A road map for transforming stroke recovery
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Review of Broken Movement: The Neurobiology of Motor Recovery after Stroke By John W. Krakauer and S. Thomas Carmichael MIT Press, Cambridge, MA, USA ISBN: 9780262037228 50 USD

As neurologists, we have always been told (by those in other fields) that we work in a specialty that has no treatments and is obsessed by clinical diagnosis and little else. The advent of biological therapeutic targets in neurological disease is of course changing all that. The popular view of neurorehabilitation on the other hand is that it is falling behind because there are no 'recovery' drugs, only physical, behavioural or adaptive therapies that are not particularly effective. As illustration, many years ago a recently appointed consultant neurologist was asked why he had an interest in neurorehabilitation when it amounted to nothing more than the provision of a walking stick or a wheelchair. That behavioural interventions are generally overlooked in neurology is curious for a specialty that deals with the brain, whose very structure and therefore function can be changed through experience. The naive reader of this book might be surprised to find that when in comes to recovery from hemiplegic stroke the potential options for treatment range from behavioural to pharmacological. What Krakauer and Carmichael show us is that with a little clear thinking and honest critical appraisal, we will be on the threshold of some remarkable breakthroughs in a field that has proved stubborn to crack. However, the crisis in confidence in neurorehabilitation that currently exists is not because existing therapies have not been properly tested in RCTs, but because these therapies are ill conceived from a neurobiological perspective in the first place. The message is clear - develop therapeutic approaches from a mechanistic perspective.

The book is divided into chapters that deal with behavioural or molecular and cellular consequences of stroke. We are provided with a detailed insight into the natural history of post-stroke events, how these provide opportunities for therapies and importantly, where we have gone wrong so far. In clinical practice, there is undoubtedly a nihilistic view towards recovery after stroke and this is reflected in the ever-dwindling provision of support for stroke survivors around the world. Discussion amongst healthcare providers has turned to improving support for life after stroke, as if all we can do is palliate the often-devastating effects. There is a lack of faith in the prospects for promoting brain repair and recovery. Although this book starts out by bluntly telling us that nothing that we are doing right now is having much effect, reading it leaves you with an overwhelmingly optimistic sense that we are not so far from some major advances. What is made absolutely clear though is that this will not happen if we base our future work on a 'hotchpotch' of 'half-baked', 'conceptually flawed' and (my favourite) 'neuroscientifically flavoured' ideas. The authors pull no punches. Their obvious frustration comes about because looking back through the literature, in other words what we should already know, tells us in no uncertain terms that we ought to be doing things very differently. In a sense, it is a road map for transforming the field of stroke recovery.

We know a great deal about the neurobiology of stroke recovery from experiments performed in pre-clinical animal models over many decades. What this work has told us is that there is a continuum of biological responses to brain injury that appear both in the ischaemic core, the penumbral perinfarct cortex and in more distant (but connected) brain regions. This is exciting because each of these processes is amenable to pharmacological manipulation in a way that could support brain repair and recovery. The prospects for stem cells, blockers of axonal growth inhibition, and pharmacological agents that may enhance post-stroke plasticity, such

as amphetamine, selective serotonin reuptake inhibitors, dopamine antagonists and drugs that reverse post-stroke increased tonic GABAergic inhibition are well described here. What makes this field complex, however, is that the growth programs that are activated by focal brain damage and augmented by pharmacological manipulation rely on behavioural activity or rehabilitative training to drive the formation of new and behaviourally important connections in a reconfigured brain.

So what is the appropriate behavioural therapy for post-stroke hemiplegia? The literature on behavioural recovery and therapies has been less well reviewed in the past. One of the delights on offer here is the opportunity to (re)acquaint ourselves with key historical milestones in recovery related research, some of it carried out over a hundred years ago. The behavioural consequences of corticospinal tract damage are discussed through the works of Sherrington, Tower, Walshe and of course Lawrence and Kuypers. Similarly, the natural history of recovery from hemiplegia is seen in the works of Ogden and Franz, Twitchell and Brunnstrom. It seems that we have forgotten many of the lessons from the past, most strikingly the conclusion from Ogden and Franz's primate recovery work in 1917 that perhaps humans recover poorly from hemiplegia because they are not adequately treated. The authors argue that little has changed.

In these and subsequent chapters, a number of prevalent and firmly held views are dismantled; for example, the proximal to distal gradient of upper limb weakness early after stroke; the relationship between spasticity and motor impairment (or control); the perceived importance of task-specific training (robotic therapy comes under particular scrutiny); the mantra that recovery from hemiplegia comes about though motor learning. Recent clinical trials (mostly performed in chronic stroke patients) are held to account for both for their rationale and conclusions. These trials are pragmatic rather than aspirational in the amount of training they deliver, with the notable exception of one study providing patients with 300 hours of varied upper limb training and consequently impressive results. Task-specific training remains the most commonly used treatment strategy but seems unable to deliver clinically meaningful improvements. Why is there no change in strategy? Why are increasing amounts of energy devoted to robotics, video games, virtual reality, or brain-computer interfaces in the face of underwhelming evidence? Bemusement is expressed rather than explanations proffered, and we are asked to consider what a visiting alien would make of our attempts at neurorehabilitation of hemiplegic stroke given the available evidence. There is acknowledgement that the problem is complex. Training is likely to require expert instruction, imitation, supervised learning and reinforcement, as well as mass practice. Plasticity enhancement is likely to be required for maximum benefit at some point. The key point is that the complexity needs to be embraced rather than avoided, else we keep repeating the same mistakes.

We all return to certain works for inspiration, or just confirmation, at certain times - to remind us what we already know and where we need to get to. I still have my copy of Bryan Kolb's 'Brain Plasticity and Behavior' and this book by Krakauer and Carmichael will sit very nicely right next to it. As the authors have said themselves, this is the book they wish they had had when starting out in the field. My hope is that this book leads the brightest and best to be impressed with what we already know about stroke recovery, be curious as to why clinical outcomes are still poor and then join the cause to make things better.

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