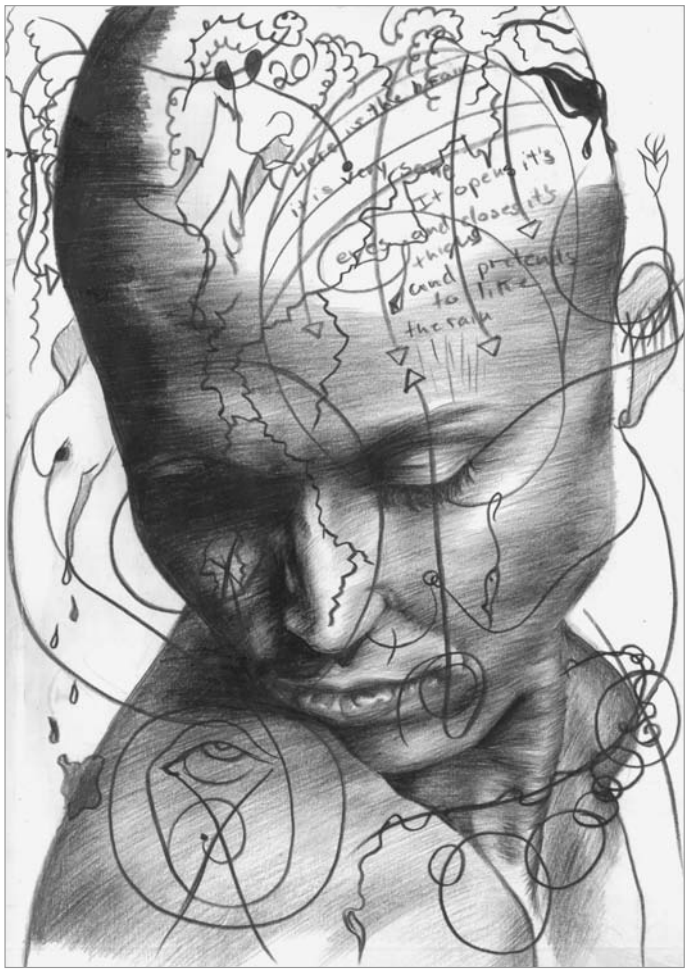
Reportage:

The unexpected idea

Reporter:

Kylie Ladd



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The unexpected idea

On a winter's day in 1869, Russian scientist Dmitri Mendeleev sat at his desk trying to write a textbook on chemistry. Almost from the start, he had had difficulty structuring the material. Sixty-three elements were known at the time, a mixture of solids, liquids and gases, metals and non-metals. Which should he discuss first? Were some more important than others? There was no obvious order in their composition or properties.

Taking a break from his work, Mendeleev pulled out a pack of playing cards and began a game of solitaire. As he laid out the rows it suddenly occurred to him that perhaps elements could be organised in a similar way. He picked up the cards, added some others and then on the back of each wrote down the name of an element and its chemical properties. Shuffling the cards in his hands, Mendeleev realised that one way of ordering the elements might be by their atomic weight. Following this principle, he dealt the cards until he reached sodium. In terms of its chemical properties, sodium was quite similar to the first element that Mendeleev had set down, lithium. On a hunch, he placed sodium under lithium and began a new row. As he continued to place cards, Mendeleev suddenly realised that each element was similar to the one above it, while also having a place between those on either side.

History records that Mendeleev stopped for a short while to play with his daughter and have dinner, then returned to his desk to draw up the first draft of what would become the periodic table. Perhaps even more impressively, he also correctly predicted the properties of three as yet unknown elements, based on the gaps in his arrangement of cards. Within the next fifteen years, all were discovered – and chemically each was exactly as Mendeleev had foretold. In a single flash of inspiration, he had conceived of an idea that would order and predict the very fabric of the cosmos.

Creative thought, the ability to look beyond what is known or familiar and see new possibilities and solutions, is both fundamental to human endeavour and part and parcel of our everyday lives. One of Mendeleev's biographers described it as 'the unexpected idea': insight that comes seemingly out of nowhere, but intuitively makes sense. More recently, researchers have delineated two defining characteristics of creativity: the ability to produce work that is not just original, but is also appropriate or useful.

Studying this ability has proved problematic, however. 'The thing about creativity is that it isn't a monolithic entity,' says Professor Jason Mattingley, foundation chair in Cognitive Neuroscience at the University of Queensland. 'Even if we agree that creativity is new ways of thinking about old things, or

being able to come up with fresh ideas and approaches, this can be expressed in any number of ways or fields: arts and science, certainly, but also in business, or even sport. Who's to say that "creativity" is the same construct for all those things?' As such, Mattingley points out, it is difficult to develop a laboratory test for creativity, and even harder to determine exactly which regions of the brain are directly involved in what he terms 'the Aha! moment'.

One area that has consistently been implicated, however, is the prefrontal cortex. The importance of this region, situated at the very front of the brain and occupying about half of the frontal lobe, was first highlighted by the case of Phineas Gage. Gage was the foreman of a construction gang working in Vermont in 1848, laying explosives to clear rock for a railway line, when an accidental detonation blew his tamping iron through his head. The iron, a metal bar weighing over thirteen pounds and more than a metre long, entered his skull just below his left cheekbone. It passed behind his eye, through his prefrontal cortex and out of the top of his head, and was said to have been found some thirty metres away. Amazingly, Gage remained conscious, and was even able to speak within minutes of the event. He was treated in hospital and returned to work a few months later.

At first it was thought that Gage had made a full recovery from his injuries. His memory and speech were normal, and he was able to resume heavy physical labour. Yet within weeks Gage's colleagues realised that he had changed. Though previously described as an efficient, respected and responsible worker, Gage was now 'fitful, irreverent … capricious and vacillating'. He was unable to consistently follow instructions, responding instead to his own drives and desires, and became impatient, obstinate and heedless of the opinions of others or the consequences of his actions. Gage lost his job, and according to some accounts was reduced to appearing – with his tamping iron – as an exhibit in PT Barnum's museum.

The changes in Gage's personality, thinking and ability to carry out his duties after the accident were the first evidence that the prefrontal cortex, previously thought to be a relatively 'silent' or unimportant area of the brain, was actually responsible for a number of sophisticated cognitive functions. It is now known that these include planning, judgement and the ability to reason abstractly, to consider and integrate differing points of view, and to inhibit inappropriate responses.

All these abilities are central to creative thought. Functional Magnetic Resonance Imaging (fMRI) is a scanning technique used to map the brain areas involved in particular activities by monitoring changes in blood flow and oxygen uptake. fMRI studies indicate that the prefrontal cortex is activated in a variety of tasks involving creativity, including generating stories, composing

music, solving puzzles requiring the mental manipulation of visual material, and imagining unusual uses for common items or incongruous objects, such as 'a living thing that is a helicopter'.

It may be that the prefrontal cortex is capable of such a disparate range of activities because cells here are different to others in the brain. 'Single-cell electrophysiology studies in monkeys, where an electrode is implanted in an individual neuron and its electrical activity is monitored as the animal performs a specific task, have shown that neurons in the prefrontal cortex are responsive to a variety of stimuli,' reports Professor Mattingley. 'This is in contrast to neurons in the posterior parts of the brain, which tend to only respond selectively – that is, to certain stimuli in certain ways. In other words, the prefrontal neurons are a kind of *tabula rasa* … they are flexible and adaptive, and thus well suited to making new connections, or co-ordinating information in the search for a solution.'

According to neuroscientist Earl Miller, the prefrontal cortex is 'like the conductor of an orchestra waving [his] baton and directing the players'. It follows, however, that if the conductor is faulty, the music will suffer. Recent research suggests that people suffering from schizophrenia frequently have structural damage and/or decreased neurotransmitter levels in their prefrontal cortex. Characteristic symptoms of this condition include hallucinations, delusions and disorganised and unusual thinking. 'In this respect, schizophrenia might be characterised as an excess of creativity, or "unsuccessful" creativity,' says cognitive psychologist Dr Andrea Kuszewski. Schizophrenics, she explains, jump too rapidly between ideas, pay too much attention to irrelevant detail and make associations – such as believing that a newsreader on television is issuing instructions to them, or talking about their life – that are certainly novel, but not appropriate or useful.

Interestingly, however, subjects with schizotypal personalities – people who exhibit unusual behaviours or thought patterns, but do not exhibit the range or severity of symptoms seen in full-blown schizophrenia – tend to score above average on measures of creativity. 'While the schizotypal personality embodies many of the essential elements of creative thinking, schizophrenia is lacking in one key area: cognitive control,' says Kuszewski. In other words, when it comes to creativity, being a little bit quirky is an advantage. Schizotypal personalities – thought to include Albert Einstein, Vincent Van Gogh and Isaac Newton – appear to enjoy the best of both worlds: the ability to more freely make connections between unrelated ideas or material, coupled with the cognitive insight to know which of these are actually valuable, and which can be discarded.

Cognitive control is obviously an important component of creativity: being able to focus on a problem or idea, assess competing solutions and evaluate outcomes. Paradoxically, however, creative insights may also emerge, seemingly at random, when the individual concerned is doing anything but focusing their attention in this manner. The epic poem *Kubla Khan* supposedly came to Coleridge in his sleep, not at his desk; Kekulé was daydreaming on a London bus when he suddenly realised he had hit upon the chemical structure of carbon; Archimedes, Newton and Picasso are all thought to have experienced flashes of genius while engaged in mundane activities. A writer friend of mine swears that some of her best ideas come to her when she is working in her garden. I find that my own emerge while I am swimming laps, or mired in housework; after two hours in a fruitless online conference with my co-editor, publisher, agent and publisher's assistant, the title for my second book suddenly came to me when I logged off in frustration and went to hang out the washing.

Neurologist and writer Dr Oliver Sacks accounts for such observations by suggesting that there must be 'a creative unconscious', a place of 'innumerable fragments, ideas, impressions, feelings, which are lying together, dancing, colliding, meeting, separating'. Intriguingly, it appears that this unconscious is only accessed when attention is defocused, not directed, and – correspondingly – when the prefrontal cortex is turned off, or at least down.

A rather striking example of this is given by Sacks in his most recent book, *Musicophilia* (Vintage 2007), which details the case of a sixty-eight-year-old man who suddenly began composing classical music despite having no prior formal training, or indeed interest, in the area. He was subsequently diagnosed with frontotemporal dementia, a degenerative condition selectively affecting the anterior areas of the brain, including the prefrontal cortex. Sacks postulated that the frontotemporal dementia had not created the musical abilities as such, but had rather unearthed them by lowering the inhibitory control usually exercised by the frontal lobes. 'Once released by damage to these inhibitory factors, musical or artistic powers can be developed, nurtured and exploited to produce a work of real artistic value,' he writes. 'This, then, may provide a brief, brilliant interlude as the frontotemporal degeneration advances. The degenerative process, unfortunately, does not come to a halt, and sooner or later all is lost – but for a brief time, for some, there can at least be music or art, with some of the fulfilment, the pleasure and joy it can so uniquely provide.' Similar cases where the subjects became accomplished artists have also been reported.

A less drastic, though more transient, way to increase creativity is to fall asleep. Robert Louis Stevenson claimed that all the ideas for his books and stories came to him in dreams, courtesy of 'the little people who manage man's

internal theatre'. The actual explanation may be somewhat more prosaic. Neuroimaging studies show that REM sleep, the stage of sleep when dreaming occurs, is characterised by a prominent decrease in the activity of the prefrontal cortex relative to other areas of the brain. Such deactivation is not uniform, however; rather, it occurs chiefly in the dorsolateral prefrontal cortex. This is the largest area of the prefrontal cortex, and is thought to be responsible for self-monitoring and focusing attention. In contrast, the much smaller medial prefrontal cortex – which has abundant links to areas of the brain concerned with memory and emotion – increases in activity during rapid eye movement (REM) sleep. Dreams and their insights, researchers suggest, may arise from this combination of heightened access to personally resonant thoughts or associations in the setting of lowered cortical self-regulation.

Such a state is not the sole preserve of sleep, however. In an intriguing study, professional jazz musicians were asked to play a modified piano keyboard while in an fMRI scanner. While the dorsolateral prefrontal cortex was active during an exercise where the subjects performed basic scales and a simple pre-memorised melody, this 'shut down completely' when they were instructed to improvise. At the same time, as in REM sleep, the medial prefrontal cortex conversely increased in activity. These results and those of the REM studies suggest that some forms of creativity appear to occur when the suppression of inhibitory, self-monitoring brain mechanisms allows the free flow of novel, unfiltered ideas and impulses.

Other activities that may deactivate the dorsolateral prefrontal cortex include hypnosis, daydreaming, meditation … and running. In a recent experiment, fit young men were instructed to run on a treadmill or cycle on a stationary bike at a moderate intensity (as measured by a designated heart-rate zone) for forty-five minutes. After a warm-up phase, two tests of cognitive function were projected on to the wall in front of them, one measuring general intelligence, the other requiring subjects to formulate and test hypotheses, monitor their responses and shift strategies when necessary – abilities thought to be dependent on the prefrontal cortex. Subjects were able to perform the intelligence tests, but showed significant impairment on the measure of prefrontal ability. This dovetails neatly with earlier, separate research that found creativity is enhanced by exercise, both at the time this is carried out and for up to two hours afterwards. The reason for this may be that during exercise, in an effort to conserve limited neural resources, the brain selectively directs these to the motor and sensory cortices and away from other areas. The result, researchers argue, is a state of 'transient hypofrontality' or defocused attention, where the inhibitory control of the prefrontal cortex is suppressed and new ideas and associations can flourish.

Of course, as Louis Pasteur pointed out: 'In the world of observation, chance only favours the prepared mind.' Truly novel and valuable creative insights rarely spring from nowhere, but are instead usually based on a sound foundation of knowledge and/or experience in the area, often built up over many years. Sacks has likened this to a backstage crew: never seen by the audience, but essential to the production. Does increased knowledge therefore inevitably mean increased creativity? Not necessarily. If the two were linked in a straightforward manner, it should follow that creativity would be enhanced by increasing age, owing to the extra learning and experience accumulated with each passing year. Yet this is only true to a point. Historiometric studies suggest instead that creative output tends to follow an inverted, backward J-curve (something that requires creativity just to envisage), peaking at mid-life then gradually deteriorating in later years.

There are likely to be at least two reasons for this. First, it appears that while the prefrontal cortex is the last structure to fully mature in the brain, it is also the first to deteriorate. While healthy elderly individuals perform at a similar level to subjects up to seventy years younger than themselves on tests of general intelligence, their performance on measures of prefrontal function – forming and testing hypotheses, switching strategies and monitoring their results – drops sharply with advancing age. This may be due to decreasing levels of the neurotransmitter dopamine in this region of the brain. Working in tandem with this, researchers have proposed that decades of reinforcement may overpower cognitive flexibility (which is diminishing anyway), so that as we age we tend to favour solutions that are consistent with our beliefs and experiences rather than seeking or accepting brand new associations.

Taking this further, it may be that in terms of creativity what matters is not chronological age, but career age – how long an individual has been working in a particular field. Psychologist John Hayes studied career development in several domains requiring creative thinking, including painting, poetry and musical composition. His results led him to propose the 'ten-year rule': that an extensive period of practice or preparation is essential for creative productivity in many fields, regardless of the innate talent or intelligence of the individual involved. Interestingly, although career and chronological age are often highly correlated, latecomers to a discipline have also been shown to conform to the ten-year rule, suggesting that it is not so much age that is important in high-level creative output, but rather years of immersion in the area.

Another factor that may be important is the field of creative endeavour. It has been observed that eminent scientists and mathematicians are statistically more likely to have made a significant contribution to their discipline at a younger age than those working in the arts and humanities. Conversely,

they are less likely to have continued contributing to the field into old age. The difference may be explained by the fact that science and mathematics require greater, and ongoing, formal knowledge acquisition, along with constant assimilation of this information into established paradigms. In contrast, creativity in the arts is usually based on emotional reactions to stimuli. Consequently, it has been hypothesised that ageing may affect the creativity of scientists more readily than that of artists because the latter can continue to draw on emotionally established first principles, rather than having to be continually updating and integrating their knowledge at a time that their prefrontal cortex is becoming less able to manage such tasks.

This leads to the question of whether creativity can be increased, or even taught. Researchers and practitioners agree that a particular set of circumstances and practices is likely to enhance creativity in any given individual, a number of which have been touched on. First, new insights and associations most frequently follow a solid theoretical and practical grounding in the area or discipline involved – as the 'ten-year rule' suggests, brilliant new ideas rarely arrive on a plate, but only after significant immersion in a subject. In a related vein, structure is also important to creativity. 'I think most people assume that being creative means being a bit airy-fairy; that creative individuals don't get much achieved,' says writer Kate Wattus. 'In actual fact, creative people are very task oriented – after all, that's what writer's block is, the inability to think an idea through to its satisfying conclusion.' Dr Catherine Cole, novelist, poet and Professor of Creative Writing at Melbourne's RMIT University, agrees: 'Sometimes the best writers I see in classes aren't the ones that go on and make names for themselves … sometimes you never hear from them again, because other things have got in the way. Maybe they haven't had the discipline to actually see a piece of work through, or maybe they haven't been able to balance their creativity with the practical demands of life … having a gift or a skill is not enough. You also need to organise yourself so that you can use it.'

But while regularly sitting down to do the work is important for creativity to flourish, so too – conversely – is allowing oneself time to daydream and chase ideas. This was the rationale behind Google's decision to give all engineering staff '20 per cent time', where employees are able use 20 per cent of their work hours to do whatever they like. To this end, Google offices are equipped with billiard tables, video games, and exercise equipment, though many staff also use the time to follow ideas or experiment with other projects they are interested in. Though one of Google's senior vice presidents, Alan Eustace, has conceded it can be 'unnerving' to watch employees spend the equivalent of a day a week seemingly wasting time, that doesn't appear to be what has

happened at all – half of Google's new product launches grew out of 20 per cent time.

Yet, despite all this research into the neurological basis of creativity, how it occurs and whether it can be nurtured, the biggest mystery remains: what begins the drive in the first place? As Catherine Cole notes: 'You can look and see what parts of the brain light up when we are creating something, but what is really interesting is the bit that comes before that, which I'm not sure you can measure or quantify: what it is that engages us, that makes us want to write or draw, that holds our attention to the extent that we pour the effort of creating into it.'

Even Mozart was unsure of the genesis of his genius. When asked how he composed, he replied that ideas 'crowded' his mind 'when I feel well and in a good humour, or when I am taking a drive, or walking after a good meal … [but] whence and how do they come? I do not know.' The unexpected idea is also frequently unexplained. ■

Kylie Ladd, PhD is a clinical neuropsychologist and freelance writer, whose most recent book is *Naked: Confessions of Adultery and Infidelity* (Allen & Unwin). Her first novel, *After The Fall*, will be published by Allen & Unwin in March 2009.