

Step One: Making Sense of Insight

Paula Wellings—paper for LSTD Seminar

December 9, 2004

objective of this paper

The purpose of this paper is to provide foundational knowledge from which to explore the research question: How do groups and individuals approach and solve insight problems? Are there differences | similarities? As a first step in this exploration, this paper will primarily investigate the process of individual insight through an exploration of selected definitions, approaches, and methods of investigation used in considering the process of individual insight.

general definition

Nuances in the definition of insight will be revealed below, but to begin insight can be defined as the sudden understanding of a complex situation or the sudden realization of the solution to a problem. Associated with the suddenness of insight is the feeling of “aha!” of surprise, wonderment or pleasure. Often people experiencing insight cannot account for the transition from not knowing to knowing. The combination of suddenness, of positive affect, and the mystery of the transition to insight make it a phenomenon rich for psychological study. In addition, insight is believed to play a formative role in the evolution of human culture, with insight being attributed to the many of the greatest scientific breakthroughs.

introduction to approaches

Throughout the history of the psychological study of insight, a number of approaches have been proposed to define and account for the characteristics of the “aha” moment. Gestalt psychologists working in the earlier part of the twentieth century characterized insight as a sudden shift in the problems’ gestalt or a spontaneous restructuring of the problem’s mental representation that lead to a new understanding. Other psychologist in the 1980s, including Robert Weisberg disputed this notion of spontaneous restructuring and argued against any such distinct phenomena as insight. They instead suggested that insight problems were solved via “business as usual”, an incremental accumulation of knowledge relevant to the solution. In response to Weisberg’s arguments, Janet Metcalfe conducted a number of experiments that lead to a clarification

between the solving of memory tasks, non-insight problems and insight problems. In these studies, subjects, while solving different types of problems, reported by a warmth rating every 10 seconds of how close they were to a solution. Metcalfe found that warmth ratings were gradual for non-insight problems, while for insight problems the warmth rating increased only seconds prior to solving the problem. In fact, if a subject reported a gradually increasing warmth rating for an insight problem, it was most likely a sign that the subject would fail to solve the problem. This research proved to be influential in further studies of insight, and Metcalfe's work is cited by many of the representative authors of the approaches I will be discussing.

The approaches included in this paper have been selected for their diversity in perspective as well as their potential relevance to developing an understanding of group insight. These approaches to studying insight include:

- the study of great thinkers and their processes of insight
- a cognitive information processing perspective with a focus on memory
- the understanding of the development of tacit knowledge as an account for insight
- a creative cognition invention-based perspective
- an investigation of insight in neuroscience through the observation of brain activity
- a situated cognition perspective derived from eye movement tracking data and insight problem solving

great thinkers

Mihaly Csikszentmihalyi is a leading researcher in the study of creativity. Basing his work on detailed interviews with people recognized as making highly creative contributions to the natural sciences, social sciences, arts, humanities, business and politics, Csikszentmihalyi has developed a comprehensive perspective on the process of insight. He describes insight as a four stage process that begins with preparation—immersion into the area where insight is required and related hard work and research to understand the knowledge and practices of the domain. Preparation is followed by incubation, a period of idle time that may be spent alone. During incubation, simultaneous cognitive functioning takes place between conscious attention and subconscious parallel processing with semiconscious filters mediating between the conscious and

unconscious thought. The incubation period is followed by the moment of insight, where a subconscious combination or pattern emerges into consciousness. In contrast to views presented in other approaches, Csikszentmihalyi reports that “although in the popular conception, insight results from a specific stimulus ...we have not found descriptions of this sort in our interviews. The insights are always described as welling up from the subconscious, but there is never mention of a specific external stimulus.” (p. 343) Following the moment of insight, a period of evaluation and elaboration takes place where ideas revealed through insight are brought to fruition.

Extending this basic framework, Csikszentmihalyi makes a distinction between two different types of insight. In utilizing Thomas Kuhn’s characterization of normal science to account for normal short-term insight and revolutionary science to account for long-term paradigmatic shifts of insight, insight can be seen as both problem solving and problem finding. Everyday insight is revealed in response to presented problems where the conditions of the problem are easily comprehended and insight yields a solution to the problem. In contrast, discovered problem insight occurs when the nature of the problem to be solved is less clear and the insight yields a new problem to be solved. In the case of discovered problems, the insight process may take years and outcomes generally represent breakthroughs and paradigmatic shifts in a domain.

cognitive information processing

“Chance favors the prepared mind,” cites Colleen Seifert et al., referring to a quote by Louis Pasteur, the famous French microbiologist and chemist. On the matter of preparation, it might appear that Csikszentmihalyi and Seifert et al. share aspects of their understandings of insight. But while Csikszentmihalyi sees preparation as a process that “sets questioning in motion”(pg. 340), Seifert sees preparation as highly related to the notion of chance.

Seifert proposes a model of insight called the Opportunistic-Assimilation Hypothesis. In this model, subjects work on a problem until they reach an impasse and cannot solve it. Failure to solve the problem results in the encoding of failure indices into long-term memory that explicitly mark that an impasse has occurred. In addition, predictive encoding takes place such that

potential characteristics of the solution are also encoded. By the subject working to the point of impasse, it can be assumed that the original information associated with the problem has been assimilated. Seifert then explicitly states that no further conscious or subconscious work is done on the problem. Insight is subsequently triggered when chance events in the world eventually lead to a fortuitous encounter with an external object or event that is related to the original problem. Recall of the initial problem is triggered and the solution can be applied.

The Opportunistic-Assimilation Hypothesis suggests that external stimuli are crucial to insight. The foundation of this hypothesis is VanLehn's notion of impasse-driven learning, that significant learning most likely occurs in situations where learners reach an impasse and then receive new information about how to overcome the impasse. Seifert et al. combine this account of learning with experiments that contrast subject's memory for problem situations where they reached an impasse and situations where they did not reach an impasse. The finding that subjects better recall situations where they have reached an impasse suggests that they are prepared to engage in opportunistic assimilation.

guided attention & situated cognition

Elizabeth Grant and Michael Spivey frame the idea that things in the world trigger insight from a somewhat different perspective. Working with Duncker's Radiation problem, a well-known and notoriously difficult insight problem, Grant and Spivey first measured the eye movements of subjects looking at a diagram associated with this problem. The eye tracking data revealed that successful problem solvers engaged in different eye movement patterns than solvers who were unsuccessful. Grant and Spivey then went on to present the diagram to a new set of subjects, subtly highlighting on a computer screen the area of the diagram where successful problem solvers tended to look. The new subjects increased in their ability to solve the problem, leading Grant and Spivey to conclude that "sometimes cognitive processing is the result of attention and eye movements", contrary to the common perception that attention and eye movements are the results of cognitive processing. These findings, in part, mirror the findings of an early insight study on the "two-string problem" conducted by Maier in 1931 in which a subtle visual hint was provided half way through the study by a researcher casually brushing against a string causing it

to swing subtly. This small movement provided the hint necessary for many subjects to solve the problem.

While the previous two approaches have focused specifically on the influence of the external environment, the next two approaches consider insight as a spontaneous event that does not rely specifically on external stimuli.

neuroscience & brain activity

In a recent series of studies, Mark Jung-Beeman et al. provided study subjects with sets of three words, such as face, table, and game. The subjects were challenged to come up with a single word that can form a compound word with each of the three words. In this case, face is the solution, as in face card, card table, and card game. The verbal problems used in this study can be solved either by brute force of trying every word that comes to mind or they can be solved by insight, where the solution suddenly appears to the subject, with a sense of “aha!” These particular studies were interested in the times that subjects solved these problems with insight. Utilizing fMRI and scalp electroencephalogram recordings Beeman et. al. were able to see, quite literally, that a “sudden flash of insight occurs when solvers engage distinct neural and cognitive processes that allow them to see connections that previously eluded them.” Similar to Metcalfe’s finding of spontaneous solutions to insight problems, Beeman et al. reveal insight solutions to flood the right hemisphere temporal lobe with a sudden burst of high-frequency activity in a manner distinct from problems solved in a gradual step-wise manner. In addition, a second unexpected EEG effect was observed.

“About 1.5 seconds prior to insight solutions, an increase in lower frequency (alpha band) activity appeared over the right posterior cortex. This effect disappeared precisely when the high-frequency activity began over the right temporal lobe. This may reflect “gating,” or attenuation, of visual input, allowing initially weak solution-related activity to gain strength, then burst into consciousness as an insight. This is like closing your eyes so you can concentrate when you are trying to solve a difficult problem but in this case, your brain is blocking out just the visual inputs to your right hemisphere.”

Beeman et al. account for their findings by describing the insight process in the following manner. First, people come to an impasse on insight problems because their retrieval efforts are

misdirected by ambiguous information in the problem or by their usual method for solving similar problems. This problem solving activity takes place largely in the left hemisphere. However, the coarse encoding of large semantic fields in the right hemisphere allows for more overlap among distantly related concepts and processing in this hemisphere may help overcome the impasse. Due to the fact that this coarse semantic processing is weak, it may remain unconscious, perhaps overshadowed by stronger processing of the misdirected information and the solver remains stuck as an impasse. Eventually, solution-related information bursts into awareness "in a sudden flash". The emergence of the insight can occur after misdirected processing decays or is suppressed, after solution-related processing grows, or after environmental cues occur.

In this description, environmental cues are not ruled out, but rather are presented as one of a number of potential events that activate insight. Beeman et al.'s description of insight shares a number of characteristics of insight described above by Metcalfe and Csikszentmihalyi. Specifically, these findings affirm Metcalfe's description of the suddenness of insight and Csikszentmihalyi's description of parallel processing.

tacit knowledge

Published some forty years before the most recent advances in neuroscience, Michael Polanyi's "The Tacit Dimension" foreshadows Beeman et al.'s recent discoveries with regards to the distilling of connections from pre-existing knowledge. Polanyi introduces the idea that there is knowledge which is not explicitly known but rather is associated with what is explicitly known.

"...in tacit knowing we attend from something for attending to something else; namely, from the first term to the second term of the tacit relation...using the language of anatomy, we may call the first term proximal, and the second term distal. It is the proximal term, then, of which we have a knowledge that we may not be able to tell." (p. 10)

Polanyi suggests that when scientists engage in insight activities in the pursuit of science, they are guided by a tacit understanding of the problem they pursue that cannot fully be accounted for in terms of explicit facts or knowledge. Based on this perspective, insight is a process that is lead

by existing but untenable knowledge that nevertheless provides the scientist with valid knowledge of a problem to be pursued.

This perspective is not necessarily contrary to the model presented by Csikszentmihalyi, in that in both accounts preparation through extensive experience in a domain of study is requisite activity in order to facilitate problem finding insight. Such activity from the tacit knowledge perspective would yield great knowledge, both explicit and tacit from which insight can emerge.

invention-based approach & creative cognition

The final approach to insight differs from the previous descriptions in that subjects neither reflect on their lives as creative professionals nor attempt to solve specific insight-type problems.

Ronald Finke instead challenges his subjects to invent as a form of insight. Finke categorizes insight as falling into two distinct categories, convergent insight and divergent insight.

Convergent insight refers to the creation of a creative structure or solution that makes sense of apparently disconnected facts. The solving of a mystery is an example of a convergent insight. In contrast, Finke's interest lies primarily in divergent insight, where one begins with a structure and seeks to find novel uses for it or novel implications for it. A popular culture analogy for this type of insight would be exemplified by the old television show *MacGyver*, where the hero invents new devices out of everyday items in order to save the day.

Finke accounts for divergent insight through his Geneplore model of creative cognition. The first phase of the model is the generative phase where subjects construct mental representations called preinventive structures that may be self-constructed or provided in the form of primary shapes and forms. Then, in the exploratory phase, subjects mentally combine and manipulate the preinventive structures in order to explore various possible interpretations of these structures. This process of exploration leads subjects to invent new creative insights and discoveries. Resulting concepts are then focused or expanded to meet the individual's needs through an iterative cycling through the generative and exploratory phases.

Significant in Finke's work on creative cognition has been the exploration of levels of task constraint that lead to enhanced insight and invention. A general finding has been that constraining subject's inventions by function does not impact the number of creative inventions produced while constraining subjects by type of object does reduce the number of creative inventions. For example when subjects are asked to invent an object such as "an appliance that would help you catch a burglar" they produced many more creative inventions than when they were asked to invent "a chair".

While Finke's approach to insight is quite distinct from the approaches which preceded it, I am expecting that it will act as a useful tool in beginning to consider the relationship between individual insight and group insight.

making sense of these approaches

While I have presented a diversity of approaches to studying and understanding insight, nearly all of these perspectives stem from two prominent and contrasting methods in the investigation of insight: laboratory experiments focused on insight problems solved within the experimental session, and qualitative interviews focused on longitudinal self-report of insight by people considered to be particularly insightful. Both of these research methods have made contributions to the understanding of insight, but may also have shortcomings for capturing the processes of insight in situ and for accurately describing the development of insight over protracted time periods of time. Some researchers in the area of insight have questioned the construction of insight problems as forms of stimuli that create artificial mental states. Polanyi's perspective on insight and tacit knowledge illuminates another challenge presented in Csikszentmihalyi's methods. How can a person tell of the aspects of insight that are essentially known but untellable?

The greatest constraint of these methods is their inability to capture the suddenness of insight within the daily lived experience of the subject. Many researchers of insight identify a preparation period and an incubation period as being key components of the insight process, but due to the suddenness of insight after these periods, it is difficult to capture the moment of

insight in daily life. In response to this challenge, experiments are conducting using problems simple enough to be solved in a short period of time or data is collected post-insight via subjects self-report of their insight experiences. In my future work, extending to the study of group insight I am especially interested in the ethnographic and longitudinal experimental methods utilized by Brigid Barron in “When Smarts Groups Fail”, Kevin Dunbar in “How scientists think: Online creativity and conceptual change in science”, Andrea diSessa et al. in “Inventing Graphic: Meta-representational Expertise in Children,” and Daniel Schwartz et al. in “Inventing to prepare for future learning: The hidden efficiency of encouraging original student production in statistics instruction.” It is my hope that by looking more explicitly in the design literature I may find mixed method approaches oriented towards understanding individual insight as well.

An outstanding challenge that has not been adequately addressed in this preparatory paper is the role of affect in individual insight. This is an area that I will need to further investigate as it is likely to play a significant role in how group insight may be manifested with regards to group function and motivation. Affect has generally not been studied as part of insight, even though it is commonly acknowledged to be a significant part of the experience. It is my hope to find work that specifically describes if affect plays a role in the generation of insight as well as describing its role as an outcome effect.

Bibliography:

Csikszentmihalyi, M and Sawyer, K.(1995). Creative insight: The social dimension of a solitary moment. In R. Steinberg and J. Davidson (Eds.) *The Nature of Insight*. Cambridge: MIT Press. pp. 329-361.

Finke, R.(1995). Creative Insight and Preinventive Forms. In R. Steinberg and J. Davidson (Eds.) *The Nature of Insight*. Cambridge: MIT Press. pp. 255-280.

Grant, E., & Spivey, M. (2003). Eye movements and problem solving: Guiding attention guides thought. *Psychological Science*, 14(5), 462-466.

Jung-Beeman M, Bowden EM, Haberman J, Frymiare JL, Arambel-Liu S, et al. (2004) Neural Activity When People Solve Verbal Problems with Insight. *PLoS Biol* 2(4): e97.

Mayer, R.(1995). The Search for Insight: Grappling with Gestalt Psychology's Unanswered Questions. In R. Steinberg and J. Davidson (Eds.) *The Nature of Insight*. Cambridge: MIT Press. pp. 3-32.

Polanyi, M. (1966). *The Tacit Dimension*. London: Routledge and Kegan Paul.

Seifert, C. M., Meyer, D. E., Davidson, N., Patalano, A. L., & Yaniv, I. (1995). Demystification of cognitive insight: Opportunistic assimilation and the prepared-mind perspective. In R. J. Sternberg & J. E. Davidson (Eds.), *The Nature of Insight* (pp. 65-124). Cambridge, MA: MIT Press.

	approach	stages of insight	types of problems and insights	evidence
Csikszentmihalyi	great minds	<ol style="list-style-type: none"> 1. preparation: hard work and research 2. incubation: period of time alone <ul style="list-style-type: none"> o conscious attention o semiconscious filters o subconscious processing entities, or the society of mind o simultaneous functioning 3. insight: moment of insight 4. evaluation and elaboration: hard work and elaboration to bring the idea to fruition 	<p>Kuhn: normal science presented problem: normal short-term insight relatively clearly formulated problem within a normal scientific paradigmatic tradition--insight yields a solution</p> <p>Kuhn: revolutionary science discovered problem: long-term paradigmatic shift general sense of intellectual or existential unease outside a paradigmatic context--insight yields a present problem as an outcome</p>	<p>60 interviews with subjects who have made creative contributions to natural sciences, social sciences, arts, humanities, business or politics</p> <p>subjects older than 60 years</p> <p>continuing to be active in their domain</p> <p>60 interviews conducted</p>
Seifert, Meyer, Davidson, Patalano & Yaniv	<p>cognitive, information processing</p> <p>"Chance favors the prepared mind."-Pasteur</p>	<p>Opportunistic-Assimilation Hypothesis</p> <ol style="list-style-type: none"> 1. initial information processing encounters a problem that cannot initially be solved, person reaches an impasse 2. failure to solve the problem leaves a failure indices in long-term memory, special memory traces explicitly mark the fact that an impasse has occurred 3. the impasse helps ensure that all originally available information has been ingested 4. no further conscious or subconscious work is done on the original problem 5. chance events in the world eventually lead to a fortuitous encounter with an external object or event that is relevant to the original problem 6. this encounter triggers recall of the problem and its subsequent solution 	<p>puzzle-problems</p> <p>problems that afford:</p> <p>impasse-driven learning: VanLehn (1988) significant learning most likely occurs and yields lasting benefits at points where an individual reaches an impasse in information processing and then receives new information about how to overcome the impasse</p> <p>predictive encoding: memory strategy whereby information about an impasse is represented and stored in terms of characteristics that helpful future stimulus cues may have--<i>person has some idea of what they are looking for</i></p> <p>failure indices: mark information in memory associated with the original occurrence of an impasse</p>	<p>consideration of transfer literature</p> <p>other studies cited</p> <p>two experimental studies conducted</p> <ul style="list-style-type: none"> • test the predication that exposing problem solvers to relevant new information after an initial failed solution attempt will best promote ultimate successful solutions • test if people have especially accessible memories for problems whose initial confrontation ends with an impasse, failure to reach solution (do not mention affect in memory) compared with people who are interrupted from problem solving before an impasse is reached
Polanyi	tacit knowledge	<p>Tacit knowing is shown to account</p> <ol style="list-style-type: none"> 1. for a valid knowledge of a problem 2. for the scientist's capacity to pursue it, guided by his sense of approaching its solution, and 3. for a valid anticipation of the yet indeterminate implications of the discovery arrived at in the end. (p. 24) 	<p>"...in tacit knowing we attend from something for attending to something else; namely, from the first term to the second term of the tacit relation...using the language of anatomy, we may call the first term proximal, and the second term distal. It is the proximal term, then, of which we have a knowledge that we may not be able to tell." (p. 10)</p>	<p>observation</p> <p>references to research, examples</p>

	approach	stages of insight	types of problems and insights	evidence
Finke	invention-based approach: creative cognition	<p>Geneplore model of creative cognition</p> <ol style="list-style-type: none"> 1. generative phase: one constructs mental representation called preinventive structures 2. exploratory phase: one explores various interpretations of these structures, leading to creative insights and discoveries 3. resulting concepts can then be focused or expanded according to task requirements or individual needs <p>appropriate levels of constraint in generative and exploratory phases facilitates important suspension expertise in creative exploration</p>	<p>divergent insight: one begins with a structure and seeks to find novel uses for it or novel implications of it--function follows form perspective, one tries to find meaning in the structure rather than to structure what is meaningful</p> <p>convergent insight: one discovers a creative structure or solution that makes sense out of apparently disconnected facts--useful is solving mysteries</p>	studies designed to investigate the use of mental synthesis in discovering creative inventions and concepts
Jung-Beeman et al.	<p>neuroscience--brain activity</p> <p>observation of neural activity when solving verbal problems with insight</p>	<ol style="list-style-type: none"> 1. people come to an impasse on insight problems because their retrieval efforts are misdirected by ambiguous information in the problem or by their usual method for solving similar problems 2. coarse encoding of large semantic fields in the right hemisphere allow for more overlap among distantly related concepts may help overcome this impasse 3. because this semantic processing is weak, it may remain unconscious, perhaps overshadowed by stronger processing of the misdirected information and the solver remains stuck as an impasse 4. eventually, solution-related information bursts into awareness "in a sudden flash" 5. this can happen after misdirected processing decays or is suppressed, after solution-related processing grows, or after environmental cues occur 	"It is striking that the insight effect observed in the right hemisphere in our experiments occurred when people solved verbal problems, which traditional views suggest should involve mostly LH processing with little or no contributions from the RH."	fMRI and scalp electroencephalogram recordings
Grant & Spivey	guided attention situated cognition	<p>for the Duncker radiation problem</p> <ol style="list-style-type: none"> 1. eye movement patterns correspond with the problem-solving process 2. inducing attentional shifts to a critical diagram feature facilitated correct inference making 3. sometimes cognitive processing is the result of attention and eye movements 	<p>guided insight</p> <p>environmentally controlled perceptual properties can guide attention and eye movements in ways that assist in developing problem-solving insights that dramatically improve reasoning</p>	eye movement tracking and perceptual highlighting of critical diagram components