

Handbook of Intuition Research

Edited by

Marta Sinclair

Senior Lecturer, Griffith University, Australia

2011

Edward Elgar

Cheltenham, UK • Northampton, MA, USA

7 Strategic intuition

William Duggan and Malia Mason

Strategic intuition is the mental mechanism that produces flashes of insight. Some scholars exclude insight from the definition of intuition, but that distinction is more than a decade out of date, following the 1998 paper by Milner et al., 'Cognitive neuroscience and the study of memory'. Recent research indicates that intuition comes from learning and automatic recall (Edelman, 2004; Gordon & Berger, 2003), in two ways. In *expert* intuition, recall comes quickly, without conscious thought, by drawing from direct experience. In *strategic* intuition, recall includes the experience of others learned through reading, seeing or hearing, which explains why it features slower recall from a wider range of weaker memory. But in both forms of intuition, the mechanism of recall is generally the same.

The precise mechanism of recall, though, differs across the two forms of intuition. These differences are the subject of a growing body of modern research. Simon (1989), in the lab and Klein (1998), in the field, pioneered expert intuition, which has become a significant field of study, as researchers identify experts and measure how they perform expert tasks. Strategic intuition is much farther behind, because it is much more difficult to capture; flashes of insight happen at odd times, in odd places, to experts and non-experts alike. The study of strategic intuition did not make much methodological progress since von Clausewitz first identified flashes of insight as the key to Napoleon's military strategy in the early 1800s (von Clausewitz, 1832 [1968]) until the end of the twentieth century. Over that time, the study of historical examples has been the primary means of capturing the fleeting phenomenon of strategic intuition (Duggan, 2007; Kuhn, 1962).

Over the past decade, however, cognitive and neuroscience research have made significant methodological progress in studying flashes of insight from three different angles. First, psychology experiments show that subjects solve problems better after sleep than both subjects who focus continuously on the problems and subjects who have periods of resting wakefulness (Stickgold et al., 2001; Wagner et al., 2004). Second, research on arousal and stress shows that the physiology of the relaxed mental state fosters this kind of 'off-line' problem-solving (Martindale, 1999; Martindale & Greenough, 1973). Third, neuroelectrical recordings and brain scans provide preliminary evidence that defocused attention

contributes to flashes of insight (Dewing & Battye, 1971; Kounios et al., 2007; Mason et al., 2007; Mendelsohn & Griswold, 1964).

INTUITION AND SLEEP

There are numerous historical examples of discoveries made in lucid dream states. Friedrich August Kekule saw benzene's ring-like structure as a snake in his dreams (as cited in Roberts, 1989). Otto Lowe awoke to discover he had penned the mysteries of neurochemical transmission during the previous night's slumber (as cited in Mazzarello, 2000). Although few people experience insights of this caliber, it is not uncommon for people to report gaining perspective on unresolved problems while asleep or in semi-conscious dream states. Scientists have debated the power of the unconscious for centuries, yet until recently few have offered explanations as to why sleep might foster insight. Some speculate that the relaxed attentional state of sleep is associated with flexible or 'fluid' cognition (Horn & Cattell, 1966), a processing mode conducive to linking loosely connected material. From this perspective, sleep promotes creative problem solving because the rigid, rule-based processing that characterizes wakeful states is supplanted by a flexible, associative processing mode (Walker et al., 2002). Others suggest that during certain sleep stages information is restructured in a manner that makes overlooked but meaningful connections (Wagner et al., 2004).

Consistent with relaxed attentional states enabling the detection of loosely connected material, Walker reported that rapid eye movement (REM) sleep, a stage rich in dreams, was associated with significant increases in cognitive flexibility compared to non-REM sleep (Walker et al., 2002). Participants awakened during REM sleep were significantly better at rearranging words to produce new phrases than participants awakened from non-REM sleep. Similarly, Stickgold et al. measured the speed at which participants recognized weak (e.g., thief-wrong) and strong associations (e.g., hot-cold) after a period of REM or non-REM sleep (Stickgold et al., 1999). Whereas performance on the recognition of strong associations was greatest after non-REM sleep, participants excelled at the detection of weak associations after periods of REM sleep. Finally, a recent study by Cai et al. provides compelling evidence that REM sleep helps integrate information. Participants in their study were more likely to identify the associate (e.g., 'salt') of three seemingly unrelated words (e.g., 'mine', 'lick', 'table') following periods of REM (Cai et al., 2009). These findings support the view that hyperassociative processes during REM sleep help people draw connections among loosely related material.

In addition to promoting fluid thinking, sleep is purported to foster intuition by reshuffling associations. Evidence suggests that information recombines during REM sleep such that previously overlooked connections are more apparent. In the most compelling demonstration of this reshuffling, Wagner et al. (2004) had participants perform a stimulus-response task by quickly pressing specific keyboard buttons (e.g., 'F') when relevant stimuli (e.g., an odd digit) appear on a computer screen. The speed at which participants perform this task improves abruptly if they gain insight into the abstract rule governing the sequences. Once uncovered, the hidden rule provides a short cut or simpler method for solving the problem. Wagner et al. found that participants who slept for eight hours following a period of task performance were twice as likely to detect the hidden rule when they resumed the task upon waking, than both participants who rested in an awake state for eight hours and participants who went about their daily activities for eight hours before resuming the task.

Scientists continue to debate precisely how sleep leads to cognitive restructuring (see Stickgold & Walker, 2004; Vertes & Siegel, 2005). During REM sleep the mind is working but not taking in new information, which may be critical for the integration of new information and the cognitive reshuffling necessary for strategic intuition. A host of evidence suggests that REM sleep is important in memory consolidation, the process by which memories strengthen and become resistant to interference (Huber et al., 2004; Pihl & Born, 1997). It is worth noting evidence which suggests that the strengthening of memories for important information during REM sleep is complemented by the forgetting of unimportant details and the weakening of non-adaptive memory traces during non-REM sleep (Giuditta et al., 1995). According to this view, sleep consists of opposite processes that work in concert to maintain memory housekeeping. In this way, sleep may help people abandon ineffective strategies, consider less obvious solutions, and tease out regularities that exist but have gone undetected.

RELAXATION AND 'OFF-LINE' PROBLEM SOLVING

Impasses in problem solving frequently result because the futility of a favored strategy has gone undetected (Sternberg & Davidson, 1995). Problem solvers who have the key pieces of information at their disposal sometimes fail simply because they abstain from exploring alternative configurations of the problem's parts. The longer the faulty strategy is explicitly considered, the more strongly it becomes associated in memory with the desired outcome. As a result, the problem solver is habitually drawn to consider how the inappropriate strategy can be reworked to produce the

solution, despite its ineffectiveness. Although focus is imperative in key stages of intuition – when judging the merit of an insight, for example – it fosters tunnel vision when implemented prematurely. In haste to reach closure, people overfixate on a framework that lacks merit and promise. Attempts at elucidating the conditions under which people experience intuition can therefore benefit from considering the factors that affect the likelihood that people will apply diffuse versus focused attention when ‘searching’ for the answer to a problem. Two important determinants appear to be the problem solver’s level of stress and physiological arousal.

Research on stress paints a bleak picture of its effect on innovation. During periods of heightened anxiety, people default to routinized thinking patterns and well-learned habits (Hull, 1943; Osgood, 1960), making them prone to dogmatically adhere to ineffective problem-solving strategies. Originality is noticeably diminished (Dentler & Mackler, 1964) and people exhibit a mindless, functional fixedness as opposed to mindfulness (Langer, 1992; Pennebaker, 1989). Although stress enhances the *encoding* of memories under certain situations, high stress interferes with the *retrieval* of information from memory (Roosendaal, 2002). This further limits people’s capacity for constructing sophisticated solutions to problems. Finally, evidence suggests that stress diminishes innovative problem solving by reducing cognitive flexibility. For example, performance on anagram tasks declines when stress hormones, like norepinephrine, are administered and improves when these hormones are blocked (Beversdorf et al., 1999). Beversdorf et al. suggest that stress hormones exert a modulatory effect on cognitive flexibility in problem solving, such that increases in stress hormone diminish cognitive flexibility. In sum, stress diminishes creative innovation by inducing people to cling to routinized habits, by interfering with effective memory retrieval and by increasing cognitive rigidity.

Research on physiological arousal yields a similar story. For decades scientists have known that arousal improves performance on simple problems while relaxation improves performance on complex problems (Duffy, 1941; Easterbrook, 1959; Yerkes & Dodson, 1908). Complexity can be defined in a myriad of ways but one critical dimension is problem structure. In contrast to structured problems (e.g., ‘Which company has the largest share of the market?’), the resolution of unstructured problems (e.g., ‘How can we increase our market share?’) requires identifying relevant information and developing a framework for thinking about the problem. Solving the latter requires searching a wider conceptual space for a solution. Although people can reach solutions to both types of problems through insight, the sheer scope of unstructured problems necessitates a broader consideration. Arousal funnels attention, reducing the range of

cues that an organism processes and uses (Derryberry & Tucker, 1994). Broadly employed attention increases the chances of bringing seemingly irrelevant information into conscious awareness. Indeed, performance on tasks that require a wide search of information (e.g., the Remote Associates Test: RAT; Mednick & Mednick, 1967) worsens when people are highly aroused (Martindale & Greenough, 1973).

DEFOCUSED ATTENTION

Although too much focus inhibits solving complex problems, insights do not come to those who simply ignore problems or wait passively for solutions to bubble to consciousness. On the contrary, focus is essential for key stages of the creative process, especially the elaboration of fragmented, incomplete insights and the verification of a solution’s legitimacy (Martindale, 1999; Mendelsohn, 1976). Nevertheless, many researchers speculate that defocused attention in the period leading up to insight fosters novel solutions (Bransford & Stein, 1984; Eysenck, 1995) and complex problem solving (Dijksterhuis et al., 2006; Dijksterhuis & Nordgren, 2006; Dijksterhuis & van Olden, 2005). Evidence suggests that individuals who allocate their attention diffusely or cast broad ‘attentional nets’ outperform those who focus well, on problems that require the connection of remote problem elements (Dewing & Battye, 1971; Mendelsohn & Griswold, 1964). Similarly, several investigators report that highly creative individuals are more subject to distraction by task-irrelevant cues than their non-creative counterparts, presumably because they habitually employ a wider focus of attention (Ansberg & Hill, 2003; Dykes & McGhie, 1976; Martindale, 2007).

Recent cognitive neuroscience research appears to substantiate these findings. While daydreaming or in a prolonged moment of reflection, the brain enters an alpha wave state, a more relaxed state of mind with a relatively slow, rhythmic electrical activity, distributed across the brain in a specific spatial pattern. The alpha power increases (synchronizes) when people are relaxing and attenuates (desynchronizes) when people engage in difficult tasks that require focus or concentration (Gevins et al., 1997; Pfurtscheller, 1992). Consistent with the view that defocused attention promotes insight, Martindale and Hasenpus (1978) demonstrated that the individuals who exhibited high magnitude alpha waves were more likely to generate a novel solution to an anagram than those who exhibited low magnitude alpha waves. Similarly, more recent work suggests that creative individuals have chronically higher alpha wave signals than non-creative individuals (Kounios et al., 2007). Although the point is still hotly debated,

some suggest that attentional control is relaxed during alpha periods, resulting in a heightened capacity for detecting non-obvious connections.

Convergent findings appear to be emerging from functional brain imaging studies. During baseline periods, when directed to 'rest' and 'clear their thoughts', participants exhibit recruitment of a set of brain regions referred to as the 'default network' (Buckner et al., 2008; Mason et al., 2007; Raichle et al., 2001). These brain areas are active when people are resting or engaged in mindless, effortless tasks and are deactivated during tasks that require focus and effort. Recent brain imaging research reveals that activity in this network increases prior to insight experiences. While there is little direct evidence that this network supports diffuse attention, these findings provide additional preliminary evidence that periods of diffuse attention are essential for insight experiences (Kounios et al., 2006).

APPLICATIONS

In all this research, the psychology experiments understandably provide stronger results than the scans. Neuroscience has only begun to reveal the precise workings of the brain. Nevertheless, there are some preliminary applications we can identify for professional domains of various kinds. And these in turn lead to further indications for future psychology and neuroscience research.

First, strategic intuition has application to creativity in all walks of life. The 1998 learning-and-memory model of Milner et al. replaced Sperry's previous model of the two-sided brain, where the left is creative and the right is analytical (Sperry, 1961, 1981). In the years between those two models, formal brainstorming sessions became the primary method of creativity in most professions. In brainstorming, following Sperry, the creative right side of the brain takes over from the analytical left side, and creative thoughts arise spontaneously. The learning-and-memory model, in contrast, argues against this kind of brainstorming. Instead, creative ideas arise at odd times when the mind is relaxed, like in the shower or exercising or falling asleep.

Nevertheless, brainstorming is still widespread in the professional world. Related methods include scattering toys and beanbag chairs around, to stimulate the creative right side of the brain, which again the learning-and-memory model contradicts. Instead this model suggests a host of alternative techniques for practitioners to try and for neuroscience and cognitive research to test. For example, what are the best sequence, timing and means of learning and relaxation to generate insights for various kinds of creative problems? And for social psychology: what are

the best organizational, management and leadership practices that follow from that?

Future research can and should seek detailed answers to these questions. Larger lessons may follow as well. When Kandel won the Nobel Prize for Physiology or Medicine in 2000, he stated in his lecture: 'we are who we are in good measure because of what we have learned and what we remember' (Kandel, 2000). For him, the learning-and-memory model covers all forms of conscious and unconscious thought, including 'analysis'. That is, all analysis requires some form of learning and automatic recall: you cannot analyze something that is completely new to you. Even mathematical calculations require you to learn and then recall each number and symbol and the rules of operation, such as addition or division. Further research might well show that underlying all the different modes of thought, such as rational analysis or creative intuition, there is a single 'meta-mode' of learning and memory.

The implications of this single meta-mode of thought could be enormous. At present, expert and strategic intuition sit alongside analysis as junior or even equal partners in problem solving. But perhaps, instead, all problem solving is either expert or strategic intuition, or a combination of the two, and analysis is a part of both. Conscious and unconscious thought might both be impossible without prior learning and automatic recall. Analysis depends on learning and memory for the subject matter analyzed as well as the method of analysis used. Analysis yields greater understanding of a problem, but not a solution, except in a field of pure logic like mathematics. All real-world problem solving requires a leap of cognition beyond analysis. That leap is either the rapid recognition of expert intuition or the flash of insight of strategic intuition, or a combination of the two.

When it comes to human action, a purely rational world is impossible. But with the right research effort, better expert and strategic intuition are very much within our grasp.

REFERENCES

- Ansberg, P., & Hill, K. 2003. Creative and analytic thinkers differ in their use of attentional resources. *Personality of Individual Differences*, 34: 1141-1152.
- Beversdorf, D., Hughes, J., Steinberg, B., Lewis, L., & Heilman, K. 1999. Noradrenergic modulation of cognitive flexibility in problem solving. *NeuroReport: For Rapid Communication of Neuroscience Research*, 19: 2763-2767.
- Bransford, J., & Stein, B. 1984. *The IDEAL problem solver*. New York: W. H. Freeman.
- Buckner, R., Andrews-Hanna, J., & Schacter, D. 2008. The brain's default network: Anatomy function and relevance to disease. *Annals of the New York Academy of Sciences*, 1124: 1-38.

- Cai, D. J., Mednick, S. A., Harrison, E. M., Kanady, J. C., & Mednick, S. C. 2009. REM, not incubation, improves creativity by priming associative networks. *Proceedings of the National Academy of Sciences of the United States of America*, 106: 10130–10134.
- Dentler, R., & Mackler, B. 1964. Originality: Some social and personal determinants. *Behavioral Science*, 9: 1–7.
- Derryberry, D., & Tucker, D. 1994. Motivating the focus of attention. In: P. Niedenthal & S. Kitayama (Eds.), *Heart's eye: Emotional influences in perception and attention*: 167–196. New York: Academic Press.
- Dewing, K., & Battye, G. 1971. Attention deployment and nonverbal fluency. *Journal of Personality and Social Psychology*, 17: 214–218.
- Dijksterhuis, A., Bos, M., Nordgren, L., & Van Baaren, R. 2006. On making the right choice: The deliberation-without-attention effect. *Science*, 311: 1005–1007.
- Dijksterhuis, A., & Nordgren, L. 2006. A theory of unconscious thought. *Perspectives on Psychological Science*, 1: 95–109.
- Dijksterhuis, A., & van Olden, Z. 2005. On the benefits of thinking unconsciously: Unconscious thought can increase post-choice satisfaction. *Journal of Experimental Social Psychology*, 42: 627–631.
- Duffy, E. 1941. The conceptual categories of psychology: A suggestion for revision. *Psychological Review*, 48: 177–203.
- Dugan, W. 2007. *Strategic intuition*. New York: Columbia Business School Publishing.
- Dykes, M., & McGhie, A. 1976. Cognitive study of attentional strategies of schizophrenic and highly creative normal subjects. *The British Journal of Psychiatry*, 128: 50–56.
- Easterbrook, J. 1959. The effect of emotion on cue utilization and the organization of behavior. *Psychological Review*, 66: 183–201.
- Edelman, G. 2004. *Wider than the sky*. New Haven, CT: Yale University Press.
- Eysenck, H. 1995. Creativity as a product of intelligence and personality. In D. H. Saklofske, & M. Zeidner (Eds.), *International handbook of personality and intelligence*: 231–247. New York: Plenum Press.
- Gevens, A., Smith, M., McEvoy, L., & Yu, D. 1997. High-resolution EEG mapping of cortical activation related to working memory: Effects of task difficulty, type of processing, and practice. *Cerebral Cortex*, 7: 374–385.
- Giuditta, A., Ambrosini, M., Montagnese, P., Mandile, P., Cotugno, M., Grassi, Z., & Vesica, S. 1995. The sequential hypothesis of the function of sleep. *Behavioral Brain Research*, 69: 157–166.
- Gordon, B., & Berger, L. 2003. *Intelligent memory*. New York: Viking.
- Horn, J., & Cattell, R. 1966. Refinement and test of the theory of fluid and crystallized intelligence. *Journal of Educational Psychology*, 57: 253–270.
- Huber, R., Ghilardi, M., Massimini, M., & Tononi, G. 2004. Local sleep and learning. *Nature*, 430: 78–81.
- Hull, C. 1943. *Principles of behavior*. New York: Appleton-Century.
- Kandel, E. 2000. *Nobel Lecture*. Stockholm Concert Hall, Stockholm, December 10.
- Klein, G. 1998. *Sources of power*. Cambridge, MA: MIT Press.
- Kounios, J., Frymire, J., Bowden, E., Fleck, J., Subramaniam, K., Parrish, T., & Jung-Beeman, M. 2006. The prepared mind: Neural activity prior to problem presentation predicts solution by sudden insight. *Psychological Science*, 17: 882–890.
- Kounios, J., Fleck, J., Green, D., Payne, J., Stevenson, J., Bowden, E., & Jung-Beeman, M. 2007. The origins of insight in resting-state brain activity. *Neuropsychologia*, 46: 281–291.
- Kuhn, T. 1962. *The structure of scientific revolutions*. Chicago: University of Chicago Press.
- Langer, E. 1992. Interpersonal mindlessness and language. *Communication Monographs*, 59: 324–327.
- Martindale, C. 1999. Biological bases of creativity. In R. J. Sternberg (Ed.), *Handbook of creativity*: 137–152. New York: Cambridge University Press.
- Martindale, C. 2007. Creativity, primordial cognition and personality. *Personality and Individual Differences*, 43: 1777–1785.
- Martindale, C., & Greenough, J. 1973. The differential effects of increased arousal on creative and intellectual performance. *Journal of Genetic Psychology*, 123: 325–329.
- Martindale, C., & Hasenbus, N. 1978. EEG differences as a function of creativity, stage of creative process and effort to be original. *Biological Psychology*, 6: 157–167.
- Mason, M., Norton, M., Van Horn, J., Wegner, D., Grafton, S., & Macrae, C. 2007. Wandering minds: The default network and stimulus-independent thought. *Science*, 315: 393–395.
- Mazzarello, P. 2000. What dreams may come? *Nature*, 408: 523.
- Mednick, S. A., & Mednick, M. T. 1967. *Examiner's manual: Remote Associates Test*. Boston, MA: Houghton Mifflin.
- Mendelsohn, G., & Griswold, B. 1964. Differential use of incidental stimuli in problem solving as a function of creativity. *Journal of Abnormal and Social Psychology*, 68: 431–436.
- Mendelsohn, G. 1976. Associative and attentional processes in creative performance. *Journal of Personality*, 44: 341–369.
- Miller, B., Squire, L., & Kandel, E. 1998. Cognitive neuroscience and the study of memory. *Neuron*, 20: 445–468.
- Osgood, C. 1960. Some effects of motivation and style on encoding. In T. A. Sebeok (Ed.), *Style in language*: 293–306. Cambridge, MA: MIT Press.
- Pennebaker, J. 1989. Stream of consciousness and stress: Levels of thinking. In J. Uleman, & J. Bargh (Eds.), *Unintended thought*: 327–350. New York: Guilford Press.
- Pfurtscheller, G. 1992. Event-related synchronization (ERS): An electrophysiological correlate of cortical areas at rest. *Electroencephalography. Clinical Neurophysiology*, 83: 62–66.
- Pihl, W., & Born, J. 1997. Effects of early and late nocturnal sleep on declarative and procedural memory. *Journal of Cognitive Neuroscience*, 9: 534–547.
- Raichle, M., MacLeod, A., Snyder, A., Powers, W., Gusnard, D., & Shulman, G. 2001. A default mode of brain function. *Proceedings of the National Academy of Sciences of the United States of America*, 98: 676–682.
- Roberts, R. 1989. *Serendipity, Accidental Discoveries in Science*: 75–81. New York: John Wiley & Sons.
- Rozenzdaal, B. 2002. Stress and memory: Opposing effects of glucocorticoids on memory consolidation and memory retrieval. *Neurobiology of Learning and Memory*, 78: 578–595.
- Simon, H. 1989. *Models of thought: Volume 2*. New Haven, CT: Yale Press.
- Sperry, R. 1961. Cerebral organization and behavior. *Science*, 133: 1749–1757.
- Sperry, R. 1981. *Nobel Lecture*. Stockholm Concert Hall, Stockholm, December 8.
- Sternberg, R., & Davidson, J. 1995. *The nature of insight*. Cambridge, MA: MIT Press.
- Stickgold, R., Hobson, J., Fosse, R., & Fosse, M. 2001. Sleep, learning, and dreams: Off-line memory reprocessing. *Science*, 294: 1052–1057.
- Stickgold, R., Scott, L., Rittenhouse, C., & Hobson, J. 1999. Sleep-induced changes in associative memory. *Journal of Cognitive Neuroscience*, 11: 182–193.
- Stickgold, R., & Walker, M. 2004. To sleep, perchance to gain creative insight? *Trends in Cognitive Sciences*, 8: 191–192.
- Vertes, R., & Siegel, J. 2005. Time for the sleep community to take a critical look at the purported role of sleep in memory processing. *Sleep*, 28: 1228–1229.
- Von Clausewitz, C. 1832 [1968]. *On war*. New York: Penguin.
- Wagner, U., Gais, S., Haider, H., Verleger, R., & Born, J. 2004. Sleep inspires insight. *Nature*, 427: 352–355.
- Walker, M., Liston, C., Hobson, A., & Stickgold, R. 2002. Cognitive flexibility across the sleep-wake cycle: REM-sleep enhancement of anagram problem solving. *Cognitive Brain Research*, 14: 317–324.
- Yerkes, R., & Dodson, J. 1908. The relation of strength of stimulus to rapidity of habit formation. *Journal of Comparative Neurology and Psychology*, 18: 459–482.