Approaches to creativity and discovery

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Should we take creativity seriously at a time of global financial and environmental crises? Not if we want to find solutions, argues Professor Julian Evans (http://www.chem.ucl.ac.uk/people/evans/biog.html) (UCL Chemistry).

In an article based on the Presidential Lecture to the Chemical and Physical Society first published in *Sophia* (http://www.sophiamagazine.co.uk) , he proposes that there is an intimate connection between laughter and creativity. Is he serious?

Where do good ideas come from? There is precious little in the curriculum about observation, creativity and discovery, which seems odd given their importance in the history of ideas. Science is presented as pictures at an exhibition after the studio is tidied; as a pristine building after the construction site is cleared; as a series of pure, clean, creative acts. We see the product but not the process. To find out what we've missed, let's break into the building site!

On the difference between looking and seeing

Most philosophers of science agree that all observations are theory-laden: students can sometimes only make observations in laboratory classes if they already know the relevant theory; something stops them seeing what is there. Perhaps there is a preconscious filter that shuts out 'what the teachers don't want'; a template for a good mark that extinguishes everything else. Similarly, postgraduate researchers have a filter based on the perceived expectation of their supervisor. If all observations are theory laden, by teaching theory do we teach what to see? Worse still, do we teach what not to see?

Before September 1985, no one had seen the hollow, often football-shaped carbon structures called fullerenes. One day, English chemist Harry Kroto found an odd mass spectrometer peak at 720 and received a Nobel Prize. After September 1985 fullerene spheres and tubes were everywhere – they are in candle soot! The important question, asked by Professor Peter Atkins in an article in the *Times Higher Education Supplement* on March 14 2009, is: why were they not seen earlier?

On Friday, March 24 1933, ICI chemists Reginald Gibson and Eric Fawcett were experimenting with ethylene and benzaldehyde at high pressure. On the Monday when they dismantled the vessel, there was waxy stuff on the wall. Instead of a cleaning challenge, this became the discovery of polyethylene, the highest tonnage synthetic polymer ever produced.

In the late 1960s an employee of a company making handbrake cables was on his way to morning coffee when he had an idea that made the company a lot of money. A handbrake cable is much like a bicycle cable, only bigger, and to secure the spiral outer to the chassis you need to turn, bore, mill and screw-cut a brass adjuster. He had worked most of his life with cables but he suddenly realised that the screw is already there, in the spiral of the outer. All they had to do was injection mould two locknuts and the brass adjuster was redundant.

In 1928, Alexander Fleming noticed that a plate contaminated with Penicillium notatum, was free of staphylococci in the vicinity of the mould. This ranks among the greatest observational achievements of all time.

Louis Pasteur gave us this aphorism: ‘In the field of observation, chance favours only the prepared mind’. When we read of Fleming’s discovery of penicillin, we find that culture dishes were always becoming contaminated. Lots of tests were discarded. What is chance in this context? Wasn’t Fleming’s genius to see what had probably been staring others in the face? Isn’t this really about the difference between looking and seeing? Was it chance that enabled the cable manufacturer to see that the thread was already there? Every hour of every working day he had been looking at handbrake cables.

What is a prepared mind? Were other chemists in Fleming’s lab educationally prepared to notice an absence of staphylococci? Were electron microscopists prepared to see fullerenes before 1985? Surely our cable manufacturer must have known everything there is to know about handbrake cables, so why did it take him so long?

Creativity in science

A huge amount has been written about creativity in science. In the 1920s the emphasis was on unconscious processes such as 'incubation' and 'intimation'. Later, in the 1960s, Liam Hudson tried to divide everyone into two groups: convergent and divergent thinkers. Divergent thinkers could, for example, write down twenty uses for a toothpick in one minute whereas convergent thinkers could only write down one or two. The 1960s 'stimulus-response' psychology of creativity also highlights the importance of making unusual associations.

In the 1950s, Humanistic psychologist Carl Rogers' approach endeared itself to scientists and articulated several principal ideas. Openness to experience expresses an absence of preconscious filters. Internal locus of evaluation expresses independence of peer pressure: we know what is good, we can trust ourselves. Allied to this idea is independence from authority; there is a hint of iconoclasm in creativity.

Toleration of ambiguity appears throughout the literature on creativity. For discussion of play, we may use Rogers' own words: '…the ability to play spontaneously with ideas, colours, shapes, relationships, to juggle elements into impossible juxtapositions, to shape wild hypotheses, to make the given problematic, to express the ridiculous, to translate from one form to another, to transform into improbable equivalents…'

Leisure also plays a part; Ernest Rutherford did not allow his staff at Cambridge's Cavendish laboratory to work after 5pm, he wanted them to relax. Among his students, John Cockcroft and Ernest Walton won Nobel Prizes.

Many people share the view that something valuable was lost when we gave up tearoom discussions, but I would suggest that also lost was an 'internal tea room'. Where can we go to be free from the barrage of emails with their demands? Herman Hesse in Demian says: 'We should be able to go inside ourselves like a tortoise.'

The role of mischievousness

Richard Dawkins tells us that children are genetically programmed for obedience. No teacher could get through the A-level if students questioned their elders: 'What is a force? What is actually between the poles of the magnet? What causes electronic charge?'

The following story has a long tradition. In an A-level physics exam, a question reads: 'You are given a barometer; explain how you would use it to estimate the height of a tall building'. One candidate replies: 'I would drop the barometer from the top of the building, time its descent, t and estimate the height, s from s = ½ gt2 where g is the acceleration due to gravity.' From one examiner, this effort gets a zero mark because the student has clearly failed to understand the question. Another examiner disagrees; the method would work, after all. They decide the student should be interviewed by the panel of examiners. The chairman begins: 'We wonder whether there are any other methods whereby you might use the barometer to estimate the height of a tall building?' 'Oh yes', says the student. There is a great deal of relief around the room. 'Please tell us', says the chairman. 'Well I would go into the caretaker's office on the ground floor and say "If you can tell me the height of this tall building, I will give you this elegant barometer."'

Here, refusal to measure air pressure is a declaration of independence from teachers and examiners, much as an adolescent gains independence from parents. Risking a zero mark is analogous to risking being thrown out of the family home after an argument. The student can take the risk because intellectual resources have appeared from beyond the examiner; in the same way the rebellious teenager finds inner emotional resources that will serve throughout life without parental consolation.

Harvard professor of education, William Perry, charted the intellectual maturation of college students. They begin in a world of duality; everything is right or wrong, true or false, good or bad. When things not known are encountered, the student first concludes that the teachers are no good, then that they are playing a game to 'make us find the answers for ourselves'. In later stages, through participation in research, the student realises that what is not known is extensive, and, set against it, knowledge seems rather limited. Young people who previously compared themselves to others now begin to compare what they know to what is not known and a new humility settles upon them, resulting in newfound openness. Perry waves them farewell thus: 'The student experiences the affirmation of identity among multiple responsibilities and realises that commitment is an ongoing, unfolding activity through which he expresses his professional lifestyle'.

In an interview in the *Financial Times*, in February 2009, one-time UCL professor of pharmacology Sir James Black said: 'Our brains seem to be organised to make random comparisons of the contents of our memories. Daydreaming allows the process to go into freefall. Suddenly there is a new idea, born with intense excitement. We cannot organise this process but we can distort or even defeat it.' Black alludes to a form of combinatorial processing which embraces many of the features in the literature on creativity: play, leisure, disorganisation etc. Combinatorial methods are used because they allow unconstrained observation.

Under the Popperian view of science, theory precedes experiment. Francis Bacon gave us a different view: experiments are done without much theory and from the array of data, we extract rules. Combinatorial experiments are based on Baconian science in which experiment precedes theory. Black's view of creativity gives an insight into how the mind can escape from the 'all observations are theory laden' trap that prevents progress.

Laughter and creativity

By what mechanism does the inner adjudicator select from the huge combinatorial pool? People often laugh when they get an idea. But what exactly is the evolutionary function of laughter? To help with breathing? The only plausible theory in the literature is to indicate to others that a putative danger was in fact a false alarm.

Why does the barometer story make us laugh? I think it originates from the moment we realised that in science, we had made a connection with something that stood above and beyond ourselves, our teachers and our parents. I have a suspicion that laughter and creativity live in adjacent semi-detached houses. When laughter laughs, creativity wakes up, and when creativity wakes, laughter laughs louder.

Is laughter connected with finding creative solutions and hence with survival? Does responsive laughter signify agreement? Is the creative solution that extinguishes compromise recognised by laughter, the shout of survival?

There is a problem with this interpretation: laughter also identifies completely ridiculous solutions. Suppose the tribe is under attack. Someone suggests digging holes so that everyone can put their head in them, ostrich-like, in order not to be seen; this might get a laugh but not promote survival. On the other hand, digging holes so that the attackers fell into them might help survival. Is it possible that laughter has chosen this particular line of thinking from the combinatorial process? How does it know that a good solution lies ahead?

It doesn't. It simply sends up a signal that a break with conventional thinking has been made. We have to do the rest. Remember, if all observations are theory laden, we cannot break free. The Baconian combinatorial method allows us to escape but we still need a way to select from the huge matrix. There is a strange similarity between a joke and a creative solution. Is it possible that these breaks with convention have been so important in the past that, through evolution, nature has conferred upon us laughter and endorphins in order to help us identify creative solutions and so survive?

Images from top: The link between laughter and discovery; Louis Pasteur; Sir James Black, one-time UCL professor; Francis Bacon

UCL context

Sophia is a volunteer-run magazine that aims to showcase talent in research, writing and art from current UCL staff and graduate students. Entries are now welcome for its 250 Graduate Writing Prize in memory of Craig Patterson on the theme of the challenge of sustainable city living and the scale of community. Find out more at the *Sophia* website (http://www.sophiamagazine.co.uk) .