrated that productivity is significantly increased when creative people activate nonconscious processes in off-task or incubation periods. There is ongoing debate about the cause(s) of this incubation effect. This research provides evidence that the incubation effect results, at least partially, from nonconscious processing and that it provides greater benefit to more creative individuals. This suggests that highly creative people should be exposed to focus problems/challenges well in advance of objective deadlines, and have freedom to generate solutions outside of structured evaluation times.