

The paradoxical brain

Narinder Kapur, Jonathan Cole and Tom Manly outline some surprising enhancements of function following brain disorder

Disorders of the brain and its sensory organs have traditionally been associated with deficits in movement, perception, cognition, emotion and behaviour. It is, however, increasingly recognised that paradoxical enhancement of functioning may occur in some settings. This article provides a selective review of such phenomena – better-than-normal performance after brain lesions; situations where two lesions can be better than one; and enhanced functioning in people with sensory loss. Such findings provide an impetus for the nascent field of positive neuropsychology, and offer new avenues to understand brain-behaviour relationships, with both theoretical and therapeutic implications.

The way of paradoxes is the way of truth.

Oscar Wilde, 1891

‘Thus, the feeling I sometimes have – which all of us who work closely with aphasics have – that one cannot lie to an aphasic... it was the grimaces, the histrionisms, the false gestures and, above all, the false tones and cadences of the voice, which rang false for these wordless but immensely sensitive patients.’ Thus wrote the neurologist Oliver Sacks (Sacks, 1985, pp. 78–79) when describing the paradoxical ability of his aphasic patients to gauge from nonverbal aspects of President Reagan’s communication that there was perhaps an element of reduced authenticity in his communication.

Paradoxes have been implicit or explicit in many revolutionary medical discoveries, leading in some cases to Nobel Prizes. For example, Chandrasekhar’s Physics Nobel Prize Lecture (1984) referred to a resolution of the ‘Eddington paradox’, named after the famous English astrophysicist, whereby a star which had cooled to absolute zero somehow found the energy to undergo major expansion. Twenty years later, in 2004, the Nobel Prize for Physics was won by Frank Wilczek. His prize lecture was entitled ‘Asymptotic freedom: From paradox to paradigm’ (Wilczek, 2005). Wilczek referred to two paradoxical findings in physics that gave rise to the discovery of a new dynamical principle, ‘asymptotic freedom’. The first paradox referred to the fact that one of the hidden building blocks

of nature, quarks, are ‘born free but everywhere they are in chains’. The second paradox related to the fact that two major theories in physics, special relativity theory and quantum mechanics theory, both seemed to be viable, even though they treated the concepts of space and time differently.

Paradoxical phenomena abound in nature (Kapur, Manly et al., 2011) and are evident in fields of inquiry such as human ageing (Zimmerman et al. (2011), child development (Lewkowicz & Ghazanfar, 2011), cognitive psychology (Dror, 2011), and psychological well-being (Mauss et al., 2011). A theme running through these examples is that the discovery of the paradoxical phenomenon itself may often be serendipitous, and that what is often key is a receptive and creative frame of mind of the clinician or researcher in question, who can grasp the clinical implications of the paradox, and may be spurred to develop new ideas and new experiments to understand its nature.

The study of individuals with cerebral pathology has traditionally been embedded in the lesion-deficit model. While this has provided valuable insights into our understanding of the organisation of function in the human brain, it has its drawbacks. By focusing on the negative effects of changes, the lesion-deficit model can overlook positive changes, such as those that can emerge from plastic reorganisation. It can also introduce potential confounds, since it may sometimes be problematical to make a direct link between a behavioural deficit and the locus of a lesion or disease state due to other nonspecific or distant effects of the lesion. Lastly, it may discourage thinking about the compensatory and adaptive strategies that the brain, and the person, may use and which may assist in coping with disease and ameliorating dysfunction.

In this article, we explore examples that question the traditional view that lesion or dysfunction of the nervous system inevitably leads to deficits in performance. We do not deny that, for

questions

How can we adapt models of cognition and the brain to take account of paradoxical phenomena?

How can we use naturally occurring paradoxical improvement and recovery to inform new therapies and treatments in psychology and neuroscience?

resources

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most people, neurological impairment reduces their possibilities within the world, and frequently requires them to relearn functions and actions which previously occurred automatically. But we do suggest that this is not always the only outcome of nervous system insults.

Such ideas are not new. 'Neurology's favourite word is deficit, denoting an impairment or incapacity of neurological function', noted Oliver Sacks in his book, *The Man Who Mistook His Wife for a Hat* (1985, p.1). Ten years later, in *An Anthropologist on Mars*, he wrote, 'Defects, disorders, diseases, in this sense, can play a paradoxical role, by bringing out latent powers, developments, evolutions, forms of life, that might never be seen, or even be imaginable, in their absence' (1995, p.xii). As early as 1929, Vygotsky made a similar point in *The Fundamental Problems of Defectology*, commenting on the importance of compensatory strategies and mechanisms in cases such as blindness (Vygotsky et al., 1929/1993). Vygotsky noted, 'The doctrine of overcompensation has an important significance and serves as a psychological basis for the theory and practice of educating a child with a loss of

hearing, sight, and so forth. What horizons will open up to the pedagogue, when he recognizes that a defect is not only a minus, a deficit, or a weakness but also a plus, a source of strength and that it has some positive implications!' (1929/1993, p.29).

While the above ideas and observations are not new, what is new are hypotheses that, for example, link genes for highly technical skills with genes for autism (Baron-Cohen, 2012), that link the neurochemical profile associated with Huntington's disease to faster perceptual learning (Beste et al., 2012; Cardosa-Leite et al., 2012), and that suggest transient ischaemia as a therapeutic option to prevent the occurrence of strokes (Meng et al., 2012).

Paradoxical enhancement of face processing

Etcoff et al. (2000) found that aphasic (language-impaired) patients were better able than healthy individuals to use facial cues to detect the presence of deception in video clips of people displaying or concealing powerful emotions. To this

extent, they confirmed the clinical observations by Oliver Sacks noted at the beginning of this article. It is uncertain whether this paradoxical facilitation represented improvement due to repeated practice at using facial expression in social settings, liberation from the 'distraction' of processing the words' meaning, or more fundamental neural reorganisation of non-linguistic social processing mechanisms.

Moscovitch et al. (1997) reported a patient, CK, who showed visual object agnosia (problems in identifying objects from their visual form) and acquired dyslexia following a closed head injury. CK was able to outperform control participants in detecting faces hidden in a painting of a woodland scene (see 'The Forest Has Eyes' below). The authors argued that competition from an intact object-recognition system prevented normal people from detecting the hidden faces.

Whilst it can be argued that this 'facilitation' of particular functions within these tasks is at the cost of more generally adaptive processes (understanding words and objects), it makes the point that enhanced levels of ability despite, indeed because of, impairments elsewhere are likely to occur in everyday life. The challenge is to find and quantify them.

When two lesions can be better than one

The disastrous effects of a forest fire can sometimes, paradoxically, be offset by deliberately starting controlled fires that will deprive the main blaze of its substrate. A similar principle is sometimes used in the treatment of intractable epilepsy when the corpus callosum, connecting the two brain hemispheres, is cut to limit the spread of the seizures (Matthews et al., 2008). These patients are often referred to as 'split-brain'



'The Forest Has Eyes'

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patients. Thus, the deleterious effects of an epileptogenic lesion in one hemisphere are counteracted by the introduction of a second lesion to an intact part of the brain, the corpus callosum. This second lesion helped to largely eliminate the spread of epileptic discharges from one hemisphere to the other. The term 'double-hit recovery' may usefully describe such a second lesion effect.

The notion that the two cerebral hemispheres are somewhat independent entities that appear, for some purposes, to compete with one and other is important in understanding some other 'double-hit recovery effects'. Sprague (1966) famously demonstrated that biased perception resulting from a cortical lesion could be resolved by a lesion to a subcortical structure. Such rebalancing effects have been observed to occur spontaneously. In one example from the realm of visual perception, Vuilleumier et al. (1996) found that the left-sided visual neglect that followed a right parietal infarct disappeared after a subsequent left frontal infarction. In the motor domain, Nakashima et al. (1993) reported the case of a 67-year-old telegrapher who developed occupational cramp in his right hand after typing. Eventually, he also developed painful and disabling dystonic cramps that were triggered by writing. After a while, he was obliged to give up writing altogether, but he was still able to use his hands normally for other purposes, such as holding chopsticks. A number of years later, a stroke damaged his left striatum, subcortical structures deep in the brain, and this resulted in weakness and numbness in the right side of his body. After a week, these symptoms had largely disappeared, though he remained too weak to use chopsticks with ease. However, paradoxically, his dystonic cramp had disappeared. Ten months later, he was able to use chopsticks normally; in addition, his dystonic cramp never returned. The second lesion from the stroke, a 'double-hit', had resulted in an improvement in his motor function. Constantino and Louis (2003) reported a further example, this

time a 75-year-old dentist who had suffered from a form of familial tremor in both hands known as essential tremor. Then two strokes affecting the right fronto-parieto-temporal region resulted in left arm and leg weakness. Although the weakness persisted, presumably because of the involvement of the primary motor cortex, his left-sided tremor disappeared. Further case reports have suggested that strokes in the area of the thalamus can resolve the tremor caused by Parkinson's disease (Choi et al., 2008).

Enhanced performance and profound sensory loss

Sensory loss, such as that associated with becoming blind or deaf, is inevitably associated with limitations in everyday adjustment. But what has become apparent in recent years is that better-than-normal performance can also be reliably found in such individuals across a range of settings. For the purposes of this article and for reasons of space, we will focus on enhanced functioning in those with blindness.

For centuries, there have been anecdotal reports about disproportionate numbers of blind individuals having musical talent. In the case of one aspect of musicality, the ability to precisely name a heard note ('absolute pitch'), Hamilton et al. (2004) found that just over half of a sample of blind musicians possessed this talent. In contrast, the highest reported rates amongst sighted musicians is just under a fifth. Gougoux et al. (2004) noted better pitch discrimination in early-blind, but not late-blind, subjects. Fieger et al. (2006), reported that blind individuals are better than sighted individuals in the localisation of sounds, especially those coming from the periphery.

In the case of touch, Goldreich and Kanics (2003) have found that in early blind subjects there was evidence for enhanced tactile discrimination in a gratings orientation task. This task evaluates an individual's tactile discrimination ability in judging fine



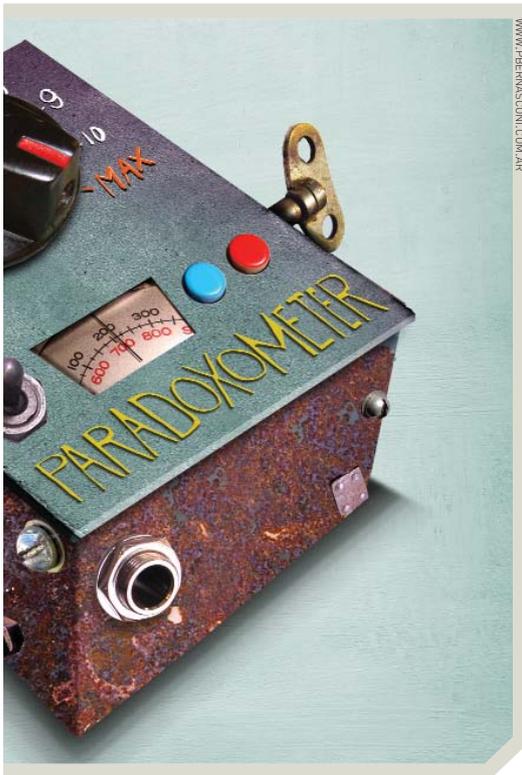
orientation differences between objects. Blind subjects also demonstrated lower thresholds on a tactile angle discrimination task compared with sighted subjects (Alary et al., 2008). Better-than-normal tactile abilities do not appear to be limited to the fingers used for Braille – some reports have also found greater tactile discrimination ability in the tongue in blind individuals (Chebat et al., 2007). In a study that examined a fascinating side-effect of enhanced sensory function in the blind, Champoux et al. (2011) reported that blind individuals were less susceptible to the parchment-skin illusion, in which the sound generated by hands rubbing together results in a change in how dry or moist the palms feel, depending on how the original sound is altered (e.g. change in frequency). The suggested explanation is that blind individuals are better at ignoring auditory stimuli while completing a tactile task.

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its environment and itself. Damage to the brain may upset one dynamic state and cause difficult-to-predict effects as it settles into a new state. Without minimising the very real losses that often arise, the paradoxical enhancements noted above emphasise the importance of looking at change rather than simply focusing on deficit. This echoes a broader approach of positive psychology and positive clinical psychology that places emphasis on dispositional optimism, flourishing, resilience and functional reserve in coping with impairment (Seligman & Csikzentmihalyi, 2000; Wood & Tarrier, 2010).

The emerging fields of 'positive neurology' and 'positive neuropsychology' in the rehabilitation of the brain-damaged individual have a similar emphasis. These fields suggest that we focus on intact skills, on past strengths and interests, and on how both rehabilitation efforts and domestic, social and work environments can be altered to take these skills and talents into account.

Research on post-traumatic growth (Joseph & Linley, 2008), for instance, points to an approach that regards an acute adverse event as, in part, a form of learning experience, one from which the individual has the potential to become stronger in terms of mental attitude and ability to cope with stress. These approaches are tailored to individuals' needs and abilities and place the patient in their social setting rather than in a purely clinical one. But the new field also, importantly, suggests that it is not only dispositional optimism that can be harnessed. In some cases, truly paradoxical improvements can occur, which may reveal important insights into brain function. Such an approach can learn from neurodevelopmental disorders, such as the autism spectrum syndrome, where enhanced abilities can sometimes result in talent (Baron-Cohen et al., 2011).

In the case of the processing of odours, Cuevas et al. (2009) reported that children with early-onset or congenital blindness perform better than sighted children at labelling common odours. In the case of memory functioning, blind people have been reported to outperform the sighted in auditory-verbal recognition (Röder et al., 2001) and recall (Amedi et al., 2003).

The neural mechanisms underlying enhanced performance in blind subjects have been unravelled in recent years, with evidence to suggest unmasking of latent auditory and tactile functions in the occipital cortex. Odour processing may also be 'taken over' by posterior areas of the brain.

Conclusions

Influential views within contemporary neuroscience view the brain as a dynamic, adaptive and evolving system shaped by

Paradoxical phenomena in clinical neuroscience point to a view of the brain as a non-linear device, which relies on dynamic synchrony and balance between neural systems. Damage to the brain may upset this dynamic state, and repair may often entail interventions that restore a degree of synchrony and balance.

We would like to propose that the paradoxical enhancements noted in this article point to a paradigm shift in how we view illnesses of the brain, and in particular point to a new, emerging field, that of positive neuropsychology. The field of positive neuropsychology in relation to such resilience has seen a greater focus over the last few years (see www.posneuroscience.org). We suggest that, however important such examples are, positive phenomena may be found more widely within neuroscience after central nervous system damage and in developmental conditions. These may open up novel ways of assisting patients, and also provide fresh insights into the functioning of the normal human brain (Kapur, Pascual-Leone et al., 2011).



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