EXPLAIN PAIN SECOND EDITION

DAVID BUTLER | LORIMER MOSELEY | ART BY SUNYATA

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WELCOME TO THE EXPLAIN PAIN SECOND EDITION EBOOK

A handbook for clinicians, people in pain and their families.

All pain is real, and for many people it is a debilitating part of everyday life. However, it is now known that the more we understand pain, the less we will hurt.

Modern neurophysiology, brain imaging, immunology, psychology, pain sciences and thousands of peoples' pain stories now provide a revolutionary and new way to treat pain. The Explain Pain Second Edition, in easy to follow language, discusses how pain experiences are constructed in response to dangers and threats in our bodies and influenced by our thoughts, beliefs and context. This knowledge is the key to recovery.

With the advances in pain sciences, Lorimer and David have subtly changed some of the language and content so that the second edition can be delivered with increased confidence. Explain Pain Second Edition is extensively referenced and links to the Explain Pain Handbook: Protectometer.

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Telephone +61 (0)8 8211 6388 Facsimile +61 (0)8 8211 8909 noi@noigroup.com The procedures and practices described in this book should be implemented in a manner consistent with professional standards set for the circumstances that apply in each situation. Every effort has been made to confirm accuracy of the information presented and to correctly relate generally accepted practices.The authors, editor and publisher cannot accept responsibility for errors or exclusions or for the outcome of the application of the material presented herein. There is no expressed or implied warranty of this book or information imparted by it.

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THE AUTHORS & ARTIST

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David is a director of the Neuro Orthopaedic Institute, an adjunct associate professor at the University of South Australia and an international freelance educator. His forty years of professional life have been a blend of education, the clinic, research and writing. Education is his great love, in particular the translation of neuroscience into palatable therapeutic stories for those in pain.

David has taught manual therapy and how to Explain Pain to thousands of clinicians on all continents over the past 30 years. His books Mobilisation of the Nervous System, The Sensitive Nervous System and The Neurodynamic Techniques Handbook are regarded as key texts for manual therapists. He presides over the widely popular noijam.com – an international blog for clinical scientists.

Lorimer Moseley

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Lorimer is Director of IIMPACT in Health, Professor of Clinical Neurosciences and Foundation Chair in Physiotherapy at the University of South Australia.

Lorimer's interests lie in the role of the brain and mind in chronic pain and is widely considered the most important researcher in this field. He has written over 170 articles, several books and numerous book chapters.

A regular keynote presenter at major international pain conferences, Lorimer is an associate editor for PAIN, The Journal of Pain, European Journal of Pain and British Journal of Sports Medicine. He has won numerous awards including the IASP's Ulf Lindblom Young Investigator Award for Clinical Science (2008).

Lorimer and David pioneered the Explain Pain approach in clinical practice. Together they have co-authored Explain Pain (2003), Explain Pain Second Edition (2013), The Explain Pain Handbook: Protectometer (2015), The Graded Motor Imagery Handbook (2015), Explain Pain Supercharged (2017) and The Explain Pain Handbook: Knee Osteoarthritis (In Press 2020).

Sunyata

Sunyata has been an exhibiting artist since 1983, originally working out of a studio in the Willunga Basin, South Australia. Sunyata's disciplines are broad and eclectic and include printmaking, sculpting, ceramics, painting and music. Shortly following the release of Explain Pain, Sunyata left to experience life in India. He is now a practicing artist of the world returning to Adelaide occasionally.

ACKNOWLEDGEMENTS: SECOND EDITION

Acknowledgement of country

We acknowledge and respect the Kaurna people, the traditional custodians on whose ancestral lands in Adelaide, South Australia, we live and work. We recognise the deep attachment and relationship of the Kaurna people to country and we respect and value their cultural beliefs and their past, present and ongoing connection to the land. We also extend that respect to other Aboriginal Language Groups and other First Nations around the world.

From the authors

We are quite chuffed that the second edition of Explain Pain is quite similar to the first edition which means that we must have written the scientific side of EP reasonably correctly the first time. You will find plenty more references and support in this edition and in particular we have refined and corrected some of our language of pain.

We would like to thank the many people from around the world who took the time to give us feedback, both good and bad, on the first one. If you look carefully, you will see we have responded. Thanks to all the team at NOI who have carried this off with their usual flare, penchant for style, eye for detail and admirable patience with the authors. Ariane Allchurch and Paula Filippone for design and typesetting, Juliet Gore for editing and the multi-tasking Karin Kosiol, Kat Waterman, Tim Cocks, Dominic Legg, Fran Ammirato, Rosa Nocera and Angela Gray.

Thanks to the growing community of clinical and basic pain scientists who are working hard to better understand pain, its prevention and its treatment. These are some of the sharpest tools in the global shed and we reckon we should all be grateful that their substantial resources are working for the common good.

Thanks to the clinicians around the world who have taken the Explain Pain ball and run with it, who have collectively raised the bar with regards to what we can realistically expect in chronic pain, by giving people the resources to master their situation.

Thanks to those clinical scientists who have not taken our word for it but undertaken their own clinical trials and shown that

Explain Pain is not just for Australians – it seems to be equally helpful for Europeans, North and South Americans, Africans, Asians and Arabs. Thanks to the many people who have respectfully asked us if they can use parts of Explain Pain for their own clinical work or teaching, and others who have advocated for us and for explaining pain with their colleagues, their judiciary, on YouTube, in industry panels, pharmaceutical campaigns, prisons, parliaments, and sporting clubs.

From Lorimer:

Thanks to the people in the Body in Mind research group (now archived) at University of South Australia and Neuroscience Research Australia – as I have often said, I am very grateful to work with a group of community minded and enjoyable people with sharp minds and good hearts. Thanks to Dave, who remains an inspiration. Thanks to TMBA, Browns and Gubs for being the real fire in my belly.

From David:

Thanks to the worldwide NOI teaching team who take the research out into the clinical and professional battlefront.

Thanks to Lozza for your clinical and research devotion to the subject and for remaining normal, despite the growing demands of the world. Thanks to Daphne and Malcolm who transport the books into the world everyday. Supercat Audrey, you have helped too, but most of all thanks to Jules who keeps me, the NOI office, the NOI standard and the books rolling on.

Lorimer and David, Adelaide, May 2015

USE OF THIS BOOK

This book has five aims:

1. First, to assist a variety of health professionals in explaining pain, we wanted to provide a conduit from the world of basic neuroscience to clinicians and to their patients.
2. Second, to enable people in pain to understand more about their situation and to become less frightened of their pain. We know that the threat value of pain contributes directly to the pain experience and by informing people about what is actually happening inside them we can reduce the threat.
3. Third, to assist people in pain, and those involved with them, to make the best choices about their management.
4. Finally, to outline modern models of management and provide the treatment essentials for overcoming pain and returning to normal life.
5. To provide support for the use of The Explain Pain Handbook: Protectometer (Moseley & Butler, 2015)

The book is designed so that it can be used as a manual for clinicians to explain pain to patients, as a workbook completed by patient and clinician together, as part of a cognitive-behavioural/multidisciplinary pain management programme, or for patients to use as a 'take-home' resource.

You will find as you read, small numbers scattered throughout the text. These relate to references for further reading or sources where we have found the information. Link to a collated list in numerical order here: "References"

The principles presented in this book are particularly suited to consideration of chronic non-specific pains (eg. low back pain, elbow pain). However, they can be extended to acute pain states and those with co-existing pathology such as rheumatoid arthritis and used in conjunction with other management strategies.

We think that one strength of this book is that anyone who suffers from persistent pain, or has a loved one, colleague or friend who has persistent pain, can directly benefit from using the book. The benefit will be greater with guidance from an informed clinician where necessary.

Finally, it is hoped that health professionals will find this book, and the view of pain and pain treatment that is presented, helpful as they try to integrate modern pain science into therapy. As the literature in this area is vast we have selected the most representative literature. Every effort has been made to reference the material with the most up-to-date and relevant scientific articles.

Lorimer and David, Adelaide, May 2013

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SECTION 1

INTRODUCTION SECTION 1

No-one really wants pain. Once you have it you want to rid yourself of it. This is understandable because pain is unpleasant. But the unpleasantness of pain is the very thing that makes it so effective and an essential part of life. Pain protects you, it alerts you to danger, often before you are injured or injured badly. It makes you move differently, think differently and behave differently, which also makes it vital for healing.

Occasionally the pain system appears to act oddly – like the nail in your toe that may not even hurt until you notice blood at the injury site. Other times, the pain system actually fails – some life-threatening cancers aren't painful, which is the very reason they can go undetected and be so nasty.

Figure 1.1 *Noticing the injury when you see the blood at the site*

We believe that all pain experiences are normal and are an excellent, though unpleasant, response to what your brain judges to be a threatening situation. We believe that even if problems do exist in your joints, muscles, ligaments, nerves, immune system or anywhere else, it won't hurt if your brain thinks you are not in danger.

In exactly the same way, even if no problems whatsoever exist in your body tissues, nerves or immune system, it will still hurt if your brain thinks you are in danger. It is as simple and as difficult as that. This book will try to explain this for you.

Most commonly, pain occurs when your body's alarm system alerts the brain to actual or potential tissue damage. But this is only part of a big story. Pain often involves all of your body systems and all of the responses that occur are aimed at protection and healing. Pain is like the light on the top of the Christmas tree – there is a lot going on in and under the tree. However, when most of us think of pain we think of the experience of pain – that unpleasant and sometimes downright horrible experience that makes you take notice and motivates you to do something about the situation.

In fact, pain can be so effective that you can't think, feel or focus on anything else. If the brain thinks that experiencing pain is not the best thing for your survival (imagine for example, a wounded soldier hiding from the enemy) you won't experience pain, no matter how serious the injury is.

There are many myths, misunderstandings and unnecessary fears about pain. Most people, including many health professionals, do not have a modern understanding of pain. This is disappointing because we know that understanding pain helps you to deal with it effectively. Here are two important things we now know about explaining pain: the biology of pain can be easily understood by men and women in the street, and understanding pain biology changes the way people think about pain, reduces its threat value and improves their management of it.[1,2,3,4,5,6,7,8,9,10,11,12]

Hopefully, you will find this journey as exciting, fascinating and empowering as we have. Read on...

Figure 1.2 *Pain is necessary for life – as the image says ‘no pain, no life’*

PAIN IS NORMAL

It's the most powerful protective device we have

Of course things hurt; life can hurt. There are many kinds of pain.

Figure 1.3 *Norman won't forget the bite on his nose*

In the unlikely event that a monkey happens to bite your nose, as it has bitten Norman's, then your nose will really hurt and you will probably remember the incident for the rest of your life – Norman probably won't show off like this to his son next time they go to the zoo; the story of Norman's nose holes will be retold at countless family gatherings; it will change the way the family thinks about monkeys; it may even become the topic of nursery rhymes (eg. *'Norman's nose got bit by the chimp... ever since then the chimp's had a limp, Norman's son knows dad is a wimp... Poor old nosey Norman'*). You get the message.

You can have pain with much less obvious damage. Pain may just emerge over time, as it has with the computer-bound Mr Lee.

Figure 1.4 Computer-bound Mr Lee in pain

Pain is useful here and will hopefully encourage him to get up and move. But pain is often unpredictable, which can make us frightened of it. Sometimes you can lift an object a thousand times without a problem. Then, all of a sudden, one lift causes extreme pain.

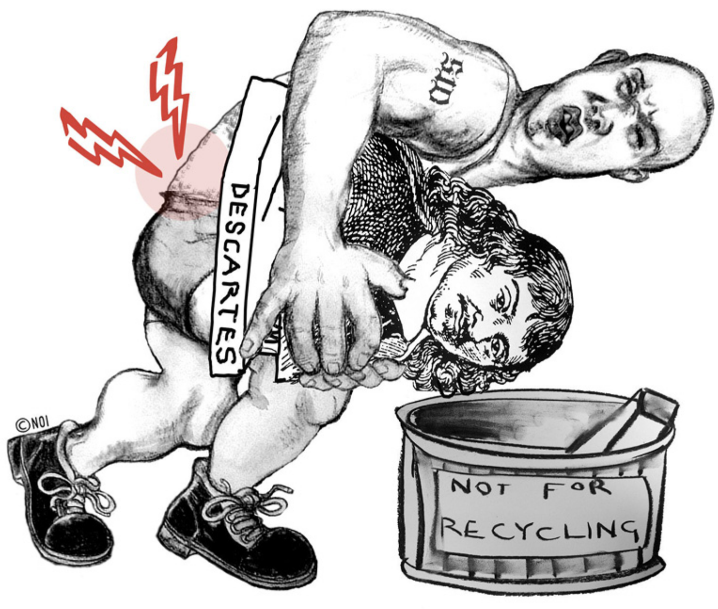

Figure 1.5 Sidney's last lift was throwing a bust of Descartes in the bin

Why would Sidney here ever want to throw Rene Descartes' bust into the bin again if it gives him back pain to do so? By the way, Rene is the French philosopher who invented the mind-body split,[13] the idea that the mind (and sometimes brain) are different from the rest of you. There is no doubt that Rene was extremely clever, but it is 400 years since he proposed his theories and those theories still provide the basis for most treatments for pain. We now know enough to be sure that this mind-body split does not exist and that there are better theories on which to base our treatments.

Pains from bites, postural pain, strains and sprains are simple ‘everyday’ pains that can be easily related to changes in tissues. The brain concludes that the tissues are under threat and that action is required, including healing behaviours. An added benefit is that memories of the pain will hopefully protect you from making the same mistake twice. Maybe the monkey bite nursery rhyme provides future protective behaviours for a whole family or even a society.

But we all know that pain can be a more complex experience. The word ‘pain’ is also used in relation to grief, loneliness and alienation. What is it about the pain of lost love that makes it as debilitating as any acute low back pain? This emotionally laden pain helps us to grasp a big picture for understanding pain. All pain (in fact, all experiences!) involves many thoughts and emotional contributions. We need the brain to help us understand why emotions, thoughts, beliefs and behaviours are important in pain.

We need the brain in order to really understand pain – especially pain that persists, spreads or seems unpredictable. That is the critical thing. If we are going to understand pain, we must engage the brain.

If you are in pain right now, then you are not alone. In fact, at any one time on the face of the earth, around 20 percent of people have pain that has persisted for more than 3 months.[14] That’s around 2 million Londoners or 4 million residents of Mexico City! In the top 10 most burdensome health issues of our time, chronic pain problems occupy first, fourth and eighth positions.[15]

When pain persists and feels like it is ruining your life, it is difficult to see how it can be serving any useful purpose. But even when pain is chronic and nasty, it hurts because the brain has concluded, for some reason or another, that you are threatened and in danger and need protecting – the trick is finding out why the brain has come to this conclusion.

AMAZING PAIN STORIES: PART 1

Losing legs and getting shot

Figure 1.6 Some warning system

Pain really is amazing. Most of us have heard stories where people have had severe injury and no pain at the time of injury. As the rat suggests – 'some warning system'! Severe injury creates lots of loud alarm signals that pour into the brain, but these do not necessarily result in pain.

The amount of pain you experience does not necessarily relate to the amount of tissue damage you have sustained.

Look at Norman (still nursing his sore nose), now unfortunately with an arrow through his neck.

Figure 1.7 *Norman's nose distracting him from the arrow in his neck: pain doesn't always equate to damage, and damage doesn't always equate to pain While the monkey bite hurt a great deal, this comparatively serious injury may not hurt at all. In emergency rooms all around the world, patients arrive impaled by various objects. Many are lucky because the object may not have interfered with vital organs, and amazingly, many report little or no pain.*[16] *Check out the story of Mr Hammerhead Shark in Painful Yarns.*[17]

There are many stories from wartime. Take the World War II veteran who had some routine chest x-rays done. They revealed a bullet that had been lodged in his neck for 60 years – he never knew![18] Many stories involve soldiers in wartime who have a severe injury, even losing a whole limb, yet who report little or no pain.[19] Those who suffered traumatic amputations in wartime and commented that there was no pain, usually described a 'bump' or a 'thump'.[20] When President Reagan was shot in March 1981 he felt no pain. On the anniversary of the shooting he said ,"I have never been shot before except in the movies. Then you act as though it hurts. Now I know that does not always happen."[21]

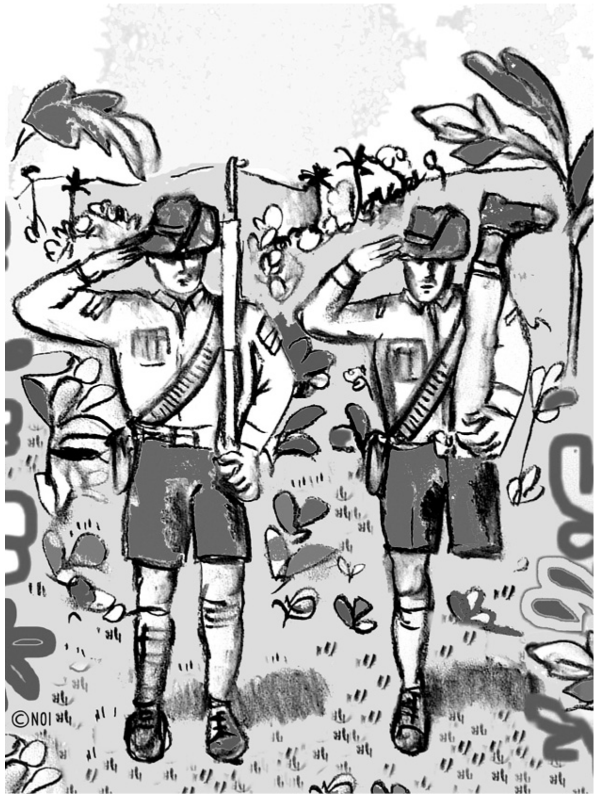

Figure 1.8 *WWII: pain doesn't always equate to damage but is influenced by context*

In other situations, severely burnt people have run back into burning houses to save children, sportsmen and women have accomplished amazing feats despite severe injury.

But the ratio of the amount of injury to the amount of pain swings the other way too. What is it about a paper cut? It's not deep, there's not much damage, but it really hurts, it stings, it makes you annoyed and you can't believe that a paper cut could hurt **that much**.

Figure 1.9 *Paper cut: small cut, big pain!*

Obviously what's happening in your tissues is just **one part** of the amazing pain experience. Let's contemplate a few more amazing pain stories...

AMAZING PAIN STORIES: PART 2

Bulging discs and shark attacks

Low back pain and headache are among the most common pains in humans. In low back pain, research has shown that the amount of disc and nerve damage rarely relates to the amount of pain experienced.[eg.22] In fact many of us have scary sounding disc bulges, even squashed nerves, yet may never have any symptoms. (We discuss this more in "Helpful nerve knowledge".

This can be a bit frightening, but it is really quite relieving when you understand pain. Many changes in tissues are just a normal part of being alive and don't have to hurt. What's more, these changes don't necessarily have to stop anyone leading a very functional and active life. It is very likely that an x-ray of an older person's spine will reveal changes which could be described as arthritic or degenerative, as you see in the yogi. Yet they can still function very well.

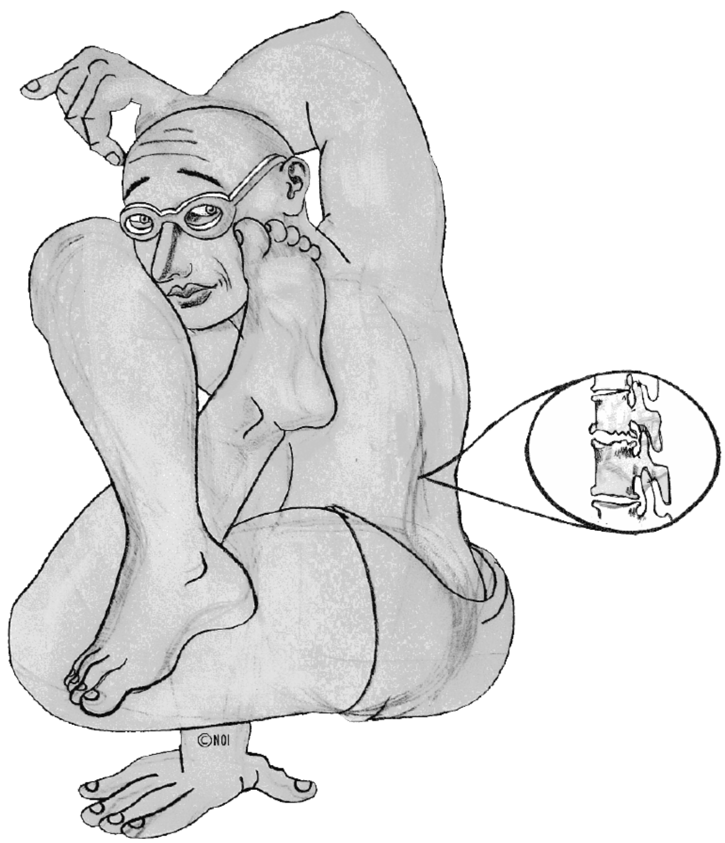

Figure 1.10 *The Yogi's brain isn't perceiveing his changes in tissues to be a threat*

Simply, if there is no pain it means that these changes in tissues are not perceived by your brain to be a threat.

We couldn’t resist another common example of extreme forces on the body without causing pain. A football player who scores a significant goal is likely to have his entire team jump on him; a weight of nearly a tonne. Yet he will always jump up smiling and keep playing, often better than before.

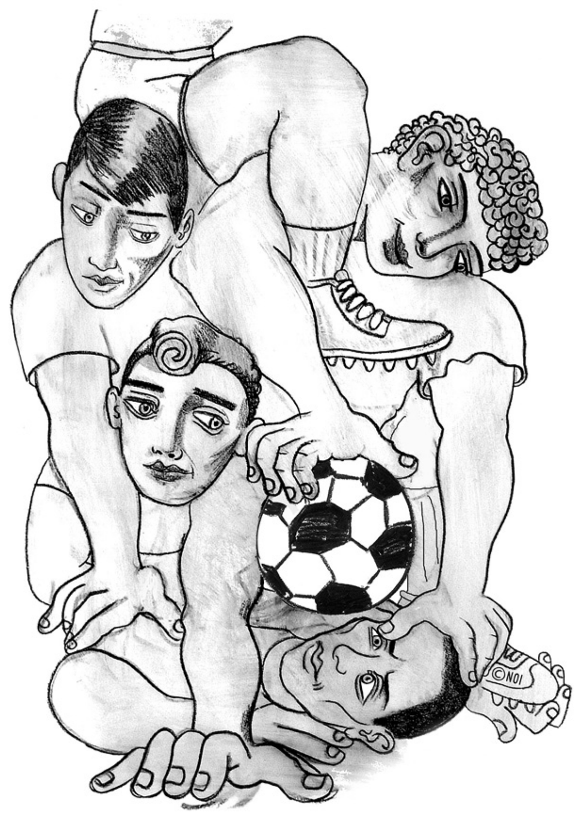

Figure 1.11 *Soccer players may not feel pain during a match*

Imagine if the same football team jumped on top of someone walking down the street – that would hurt a lot and there may be legal consequences. And under these circumstances a minor injury may be sufficient to lead a person into a life of chronic pain.

Look at Sidney on his surfboard waiting for the perfect wave at Bondi Beach in Sydney.

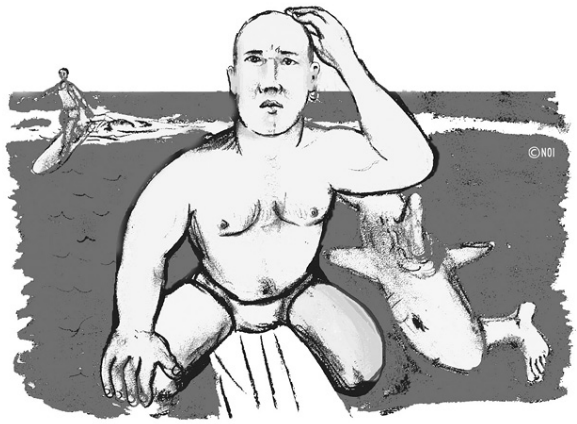

Figure 1.12 *Shark bite may not be felt by a surfer*

Surfers who have had their legs bitten off by sharks also have reported feeling nothing more than a bump at the time.[23]

AMAZING PAIN STORIES: PART 3

Pills and acupuncture

What about these true and amazing stories?

Pain is indeed complex. There is a well reported syndrome called the Couvade syndrome, in which the father experiences labour pain. In some societies people believe that the more pain the father displays the better father he will be. Some wives actually look after the husband while delivering the child.[eg.24,25]

Figure 1.13 *Couvade syndrome – when the partner shares the labour pain*

Acupuncture can reduce pain, but it doesn't always work. In fact it is thought that acupuncture works best if it is performed by a Chinese man on a Chinese woman in China and worst if it is performed by a non-Chinese woman, on a Chinese man, outside of China.

Figure 1.14 *Acupuncture*

Hypnosis is fascinating. There are many records of people who have undergone major surgery while hypnotised, without medical anaesthesia.[26] How can this be? The alarm bells in the tissues would still ring as the scalpel slices through skin and muscle, yet there is no pain.

Figure 1.15 *Hypnosis*

A little trivia – people around the world consume more than 100 billion aspirin tablets (40,000 tonnes) per year. If you put them all in line, the line would be one million kilometres long (that's to the moon and back).[27] We may not need to eat so many tablets when we understand pain better. It's a known fact that the shape of the tablet plays a part in the effectiveness of the drug. Transparent capsules with coloured beads work better than capsules with white beads, which work better than coloured tablets, which work better than square tablets with the corners missing, which work better than round tablets.[28]

Figure 1.16 *Effectiveness of tablets influenced by their appearance*

The point is that pain depends on many different factors and it is the brain that decides whether something hurts or not, 100% of the time, with NO exceptions.

PAIN RELIES ON CONTEXT: PART 1

Violinists' fingers and the pain of grief

Sensory information, or 'sensory cues', (any information coming from your senses, such as vision and touch) needs to be evaluated by your nervous system. Evaluation of these cues involves complex memory, reasoning and emotional processes, and must include consideration of the potential consequences of a response.[29,30]

Figure 1.17 *the same minor finger injury will cause more pain in a professional violinist than in a professional who doesn't have such a strong reliance on their fingers The context of the pain experience is critical. Here is a simple example: exactly the same minor finger injury will cause more pain in a professional violinist than in a professional dancer[31] because finger damage poses a greater threat to the violinist. The event plays a greater role in the violinist's livelihood and identity. What's more, it will cause more pain if it involves the left hand than the right hand. See if you can work out why by comparing the role of the left and right fingers. The fingers of which hand are the most important?*

Here is another amazing experiment – a painful stimulus will hurt more if you are told it is hot, than if you are told it is cold.[32] In fact just pairing a painful stimulus with a red light hurts more than when it is paired with a blue light.[33]

It's not only pain which relies on context – if someone tickles you, you may giggle – it depends on who tickles you and the time and place of the tickle.

Reflect back to the first image in the book of the large nail piercing the man's toe.

Figure 1.18 *Nail in the toe: pain is relative to environmental context*

When you step on a nail in the garden, it may or may not hurt immediately. The brain has to decide whether pain is the best thing for you at that moment. Other influences which may exist at the time include avoiding other nails, the fear of serious damage and infection, and the need to protect others. It probably won't hurt if you also observed that a deadly looking snake is lying close to your foot.

Emotional and physical pain are frequently used terms which can be unhelpful. Although many people tend to separate these pains, the processing in the brain of painful tissue injury and anguish has some similarities.[34,35] In fact the processing of any cue that is important is similar.[36,37,38]

Figure 1.19 *Pain is relative to emotional context*

Some pain experiences include more tissue injury or disease than others, but there will always be varying emotional content. In pain experiences such as grief or rejection from a loved one, where there is a high emotional content, there will still be physical issues such as changes in muscle tension and altered cellular healing. In a situation where a man has had a work injury, say from lifting or falling, and his pain state is denied by a supervisor or health professional, there may be very strong emotional and physical components. The extent of emotional and physical components of a pain experience clearly exist in a spectrum.

To effectively deal with pain, it is important to identify the contextual cues. We like to call them the cues that help ignite a pain experience, or **'ignition cues'**.

PAIN RELIES ON CONTEXT: PART 2

The issues of context, and thus identification of ignition cues, are so important in the pain experience. Here are some more examples.

Figure 1.20 *Pain is relative to stress, for example in the workplace*

Pain in the office is common. It may be worse when the boss is present, depending on your relationship with the boss. Here the environment is a critical cue with many contributing subplots. This image is a reminder of the contribution of gender roles, sexism, sense of control, workload and ergonomics in pain experiences.

A pimple is never desirable. But that pimple might feel enormous and be more painful to touch if you are about to go out on an important date, business meeting or school photo session. You may even touch and play with it even more.

Pain is dependent on its perceived cause. For example post-breast surgery, patients who attribute pain to returning cancer have more intense and unpleasant pain than those who attribute it to another cause, regardless of what is actually happening in the tissues.[39]

In another example, subjects (volunteers!) placed their head inside a sham stimulator and were told that a current would be run through their head. Pain increased in line with the instructed intensity of stimulation even though no stimulation was given.[40]

A lack of knowledge and understanding also creates its own inputs and increases fear. For example, unexplained and ongoing pain and deep injuries that you can't see, unlike most skin injuries, increase the threat of pain. The more information that a patient has about a surgical procedure, even knowing that pain after surgery is quite normal, the smaller the amount of analgesics required[eg.41] and the length of the hospital stay will be shorter.[42]

The amount of pain a person experiences is influenced by who else is around. In pain experiments, males have been shown to have higher pain thresholds if tested by females.[43] Also, when accompanied by their spouse, a patient with a very attentive and caring spouse will have more pain than a patient with an uncaring spouse.[44]

Ask yourself why?

Figure 1.21 *The experince of having a needle is influenced by who gives the needle*

And finally, one of the most common pains on the planet is toothache.

It too is dependent on context. Does it hurt more because dental work is expensive? All dentists are aware of the patient who makes an emergency appointment, yet the toothache disappears the moment the person enters the dentist's surgery. Toothache is a great example of pain making you take action. If your pain has gone, your brain is probably satisfied that you have taken the required action before the dentist has even looked in your mouth.

Figure 1.22 *Finances can influence pain level*

THE PHANTOM IN THE BODY

The idea of the virtual body

Phantom limb pain is the experience of pain in a body part that does not exist. Seventy percent of people who lose a limb experience a phantom limb. It's not all legs and arms either. Phantom breasts, penises and tongues have been reported.[eg.45] We believe that all pain sufferers could benefit from knowing more about phantom pain.

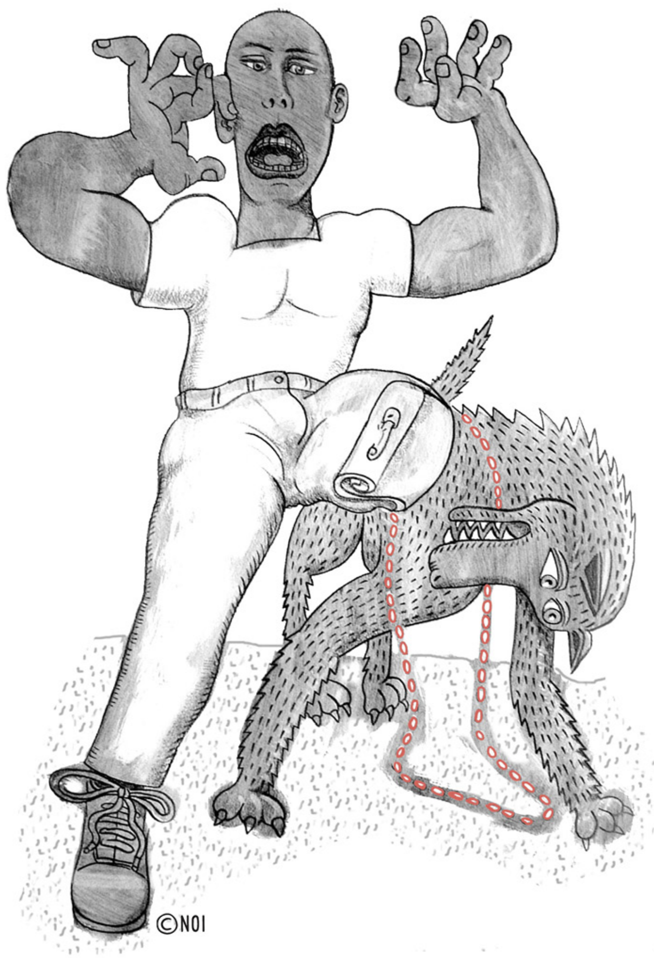

Figure 1.23 *Phantom limb pain: the lost limb can still hurt*

The feelings in a phantom limb are completely real. It can itch, tingle and hurt. Like other pains, phantom pain worsens when the person becomes stressed. The symptoms worsen when someone comes close to where the body part would have been, some feel morning stiffness in phantom joints.[46] Others have reported feeling rings on phantom fingers, old surgery sites, and hands still clenched as though on a motorbike handlebar. Some report phantom legs that ‘can’t stop walking’.

Pain after amputation is usually more severe if there was pain before amputation.[47] This is a type of pain memory.

Phantom limb pain tells us about the representation or map of the limb (the ‘virtual limb’) inside the brain. In fact, the brain holds many virtual bodies. Our virtual bodies let us know where our actual body is in space. Try closing your eyes and reaching for a cup. You can still do it because your brain uses the virtual body to know where the real body is. In phantoms, although the leg is missing, the virtual leg and the relationship of the leg to the rest of the body is still represented in the brain.

Even if you are born without limbs, it is still possible to have phantom limbs.[48] What this tells us is that there must be a virtual body in the brain from birth. This virtual body is further constructed, refined and added to as we grow and do new things. Take, for example, learning to kick a ball. The map of the leg would link to areas in your brain that are involved in balance and coordination and the use of particular muscles.

Some studies using brain imaging[49,50,51] have shown that phantom pain is associated with extensive alterations in the way that parts of the brain are organised. In fact, imaging studies show that marked changes occur in the brain with any chronic pain situation, not just phantom pain.[52,53,54] These alterations result in changes in the virtual body. For example, in the case of phantom leg pain, the brain area related to the leg actually ‘smudges’ so that there is no longer a clearly outlined virtual leg in the brain.

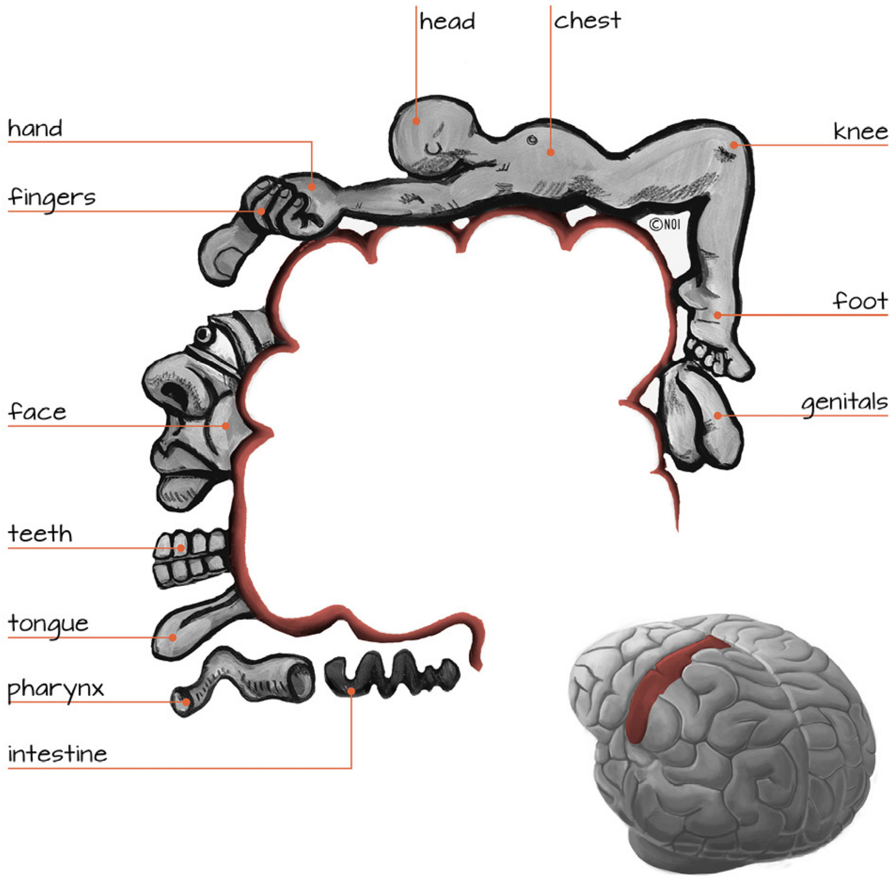

__Figure 1.24__ The sensory map in the brain – groups of neurones devoted to body parts (the homunculus) are in a thin strip of brain just above your ear Age, gender, culture and pain

The exact effects of age, culture and gender on pain are difficult to study and are not fully understood, although research in the area is developing quickly.

Age

The medical view has often been that older and younger people feel less pain than middle-aged people. This is not true.[55,56] The way of thinking about pain that is presented in this book is of equal use for all ages, with adaptation where necessary. Generally speaking, if a railway crossing boomgate falls evenly on a 10 year old, a 45 year old and a 62 year old they will all say it hurts at about the same amount of force. That said, the response to being struck will vary according to age. A baby will scream, a child will cry, an adult may react in various ways, including suing the railways.

Figure 1.25 *Contrary to historical beliefs, your age doesn't necessarily influence your pain experience*

The prevalence of some pains, such as back pain, varies throughout the lifetime.[57] For example, the over 60s have less back pain than the under 60s.[58] This shows again that pain is not necessarily related to the amount of degeneration in tissue, although some conditions which may be painful such as osteoarthritis become more common with increasing age.

Have you ever noticed that when infants hurt themselves, they often look to their parents before screaming with pain? Parents can 'inform' infants about the meaning of the sensory input they are receiving (health professionals also inform patients, rightly or wrongly about the meaning of sensory inputs). The early impact of meaning has been investigated in association with injections: the second injection a child receives usually causes more pain behaviour (eg. screaming, avoidance) than the first.[59] Also, during immunisation the pain behaviours of a young circumcised boy are more obvious than those of a non-circumcised boy.[60]

Gender

Differences in pain experiences might be due to reproductive organs and/or societal gender roles. For example, they might follow stereotypes: mother or father roles, women wearing high heels, men with beer bellies, women with big breasts, stereotypical job demands, hobbies or sports played. These differences in pain are usually caused by different societal roles not different biology.

There is a popular myth that females have a lower pain threshold and tolerance than males, at least until females go through labour, at which time their pain threshold and tolerance 'magically' rises. It is more likely many females will report pain more honestly until they have experienced labour, at which time they feel 'obliged' to be 'tougher'. There is still a tendency to undermedicate female pain patients in comparison to males, which suggests health professionals may 'psychologise' the pain of females more than the pain of males.[61]

We should also acknowledge that most pain research to date has been done on male animals by male researchers. Perhaps our understanding of pain will change when these research conventions change.

Culture

Initiations are a great example of cultural influences they often involve severe injury but are rarely described as painful. Why would pain be a sensible response when the point of the initiation is to enter manhood? What about the Easter crucifixions (voluntary) in the Philippines – little or no pain is reported. Now, why would pain be sensible when the point of the crucifixion is to come closer to God?

Many studies[62,63] report differences in pain thresholds and responses between people in different cultures. For example, the level of radiant heat found to be painful to Mediterranean people is merely regarded as warm to northern Europeans.[64]

Figure 1.26 Cultural influencers in pain

Your pain will never be the same pain as that experienced by your health professional or anyone else for that matter.

RECAP

Recap Section 1

- All pain experiences are a normal response to what your brain thinks is a threat.
- The amount of pain you experience does not necessarily relate to the amount of tissue damage.
- The construction of the pain experience of the brain relies on many sensory cues.
- Phantom limb pain serves as a reminder of the virtual limb in the brain.

Section 2

INTRODUCTION SECTION 2: YOUR REMARKABLE DANGER ALARM SYSTEM

Over thousands of years we have evolved a remarkable sensory system that is constantly detecting even small changes in the body and telling the brain about them. Almost always, the brain responds without it ever reaching our consciousness.[65,66,67,68] One component of this sensory system is the danger alarm system – a highly sophisticated system that detects changes that are big enough to be dangerous. This is how our brain is warned. It will tell the brain where in our body the danger is. It will tell us about the amount of danger and the nature of the danger (eg. a burn compared to a pinch).

Be grateful for your alarm system. Some diseases and injuries may involve faulty alarm systems (eg. diabetes and some forms of whiplash). The ramifications of this can be huge, for example in leprosy, which is famous for gangrene, limb loss and deformity, there is actually a failure of the alarm system.

There are rare cases of people born with a faulty danger detection system. This is a major problem because they don't feel pain when their bodies are truly in danger.[69] Life threatening situations such as acute appendicitis may not be detected and these rare cases remind us that despite pain being often nasty, we all need a pain system.

The alarm system has great back-up systems. Vision, smell, hearing and taste all combine to keep the body from self-destruction. One of the main advantages that humans have over the rest of the animal kingdom is that we can predict the future. We can use our memories and reasoning ability to avoid danger before it happens. It's a tough world out there and our bodies are trying to help us as much as they can.

The alarm system has to have a command centre, obviously the brain. In the same way your most precious possessions would preferably be stored inside an alarmed safe with soft padding, the alarm command centre is located in the safest place in the body – the bony safety of the skull (skull bones are our strongest bones) and nestled in a hydraulically- cushioned environment. There are other subcommand centres too. These are also located in reasonably safe places – next to the bony vertebrae. In the next picture, a paper cut has damaged some tissues in the skin and rung a few alarm bells. But it is more complex than this. Alarm bells ringing does not necessarily mean that there will be pain.

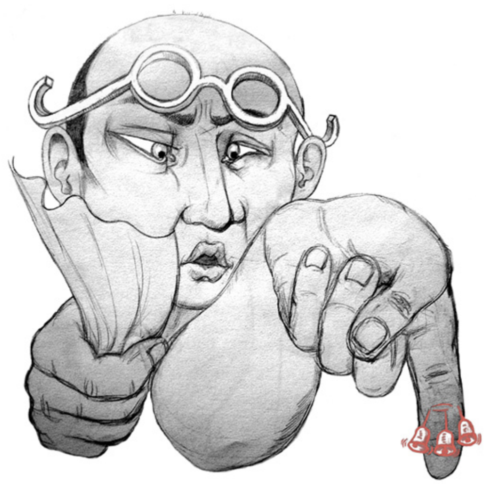

Figure 2.1 *Alarm bells alerting tissue damage*

If you place your hand over a hot surface, the increasing warmth will begin to ring a few bells and a few messages of impending danger will be sent from the skin in your hand. The process which may eventually turn these danger messages into pain is far more complex. In this next section we take a look down the microscope at this remarkable alarm system which exists in us all.

A CLOSER LOOK AT ALARM SIGNALS

Sniffing little reporters can set off alarm bells

Throughout your entire nervous system, there are millions of sensors. They are like reporters that are constantly sniffing around and surveying their area for activity. These sensors sit in the walls and at the end of individual nerve cells (neurones), and they give the neurones the ability to convey information. See “The peripheral nerves” for more on neurones.

Sensors can be quite specialised. Some will respond to mechanical forces (M) such as pinch or pressure. Some respond to temperature changes (T), both hot and cold. Others respond to the presence of chemical changes (C), either from outside your body (eg. nettles, allergens) or from inside your body (chemicals released by cells, or carried in body fluids eg. lactic acid). When sensors respond to a stimulus, such as acid or a pinch, they open so that positively charged particles from outside the neurone rush into the neurone. This sets up an electrical impulse in the neurone.

These sensors, along with the sensors in your eyes (specialised to respond to light), ears (specialised to respond to sound waves) and nose (specialised to respond to chemicals in the air) are your first protection against potential harm. Your brain will be warned about the most dangerous stimuli and if one type of sensor fails another may take over.

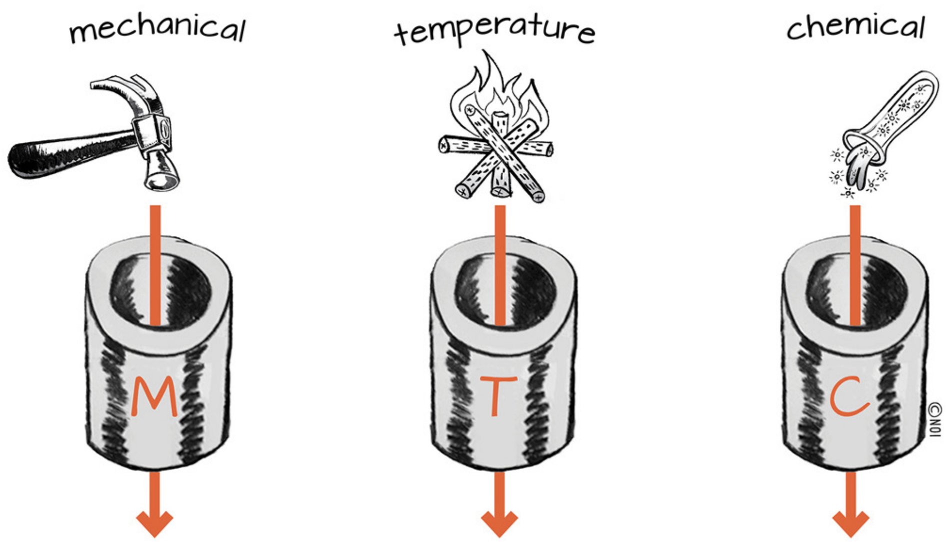

Figure 2.2

Meet some mechanical, temperature and chemical sensors responding to inputs As well as the sensors being specialised, the neurones in which they sit can be specialised. For example, the electrical impulses in some neurones travel 150 kilometres per hour and in others, only one kilometre per hour. The information that the neurones give the central nervous system is quite limited. For example, the spinal cord is told ‘increased temperature in my area’, or ‘increased acid level in my area’, or ‘DANGER! in my area’. The complex sensations that we are aware of, like ‘tearing’, ‘stretching’, ‘ripping’, ‘painful’ and ‘agonising’, are produced by the brain’s construction of events, which is based on its evaluation of all the information available to it, not only the danger messages.

Vital sensor information

1. Most sensors are in your brain. These sensors are specially suited to chemical activation. All sorts of thoughts can make alarm bells in the brain ring, just as stinging nettles and other stimuli can make the alarm bells in the peripheral nerves ring. Let’s start with the sensors in the nerves from your skin, muscles and bones.
2. When you look at neurones under the microscope, there is a lot of action at the sensors. We have drawn a mechanical (M), a temperature (T) and a chemical (C) sensor. A mechanical sensor can be opened or shut by particular chemicals. For example, if you go to the dentist and have a needle, the chemicals in the injected drug close the sensors so they can’t detect mechanical stimuli. This means that no impulses go to the spinal cord and onto the brain. Other drugs and chemicals

can keep the sensors open. For example, the sting of a sting ray, regarded by anyone who has been stung as the most painful thing they have experienced, works by locking sensors open.

3. The life of a sensor is short – they only live for a few days and then they are replaced by fresh sensors.[70] This means that your sensitivity is continually changing. Remember this point. If you are a pain sufferer, it may give you fresh hope. Your current level of sensitivity is not fixed.
4. Sensors are made inside your neurones under the direction of the DNA – the greatest recipe book of all. There are all sorts of recipes in the DNA – including those for many different kinds of sensors. The particular sensor made by a particular neurone depends on which recipes are activated. The recipes activated depend on your individual survival and comfort needs at the time. The sensor mix is normally relatively stable but can change quickly. If your brain decides that increased sensitivity is best for your survival, the DNA can increase the manufacture of more sensors that open to stress chemicals such as adrenaline.
5. Similarly, the rate at which sensors are made is normally relatively stable but can change quickly. A change in the rate of sensor production increases or decreases the sensitivity of that neurone to a particular stimulus. If you have persistent pain, you should take hope from this because the rate of sensor manufacture can be reduced if the demands for production are reduced.

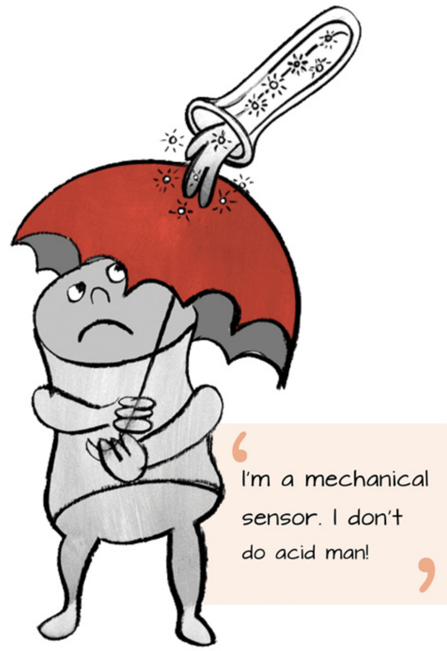

Figure 2.3 *A sensor primed for mechanical activation won't be activated by a temperature or chemical trigger*

A CLOSER LOOK AT ALARM SIGNALS (CONTINUED)

So, how do sensors and sensor activity relate to pain?

This book is about pain, but we don't actually have 'pain receptors', or 'pain nerves' or 'pain pathways' or 'pain centres', despite what you will read elsewhere. However, there are some neurones in your tissues that respond to all manner of stimuli, if those stimuli are sufficient to be dangerous to the tissue. Activation of these special neurones sends an alarm signal to your spinal cord, which may be sent on towards your brain. Activity of this type in these nerves is called 'nociception', which literally means 'danger reception' and danger reception is neither sufficient nor necessary for pain. We all have nociception happening nearly all of the time – but only sometimes does it end in pain. For example, the pressure on your bottom from sitting and reading this book will send danger messages to your spinal cord. It is unlikely to hurt, though now that we have reminded you, you will probably wriggle a bit!

Nociception is the most common but by no means the only precursor of pain. For example, some thoughts and places can activate alarm signals right inside your brain without nociception occurring anywhere. Remember the “sham stimulator”

Remember, nociception is neither sufficient nor necessary for pain.

Various sensors are embedded in the membrane of a neurone. If a sensor is open, ions flow through. Many sensors only open to specific input. **M** opens to **mechanical** forces, **A** opens to **acidic** or chemical forces, and **T** opens to **temperature** changes. If there are enough sensors open, positive ions flow into the neurone and send a danger message to the spinal cord.

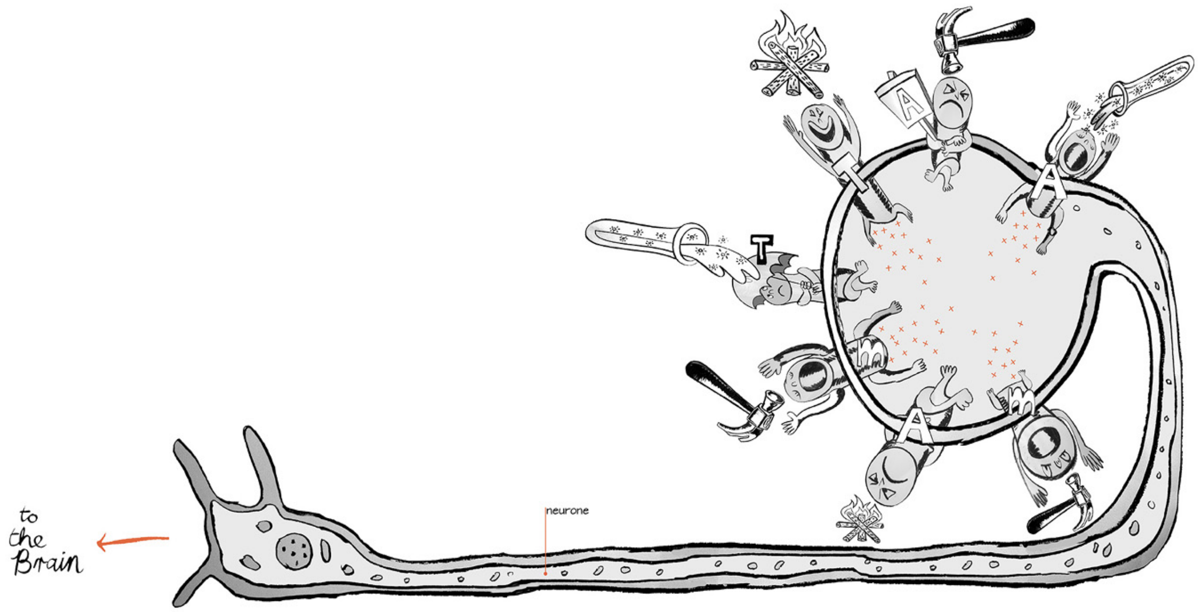

Figure 2.4 *Sensor activity relating to pain*

SENDING MESSAGES

A critical number of open sensors will start the response

Neurones are electrically excitable. Every time a sensor opens and positively charged particles rush in, the neurone becomes a little more excited. When more sensors open and the excitement inside the neurone reaches a critical level, a rapid wave of electrical current travels up the neurone. This electrical current is the message, technically called a ‘spike’, or an ‘action potential’. Action potentials are the way that nerves carry messages – an action potential is a single message.

On the graph on the facing page, the horizontal axis is time and the vertical axis is level of excitement (electrical charge or, for the electricians amongst you, the potential difference or voltage across the membrane of the neurone). Note at the start of the graph, how the level of excitement varies, mainly due to the number of sensors that are open. Also note the critical **‘all or none’** threshold at which an action potential (message) occurs.

When the actual level of excitement gets close to the critical level of excitement, then even small events that only open a few sensors may set off the message. So, if this neurone was specialised to carry ‘danger’ messages, then just a small stimulus like a tiny movement or a change in temperature can be enough to make it reach the critical threshold and may make it hurt (depending of course on the conclusions made by the brain).

Remember, when we are talking about danger reception, the message that is sent along the nerve to your spinal cord only says ‘danger’.

It does not say ‘pain’. Somehow the spinal cord and brain has to receive and analyse these inputs and create meaningful experiences which may or may not include pain.

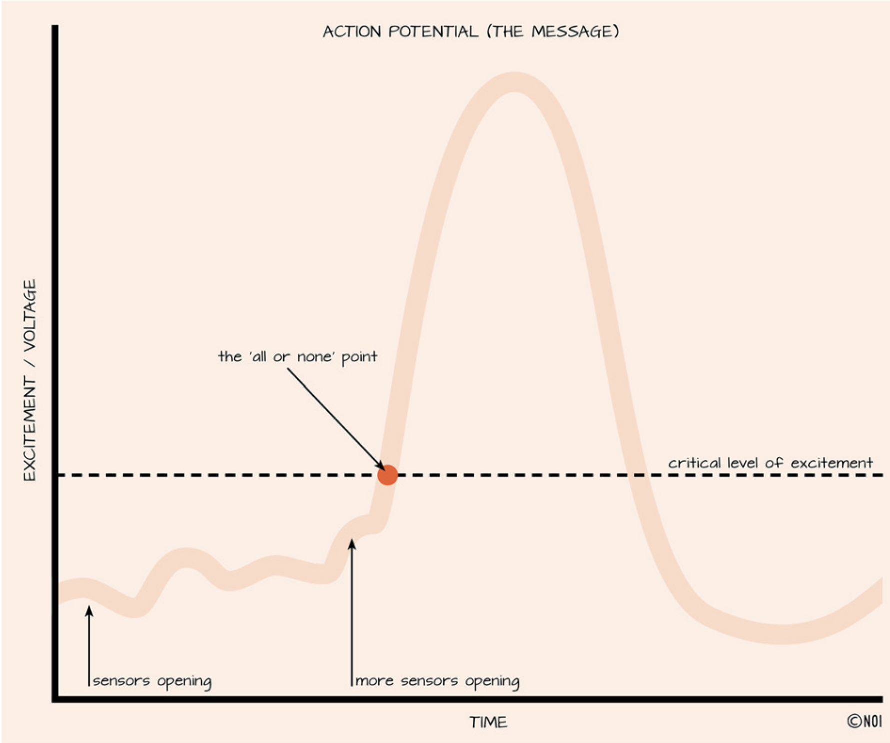

Figure 2.5 *Action potential graph*

THE ALARM MESSAGE MEETS THE SPINAL CORD

When the message reaches the end of the neurone in the spinal cord (inside your back or neck) it causes chemicals to be poured out into the gap (synapse) between the end of the neurone and neighbouring neurones.

Check out the drawing and note the following:

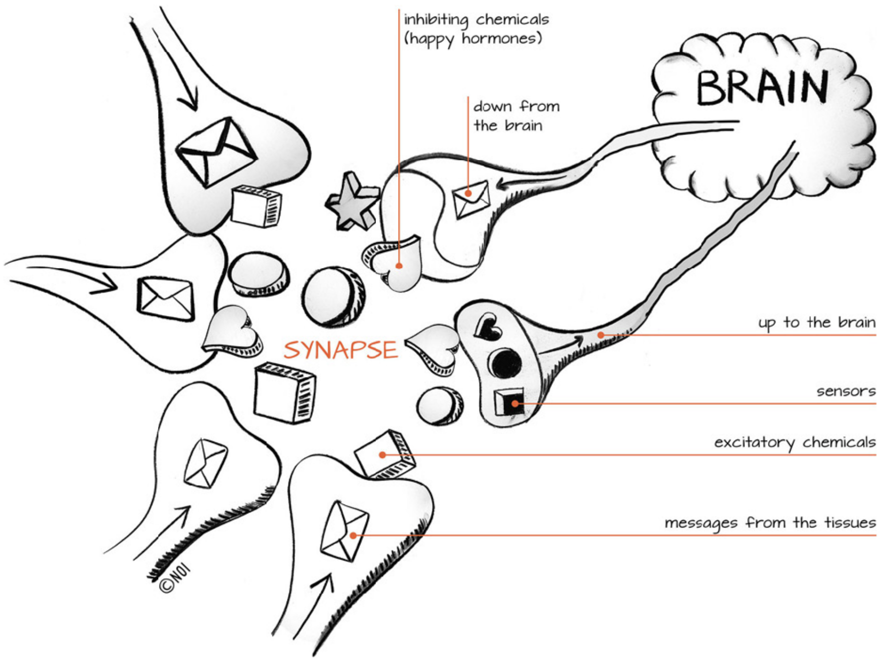

Figure 2.6 *The alarm message meets the spinal cord*

- The synapse (gap between the neurones).
- Many neurones carrying messages from the tissues converge on one neurone to the brain (this is one way in which pain can spread – one neurone carrying messages from tissues could come from the foot, another could come from the knee).
- There is a neurone that comes down from the brain. This stops action at the synapse and danger messages may go no further – more on this important one later.
- How each tissue message neurone releases a mix of chemicals into the synapse – symbolised here by circles, squares, hearts and stars.
- How at the other side of the synapse, the neurone to the brain

has heart, square and round sensors. This allows it to respond to some chemicals but not others.

- Basically, round chemicals fit in round sensors, square chemicals in square sensors, etc etc. If they fit, they open the sensor. This is called the ‘lock and key’ principle. You have just completed second year university biology.

Sensors in the neurones to the brain

Some of these sensors in the next neurone act for day to day danger messages: some are special memory sensors; some are reinforcing sensors and some sensor activity can be reinforced by activation of the immune system.

When your whole body is under threat, for example when you have the flu, increased sensitivity is a common feature.

A danger message will pour particular (let’s say square) chemicals into the synapse. The square chemicals are the keys to unlock the square sensors on the second neurone. When the excitement level of the second neurone reaches the critical level – WHAM! – the second neurone sends a message up to the brain. This message says ‘Danger!’ This is why these second neurones are called ‘second order nociceptors’. We call them danger messenger neurones.

Sorting at the synapse

The synapse in the spinal cord is an important sorting site – a bit like a post office. The inputs and outputs of a post office are constantly changing. If there is a party in the post office and everyone is excited, all sorts of messages may pass. However, this is just a regional post office and, to some degree, its activity is controlled by the central post office (brain). In fact, the central post office (brain) can even shut down the regional office (spinal cord) via a very powerful internal danger management system (the neurone from the brain).

The drug cabinet in the brain

How is that done? A pathway comes down from the brain to meet any arriving impulses. Have no doubt about the strength of this pathway, so powerfully shown in the amazing pain stories. It must be more powerful than any drug you can inject or ingest (and no side effects or prescription required). It allows a flood of chemicals (happy hormones) such as opioids, serotonin, and some morphine which are all different in shape and which therefore activate different sensors. These sensors actually make positively charged particles **leave** the neurone, which makes it **less excited**, which in turn makes it less likely to send a message. So, the descending input dampens down the alarm signals.

Yes, with this system, you can win the grand final or the world championships or cook for twenty while still carrying injuries. The best way to power it up is to have knowledge and understanding.

THE MESSAGE IS PROCESSED THROUGHOUT THE BRAIN

Lots of others are processed at the same time

So, if the danger messenger nerve from the tissues gets past the synapse, the danger message goes up the spinal cord into the brain. The danger message arrives along with a lot of other messages and they are all processed by the brain. **The challenge for the brain is to construct as sensible a story as possible, based on all the information that is arriving and the vast amount that is already stored inside.** The brain 'weighs the world' and responds by doing many things, one of which is giving you a perception of what is happening. One way to think of pain is that it is part of the response of the brain to the information that is arriving. (Other responses could be moving, sweating, speaking etc.).

In the last ten years, technology has allowed scientists to take pictures of what is happening in the brain when people experience things such as pain.[71,72] We have probably learnt more about the biology of pain in the last twenty years than in the previous thousand years.

One of the most important things that we have learnt is that in a pain experience, hundreds of brain parts are involved simultaneously. Although consistent patterns can be seen during pain experiences, the exact parts and amount of activity vary between people and even between measuring occasions in the same person.[73,74] Every pain experience is unique.

There is not just one pain centre in the brain, as people used to think. There are many areas which may be involved in pain. We call these areas 'ignition nodes'.

These brain parts include clusters of nodes used for sensation, movement, emotions and memory. Pain just uses these parts to express itself. In chronic pain, some of these nodes become very sensitive and it is as though they are repeatedly hijacked into what we call a pain neurotag. (See Ornithology and Amazing Grace in Painful Yarns[75]) In the next figure, we have identified some of the brain parts that are often active ('ignited') during a pain experience. These parts all link up to each other electrically and chemically. It's a bit like the picture you find in the back of an airline magazine that shows all the routes across the country. The particular pattern of activity which creates the perception of pain can be considered a 'neurotag' for pain.We acknowledge its origins from Melzack's neuromatrix.[76]

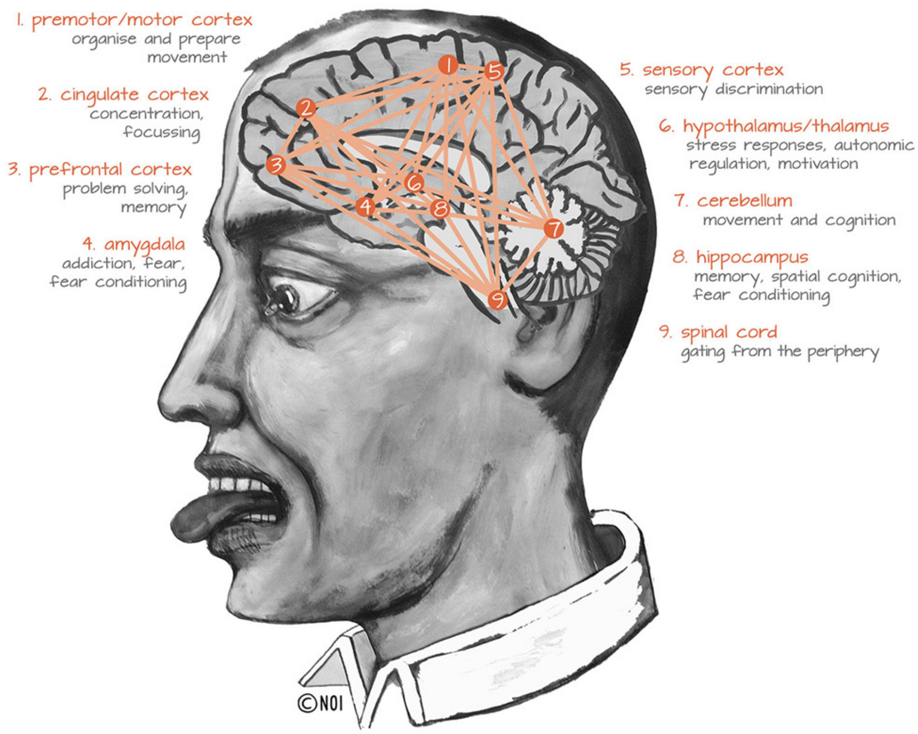

Figure 2.7 *A possible pain neurotag*

Now, we have to acknowledge that the danger message from the tissues via the spinal cord is just one of the inputs to the brain. Although that message is very important, on its own it is not enough to cause pain.

Remember the story of phantom limb pain, see "The phantom in the body". The actual body part doesn't even exist, but it hurts in fresh air. Brain imaging studies show activity in all the same brain areas, whether you have the limb or not![77]

Many of the ignition nodes are also activated by a wide range of stimuli that grab your immediate attention.[78,79] This can make some people with chronic pain hypersensitive to all sorts of stimuli such as noise, light and temperature changes.[80,81,82,83,84,85]

The neurotag waltz

One way to think about how the brain works, including how it produces pain, is to think about it as an orchestra. A skilled orchestra can play many thousands of tunes. It can play the same tunes with different tempos, in different keys, with different emphases, and with different instruments taking different roles. New tunes can be made up, old tunes revived, variations improvised, depending on the audience. Pain can be thought of as one tune that is played by the orchestra.

A good orchestra can play all the tunes. And can easily learn more tunes. However, if the orchestra plays the same tune over and over, it becomes automatic, it plays by memory, and it becomes more and more difficult to play anything else.

Curiosity and creativity becomes lost. Audiences stay away...

And this orchestra in our heads is awe-inspiring. It is actually a yellowish lump of neurones, the consistency of a soft-boiled egg. It contains around one hundred billion neurones, each of which can make thousands of connections. There are more possible connections in the brain than particles in the universe. Neurones are so keen to make connections that a single neurone placed in a saltwater bath will wriggle up to 30% of its length in search of another neurone.[86] Babies make millions of synapses per second, 3 million synapses fit on a pinhead.[87,88] You, the reader, have a dynamic ever-changing brain; millions of synapses link and unlink every second. You could donate 10,000 synapses to every man, woman and child on the planet, and still function reasonably! And each synapse is surrounded by an immune cell which can influence the synapse and 100,000 surrounding synapses![89] How amazing is that! It gives us goose bumps to even think about it. This incredible complexity means that even though pain seems to be taking over your life it is only one part of the orchestra’s huge repertoire.

Figure 2.8 *The orchestra in the brain playing happily*

SYSTEMS TO GET YOU OUT OF TROUBLE

A tune will always have some effect

Messages into the brain do not end in the brain. In a dynamic living system, what goes in must come out in some form. As part of the brain weighing the world, it makes a **value judgement** on the inputs and responds. When you are cold there are many ways your brain and body can respond. When you are in danger, the brain calls upon many systems to get you out of trouble.

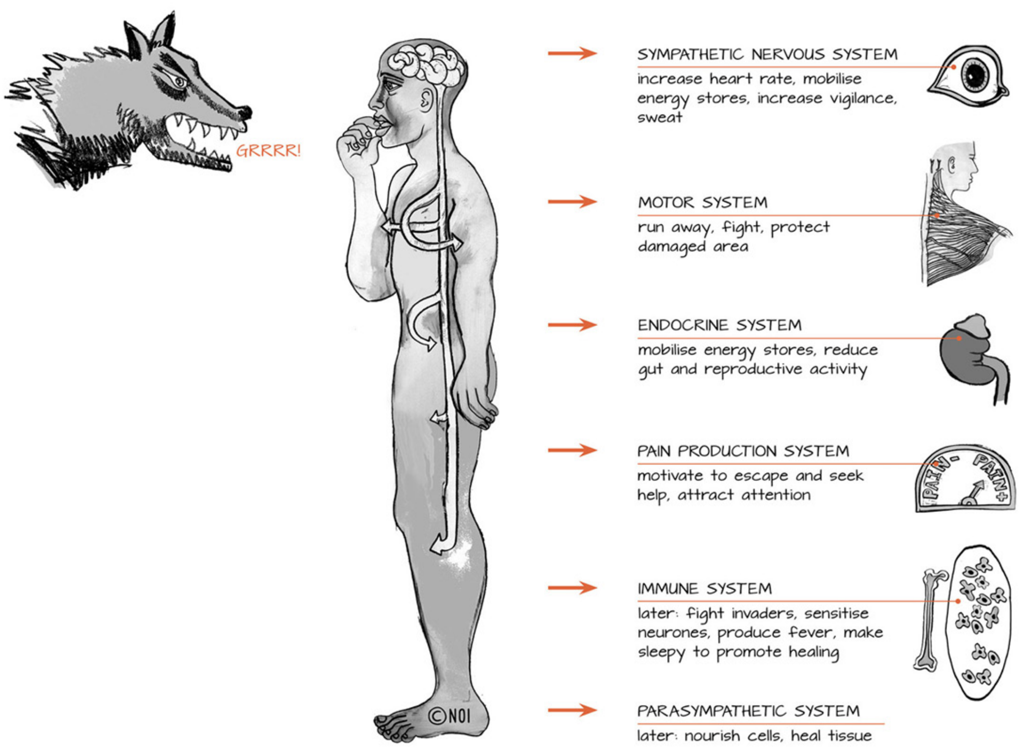

Figure 2.9 *Protective systems to help us escape trouble*

These systems are working all the time. The most obvious examples are: the **muscle system**, which enables you to run away, spasm and protect an injured part, hide or fight, and the **sympathetic system**, which helps manage sweating and blood distribution. Other systems such as the **immune system** and **endocrine system** work silently but diligently. A pain experience is often associated with altered activity of these other systems too. All of our systems can help us escape trouble.

In a threatening situation, and especially during pain, these systems will work really hard for you. They are at their best for short periods just like a sprinter who performs at a super high level of activity. However, if you are in pain for a long time, the sustained activity of these systems starts to cause other problems – they can't be expected to sprint for a marathon. In "Altered central nervous system alarms – the spinal cord", we discuss the consequences of long-term activation of these protective systems.

RECAP

Recap section 1

- All pain experiences are a normal response to what your brain thinks is a threat.
- The amount of pain you experience does not necessarily relate to the amount of tissue damage.
- The construction of the pain experience of the brain relies on many sensory cues.
- Phantom limb pain serves as a reminder of the virtual limb in the brain.

Recap section 2

- Danger sensors are scattered all over the body.
- When the excitement level within a neurone reaches the critical level, a message is sent towards the spinal cord.
- When a danger message reaches the spinal cord it causes release of excitatory chemicals into the synapse.
- Sensors in the danger messenger neurone are activated by those excitatory chemicals and when the excitement level of the danger messenger neurone reaches the critical level, a danger message is sent to the brain.
- The message is processed throughout the brain and if the brain concludes you are in danger and you need to take action, it will produce pain.
- The brain activates several systems that work together to get you out of danger.

Section 3

INTRODUCTION SECTION 3: THE DAMAGED AND DECONDITIONED BODY

We have talked about pain being part of the unstoppable force within the human body to promote survival. It is not the only part. In fact, whenever you are injured, even in a tiny way as part of everyday 'wear and tear', the healing power of the human body kicks in. Sometimes it is really quick – the aim is to return the injured tissue to a functional state as quickly as possible. Even when there is much healing to do as there is in broken bones or torn tendons, it is a dependable and powerful process... unless we don't let it do what it needs to. By understanding about injury and healing, you can assist the process with appropriate rest, movement, diet, drugs, surgery. Pain is often a good guide to the best healing behaviours – sometimes rest is beneficial and sometimes movement is beneficial.

Figure 3.1 *Toes mend – healing is a dependable and powerful process*

No matter what tissues you have injured, a similar healing process occurs. Healing of the gut or skin follows the same general processes as healing of the muscles and joints. Tissues become inflamed, which in the first instance is a good thing because inflammation brings the body's immune cells and rebuilding cells to the affected area. A scar is formed, then the tissue is remodelled to make it as good a match to the original as is possible. The two main things that determine the speed of healing are blood supply and tissue requirements. Tissues with poorer blood supply such as ligaments and LAFTs (see "Get to

know your LAFTs”) take longer to heal than those with better blood supply such as skin and muscle.

The following graph illustrates the tissue healing process. Pain should diminish as the tissues heal, in fact it often goes before the healing is completed. This is not surprising because pain follows the need to protect the tissues. It is not a measure of the condition of the tissues. Sometimes pain associated with nerve damage persists, but this is a story we will deal with in later sections.

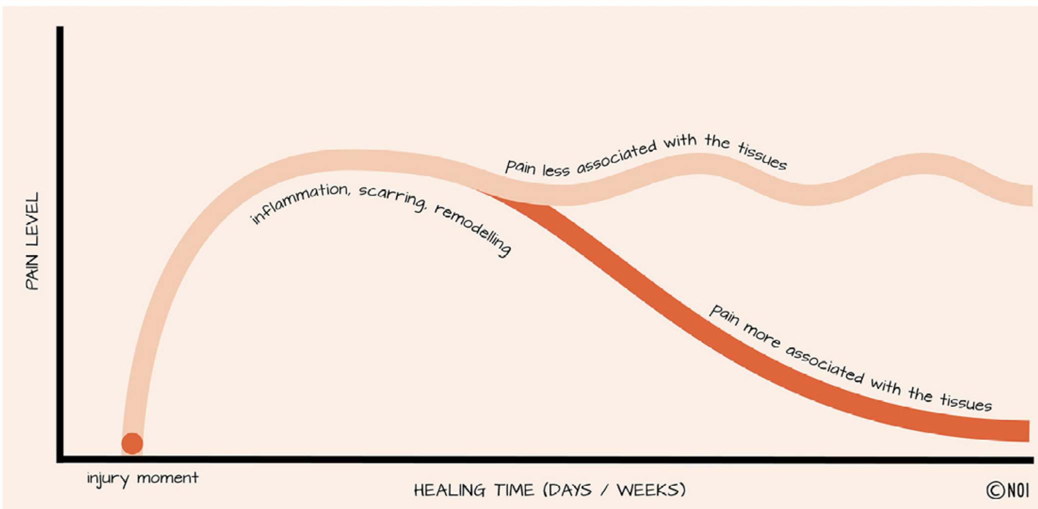

Figure 3.2 *The tissue healing process – graph showing pain more associated with the tissues*

Most importantly, all tissues have a fairly predictable healing time. Once the healing time has passed they don’t get another chance. Think of a cut to your skin, perhaps even look at one of your old scars right now – the skin and tissues underneath have been through a healing process – they don’t have another chance and the skin may not be as mobile as it was, **but it has repaired.**

There are many tissues that may (or may not) be involved in your pain. In the next few pages we will try to explain different types of tissue injuries, how they might contribute to your pain experience, and how they heal. Managing the tissues involved helps you manage and treat your pain.

ACID AND INFLAMMATION IN THE TISSUES

Acid in the tissues

The alarm system works for you all the time. Frequently it makes simple calls for change. Take for example when you don't move for a while, or you are sitting on a rock which creates pressure on your bottom. Movement is important to keep your system flushed. A lack of movement or a physical obstruction like sitting on a rock, leads to a build up of the by-products of cell activity (including acid) in your muscles and joints.

Figure 3.3 *Mr Lee's tissues need movement to flush the acid*

Have a look at Mr Lee, now in his pyjamas after a long day. He has been at the computer for too long. In such an instance, the acid build-up in muscles and other soft tissues makes acid sensors open, which leads to impulses running up Mr Lee's spinal cord and perhaps on to his brain. If his brain concludes that his muscles are in danger (which would seem logical) and he should do something (which also seems logical) then it will hurt. The solution? Move. Just move. Any kind of movement. Varied movements and some stretches are best.

In fact, the thought of 'acid tissues' should make us all get up and move. This is cheap treatment – no drugs are needed, nor fancy therapies.

Inflammation in the tissues

Anything with ‘-itis’ on the end refers to inflammation: tonsillitis – inflammation of the tonsils; tendonitis – inflammation of a tendon. Inflammation increases sensitivity and that’s a great thing. Remember your last sprained ankle, toothache, or appendicitis. Inflammation is a primitive form of defence that is essential to the tissue repair process. Think of the swelling, redness and pain after injury as part of your own internal repair system and be grateful and even proud of it. This really is fantastic – imagine if cars could do this and repair themselves – a swollen bumper bar for two days and then it’s all over!

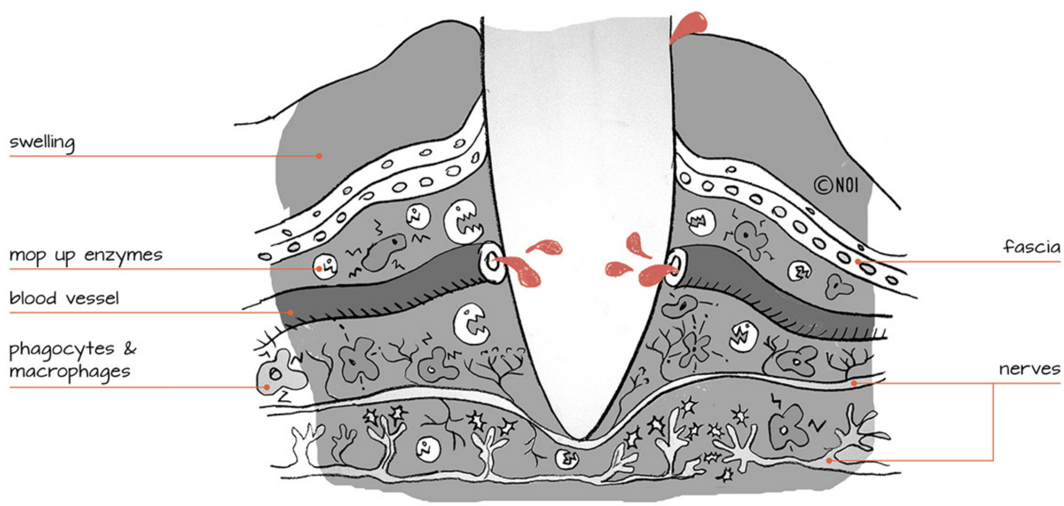

Figure 3.4 *The nail in the foot: inflammation in the tissues is essential to the tissue repair process Here is a close-up view of a nail lodged in a foot. There is lots happening and it is all about repair. Blood vessels may be damaged and small nerve endings stretched. Small cells, which normally just hang around waiting for trouble, release histamine which makes blood vessels release plasma, which in turn causes more swelling. This process releases white blood cells and delivers cells that mop up the mess in the area and, if the skin has been broken, deal harshly with any bacteria present. These mopping up cells are called phagocytes and macrophages. Cells that help scabs form and create scar tissue are also activated.*

Damaged nerves may also release chemicals (see “Backfiring nerves”), that aid the process. All this stuff is called **‘inflammatory soup’**. Inflammatory soup sensitises danger sensors and this increased sensitivity further protects the injured tissue.

Inflammation makes joints stiff in the morning, produces sharp pains, redness and warmth. Often, anti-inflammatory drugs such as ibuprofen, naproxen, aspirin and paracetamol reduce the effects including the pain. Anti-inflammatories probably work by stopping the production of prostaglandins,[90] which are key sensitising chemicals in inflammation. The swelling, which is the most obvious part of inflammation and which worries so many people, is just a by-product of the need to get blood and healing chemicals into the area.

Note that we are talking mainly about acute inflammation. Chronic inflammation is a part of certain disease states such as rheumatoid arthritis and can have different and extra effects.

INFLAMMATION: MORE DANGER BANG FOR YOUR INJURY BUCK

Inflammation accompanies every tissue injury and the brain will nearly always be interested. Not just in nails in the feet, but strains and sprains and all sorts of injuries. Humans are able to draw on a wide variety of cues in order to make the danger message meaningful. We thought it important to remind you of this as you think about injured tissues.

Think about the man with a nail in his foot in the next image. Think about what other cues might be used by this man's brain in order to construct the most meaningful response, including the pain response, the motor response, the sympathetic, immune, and endocrine responses. After all, this man needs to draw on every piece of information that will best serve him in the quest to protect and preserve (Charles Darwin would argue it is all in aid of making sure that by the time he dies, he has more offspring than the next person).

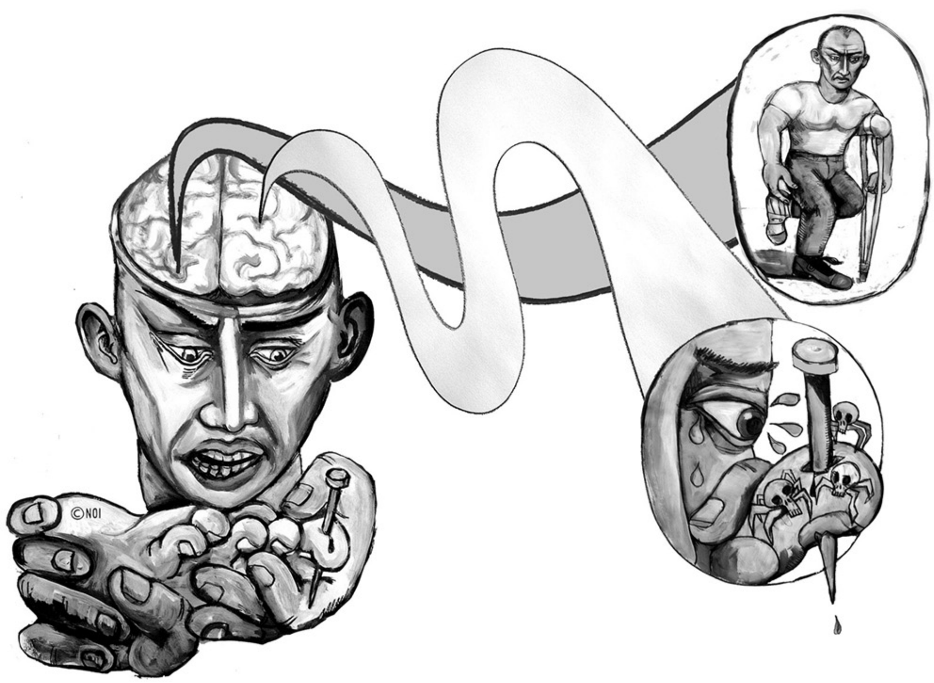

Figure 3.5 *Sensory cues flood in from the periphery to the brain*

With a nail in the foot, your brain will be computing and retrieving information about previous similar events, trying to determine the best way to respond. There will be computations related to previous injury.

Do I need a tetanus shot? When was my last tetanus shot? There will be computations about the immediate circumstances. I should move the nail in case someone else stands on it. How silly will I look later? I haven’t time for this! Is the blood making a mess? Have I punctured an artery? There will also be computations relating to the future. Is my Fred Astaire dancing career finished? Will I need crutches? Will I have to go to hospital? Will it become infected? There will be further computations related to similar events in the lives of others. Will I end up like that woman on the Jerry Springer show? Will I be treated by that new doctor at the hospital? Or computations related to livelihood. Can I work? Will I need to get new shoes? Can I claim compensation?

The amazing thing is that this man will have no idea that all of these things might be contributing to his pain. All he knows is that **it hurts!**

THE TRUTH ABOUT MUSCLES

Muscles take a lot of blame for pain. Advertisements for products to manage muscle pain abound and it is easy to think that you have torn a muscle. But let's see if we can put muscle pain in perspective with these six key points:

1. Muscles have many sensors in them so they can easily be a significant contributor to a pain experience.
2. Muscles can become unhealthy and weak, especially if they are underused, or used in ways to which they are not suited.
3. Muscles are actually quite hard to injure. Sure they bruise a bit, microtears (small injuries to the lining of muscle fibres) can happen, but it is difficult to severely injure a muscle. There can be a build-up of acid, which will make the alarm bells ring, and sometimes new exercises can be associated with delayed onset pain in muscles – perhaps eight hours after activity. This pain can hang around for a few days and may be quite worrying if sufferers don't understand why. Delayed muscle pains often occur after eccentric exercise where muscles contract as they lengthen (for example the biceps muscle when you lower a weight). But in general, muscles are very responsive, stretchy structures. They have to be to protect you and allow you to express yourself.
4. Muscles have a great blood supply, so when they become injured they are champion healers. After all, movement and protection are so important to our survival. If you have ever damaged your tongue, you would know how much it hurts and how quickly it heals. Your tongue is made of muscle and eating and speaking are very important for life.
5. Altered muscle activity is part of your response to injury and threat. Changes in muscle activity in the short term serve short term purposes – like escape or bracing.[91] But in the long term there can be costs. We discuss this in "Movement strategies".
6. Most muscle activity is about making sense of the world and

how to cope with and interact with it. In this way, muscles are windows onto the brain. So if your muscles are working differently you must ask yourself why. Tone of voice is determined by muscles in your throat. Spasm is a powerful protective muscular process. So are limping and other protective behaviours. It is the brain that al-lows freedom and quality of muscle expression. Without muscles, you can't walk, talk, laugh, lie, wink, spit, fart or cry.

Figure 3.6 *Yogi's muscles are strong and flexible*

GET TO KNOW YOUR LAFTS

Formerly known as discs

'Disc' is an unfortunate name for the remarkable structures that intermarry vertebrae. They are not, at any stage of life, like discs. In anatomy and medical books, they are usually drawn in a manner that makes them recognisable as discs, but such drawings bear no resemblance to the real thing. In drawings, discussion and diagnoses, they are made to resemble free-floating frisbees.

They are not like frisbees! **We suggest they should be called 'living adaptable force transducers' (LAFTs)**. (Which, incidentally, means that between the 5th lumbar vertebrae and the pelvis is the 'last LAFT').

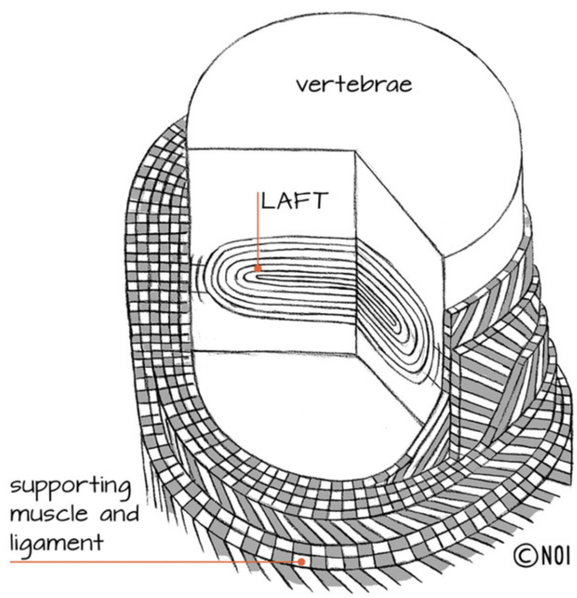

Figure 3.7 *'Discs' are LAFTS – Living Adaptable Force Transducers*

LAFTs are firmly integrated with adjacent vertebrae and are made of the same material as your ear plus some super strong ligament, just like the ligaments in your ankle. In 1934 a famous study[92] showed that the LAFT could swell onto a nerve in the lumbar spine. Since then, all sorts of therapies have been aimed at the LAFT. Current approaches include: manual techniques of manipulating it and squeezing it backwards; surgical techniques of removing it or snipping pieces off; injecting it with extract of pawpaw (papaya) or even just blue dye[93] and superheating or burning it. Practitioners of the various techniques have reported some successes, but nothing has been overly successful for back pain. The wide variability of treatments focussing on LAFTs suggests that LAFT injuries are not fully understood.

LAFT injuries also attract some very strong adjectives like ‘ruptured’, ‘crumbling’, ‘degenerated’, ‘herniated’ and ‘slipped’. These words alone are strong enough to stop you moving properly and they may not be giving you a true indication of what is happening in the LAFT.

LAFTs have become so famous and blamed for so much that people often think about them in isolation. The figure to the left shows a stylised LAFT. Note that it is attached to the surrounding bones and also note the concentric shock absorbing rings that give it the look of a squashed onion. The joints and vertebrae are surrounded by lots of ligament and muscle.

LAFT facts

1. The outer layers of all LAFTs have a nerve supply,[94] so danger sensors can be activated if those layers are in danger. If the LAFT is injured, surrounding structures also full of danger sensors are probably affected as well. In fact, the nerve supply to the LAFT is not as rich as the nerve supply to surrounding ligaments and bones. Remember that we are in the area of the spinal cord so it is sensible to pack the surrounding tissues with danger sensors – wouldn’t you install a sensitive alarm system to protect your most precious possessions?
2. An injured LAFT may not necessarily result in pain. As the LAFT slowly inflames, pain may emerge 8-12 hours later. It is quite common that a LAFT injury will result in pain and stiffness the day after injury but if you are aware of this, you shouldn’t be too bothered.
3. LAFTs degenerate naturally. Degeneration is a normal part of aging of all tissues. It does not have to contribute to a pain experience. The LAFT is married to the bones (vertebrae) around it and they stick together and age together and dance through life. At least 30% of people who have no low back pain, have LAFTs bulging into their spinal canal, sometimes

markedly. This fact has been known for many years but it is still not common knowledge among the general public.[95,96]

4. LAFTs never slip. They age, bulge, sometimes herniate, and only sometimes squeeze onto a nerve or release chemicals that irritate a nerve. Despite these dramatic sounding changes this does not necessarily alarm the nervous system. In fact, the most common kind of LAFT injury is a strain of its ligament tissue – a bit like twisting your ankle.
5. LAFTs heal slowly, but they will always be a bit tatty around the edges. Age changes may be indistinguishable from injury changes.
6. LAFTs, spinal joints and nerves are not delicate structures. Watch a person playing sport and contemplate the forces that go through these structures.

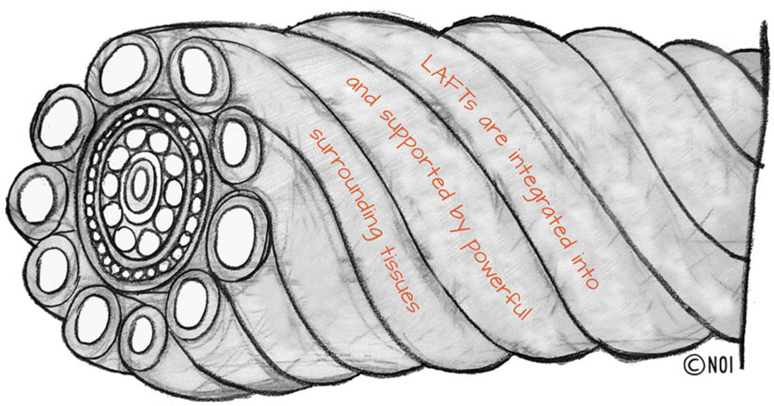

Figure 3.8 *LAFTs are integrated into and supported by powerful surrounding tissues*

GET TO KNOW YOUR SKIN AND SOFT TISSUES

Adults have nearly 2 square metres of skin. Skin makes up about 15 to 20% of body weight. Skin is only half a millimetre thick on the eyelids but could be as thick as six millimetres on the soles of the feet and the back. The skin is a critical protector and as the first physical contact with the outside world, it contains many alarm bells.

Much of what we know about pain is based on the skin. In this sense, it mirrors the state of the nervous system. Interestingly, an injury to the skin very rarely leads to chronic pain, with the exception of severe burns. That said, painful skin zones, changes in skin health and altered sweating or hair growth can all be indicators of damaged nerves.

In some pain states that are initiated by joint or nerve damage, skin can be sensitive to light touch and brushing. Sometimes even the touch of an item of clothing may evoke severe pain. Of course, light touch would not normally be able to evoke pain unless the skin is badly damaged. However, if there is a change in the way the nervous system works and the alarm system is altered, gentle touch or small movements may cause pain. The pain that is common after shingles (post-herpetic neuralgia) is a good example. We will discuss nerve changes in the next section.

The strange creature pictured on the right is known as 'homuncular man'. Contained in a little strip of brain (sensory cortex), which is as long as your finger and just above your ear, is the representation of the skin in the brain (review "The phantom in the body"). This means that if you put a pin in your finger, the virtual finger in the brain would 'light up'. All skin (all body parts too) has a little section devoted to it in the brain. Some areas of skin which we rely on more for day to day activities (for example our fingers and lips) have more brain 'real estate' than areas of skin that we don't rely on so much, for example the back. If the body was shaped in the same proportions that the virtual body in the brain was, then humans would look a little bit like this odd figure – not a good look! This suggests a use-dependent brain. Just to be clear, the areas that you use more and which require the best sensation have a larger brain representation. If you demand more of a body part, then that part will have a bigger representation in the brain. For example, violinists, cellists and guitarists have a bigger left virtual hand in the brain than non-musicians.[97] And London taxi drivers have a bigger hippocampus (the part of the brain used in navigation) than healthy non-taxi drivers.[98,99]

Some more skin and soft tissue facts

1. Damaged skin heals quickly, much faster than ligaments and muscles. It is such an important protector, it has to heal fast.
2. Skin has a high density of sensors, including alarm sensors, for heat, cold, mechanical forces and various chemicals. See "A closer look at alarm signals" for a review of sensors.
3. Skin is usually very mobile. It slides as we move. It doesn't like to be scarred. It likes movement and it usually revels in being touched.
4. Fascia lies under the skin. Fascia is a tough, strong tissue, also containing many danger sensors. Fascia is connected throughout the body in sheets and it sometimes links to muscles.
5. When you massage skin, you are moving tissues and also sending useful impulses to the brain. So, movement and touch are useful ways to refresh your 'virtual' and actual body.

Figure 3.9 *Homuncular man: the size of the body part represents the area of brain devoted to sensation*

BONE AND JOINT CONTRIBUTIONS TO PAIN

Bones and joints are often blamed for deep, movement-related pain. This may make people fearful of movement because they are afraid it will injure their joints. We have all grown up with the concept of pain 'deep in the joint' and 'in the bones'. Many a patient has said 'I need to get a bit of oil into my joints'.

There are 206 bones in the body and many more joints. Bones are not normally brittle. They absorb pressures well and will adapt and change their shape in response to the body's needs. Bones are living, healing structures. They are full of danger sensors and so are joints. Bones are covered in a supersensitive layer (the 'periosteum'), which acts as an extra protection system. Try tapping your shin with your knuckles – it's the periosteum that makes it so sensitive.

Joints come in different shapes and sizes. Some are fibrous with interlocking bones, for example the joints in your skull. Most are synovial joints (eg. hip, elbow, finger joints), which means that the joint cavity is enclosed and contains a slippery lubricating fluid. The linings inside these joints are particularly full of danger sensors – especially the synovium, which is the layer of tissue that makes the lubricating fluid. These danger sensors can go berzerk with injury or inflammatory diseases such as rheumatoid arthritis, which frequently result in very painful joints. But remember, inflamed joints are not necessarily painful.

Figure 3.10 *Esmerelda describing her 'deep' pain*

Here are some bone and joint facts

1. Joint pains are often described as 'grinding', 'stabbing', 'gnawing', 'compressed' and 'aching'. However, these words are brain-derived constructions based on the input from the joint plus a whole lot of other inputs. Part of the reason we describe joints as grinding is because it makes sense mechanically.
2. An important factor related to joints and pain seems to be the speed at which joints are damaged – if the changes are slow, the brain probably concludes that there is no real danger. Dislocations and fractures are nearly always painful, however most people with worn joints never know about it.
3. Our bones and joints are not attractive when x-rayed, especially if we are a bit older. We all have worn joint surfaces and little bony outgrowths. The magnitude of x-ray findings relates poorly to the amount of pain. A person with a horrible looking x-ray may have no pain and a person with a pristine x-ray could be in agony. In one person, pain could be in the left knee yet the right knee has the worst x-ray. In many cases, changes are likely to

be age-related changes ('the kisses of time').

4. Joints adore movement and regular compression, which is essential for joint health. Movement distributes the slippery joint fluid (synovial fluid), and cartilage loves the pumping compression. The brain eagerly welcomes sensory inputs from joints as it wants to know what is happening so it can construct the best responses for you, (eg. it tells you to alter balance or position).
5. Smashed bones can heal, sometimes stronger than before. The repair process is powerful – and most of it is accomplished within six weeks.
6. Some joints in your back or neck can get injured, eg. in car accidents, but the injuries can be too small to see on x-rays and scans.[100] Your brain may have recognised the threat, which may, or may not, result in pain. Remember, though, activity of the alarm system (nociception) is neither sufficient nor necessary to cause pain.

THE PERIPHERAL NERVES

Get on your own nerves

Most people know about muscles and joints. You can see and touch them. You often see pictures of them on medical clinic walls. Unfortunately, nerves are often forgotten. There are hundreds of metres of peripheral nerves in your body. The peripheral nerves connect the brain and spinal cord to your tissues and thus to the outside world. This makes them really important, especially if a nerve is damaged or stops working properly. Leading neuroscientists argue that peripheral nerve problems are far more common than clinicians believe.[101,102,103]

One way to learn the key facts about nerves is to get on your own nerves. Find the point of your elbow (olecranon) and then find the bony point (medial epicondyle) a few centimetres away from the olecranon towards your trunk. The ulnar nerve travels right between the two points. If you then go a few centimetres towards your wrist (check Mr Lee) and rub your finger sideways you should roll over the ulnar nerve. Notice that it is at least half as thick as a pencil, and slippery too. There are tens of thousands of transmitting fibres (neurones) in this nerve and they will transmit impulses while you move and stretch. If you run your finger back and forth across the nerve you will probably feel some pins and needles in your little finger.

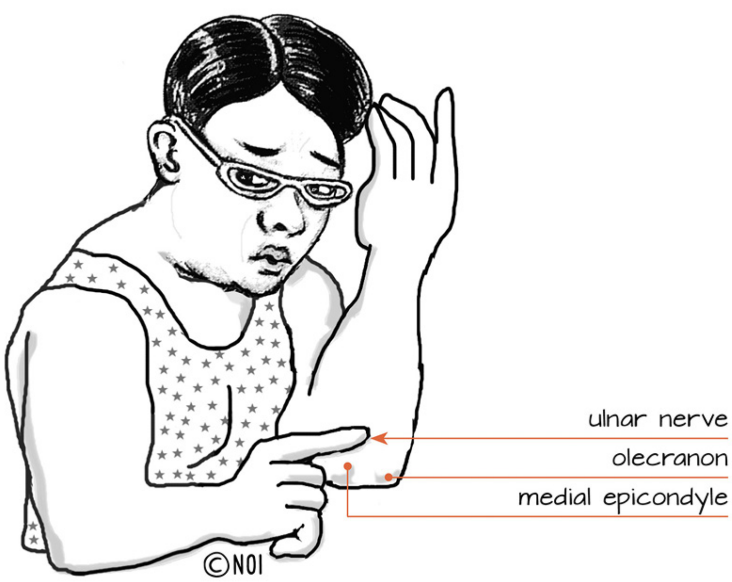

Figure 3.11 Mr Lee finding his ulnar nerve

You have probably opened a few mechanical sensors and the nerve is reacting normally. You may feel it in the fingers – this is because the brain thinks it is coming from your fingers.

Look at the next nerve image. Nerves are cords. They are about 50% ligament, which makes them quite strong, and about 50% neurones. Some of these neurones inform the spinal cord and brain about activity of the sensors and others drive muscles and sweat glands.

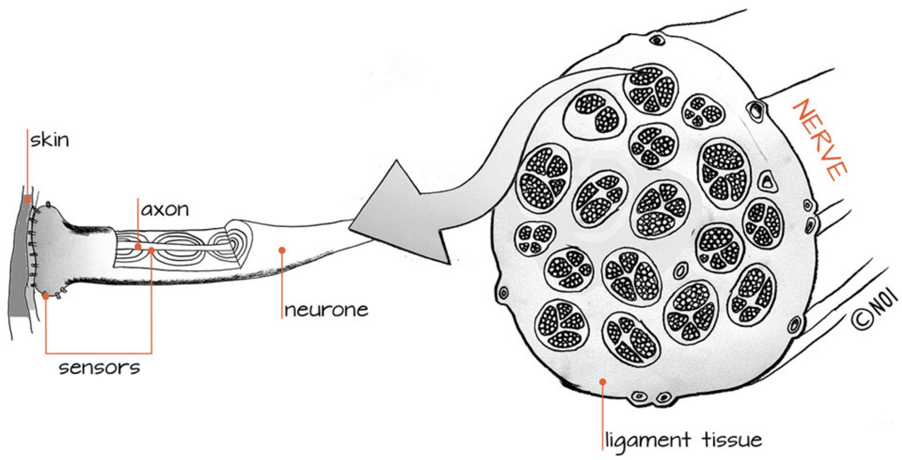

Figure 3.12 *Nerves are cord-like and made up of 50% ligament and 50% neurones*

Helpful nerve knowledge

1. The ligament part of a nerve has danger sensors in it just like any ligament in the body.
2. The neurones in a nerve can be a real source of danger messages and a contributor to pain. This is due to an increase in the number of sensors at a damage site. Some of these sensors may be activated by mechanical stimuli, some by lack of blood, and some by stress chemicals. If there are enough sensors open the damaged area of nerve can ‘ignite’ and send danger messages.
3. If a nerve is injured and your brain computes (rightly or wrongly) that more sensitivity is required for your survival, more stress sensors may be made by the DNA in the neurone and put into the nerve membrane. This means that various stress states may contribute to nerve sensitivity.[104,105,106]

4. Nerves can be injured by cutting, too much squeezing and pulling, by irritating chemicals around the nerve, and by sustained reduction in blood supply.[107]
5. All around the body, nerves slide as you move. Injury or problems (for example carpal tunnel syndrome) which may alter this movement may lead to pain when you move.[108,109] More mechanical sensors may be opened. Nerves love the freedom to move – exercises such as yoga and tai chi get the nerves moving.
6. Nerves change appearance with age. They can become a little thinner or, in areas where they need more protection or where they rub a bit, for example at the wrist, they can become thickened. Just as changes in bones and joints may not hurt, changes in nerves do not have to be painful either.
7. All the fancy scans and conduction tests in the world may not necessarily identify a damaged nerve, but minor nerve problems can be very troublesome. They are usually sensitive to mechanical forces such as pressure or stretch.
8. Sometimes nerves can be injured but not create danger messages for days or weeks. This is because slightly different alarm systems can be activated when nerves are damaged.

THE DORSAL ROOT GANGLION – THE PERIPHERAL NERVE'S MINIBRAIN

There is a little bulge in the peripheral nerve just where it is about to enter the spinal cord. This bulge is important because it contains the nuclei of the neurones. The bulge is called the dorsal root ganglion (DRG). It is effectively a 'minibrain' because it is the first place that messages coming in from your tissues can undergo some modulation and evaluation. You could say it is the most peripheral place in which you think!

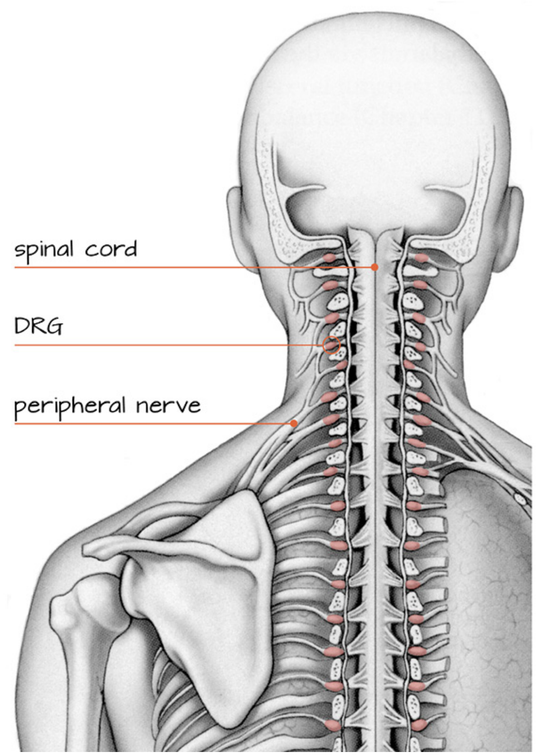

Figure 3.13 *The DRG (Adapted from Bear at el.[110]) Some interesting features of the DRG*

1. All the sensory neurones that make up the peripheral nerve have their nucleus (control centre) in the DRG. The nucleus is where the DNA of the neurone resides, ready to be activated to start making sensors, which are transported to the rest of the neurone (see "A closer look at alarm signals"). This means that anything that affects the DRG can have profound effects on the whole peripheral nerve, including changes in transmission and manufacture of sensors.[111]

2. The DRG is really sensitive and changeable. When nerves are injured, neurones sprout in the DRG and can lead to all sorts of 'short circuits'.[112,113] The bones which usually protect the DRG can sometimes actually interfere with it.[114,115] Fluids such as blood and inflammatory soup' (say, produced by a soft tissue injury nearby) can irritate it.[116] Sometimes, when there are arthritic changes in the joints nearby, and you bend your head back, the DRG can be squeezed by the bones around it. Because the DRG is so sensitive, this sort of thing can really hurt. No wonder some people with neck pain hold their head forward.
3. The DRG is particularly 'tuned in' to whatever is in your blood, including adrenaline, and other chemicals[eg.117] that gush into the bloodstream when you are stressed. Manufacturing more adrenaline sensors to put in the DRG is one of many ways that the body can increase sensitivity. This is very sophisticated protection and good news for your tissues when you consider how effective it is, but bad news for you because the result is often more or worsening pain (we will talk more about this later).
4. Occasionally the DRG can be 'set off' – especially if you sustain an injury in the area. Sometimes when this happens, the DRG may just keep on firing. It's sort of like a car alarm. You can move around but it keeps sending messages. It can be a real pain in the neck. Unfortunately, even super-powerful drugs don't do a lot, though it will eventually quieten down of its own accord.

But wait! The DRG can also be squashed without pain – think about this: some bodies (especially older ones) that have been donated to science reveal squashed nerves but there is no record of them ever having had pain when they were alive.[eg.118] You would think they would have been in absolute agony! The most likely explanation for this is that the compression occurred gradually over time, which meant that the brain must have concluded that there was no danger in the tissues.

Figure 3.14 *Guy bending his head back experiencing pain*

BACKFIRING NERVES

Neurones backfire. Especially if they are injured.[119] This is something that most people (including some health professionals!) don't know, but it helps to explain some types of persistent pain. We are all familiar with the image of impulses going up to the spinal cord and brain, but neurones are just like a long trail of dominoes – if you start the transmission, it will keep going in any direction available to it.[120]

Figure 3.15 *Trouble in a nerve sends impulses both ways*

The only reason that sensory neurones most often send messages up the system is that the impulses normally begin at the bottom end! Backfiring happens a lot in the brain, where it is quite normal and all part of an active brain. When it happens in peripheral neurones, it can have surprising effects. When the impulse travels back down the neurone, it causes the release of chemicals at the end of the neurone, wherever that may be.

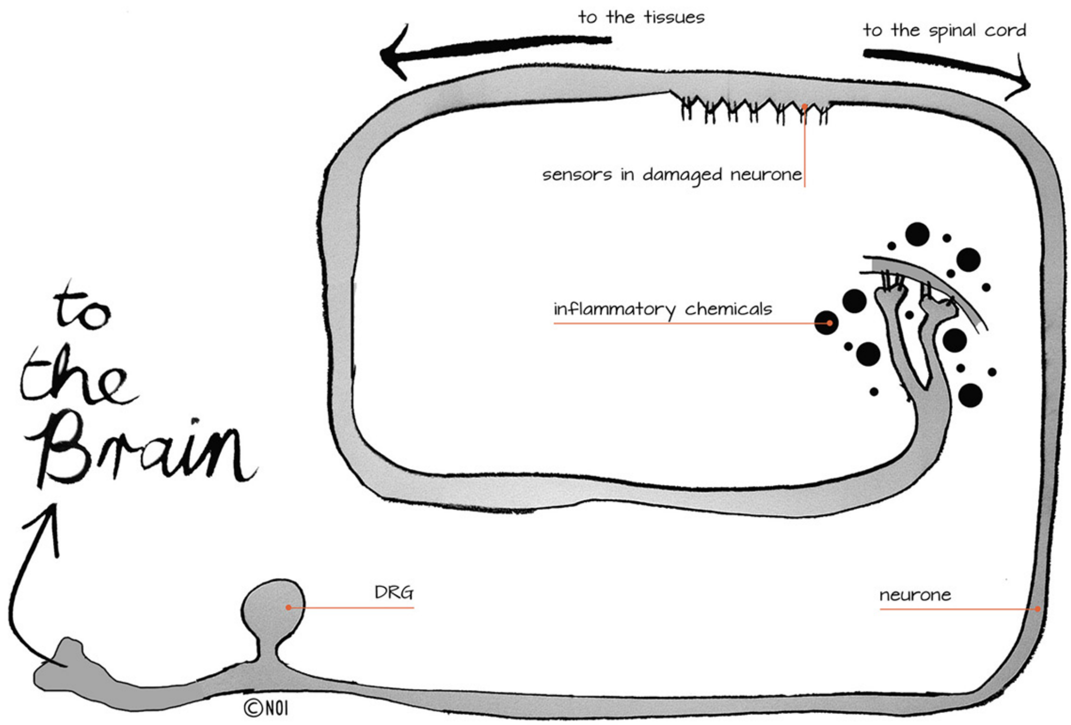

Figure 3.16 *Signals can backfire*

These chemicals help damaged tissues to heal. They do all the good stuff outlined in "Figure 3.4" – encourage blood to the area, promote the release of sensitising chemicals from cells in the area and they even signal mop up enzymes to get going and clean up. So, by backfiring, injured neurones can actually cause inflammation in the peripheral tissues (for example, an injured nerve in the back may cause swelling in the foot).

This may not be an issue in the short term (unless some drastic treatment measure is suggested for a problem that isn't even at the inflamed site). However, if the backfiring persists, sustained inflammation may result, therefore, the problem can worsen because sustained inflammation makes for boggy, soggy tissues. A less sensitive nervous system can lessen the amount of inflammation in your tissues.

WHAT YOU MIGHT NOTICE WITH PERIPHERAL NERVE PROBLEMS

Injured peripheral nerves can result in a wide variety of sensations. Thanks to modern neuroscience, most of these seemingly odd sensations are no longer a mystery. Many common syndromes such as tennis elbow, plantar fasciitis and carpal tunnel syndrome are likely to involve peripheral nerves.

Common symptoms associated with peripheral nerve problems[121]

What sort of symptoms could there be?

- Pins and needles
- Sometimes burning pain
- Pain at night when you are in bed, especially in the hands and feet

Where would the symptoms be?

- In 'skin zones' or part of the skin supplied by the damaged nerve
- Small, tender 'hot spots' (may be called 'trigger points')

What else might you notice?

- Movement often makes it worse. Nerves are more comfortable in some positions than in others. When a nerve is sensitive, you tend to favour postures that avoid putting mechanical load on the affected nerve, eg. by raising your shoulder up, bending your spine sideways or poking your head forward.
- As in most persistent pains, stress can make it worse – remember that nerves, especially damaged ones, can become sensitive to the chemicals you produce when you are stressed. This can be a bit of a vicious cycle. The brain concludes that you are under threat by virtue of this 'unexplained' pain, which makes you produce stress chemicals, which activate the

chemical sensors, which fire danger messages, which tell the brain you are under threat, and so on...

- Zings'. Without warning, when you move, a quick 'zing' may occur.[122] It doesn't necessarily happen every time you move. Such unpredictability can lift the fear factor.[123]
- Movement or even just a sustained posture may ignite an injured nerve which keeps ringing like a car alarm. This is probably due to DRG involvement[124] but it can be really disturbing because it just keeps on ringing.

Peripheral nerves can produce some really 'odd' symptoms:

- after injury there may actually be no symptoms for days, even weeks, then SHEBANG![125]
- itchiness in skin zones[126]
- it might just feel plain weird. We have heard patients say things like 'it's strings pulling', or 'it's water running in my skin', 'it's ants on me', or 'it's prickly'.

As long as you realise that, despite some odd symptoms, you are not going crazy! The nerves aren't dying or decaying, they are rarely injured, they are just doing the wrong thing and in many cases, they are responding to signals from your brain that tell them that increased sensitivity and better warnings are required.

Many people have altered, damaged and compressed nerves, yet no symptoms. If you have peripheral nerve problems, and all the cues (eg. fear, mechanical forces, anxiety) that exist to keep the nerve sending danger signals are taken away, the nerve may not hurt.

However, the nerve will still look like it did when it was sending danger signals.

RECAP

Recap section 1

- All pain experiences are a normal response to what your brain thinks is a threat.

- The amount of pain you experience does not necessarily relate to the amount of tissue damage.
- The construction of the pain experience of the brain relies on many sensory cues.
- Phantom limb pain serves as a reminder of the virtual limb in the brain.

Recap section 2

- Danger sensors are scattered all over the body.
- When the excitement level within a neurone reaches the critical level, a message is sent towards the spinal cord.
- When a danger message reaches the spinal cord it causes release of excitatory chemicals into the synapse.
- Sensors in the danger messenger neurone are activated by those excitatory chemicals and when the excitement level of the danger messenger neurone reaches the critical level, a danger message is sent to the brain.
- The message is processed throughout the brain and if the brain concludes you are in danger and you need to take action, it will produce pain.
- The brain activates several systems that work together to get you out of danger.

Recap section 3

- Tissue damage causes inflammation, which directly activates danger sensors and makes neurones more sensitive.
- Inflammation in the short term promotes healing.
- Tissue healing depends on the blood supply and demands of the tissue involved, but all tissues can heal.

- The peripheral nerves themselves and the dorsal root ganglion (DRG) can stimulate danger receptors. Normally, pain initiated by danger messages from the nerves and DRG follows a particular pattern

Section 4

INTRODUCTION SECTION 4: ALTERED CENTRAL NERVOUS SYSTEM ALARMS

The 'issues in the tissues' discussed in the last section helps explain many aspects of pain, even some features of pain which are often wrongly considered a bit odd. Pain nearly always involves something going on in the tissues. This might be inflammation, slow healing or tissues that are just unfit and unused.

But to discover more about pain we must go further. So let's head into the spinal cord, then go right up inside your skull and into the brain, the command centre of the alarm system. When something happens in your tissues and peripheral nerves, there will be repercussions right through the entire system. Remember that it is the brain that has to make the final decision as to whether or not you should be in pain.

Figure 4.1 *Paper cut alarm bells*

'So, are you saying that the pain is all in my head?'

This is probably the most often asked question from people learning about the biology of pain. We have to be honest and say, '**yes** – all pain is produced by the brain – no brain, no pain!' This doesn't mean for a second that it is not real – much to the contrary – **all pain is real**. In fact, anyone who tells you 'it' is all in your head, implying that therefore 'it' is not real – **does not understand biology**. A deep understanding of pain is greatly empowering.

Understanding the spinal cord and the brain processes behind the pain experience can provide you with enormous control. We admit that it's a bit new for us all – some of the science behind the understanding is very new.

Take another look at the graph below. Injured tissues have reasonably defined healing times. However, healing times may vary because of associated disease processes, how the tissue is used, and the things that people do in life. Reflect on the amazing pain stories and a key point from that section – that damage and healing does not necessarily relate to pain. We know that pain persists in many cases even though the initial injury has had time to heal.

In these situations, the brain concludes that a threat remains and that you need all the protection you can get. There are many explanations for why this occurs. Many of them involve changes in the way the alarm system itself works. We've covered the changes that occur in the periphery in the last section. Changes also happen in the spinal cord and brain.

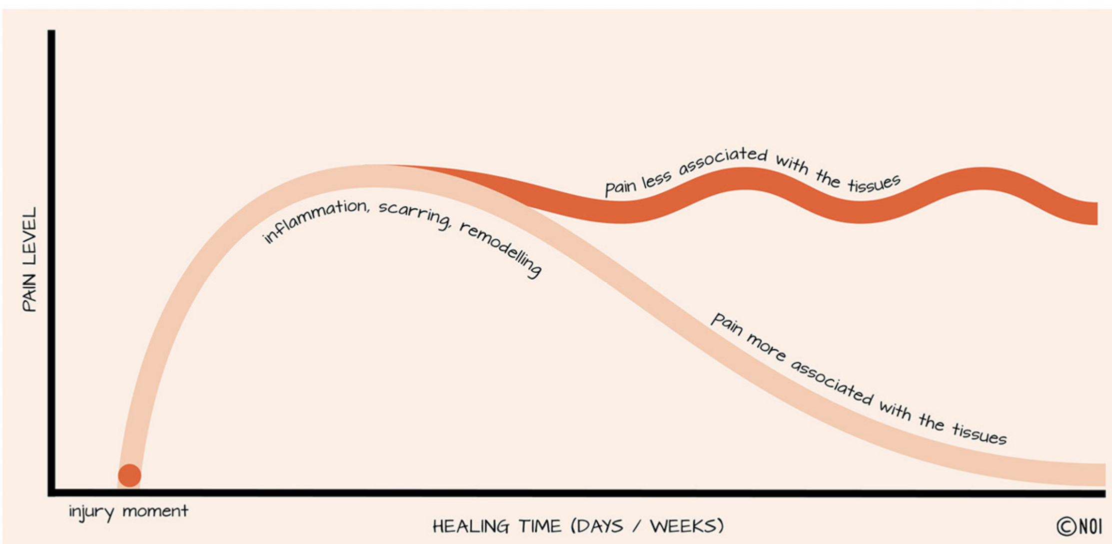

Figure 4.2 *Healing time graph – pain less associated with the tissues*

ALTERED CENTRAL NERVOUS SYSTEM ALARMS – THE SPINAL CORD

Let's hop into the spinal cord before we move to the brain. You may need to keep your hat on here! Read slowly and\ hang in there! Remember that sensors in the tissues cause danger messages to be sent to the spinal cord, which in turn cause the release of chemicals into the synapse there (see "The alarm message meets the spinal cord"). Those chemicals activate chemical sensors on the next neurone, (the spinal messenger neurone on the way to the brain) which open and allow positively charged particles to rush into that neurone, bringing it closer to firing. Remember too that chemicals released from descending neurones from the brain activate different sensors on the neurone. This can increase or decrease the excitement of the spinal messenger neurone and take it closer or further away from firing. We are now talking about the dorsal horn of the spinal cord. See the figure below to remind yourself where that is located.

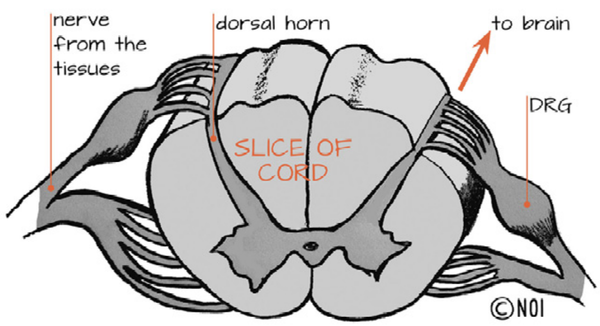

Figure 4.3 *Cross section of spinal cord*

The essential neuroscience[127]

The nervous system is highly adaptable and will respond to most demands that it is given. So, when impulses from inflamed, scarred, weak or acidic tissues keep arriving at the synapse in the dorsal horn, or when eurons from the brain release excitatory chemicals, the spinal danger messenger neurone in the spinal cord adapts to meet the demand – that is, to get better at sending danger messages up to the brain. This adaptation begins within seconds of the demand increasing.

In the short term, the spinal danger messenger neurone increases its sensitivity to the incoming excitatory chemicals.[128,129] This means that things that used to hurt now hurt more. This is called **'hyperalgesia'**. It also means that things that didn't hurt before now hurt. This is called **'allodynia'**. Hyperalgesia and allodynia are just two effects of increased sensitivity.

The sensors then change the way they work so that they stay open longer each time they are opened, which lets more positively charged particles into the danger messenger neurone. Finally, the danger messenger neurone increases its manufacture of sensors for excitatory chemicals, including sensors that 'sleep' until they are needed (this is as though a danger memory is placed in the cells). All of these things change the sensitivity of the danger messenger neurone. Your alarm system is really looking out for you.

More long-term processes also happen – floods of sensitivity-enhancing chemicals can swamp the synapse and some of the incoming neurones can go sprouting.[130] For example, neurones that don't even carry danger messages sprout in close to the danger messenger neurone so that the chemicals that they release activate that neurone. This means that just touching the skin or a slight temperature change, might cause danger messages to be sent to the brain.

In a way, your brain is being tricked. It is operating on faulty information about the condition of your tissues. But remember – your body and brain are acting in your best interests – it's to protect you.

Enhanced sensitivity of the alarm system is nearly always a main feature in persistent pain. Remember that the **pain is normal, but the processes behind it are altered.**

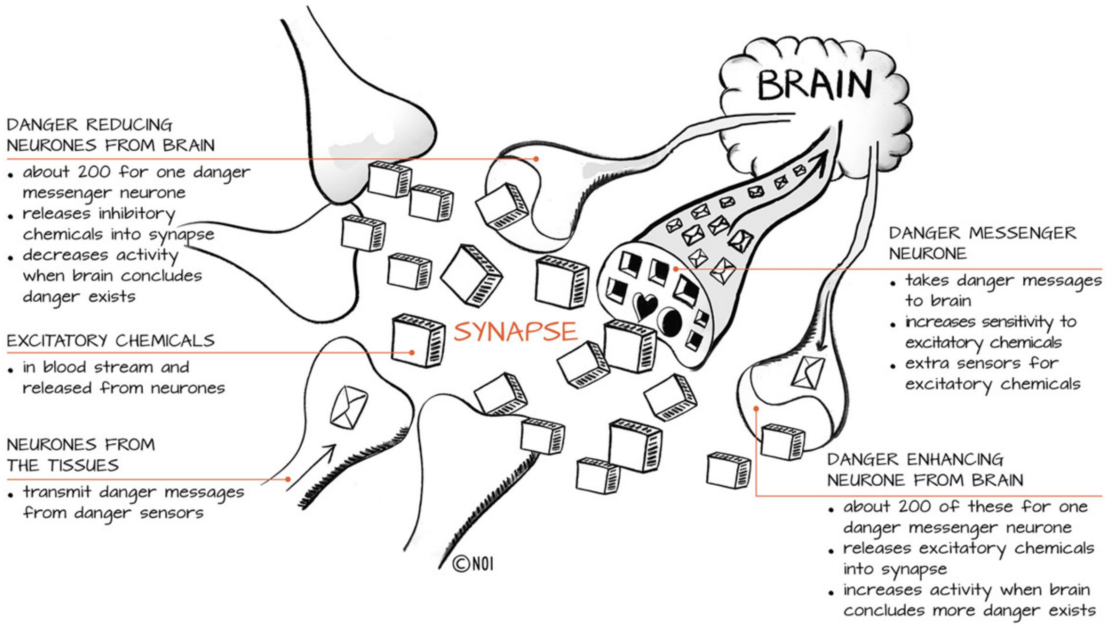

Figure 4.4 *Synapse activity to and from the brain*

THE SPINAL CORD AS A MAGNIFIER OF TISSUE REALITY

Metaphors may make it clearer

From the last few pages, it should be clear that when there are changes in the spinal cord, the brain may no longer receive accurate information about what is happening in the tissues. Instead of a nice clear view of the tissues, there is now a 'magnifier' or 'distorter' in the dorsal horn of the spinal cord. One message into the spinal cord is turned into many messages going up to the brain. It kind of 'winds up' the danger.

For many people in persistent pain, this is a critical issue to understand and it is well worth repeating. In this sensitised state, the brain is being fed information that no longer reflects the true health and abilities of the tissues at the end of the neurones. Put another way, **the brain is being told that there is more danger in the tissues than there actually is.** The 'gain' of the system is increased.[131] Brain responses such as movements, thoughts, autonomic (eg. heart rate), endocrine responses (eg. digestion) and emotional responses are now based on faulty information about the health of the tissues at the end of the neurone.

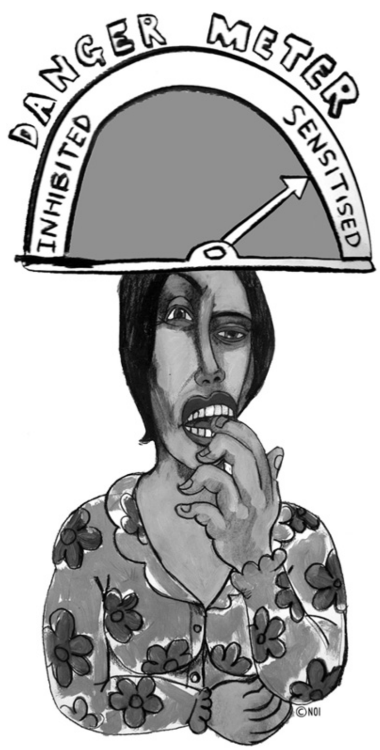

Figure 4.5 *Danger meter*

Here are some metaphors that may help you understand this increase in sensitivity:

- It is as though an amplifier on a hi-fi system is turned up.
- It is a bit like someone has broken into your tool shed a few times and you have to install a super-duper alarm system – make it infra-red as well as motion-activated. Sure – it's well protected but now rats running across the floor will trigger the alarm.
- Perhaps you have got a Ferrari engine installed into your VW beetle – one touch on the throttle will really get you moving.
- A computer malfunctions. One key stroke on the keyboard (the tissues) such as a D (for danger in the tissues) creates many D's on the computer screen (spinal cord).[132]
- The spinal cord has a magnifying glass in it.
- Noise which was not bothersome before is now bothersome. Even certain types of music may become intolerable.
- The spinal cord is a bit like the tax office. Let's say you had a 'miscalculation' on your tax return one year. The tax office knows that there is trouble with your accounting. Next time you send in your tax return, all the inspectors scrutinise it carefully and will exaggerate any tiny 'miscalculation' you make. It's not fair![133]
- It's like the dripping tap torture on your forehead. Every little drip just keeps getting more and more magnified.

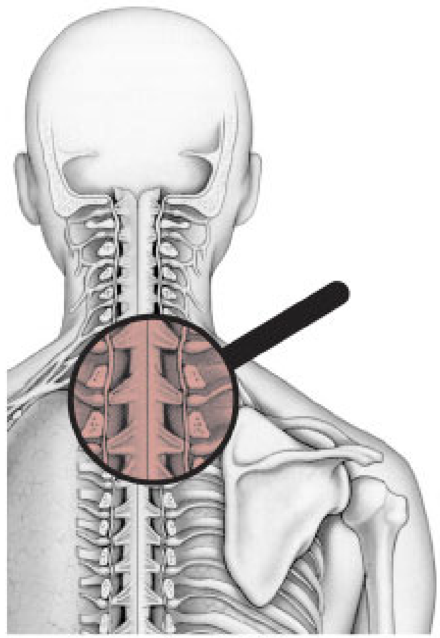

Figure 4.6 *Metaphor 'the spinal cord has a magnifying glass in it' (Adapted from Bear et al.*[134]) *Remember the regional post office? (See* *"Sorting at the synapse"**). The post office staff are now in a perpetual state of paranoia – sending danger messages off at will; the post office starts to send messages on behalf of other localities; letters are sent free of charge; the regional sorting office is sending itself letters via that post office.*

The concept of increased sensitivity is often challenging, but this is what happens to some degree in all of us when we are injured. This increased sensitivity should fade once the damaged structures are under control, and/or you fully understand what is going on.

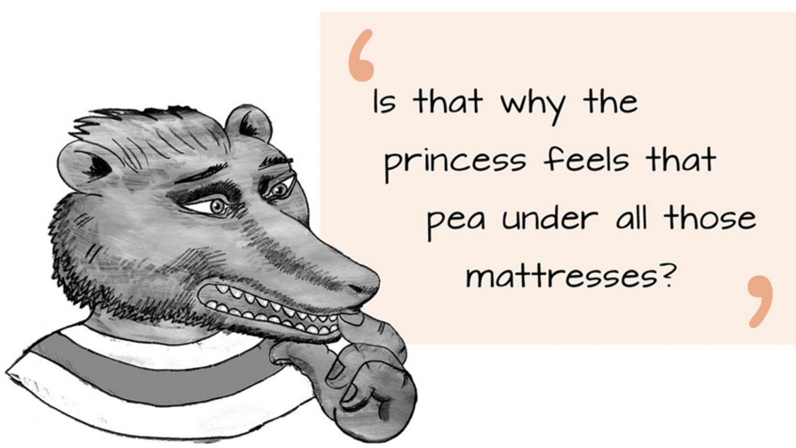

Figure 4.7 *The princess and the pea is a metaphorical story about magnification*

THE BRAIN ADAPTS AND TRIES TO HELP

Smudging the neurotag

Let's move up to the brain. These changes in the spinal cord will lead to changes in the brain. The same changes that occur in the spinal cord with persistent pain also occur in pain ignition nodes in the brain. Not only does the brain have to process and adapt to all the information about the threat, the brain itself starts to change. Don't panic! Our brains are changing all the time, this is a change aimed at lifting sensitivity, in order to protect us.[135,136]

The main changes that occur in the brain are the manufacture of more sensors in the pain ignition nodes (remember the neurotag – see "The message is processed throughout the brain" and of more chemicals in the body to activate the sensors. This means it is easier to ignite for example, a memory area. If you had a nasty accident on a street corner, every time you pass that area you may have a reminder, perhaps just a shudder, or maybe even a pain neurotag is constructed in your brain. Your brain is looking out for you. Hopefully you are starting to see how sophisticated this protective mechanism can be.

Another change that is known to occur in the outer brain, the cortex, is 'smudging' – brain areas normally devoted to different body parts or different functions, start to overlap.

In fact, the longer pain persists, the more advanced the changes in the brain become.[137,138,139,140] We think both types of change might be strategies by which the brain 'looks out' for you – by making the body part difficult to use (smudging of motor areas in the brain, thus limiting movement), or by making nearby body parts sensitive too (smudging of sensory areas in the brain).

But don't panic! Reflect on the homunculus again (see "Get to know your skin and soft tissues") – it is always changing anyway. So if you kept stroking an index finger, the area of the brain involved in sensing the index finger would start to enlarge. In this way, the brain reflects the history of inputs. Braille users have larger virtual index fingers – they shrink over a weekend if they don't use Braille.[141] Musicians with painful non- functional hands may have distortion of the virtual hand in the brain.[142] However, recent developments show that smudging associated with persistent pain can be reversed with training.[143,144,145]

To be clear – smudging sounds serious. The good news is that it is reversible. In the same way that muscles and joints can be made more healthy and robust, so too can the homuncular arrangements in your brain.

Figure 4.8 *Smudging in the virtual hand*

THE ORCHESTRA PLAYS THE PAIN TUNE

Orchestral changes

We can use the metaphor of the brain as an orchestra to make sense of the brain changes that we've been talking about, for instance those brain changes that occur as pain becomes chronic. It is like the orchestra in your brain has been playing the same pain tune over and over and over and over... It can no longer play a full repertoire of tunes. Nor can it be creative, curious or seek new musical challenges. Key musicians quit because they have nothing to play. Other musicians become tired and sick because they play all the time. Some musicians take over others' roles, for example the trumpeters take over the violinist's part.

The pain tune is not a happy tune and it's the same tune again and again (we all get songs stuck in our heads from time to time). Tours get cancelled as the orchestra stays home. Audiences stop coming. Record sales drop. iTunes downloads dry up. You get the picture: the pain starts to dominate every aspect of life – work, friendships, family life, hobbies, thoughts, sports, emotions, devotions and beliefs. Although pain may completely take you over, we would like to remind you that your brain with its billions of neurones and trillions of everchanging connections has vastly greater capacities and abilities than just making pain.

It is important to emphasise here, that when the brain is sensitised, it is not just the experience of pain that is persistently produced. It also draws in other protective systems such as the sympathetic nervous system (making you aware and vigilant), endocrine system (transports energy to muscles, speeds up digestion) and the motor system (the long muscles like your hamstrings are 'turned on' and ready to run). These systems and others can feed back into the brain and combine to perpetuate the pain tune, which we have also called the 'pain neurotag'. Changes in these systems are discussed later in this section .

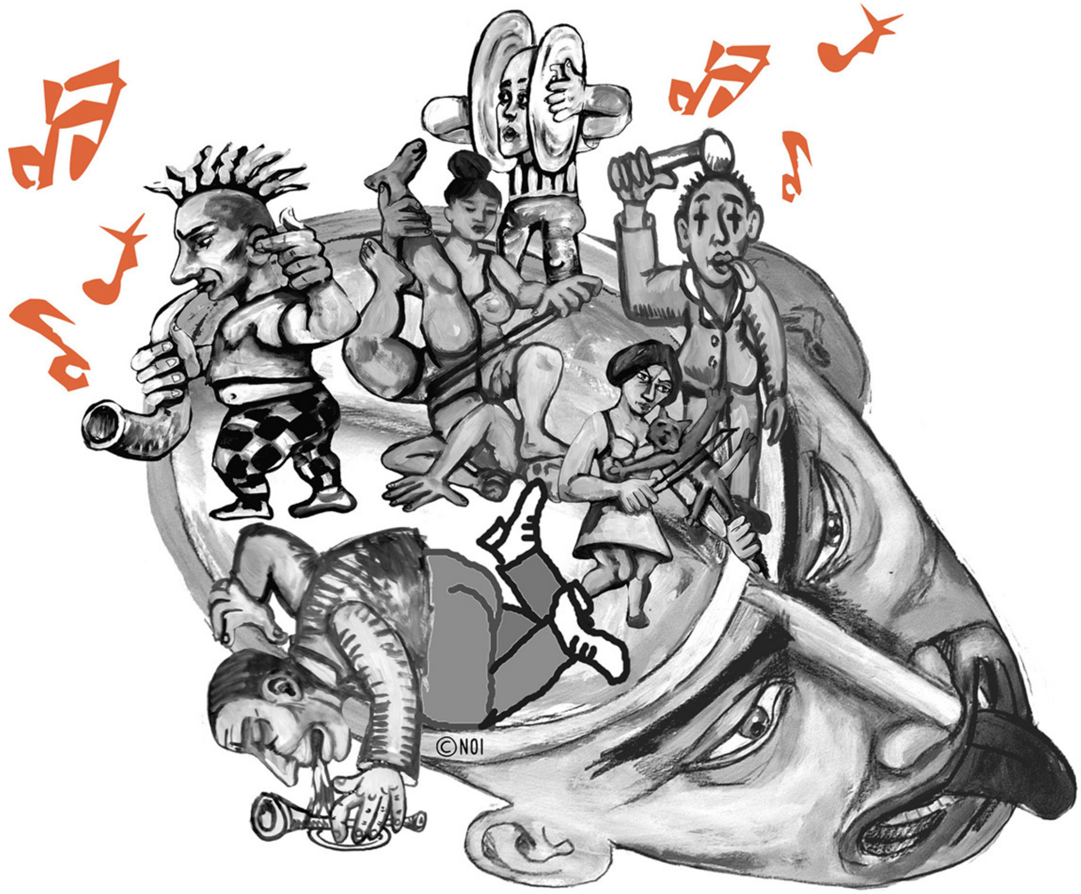

Figure 4.9 *The orchestra in the brain playing a painful tune*

THOUGHTS AND BELIEFS ARE NERVE IMPULSES TOO

Thought viruses are very common and very worrying

The brain is responsible for making the final decision as to whether something is dangerous for body tissue and action is required. We wrote earlier that as humans, we have a terrific advantage over non-humans because we can plan for events and are better at learning quickly from experiences, using logic to predict the future. This means that we can identify a situation as potentially dangerous before there is any input at a tissue level. This is all very well, but when the system is really sensitive (as it is in chronic pain), inputs unrelated to tissue damage but judged by our brain as dangerous, can be enough to cause pain. You won't know that it is your brain that has decided that it is dangerous. You just know that it hurts!!

You are a copycat and you don't know it

It is well known that some people with persistent pain need only think of a movement or watch someone else perform a movement for it to produce pain. In fact, for some patients, just imagining movement can also cause swelling in the painful part.[146,147,148,149] Many patients have told us that 'it hurts if I think about it'. This is completely understandable, and these people are definitely not going crazy. An amazing thing about the brain is that it is always copying other people – for example, smiling, yawning even crying. But think about this – if you see someone in pain, lifting a heavy box, hear someone swear or read about an injury in the paper, if your protection system is sensitised even these things can turn up the ignition nodes and perhaps turn on a pain neurotag. In fact, this is very sensible if you remember that your brain has learned to be very good at protecting you from anything that might be dangerous to your tissues. There are copycat neurones in our brains, known as mirror neurones which fire when you think of moving or if you imagine a movement.

Thoughts are nerve impulses

Our thoughts are very real. They are due to chemicals released in the brain and nerve impulses. Thoughts like 'this health professional thinks I am putting it on', 'the MRI couldn't find it so it must be really bad and deep', and 'Aunt Deidre had back pain and she is now in a wheelchair' are threatening to a brain concerned about your survival. These thoughts and the fear of certain activities, or a fear of re-injury, can increase pain.

Through scientific research, we are now aware of the thought processes which are powerful enough to maintain a pain state.[eg.150,151] We call them 'thought viruses'. Some of the most powerful thought viruses known to cause and enhance a low back pain experience (and probably pain experiences anywhere in the body) are described in the next figure.

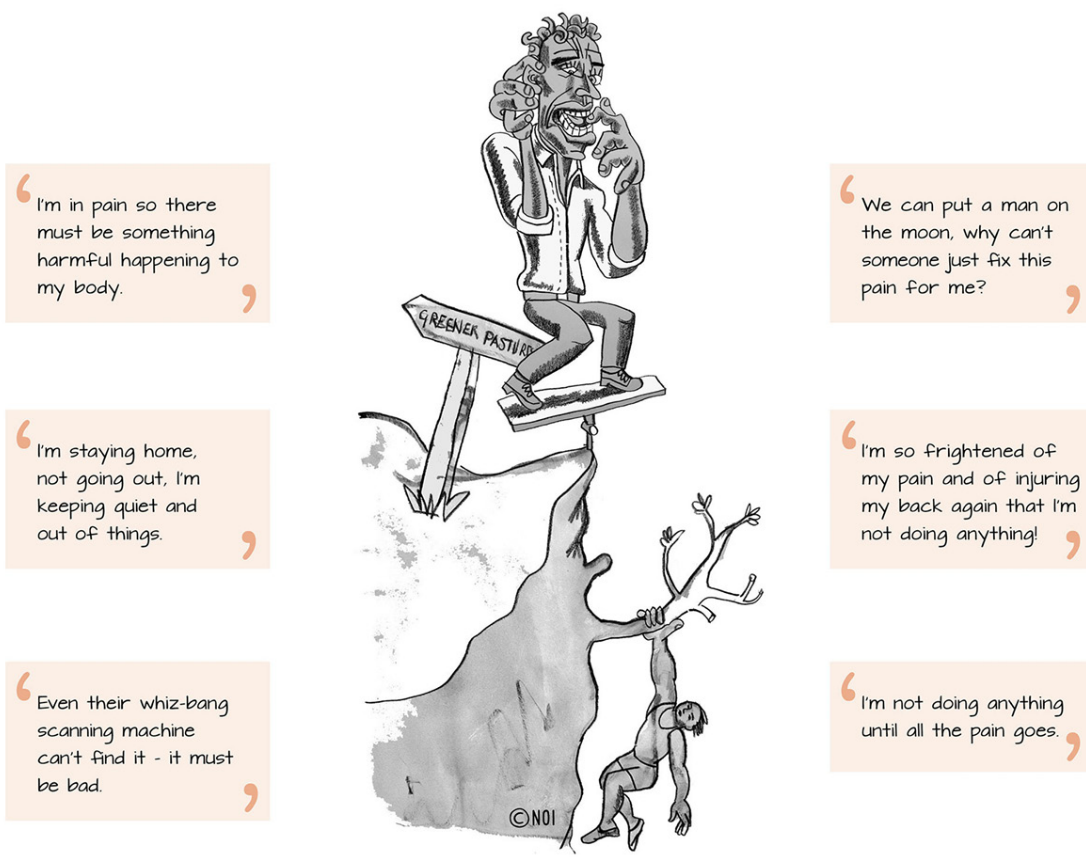

Figure 4.10 Thought viruses are often enough to take you right 'to the edge'

Can you spot it?

Sensitisation of the brain and spinal cord is called central sensitisation. Read through the common features below. Perhaps you have some of them. They may provide a clue that your pain is more related to central nervous system processes than tissue processes.

Your label: Because tissues heal, and because your alarm system and brain have changed to protect you, diagnoses based on tissue processes no longer fit. Often you end up with multiple diagnoses including fibromyalgia, somatoform pain disorder, chronic fatigue syndrome, myofascial syndrome, non-specific back pain, psychosomatic pain syndrome, repetitive strain injury, non-specific neuropathic pain etc. Your diagnosis often depends on where you live and which particular health professional you see. Some diagnoses may have been given to get you out of the clinic as quickly as possible. The signs and symptoms of all of these 'diagnoses' can readily be explained by sensitisation of the central alarm system and by contemplating how the orchestra in your brain is playing.

Because tissues are no longer the main issue, it is often not helpful to seek an understanding of the diagnostic label. It is better to seek an understanding of the particular symptoms which are a feature of your unique presentation. Here are some common symptoms of a sensitised alarm system.

The pain persists: Self-analysis is needed here. The known healing time for tissues involved has long passed. Is there any reason that the damaged tissue wouldn't have healed? After all, broken bones are almost healed in six weeks.

The pain spreads: There are no fences in the nervous system. Sensitisation of the alarm system and brain means the brain is (wrongly) told that more of the body is in danger and the brain therefore spreads pain.

The pain worsens: This is the most obvious strategy for your alarm system and brain if it wants you to escape. Most of the changes in the alarm system aim to increase the frequency of danger messages sent to your brain. It is, therefore, sensible for your brain to conclude that the danger level has actually increased. This will make it hurt more.

Lots of movements (even small ones) hurt: Each increase in the sensitivity of the alarm system will reduce the amount of movement that can occur before the alarm system stops you from going further. If there is ongoing inflammation in the tissues, the danger sensors in the tissues are also sensitive, further reducing the amount of movement you can perform without pain. When the orchestra becomes really used to playing the pain tune, even imagining a movement can produce pain.[eg.152] This is a highly protective mechanism.

Pain becomes less predictable: It may hurt one day but not the next. You may be able to play with your children for an hour one day but not even pick them up on the next day. Sudden stabs of pain can occur which are seemingly unrelated to anything. The best explanation for this unpredictability is that pain is evoked by much more than the demands on your tissues. There may be a latent period before pain presents after an activity. There could be a delay of hours or even days. This latency does not usually occur with damaged tissues and is a feature of a sensitised central alarm system.

Pain links more to your thoughts and feelings: It may be worse when you feel down or upset or have the flu. It may be better when you are happy and occupied.

Pain may be linked to other threats in life previous, current and anticipated: Sometimes it is possible to identify physically and emotionally traumatic events, even from many years ago, that might make the brain more vigilant to threat. Of course, recurrent or multiple traumatic events would give the brain more reason to be protective of the body. Remember, the best way to protect the body is to make it hurt.

Can you identify with any of these commonly heard statements:

'It comes on when I think about it.'

'Watching someone move makes it hurt.'

'It started off so simply and now it has spread.'

'It's worse on Monday.'

‘Now there is a ‘mirror’ pain on the other side of my body.’

‘The pain has a mind of its own.’

‘I get lots of different diagnoses – you name it, I’ve had it.’

‘It gets better with a gin and tonic or a vodka.’

‘It follows a seasonal, monthly, weekly or other cycle.’

‘Treatment only ever gives me temporary relief.’

‘My pain is worse when I am anxious or depressed.’

‘It’s the same pain my mother had.’

‘The pain moves around my body.’

‘No-one seems to believe me.’

‘I am sick of taking pills that don’t help’

With this pattern it is likely that the processes underpinning the pain experience are not predominantly in the tissues, they are more in the nervous system and brain in a very real, understandable, and manageable way.

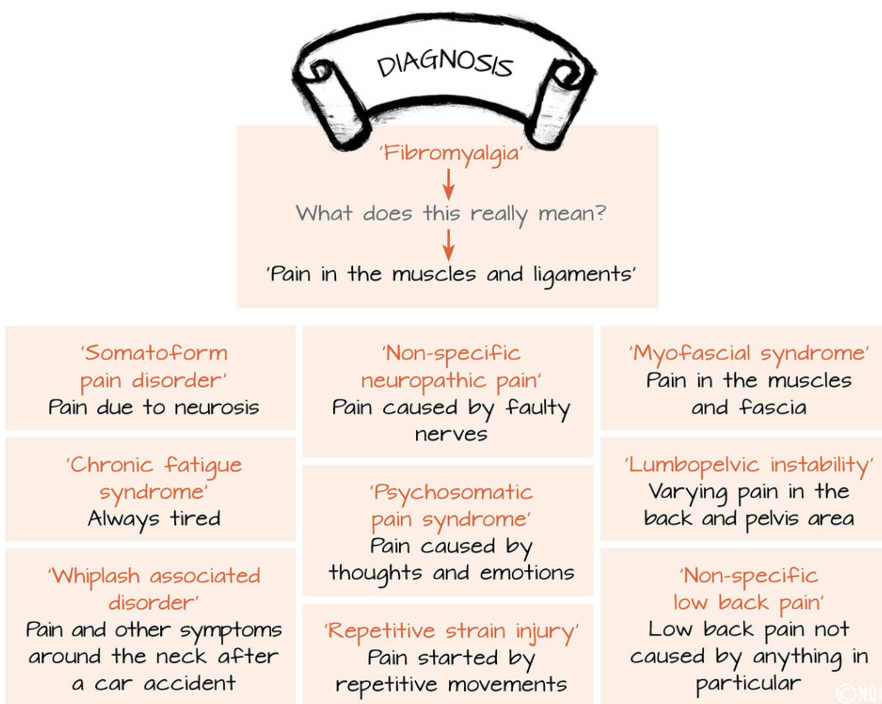

***Figure 4.11** ‘Scary’ diagnoses – what the labels really mean*

RESPONSE SYSTEMS – THE SYMPATHETIC AND PARASYMPATHETIC NERVOUS SYSTEMS

The buzz on adrenaline

The sympathetic nervous system is a powerful and rapidly responding system that helps you to cope, protects you from threat, and allows you to do superhuman things, for example 'bungee jumping', for a short time. This is the system which liberates adrenaline into your body. Normally, adrenaline does a lot of housekeeping in your body for you, for example it regulates breathing and the digestive system. It also regulates many things that you may never know about, such as blood pressure and the size of your pupils.

There are two systems that combine to liberate adrenaline. When required, the inside of the adrenal glands (parked on top of your kidneys) quickly pours adrenaline into the blood. The sympathetic nervous system – a highly developed network of neurones spread right throughout the body and acting more as a gland than as an electrical system – will distribute adrenaline into all your tissues. With these two systems, adrenaline has widespread and important effects. It's all brain driven and occurs in response to sensory inputs from the tissues, the eyes and ears, thoughts, beliefs, perceptions, moods and memories. The blush that comes to your face if you recall something you might have done years ago, is an example of the sympathetic nervous system responding to a memory. And remember, threatening cues can come from cuts, cats, teachers, preachers, leeches, lergies, bumps, bruises, movies, monsters and muggers (just to name a few).

Together with cortisol (also see next pages "The endocrine response") adrenaline diverts energy to the brain, muscles and heart, makes oxygen available, stands your hair on end, dilates your pupils, constricts your gut, suppresses immune activity and turns down sperm production.[153,154] All of this is extremely useful in the short term as your brain decides whether to fight or fly.

Figure 4.12 *Adrenaline and cortisol used in the edocrine repsonse preparing you for fight or flight*

Adrenaline and pain

The sympathetic nervous system is as an on/off system – quickly activated and then returning to normal (up to an hour later) once the stressful situation has gone.

Chronic pain and stress are usually associated with persistently increased levels of adrenaline (although sometimes adrenaline can become depleted). Many a patient has said 'I can't turn the adrenaline switch off'. Adrenaline doesn't usually cause pain by itself, but with a little help from changes in body parts and heightened alarm system sensitivity, it can.[155] Chronic inflammation, nerve damage and increased numbers of adrenaline sensors all mean that adrenaline can magnify the danger message and cause pain. Normally, adrenaline is good stuff. The buzz is great, the anger, anxiety and sweating it promotes may be helpful, but don't let it hang around for too long.

The parasympathetic nervous system

Whereas stimulation of the sympathetic system gives rise to a liberation of energy, the parasympathetic is usually more concerned with slowing and conserving energy – it helps digestion, storing of energy, cellular replenishment, and reproduction. Instead of 'fight and flight', it's 'rest and digest'.

Feeling supported and appreciated are likely to shift sympathetically excited people towards the more protective calming parasympathetic state. The parasympathetic system is more active during sleep, rest and meditation. Disturbed sleep, sleeplessness at night and sleepiness during the day may all contribute to ill health and sensitivity of tissues. Not enough sleep, not enough ongoing repair. This may be a good reason to try some relaxation or meditation during the day to try to give the parasympathetic system a chance to assist in tissue replenishment and growth.

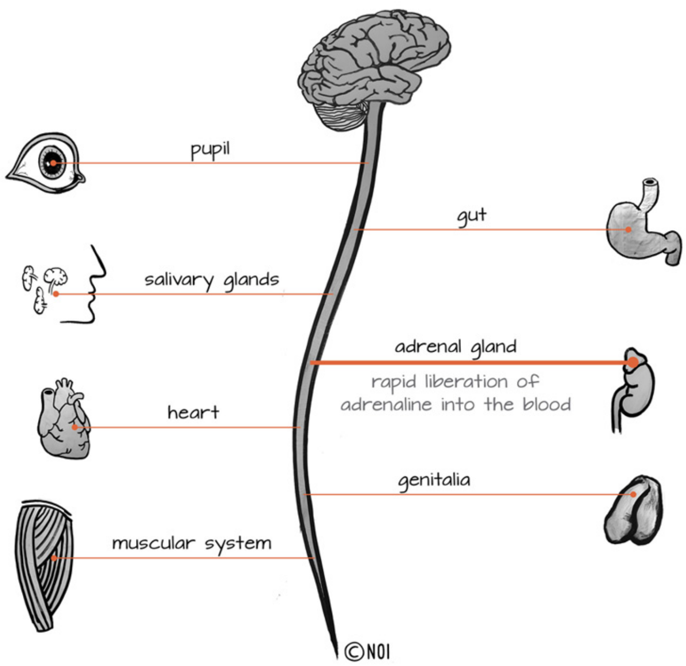

Figure 4.13 *The sympathetic nervous system and the systems it affects*

THE ENDOCRINE RESPONSE

The good and bad of cortisol

Along with the sympathetic and immune systems, the endocrine system is the other key player in the stress response. It works with the sympathetic system but its effects may last weeks or months rather than minutes or hours. The sympathetic nervous system is like a match – easy to light and goes out fast, whereas the endocrine response is more like a fire – harder to get going but lasts longer.

The key bits of anatomy are the stress control areas of the brain (pituitary and the hypothalamus) and the adrenal glands, which perch atop your kidneys. You will be able to see them in the figure.

Threatening inputs, memories and circumstances make the hypothalamus release hormones, which in turn make the pituitary gland release hormones (adrenocorticotropic hormone or ACTH) into the blood. Within a couple of minutes, ACTH is picked up by chemical sensors (remember them?) in the outer layer of the adrenal gland. This gland then produces a number of hormones necessary for maintaining a balance in life. A key hormone is called cortisol.

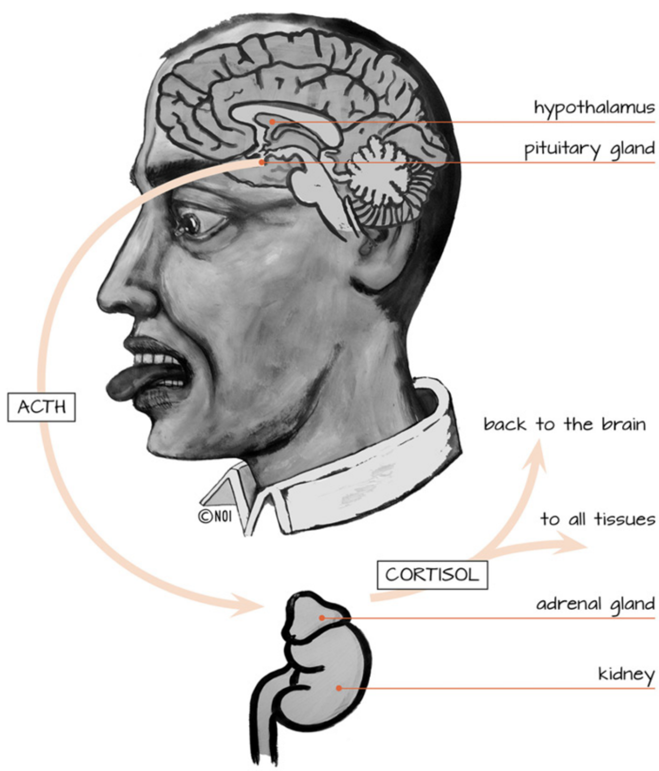

Figure 4.14 The endocrine system at work

What does cortisol do?

The term 'stress chemical' is often applied to cortisol, and it sometimes gets a bad rap. But remember it is above all a **protector**. Along with adrenaline, cortisol is a chemical that protects you when you are challenged. It slows down body processes which are not needed for immediate protection and enhances those which are.

So if you have just lifted a very heavy, awkward weight and hurt your back, or you are in an armed robbery, or you are about to do a mathematics exam, or a health professional has implied that your pain is not real, you probably have no interest in reproduction and digestion. And any healing of tissues can be put on hold – the processes in inflammation draw too much energy. However, the systems you will need are muscles (to support, run away), and your brain (for quick thinking) and maybe some endorphin support (a brain-produced danger message suppressor). No matter whether the threat involves a physical or mental challenge, the emergency increases cortisol production.

If threats continue, persistent altered levels of cortisol can create a few problems. Altered levels of cortisol has been linked to slow healing, poor healing, loss of memory, loss of libido, depression, despair and a decline in physical performance.[156,157]

Cortisol production changes during the day. It peaks in the early morning, then declines until lunch when it rises a little bit and then it is at its lowest in the early evening. Our sensory abilities parallel this. People with maintained inflammation often have more pain in the evening when cortisol levels are down.

Cortisol is only one hormone of interest. Oxytocin is another which affects the body in many ways, from speeding up childbirth, relieving pain and preventing weight gain. It's easy to make – love someone, even look at someone you love, give them a hug. If you pat a dog or cat, you'll both get a blast of oxytocin.

THE IMMUNE SYSTEM

The new kid on the block in the pain story

The immune system is a powerful system that also looks after you, especially when things turn bad. It's a key player in pain too, although this is quite a recent discovery. It has close links with the cortisol and adrenaline based systems. Your immune system knows who you are and will react when you are not you – either from an injury or infection or from psychological distress when you aren't quite yourself.

There are immune molecules called cytokines, which form a mobile protective system floating inside the body. Many cells and organs (such as the spleen) can make them. Some cytokines promote inflammation and some try to stop it. It's good to have them in balance. When you have the flu there will be more of the pro-inflammatory cytokines around. If you remember your last flu attack, you may recall that as well as fever and lethargy, loss of appetite etc, your movements were more sensitive and occasionally, old pains may have come back to revisit. This is due in part to an increase in the pro-inflammatory cytokines.

The neurones and the immune system talk to each other all the time and keep up a lively chat with the endocrine, sympathetic and parasympathetic systems. For example, cortisol and adrenaline can activate the immune system which can signal neurones in the brain, the brain activates the cortisol system etc etc. It's quite a cycle!

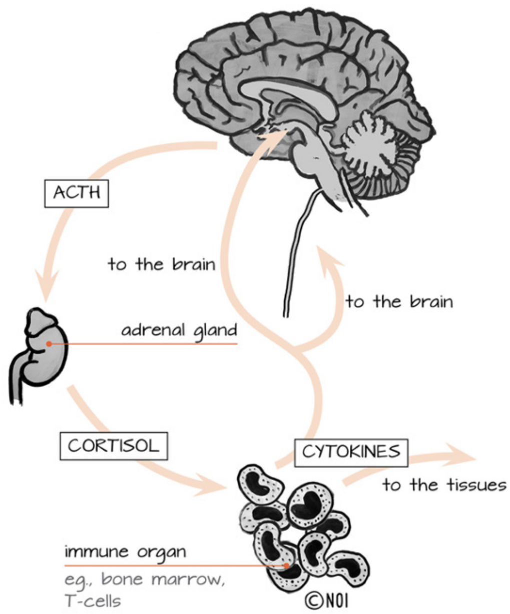

Figure 4.15 *The immune system at work*

Here are some interesting things about the immune system which are relevant to pain:

1. While our immune system helps us learn and is involved in everyday stress and pain, it becomes really involved when things get serious or chronic.
2. Immune system responses can be learnt responses.[158] Our immune systems hold memories. Vaccinations are a great example.
3. Long-term stress and pain usually leads to an alteration in activity which results in more circulating pro-inflammatory cytokines.[159]
4. Immune stressors can be one major event or many minor events (microstressors).
5. The immune system may actually underpin some pain states, such as ‘mirror pains’ (the same pain on both sides of the body), and the spread of pain. Smudging in the brain is due in part to the immune response. Damaged peripheral nerves are particularly reactive to pro-inflammatory cytokines.[160,161] Old

injuries can ‘come back’ when you have the flu.

6. Finally, the immune system, like other systems, can be activated not only by events happening in the tissues but by the brain’s interpretation of events.[162] If you think something is really bad, the thoughts can lead to an immune response.[163]

The immune boosting behaviours

This is a good time to talk about the immune boosting behaviours, behaviours that you can use to counteract the processes that can combine to cause pain. Here is a very general list of things that we know can help to buffer the immune system:[164]

- To have an influence on the quality of one’s life
- To be in control of your life and your treatment options
- To have family and medical support
- To have strong belief systems
- To have and use a sense of humour
- To exercise appropriately

While these behaviours buffer the immune system, they are also known factors which can improve a pain state.

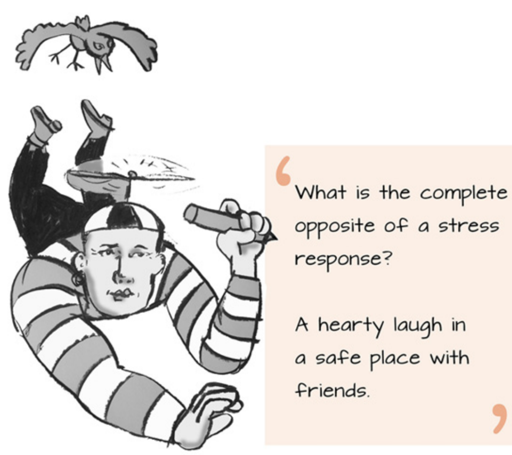

Figure 4.16 *A hearty laugh with friends in a safe place*

MOVEMENT STRATEGIES

We have learnt that the brain produces pain to motivate you to protect your body. The brain also 'primes' muscles to help you escape. This is great in the short term – you get ready to run away or fight by 'priming' your big long muscles such as a hamstring or a trapezius as in the image. These muscles are best suited to this job because they can produce a great deal of torque (torque is the twisting force that makes joints move), partly because they cross more than one joint and partly because they can shorten a great deal.

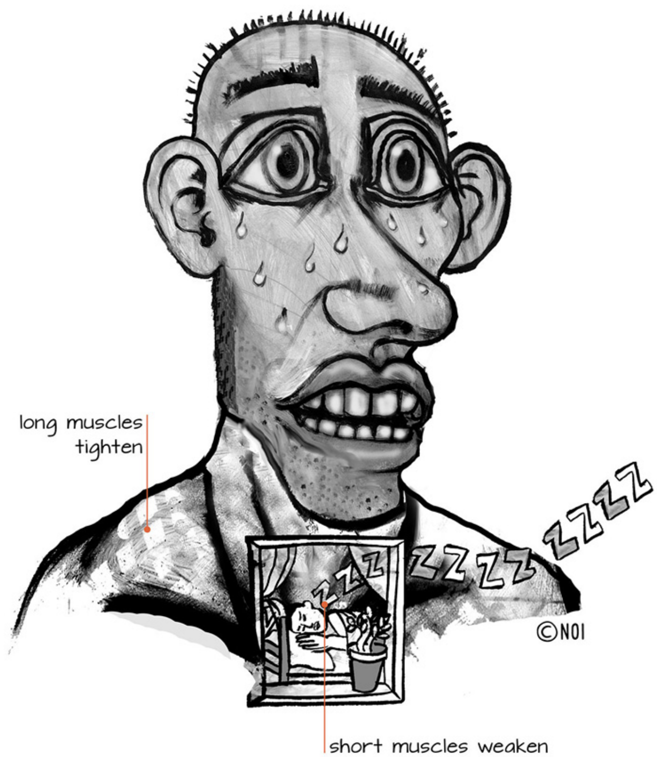

Figure 4.17 *Long muscles are 'primed' for a flight response*

In the long term, continued and overactivation of these muscles is not smart. As a general rule, when these muscles stay active for a long time they tend to contract, there is a build-up of acid (see movement strategies in "Acid and inflammation in the tissues"), and they start to feel 'stiff'. It's a bit like sprinting a marathon. However, if the long muscles are turned on, the shorter ones, for example the stabilising muscles between vertebrae, go to sleep – there is no need for them if you are trying to avoid danger.

Take back pain for example. Back pain is associated with changes in trunk muscle activity.[165,166,167] The changes probably help the brain splint the trunk. However, muscle activity sometimes doesn't return to normal even if the pain eventually resolves. Fear or anticipation of pain may be enough to prevent changes returning to normal[168,169,170] – it seems that the thought viruses have an effect on all systems.

These changes may place different body tissues at risk of injury, or prevent body parts from healing to the best of their abilities.

Long-term movement changes make you behave differently, hold yourself differently, move differently and even talk differently – all of which have long-term consequences. Once new motor patterns have been learnt, they can be very hard to reverse. It's not difficult to pick someone with an old arm injury by the way he/she hangs out the washing, or people with old ankle injuries by the way they walk up stairs. These patterns are often more obvious when there is psychological stress.

It's probably a good thing to stretch tight muscles and strengthen weak ones, but we think it is also important to try to work out the threats that are making the muscle system work so hard to protect you.

RECAP

Recap section 1

- All pain experiences are a normal response to what your brain thinks is a threat.
- The amount of pain you experience does not necessarily relate to the amount of tissue damage.
- The construction of the pain experience of the brain relies on many sensory cues.
- Phantom limb pain serves as a reminder of the virtual limb in the brain.

Recap section 2

- Danger sensors are scattered all over the body.
- When the excitement level within a neurone reaches the critical level, a message is sent towards the spinal cord.
- When a danger message reaches the spinal cord it causes release of excitatory chemicals into the synapse.
- Sensors in the danger messenger neurone are activated by those excitatory chemicals and when the excitement level of the danger messenger neurone reaches the critical level, a danger message is sent to the brain.
- The message is processed throughout the brain and if the brain concludes you are in danger and you need to take action, it will produce pain.
- The brain activates several systems that work together to get you out of danger.

Recap section 3

- Tissue damage causes inflammation, which directly activates danger sensors and makes neurones more

sensitive.

- Inflammation in the short term promotes healing.
- Tissue healing depends on the blood supply and demands of the tissue involved, but all tissues can heal.
- The peripheral nerves themselves and the dorsal root ganglion (DRG) can stimulate danger receptors. Normally, pain initiated by danger messages from the nerves and DRG follows a particular pattern.

Recap section 4

- When pain persists, the danger alarm system becomes more sensitive.
- The danger messenger neurone becomes more excitable and manufactures more sensors for excitatory chemicals.
- The brain starts activating neurones that release excitatory chemicals at the dorsal horn of the spinal cord.
- Response systems become more involved and start contributing to the problem.
- Thoughts and beliefs become more involved and start contributing to the problem.
- The brain adapts to become better at producing the neurotag for pain (the ‘pain tune’).
- Danger sensors in the tissues contribute less and less to the danger message arriving at the brain.

Section 5

INTRODUCTION SECTION 5: MODERN MANAGEMENT MODELS

There are many people and groups of people who would like to help you with your pain. But be prepared. A clinical nightmare may be waiting.

The more orthodox groups include doctors, surgeons, psychologists and physiotherapists. Slightly less orthodox include chiropractors and osteopaths, and the non-orthodox groups include faith healers and iridologists. Within each group of health profession, there are factions. For example, one surgeon may fuse your vertebrae together (orthopaedic surgeon) while another may insert a stimulator on your spinal cord (neurosurgeon). So too, there are different kinds of physiotherapists, chiropractors, osteopaths, psychologists etc. There is often argument between and within groups.

You need to be careful and in control. In particular, be wary because you are likely to hear or have heard many different explanations for your problem. This can make it worse and add confusion. Remember that you are the owner of your pain, no one else. In the end, it is you who has the most power to manage and rid yourself of it.

The skills of the practitioners in the various groups may help you with parts of the pain problem, but we believe that you will be better informed and in control if you understand the science behind your pain state.

We are not recommending for or against particular practitioners but suggest that the following guidelines may help you to make informed choices:

1. People with ongoing pain states will require a medical examination. Medicine is very effective at diagnosing the nasty but rare problems.
2. Make sure that any prescribed help makes sense to you and to your understanding of the problem. Ask the health professional if there are any scientific studies supporting what they propose.
3. Have ALL your questions answered satisfactorily.

4. Avoid total dependence on any health professional. **You must take control.**
5. Always have goals that are understood by both you and your health professional. These could be measurable physical, social and work goals.

Good clinicians have numerous qualities. They are compassionate, enthusiastic and informed. They are curious about new ideas. They are experts.

They assist you in mastering your situation.

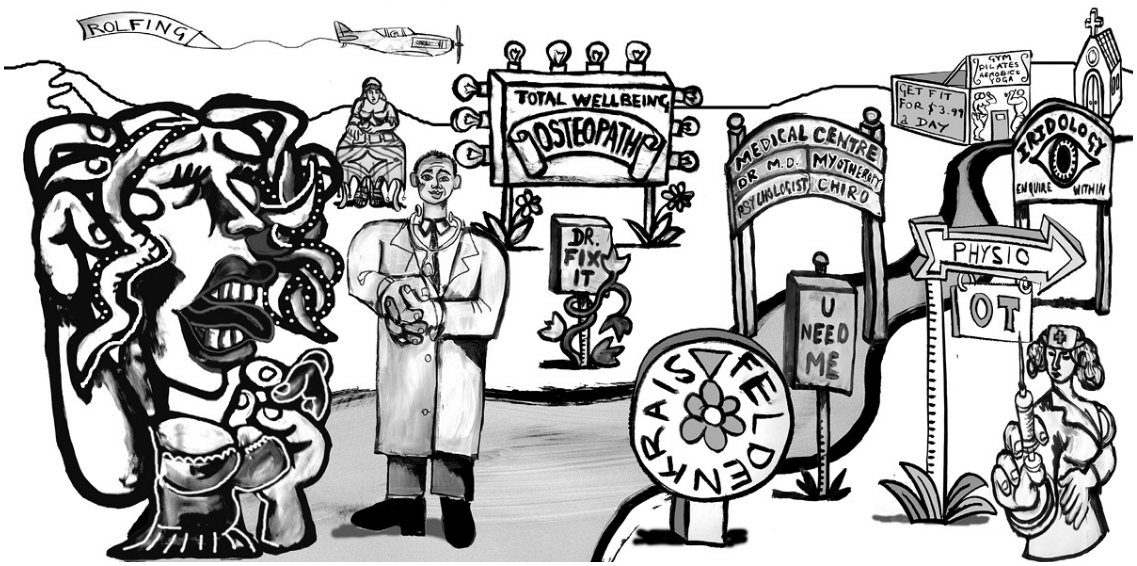

Figure 5.1 *The nightmare of choice*

MODELS OF ENGAGEMENT

Think like a modern health professional

Health professionals have models or frameworks on which they base their work. We believe that an understanding of these models could help you, the person in pain. These models can give you platforms to understand pain, identify the threats that contribute to, ignite, or maintain your pain and help you plan for the road to recovery. They can help you make sense of some of the advice you have been given.

Figure 5.2 *The orchestra model*

'Orchestras and onions'

We would like to take you through the unusual blend of orchestras and onions. Orchestras first.

The orchestra model (virtual body, neuromatrix, neurotag) is the major model on which this book is based. It draws from many areas of pain science knowledge including brain imaging, cellular biology and immunology. It considers that pain results from a combination of processes in tissues and the processing of danger messages. This processing is carried out in many parts of the nervous system and the brain in particular can change to represent what it ‘decides’ is best to help you cope.

The model is powerful as it recognises that various ignition cues (eg. fear, memories, damaged tissues, the wrong information, various circumstances) can be a part of the pain experience. It is a model that provides an understanding of the biological bases of pain and acknowledges that even though the processes are happening in the brain, they manifest themselves in very real, anatomical and biological ways. Thoughts, ideas, fears, knowledge and emotions are seen as nerve impulses which have electrochemical consequences in the brain, just as inputs from damaged tissues have electrochemical consequences.

The orchestra model blends beautifully with the onion skin model. Bear with us as we link your pain to a vegetable!

This model comes from psychology, was around before the orchestra model and it can really power that model up. We teach it to all our students.

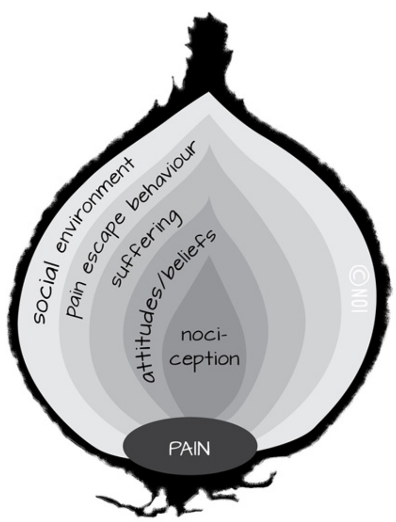

Figure 5.3 *The onion skin model (Adapted from Loeser[171]) Check out the onion cut in half and note the rings. The rings are a way to tag all the factors that can contribute to a pain experience at any one time.[eg.172,173] Each ring represents a group of factors. Pain experiences usually involve inputs from all rings of the onion. At the right time and place, these factors can kick off the ignition nodes in the brain and cause the orchestra to play the pain tune.*

Let’s use the model to think about a common example – say a woman who has had a low back injury and still has back pain a year later.

Nothing can be found on scans and x-rays.

a. **Nociception.** Here is some revision for you! (see “A closer look at alarm signals” and “Here are some bone and joint facts”.) Her alarm system may be firing from sensitive, unfit and maybe scarred tissues in the back. As we know, firing of the alarm system does not have to hurt but it can be a part of the pain experience. You may need action from other rings of the onion to construct enough brain activity to make the orchestra play ‘Pain’.
b. **Attitudes and beliefs.** Perhaps she feels as if she should ‘soldier on’ no matter what and hopefully it will go away, but she realises that this isn’t helping. She constantly recalls the incident that started it all, sometimes has thoughts that it was her fault, but is starting to get angry with unsupportive work colleagues. Some common beliefs in this situation could be: ‘something must be broken in my back, why can’t they find it’ or ‘am I being punished for something’. Beliefs can also foster fear, anger, blame (including ‘why me?’), all of which are common in people with ongoing back pain.[174,175,176] Attitudes and beliefs can be powerful contributors to getting the orchestra warmed up and ready to play.
c. **Suffering.** At the moment she is suffering in silence, but she feels the need to scream and tell everyone. She is also thinking there is no end to this pain and treatment. Her husband and family, even the pet cat are beginning to suffer. Suffering activates nerves and synapses just like attitudes and beliefs.
d. **Pain escape behaviours.** For various reasons she may go doctor or therapist ‘shopping’, looking for an answer. She may pray, go to lawyers, turn to ‘recreational’ drugs, sleep, travel long distances to famous gurus, or spend inordinately large amounts of money to find a cure. All these thoughts and associated activity might have the strings in the orchestra playing already.
e. **Social environment.** Perhaps her family are tired of hearing

her complaints and are becoming less and less helpful. She may join a back pain support group, spend all her time on back pain blogs and actively chase compensation. She may feel that some of her friends do not want to spend time with her anymore (if they really understood what is going on they would!). Health professionals become sick of seeing her and she may feel isolated. The sound of an orchestra reflects its member components but also what society wants and expects. Like pain.

THE CLINICAL DECISION-MAKING MODEL

One recipe does not fit all

Pain is a very personal event. No-one knows the exact mix of biological processes that are in action in any particular pain situation, although these days we can make sensible predictions. If you have chosen a person to help with your management, we hope that person is an informed clinical decision maker.

Clinical decision making is a vital science in pain treatment. Your pain is so unique that a 'recipe' for treatment that is the same for all pain situations will not do. Clinical decision makers should be able to make decisions based on your particular presentation and on the very best of science.[177,178,179]

Figure 5.4 *Clinicial decision making model*

Ideally, health professionals should be able to give you an answer to all the following questions:

'What is happening in my body?

... Is there some scientific backing to what you think?'

'How long will it take to get better?

... Short and long term goals.'

'What are all the options for management?

... From science, what is most likely to help?

... What might help?

... What won’t help?’

‘What can I do for it, because I want to do as much as I can?’

‘What can you do for it?’

‘Is there anything nasty which needs special attention?’

‘What do my physical findings, x-rays and scans really mean?’

THREATS HIDE IN HARD TO SPOT PLACES

It's one sophisticated protective system!

An important theme of this book is that pain is a protective device. Your brain is so sophisticated that it can take into account anything that might be threatening your livelihood. This means that the sources of threat are diverse – they can be lurking in places where you would not look unless you understood the true complexity of pain.

We have listed some threats in the table that are really common for people with persistent pain. You might recognise some of them. You might have some others you could add. Remember – ANYTHING that increases the brain's perception of the need to protect you can increase your pain.

This diversity of potential threats can lead you into a cycle of pain and disability from which it can be really difficult to break free. Some of the information that comes from well- meaning but uninformed health professionals, friends, family, lawyers and media can make important contributions to threat. Of course, different threats are relevant to different people at different times.

Remind yourself of these two things: (1) your brain wants to protect you from anything that it concludes is dangerous, and (2) in persistent pain, when the danger messenger nerve and the pain ignition nodes are sensitised, any of these threats, even minor, can help maintain the pain because they can activate the ignition nodes and set up the orchestra to play the pain tune. And keep playing it.

You are in the driver's seat here – you need to identify all the threats that might be affecting your pain. You need to be informed and understand as much as possible about your body and your pain. Critically, you need to be brave because some threats are more difficult to accept than others.

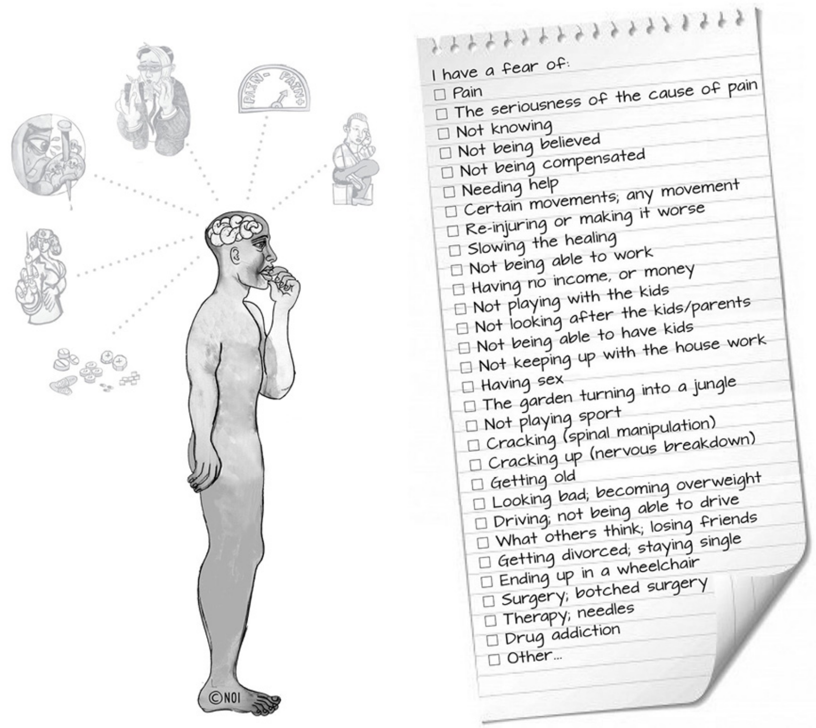

Figure 5.5 *Threats hide in hard to find places*

HOW ARE YOU TRAVELLING?

Watch the fork in the road and don't get stuck on a roundabout

What about fear of pain itself? Pain is frightening, especially if you don't know what is causing it. In fact, some people reckon that fear of pain is more disabling than pain itself.[180] There is a lot to this idea – take a look at the map in the next image. This is our version of a very famous model called the fear avoidance model.[181,182,183,184] It goes like this – you might sustain an injury and then you quickly hit a fork in the road. One direction is associated with anxiety about the cause, worrying about making the injury worse, seeing a bunch of clinicians who tell you how bad your injury is, increasing your fear of reinjury or pain.

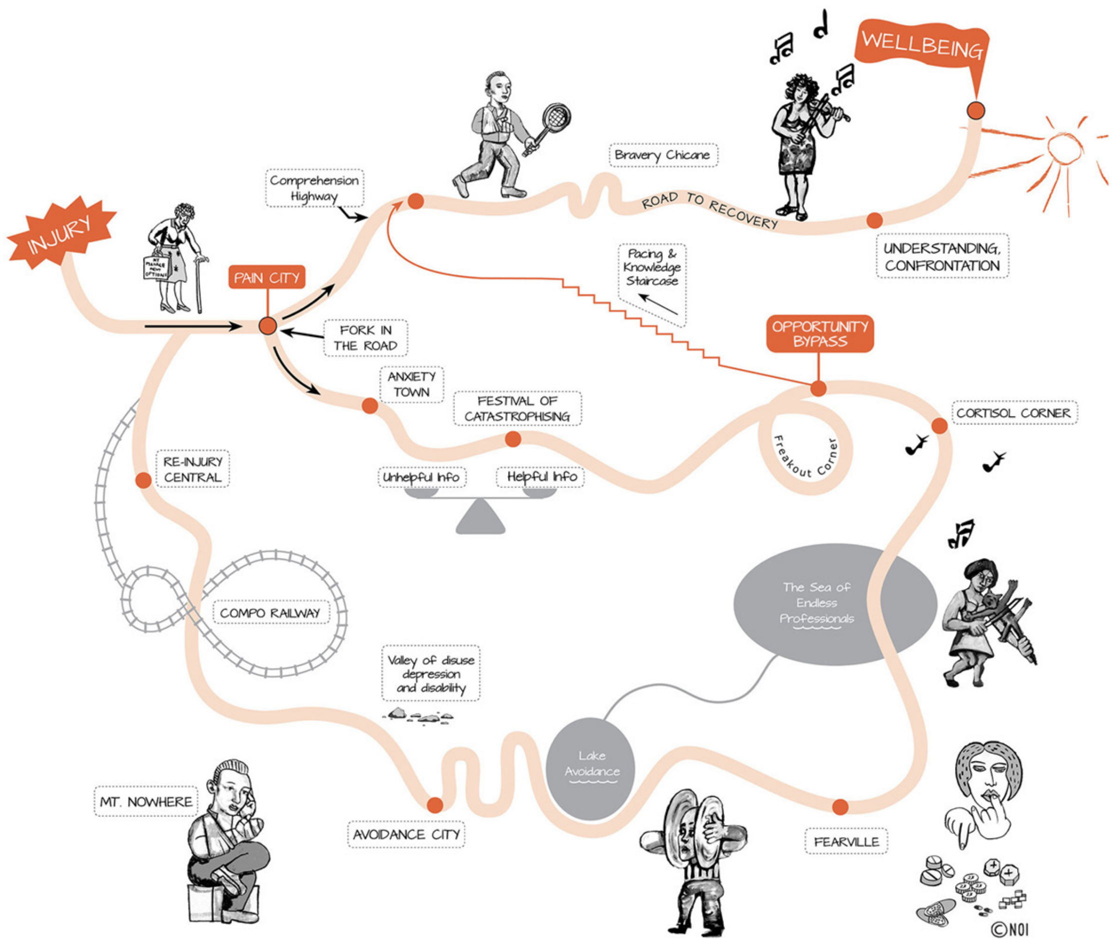

Figure 5.6 *The road to recovery (Adapted from Vlaeyen and Crombez[185]) Understandably,*

you start to avoid some activities and movements, which reduces your fitness and strength. This avoidance also reduces your quality of life, which increases your anxiety and worry about your pain, sends you off to more clinicians who tell you how bad it all is again, which increases your fear and you avoid even more activities and movements, your life loses a bit more meaning and reduces in quality. You get the picture – this is one vicious cycle.

Now, not everyone fits into this model, and those who do, may fit in different ways. What about you? Can you recognize this vicious cycle? We know that many people in pain feel like they are on this brutal whirligig of things getting worse and worse and it feels like they will never get off. But here is the good news – you can!

Take a look at the opportunity bypass. By taking the pacing and knowledge staircase, really working to understand your pain and the biology that underpins, powerful therapy opportunities open up. Sure you might have to be brave and confront some demons along the way. Sure it is not quick – it won’t happen overnight. But make no bones about it, this is the road to wellbeing. We now know that if you understand why there is a better way, that you have the resources to overcome your pain, and you commit to making the journey, you get better and better and better.

One way to help you take on this journey is to help you work out how your own style and skills can help.

WHAT'S YOUR STYLE?

Coping with threats and pain

Everyday we all face many things we need to cope with. Coping is the ability to identify, manage and overcome the issues that stress us. There are many different ways to cope and coping skills vary between people. One thing is for sure, we can all improve our coping skills. And the good news? Good coping can be learnt. First, let's cover some background again.

Remind yourself that the brain and body can use the same systems to protect us from physical threats and non- physical threats. In fact, ALL threats require physical and psychological coping strategies.

Some coping skills that have been shown to be effective when it comes to pain include problem solving, seeking knowledge and understanding, and then changing thoughts, behaviours and beliefs. Coping with your pain means you have the power to change it. Coping aims to reduce the threat value of different cues, which will change the feelings and thoughts that those cues trigger, and the associated biological effects too.[186,187]

Most coping strategies can be categorised as active or passive. There is a large amount of research that shows that active strategies are more effective than passive strategies when it comes to pain, and to a variety of health issues.

Now is a good time to ask yourself 'What's your style?' What do you do to cope with your pain?

Active coping strategy examples

- Seeking better understanding about the problem (and articulating your understanding with courage and honesty)
- Exploring different ways to move and do things
- Nudging the edges of pain – not avoiding it altogether and not trying to ‘break through it’
- Staying positive
- Making plans, setting small, attainable goals and moving, gradually, towards them
- Setting longer term and bigger goals and being patient!

Passive coping strategy examples

- Avoiding activity and anything that might be painful
- Doing nothing
- Resting
- Waiting for something to change
- Waiting for the right person to change it (the right person is you).

Figure 5.7 *Should I talk about it?*

No, evidence shows that just talking about it, for example in support groups and online chat groups, does not help. You need to talk to people who really understand the biology of pain.

There are training programmes that focus on coping skills – for example mindfulness, acceptance and commitment therapy, cognitive behavioural therapy, coping skills training. All these approaches have an important place – they are not right for everyone, but everyone can get some benefit from at least one of them.

Remember though, until you really understand your pain, learning how to cope with it in an active way might not make sense. This is one reason we wrote this book – so you and your clinician can really understand your pain and why these things are helpful.

Figure 5.8 *Passive and active coping strategies, finding the balance*

YOUR RELATIONSHIP WITH PAIN

Are you a boom-buster?

Before we talk about the most important treatment tools, we believe it is important for you to have an idea of how you are 'travelling' and for you to understand the relationship between your pain and your activity level. This will not only further demystify your pain but will allow you to establish a starting point, a baseline by which you can evaluate your progress. You can do this yourself, although you may benefit from a helpful, thinking, informed, clinical decision-making professional.

Do you recognise either of the following relationships between activity and pain?

Avoiding pain (Graph 1)

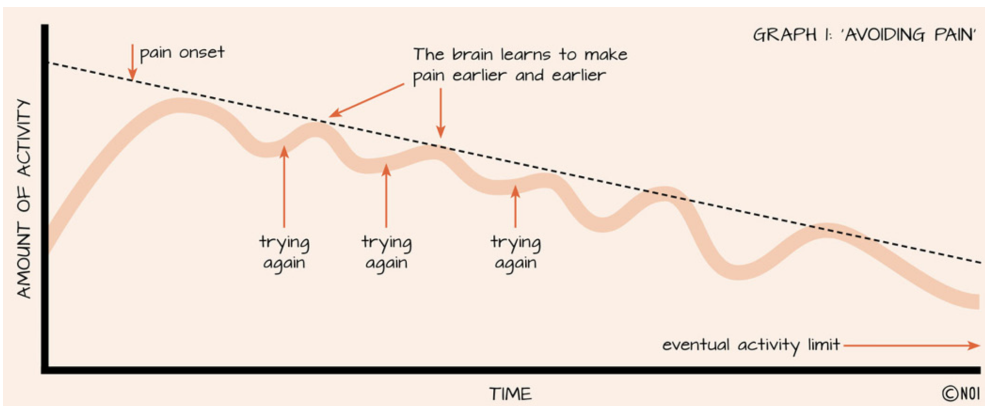

Figure 5.9 *Avoiding pain graph – the gradual decline pattern*

This is the gradual decline pattern. Pain kicks in after a certain amount of activity. This could be anything, for example sleeping, standing, sweeping, branding (for the farmer), having dinner, having sex, having visitors and having deadlines.

The natural response is to stop the activity when pain starts. Over time the amount of activity at which pain is experienced slowly reduces, eventually leading to disability, disuse and probably depression. In our experience, this pattern is more common in people who are afraid of pain and re-injuring tissues and for people who are 'passive copers'.

Trying to beat pain (Graph 2)

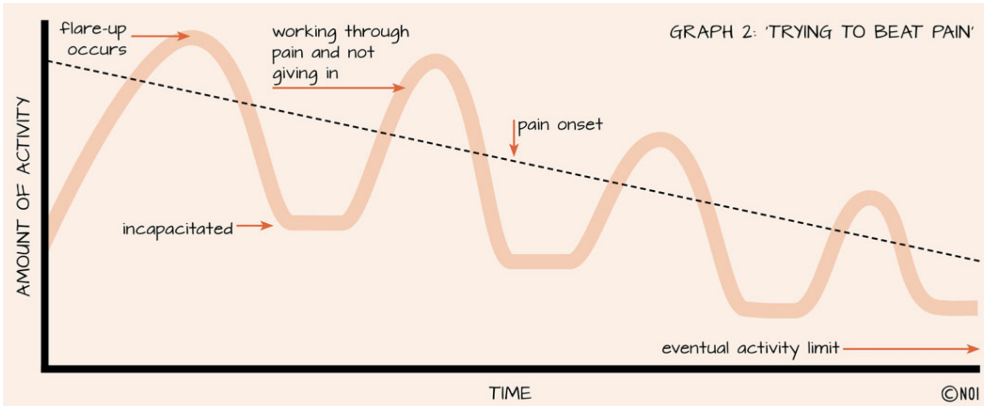

Figure 5.10 *Trying to beat pain – the 'boom bust' pattern*

This is also known as the 'boom-bust' pattern. Pain comes on but you persevere, you tolerate it as much as you can and try to ignore it, keep going, distracting yourself ('boom') until suddenly your pain is unbearable and you 'bust' – flooding your nervous system with danger chemicals and leaving yourself completely wiped out for days, maybe even weeks. In our experience, this pattern is more common in people who are perfectionists, high achievers, stoic, energetic or who perceive that other people or institutions are in control of their situation.

The common feature of both graphs is that the activity limit keeps dropping and is eventually very low. It's low because pain has become the master.

Avoiding pain or trying to beat pain won't work. We need to respect it, not fear it, and plan a road to recovery.

RECAP

Recap section 1

- All pain experiences are a normal response to what your brain thinks is a threat.
- The amount of pain you experience does not necessarily relate to the amount of tissue damage.
- The construction of the pain experience of the brain relies on many sensory cues.
- Phantom limb pain serves as a reminder of the virtual limb in the brain.

Recap section 2

- Danger sensors are scattered all over the body.
- When the excitement level within a neurone reaches the critical level, a message is sent towards the spinal cord.
- When a danger message reaches the spinal cord it causes release of excitatory chemicals into the synapse.
- Sensors in the danger messenger neurone are activated by those excitatory chemicals and when the excitement level of the danger messenger neurone reaches the critical level, a danger message is sent to the brain.
- The message is processed throughout the brain and if the brain concludes you are in danger and you need to take action, it will produce pain.
- The brain activates several systems that work together to get you out of danger.

Recap section 3

- Tissue damage causes inflammation, which directly activates danger sensors and makes neurones more

sensitive.

- Inflammation in the short term promotes healing.
- Tissue healing depends on the blood supply and demands of the tissue involved, but all tissues can heal.
- The peripheral nerves themselves and the dorsal root ganglion (DRG) can stimulate danger receptors. Normally, pain initiated by danger messages from the nerves and DRG follows a particular pattern.

Recap section 4

- When pain persists, the danger alarm system becomes more sensitive.
- The danger messenger neurone becomes more excitable and manufactures more sensors for excitatory chemicals.
- The brain starts activating neurones that release excitatory chemicals at the dorsal horn of the spinal cord.
- Response systems become more involved and start contributing to the problem.
- Thoughts and beliefs become more involved and start contributing to the problem.
- The brain adapts to become better at producing the neurotag for pain (the ‘pain tune’).
- Danger sensors in the tissues contribute less and less to the danger message arriving at the brain.

Recap section 5

- Modern management models incorporate the current scientific knowledge and do not focus solely on tissues.
- These models recognise the importance of alarm system sensitivity, fears, attitudes and beliefs in a chronic pain state.
- How you understand and cope with pain affects your pain as

well as your life.

- Many people with persistent pain relate to ‘avoid pain’ or ‘try to beat pain’ (boom-bust) approaches. While understandable, these approaches are not helpful and lead to drastic limitation of activity and meaning in life.

Section 6

INTRODUCTION SECTION 6: MANAGEMENT ESSENTIALS

There is no single solution for all pains. Pain, like people, is always different. The pain experience, as we have shown in ‘onions’ and ‘orchestras’ is an experience which occurs as a result of the merging of your body (including your brain of course), your environment and your community.

Of the many non-drug-based management tools that have been suggested for managing pain, there are three tools that have consistently been shown to be helpful.[188] They revolve around activity and understanding and if necessary they can be combined with appropriate short-term drug therapy. But hang on – education and activity uses the most powerful and personalised drug cabinet on earth – the one in your brain, so it’s unfair to say non-drug based!

Education, knowledge and the ability to act on that knowledge provide the foundation for therapeutic activity. Why perform painful activities or activities which might be painful if you don’t understand the hurt that they cause or could cause? Why do something that hurts if you don’t understand the difference between tissue damage and pain. That would be daft and it would just further provoke the protective mechanisms. Education, knowledge and understanding reduce the threat associated with pain. Reduced threat has a positive effect on all the input and response systems.

Movement not only increases the health of joints, soft tissues, circulatory and respiratory systems, it has another very important function. Educated movement is brain nourishing, because it establishes and re-establishes fine functional sensory and motor representations in the brain, using pathways laid low by fear and ignorance. Our aim is to teach the orchestra to play all the tunes again, to regain its creativity, curiosity and resilience.

Obviously, because we are highly integrated beings and fearfully and wonderfully complex, there are many other tools which may help different people at different times. For example medication, diet, skilled attention to unhealthy tissues, cognitive and behavioural therapy, relaxation strategies, spiritual enlightenment, love. Our focus here is on biologically-based education, knowledge, understanding and movement.

Figure 6.1 *You own your own pain, medicine doesn't*

TOOL 1: EDUCATION AND UNDERSTANDING

The primary step in management

By the time you reach this point in the book, and you understand what we've been saying, you will know more about pain than many health professionals do.[189] Well done! Unless clinicians are up to date with science, some of the notions presented in this book may be unfamiliar to them.

Figure 6.2 *With so many choices how do you choose which road to take?*

Test yourself. The 'rat' (is that really a rat?) has a choice of three roads to travel on: the well-trodden roads of 'no pain, no gain', and 'let pain be your guide' or 'the road less travelled'. Which road will he take?

Let's think about the **no pain, no gain** road. People talk about pushing through the 'pain barrier'. We don't support this, although for some people there is no harm in vigorous exercise as long as they understand any pain that is provoked. For example, some discomfort as you rehabilitate stiff joints and tight muscles is probably necessary. But pain is a bit like love, joy or jealousy – have you ever heard of anyone pushing through the love or joy or jealousy barrier? Maybe we should say, '**know** pain, or no gain'.

What about the **let pain be your guide** road? For most people in chronic pain this is not useful either, as we suggest in the 'avoid pain' graph. If you were to let pain be your guide you would do nothing.

Sure, it may be of some use when you have acute pain, so that you don't interfere with the healing process – but even in that situation you will not usually avoid pain altogether. To let pain be your guide usually means that you are giving in to it, making it your master, encouraging yourself to be fearful of it. You have to take control.

We go for the third way: understand pain so that you don't fear it. This is **the road less travelled**, but ultimately the road to recovery.

Here are a few important things we now know about explaining pain. We have learnt a lot in the last ten years from research projects (many based on this book) in several countries and from the thousands of clinicians who now explain pain as a part of everyday practice. A few things have become clearer.

1. It doesn't help if it is boring! For all you clinicians out there, explaining pain successfully requires practice, educational and coaching skills, knowledge, the ability to adapt knowledge and skillful delivery.
2. People without any training in the health professions or biology can understand the biology of pain, even though some health professionals think that they can't.[190]
3. Learning about pain biology reduces the threat value of pain.[191,192,193,194] Reduced threat will reduce the activation of all of our protective systems: sympathetic, immune, endocrine and motor. Some people learn pain biology more easily than others, but nearly everyone can, regardless of education and language, given the right opportunities.[195,196] Combining pain biology education with movement approaches will increase physical capacity, reduce pain and improve quality of life.[197,198]
4. Understanding why so many things affect pain actually reduces their effect on pain.[199]

One aim of understanding the biology of pain is to facilitate what is called 'deep learning', in which information is retained and understood and applied to problems at hand.[200] Just learning about what to do, but not learning why, can be thought of as 'superficial' or 'surface' learning, which is when information is remembered but not understood or integrated with attitudes and beliefs.[201,202,203]

So, **understand** as much as you can about what is causing pain, not just what you should do about it. Remember – knowledge is the great liberator!

EDUCATION AND UNDERSTANDING (CONTINUED)

Your hurts won’t harm you

Test yourself... if you have understood a key theme of this book, then you will now be able to understand, acute trauma aside, that **‘when I am in pain, it doesn’t necessarily mean that I am damaging myself’.**

Remember – because of the ways the entire system changes in order to protect your tissues, we can be confident that persistent pain does not necessarily reflect the condition of your tissues. So, if your pain has persisted for longer than tissues take to heal, then increases in pain are far less likely to relate to changes in the state of your tissues and are far more likely to be due to other threats. (Remember – threats hide in hard to spot places – see “Threats hide in hard to spot places”.) In the same way, recurrent pains are often over-protective. If you have had a recurring pain for many years, each recurrence does not mean you have re-injured that muscle, joint, ligament or nerve. It makes more sense **scientifically** to conclude that recurrences occur because some cue or set of cues has been sufficient to activate the virtual representation of the old injury. A little like your brain checking up on you – like a fire alarm to make you check all systems and make sure your body is OK, safe and sound. Perhaps the orchestra has decided to play the pain tune to make sure it doesn’t forget it.

So, **hurt does not always equal harm** (or ‘you can be sore but safe’). Simply by reminding yourself of this each time you are in pain can help reset the system; the sophisticated name for this strategy is ‘self-talking’. It also means that you can be less worried when you have pain.

Figure 6.3 *Sore but safe*

But wait! This certainly does not mean that you go out and learn bungee jumping, decide to walk across town or go on a ballroom dancing marathon. Your body is not prepared for such a big step and your already sensitised nervous system will take drastic measures to stop you doing that again. In fact, when the central nervous system gets really desperate to prevent you from damaging yourself, it can do all sorts of things – stop your muscles from working properly, make you faint, vomit or want to sleep all the time. The critical thing is that these protective strategies are all being operated by your central nervous system and not voluntarily by you.

When you understand that hurt does not equal harm, we hope you will also understand why your **nervous system** will only let you increase your activity or exercise level **gradually**.

A practical exercise:

Let's say you are just sitting around and you feel some pain. Think about it. Think about what you know about pain. Think of what may have activated the alarm systems. Reflect on what cues may have ignited the pain nodes in your brain. Why has the orchestra started the pain tune even though you haven’t touched the tissues? Why now and not later? Get to know your pain and certainly don’t panic. Use what you learnt in this book to answer the question.

TOOL 2: PACING AND GRADED EXPOSURE

Patience and persistence required

Movement is essential for the health of all body systems and processes. It is the principal body function that isaffected, altered and sometimes controlled by pain.

The body tissues, especially the muscles, joints, skin and nerves, love activity. Movement will always be of benefit for tissues. Muscles can be made stronger right throughout the life span and all the tissues can be kept happily sliding via movement. Many therapists know the term ‘motion is lotion’. There are many health professionals skilled in movement rehabilitation and fitness of tissues.

But if you are in pain for a long time, you might know you need to move, you really want to move, but you are ‘trapped’ by pain. You have to be clever here – smart activities are required.

If you can understand your pain, and you know that it will not damage your tissues, you can move. Here are the basic principles that you can use as a guide.[204]

1. Decide what you **want** to do more of. If you feel you would like to do more of everything, to pick just one may seem silly. However, start by picking an activity that you particularly want to do more of, for example reading, walking, ironing, working, not wearing a neck collar, playing with the children, sitting, sleeping, driving etc. You could also consider what you **need** to do more of.
2. **Find your baseline.** A baseline is that amount of the activity that you can do and **know** that the pain won’t flare-up. A flare-up is that increase in pain, often sudden, that leaves you debilitated for hours, sometimes days, feeling really desperate and doing desperate things. For some people a flare-up could occur the next day or even later. Good biological reasons exist for this pain delay but that’s a whole new book. Try running conversations like this through your mind (we have supplied some typical example answers): How long can I walk before I flare-up?

– I can walk for 30 minutes but I pay for it the next day.

Can I walk for 20 minutes without flaring up?
– No, I will still pay for it.

Can I walk for 10 minutes without flaring up?
– Probably not, definitely not up hills.

Five minutes on a flat surface?
– Probably.

Three minutes on a flat surface?
– Definitely.

So, for walking, your baseline would be three minutes on a flat surface. You can go through this process for every activity, or combination of activities. Remember, going out to a party or function is an activity also. So are talking to your mum and going to a parent-teacher night etc.

3. **Plan your progression.** Because you know that 'let pain be your guide' and 'no pain, no gain' are not the ideal paths to choose, you need to plan your baseline increases in advance. Be gentle on yourself. Taking the example above, you could plan to walk *slightly* further each day for the next week – 3.5 minutes, 4, 4.5, 5, 5.5 etc. Often, time is a good measure. An alarm clock is invaluable: setting an alarm for your pre-planned period will allow you to benefit from distraction (eg. read a good book, send a text, talk to your best friend) without exceeding the limit and flaring up. When you have planned ahead, you will often complete the set amount of activity and be feeling really good – do not be tempted to break the plan and push on. This will lead you right into the boom-bust trap. One step at a time – **be patient**.
4. **Don't flare up, but don't freak out if you do!** Because the alarm system is so sensitive, it is very difficult to completely avoid flare-ups. If you do flare up – do not give yourself a hard time and stress out! Remember what a flare-up is – your nervous system trying to protect you. When you flare up, it can be tempting to give up, forget what you know about pain, and seek some radical but inappropriate quick-fix treatment. Don't

give up – **be persistent**.

5. **It’s a lifestyle thing.** In the short term you will have to plan your life a little more. You will benefit from seeking out ‘happy activities’, because they have known physiological effects on your alarm system and pain ignition nodes. Choose fun activities if you can, and do them with fun people, or to your favourite music. Challenge some feared activities when you become more confident. It is difficult to do this on your own. Have your loved ones read this book and join in the reasoned discussion about your pain and what to do about it.

We know that this sounds simple. However, if you have had pain for a long time you will know how difficult it really is. This process is doing some pretty complex things to your brain. However, we know that if you stick with these principles you will gradually return to normal life and overcome your pain.[205, 206, 207, 208, 209, 210, 211, 212]

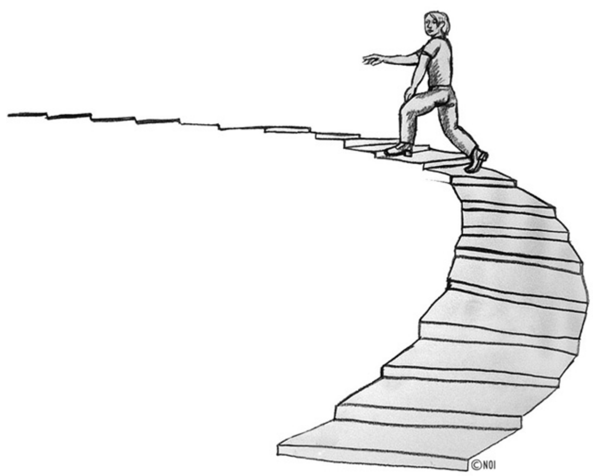

Figure 6.4 *The art of graded pacing and exposure – scoring some brain triumphs*

PACING AND GRADED EXPOSURE (CONTINUED)

Stay patient

In the 10 years since Explain Pain was first published, many people have found these mountain figures are a useful way of understanding the relationship between your pain, the nervous system changes that occur with persistent pain, and the brain retraining activities of graded exposure and graded motor imagery.[213,214] The images are often affectionately called 'Twin Peaks'. Let's walk through the left side of the top figure.

TT (initial) The old tissue tolerance line

Before your pain started, your tissues were fit and healthy. There was a certain amount of activity or specific movement that you could do before your tissues would react in some way. Most tissues are damaged by reaching the tissue tolerance line too quickly (eg. falling, lifting a heavy weight, a car accident). Sometimes, this line is reached slowly while you are distracted (eg. working or training).

PBP (initial) Protect by pain line

Danger sensors are activated before damage occurs and your brain is alerted. Usually, the pain ignition nodes are activated, the neurotag for pain is produced and it hurts. Pain motivates you to stop or change the activity to get your tissues out of danger. A great system. You could go further or climb higher, but it becomes more dangerous.

NTT The new tissue tolerance line

Look at the mountain on the top right. If you have had pain for some time, the tissue tolerance line shifts. Your tissues are not like they were – especially if they have sustained an injury. Although the tissues might have healed, they may not perform in quite the same way. More importantly, you have not used the tissues as much or in the same way since your pain started. They are unfit, weaker, more easily fatigued.

This is one reason you shouldn't just push through pain, try to beat pain, dose up on analgesics or climb a steep mountain for example.

NPBP New protect by pain line

Look at the position of this line. Your alarm system and pain ignition nodes are sensitised. You have pain at very low levels of activity, or maybe even imagining or thinking of movement. Your brain is really looking out for you. Now the protective buffer between the onset of pain and the new tissue tolerance line is huge. If you progress slowly, it will be impossible to re-injure the tissues because it will hurt too much to even get close to this line.

FUL The flare-up line

BL The baseline from which to begin training

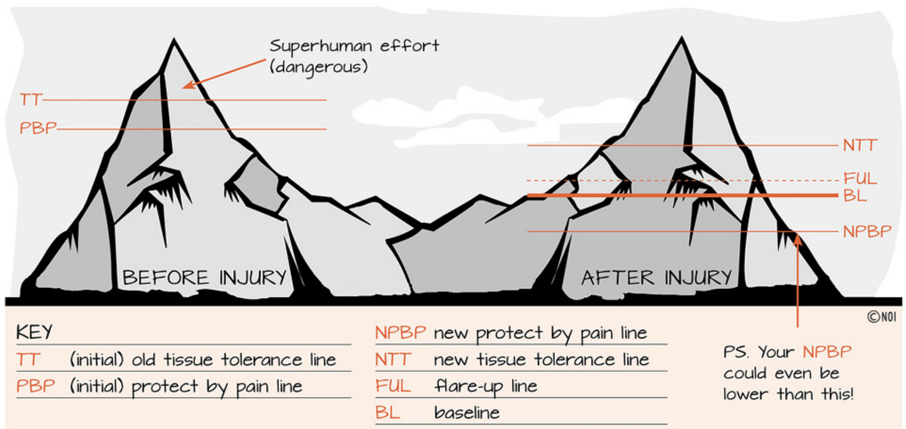

Figure 6.5 *Twin Peaks model*

And now plan your 'training'. Let's walk through the first of the small mountains in the figure below.

a. Starting below the flare- up line, gradually increase your activity, planning steps in advance: '**always do more than you did yesterda**y, but not much more'.
b. The flare-up line will slowly lift along with your training level. This is because you are training your brain, reducing the perceived threat, accessing the virtual body in a non-threatening way.
c. The protect by pain line will slowly lift – the sensitivity of the system reduces.
d. The tissue tolerance line will also lift – this is one of the beautiful properties of highly adaptable beings– the tissues get stronger, fitter and better controlled.

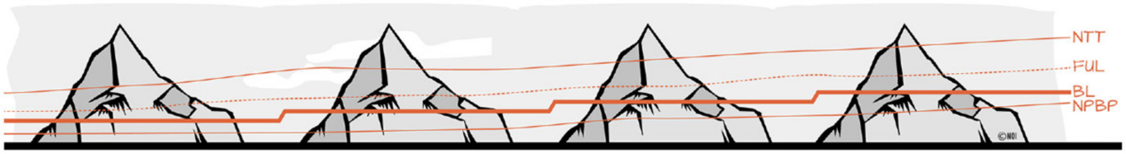

Figure 6.6 *Pacing and graded exposure model – on the four mountains you can see gradual improvement over time*

TOOL 3: ACCESSING THE VIRTUAL BODY

Getting tricky and sneaking under the pain radar

The virtual body in the brain can be exercised just like the actual body. The techniques of pacing discussed in the last few pages can be used for actual and/or virtual body exercises. The good thing about virtual body activities is that you can do them anywhere, you can integrate them into daily life and you don't even have to get a sweat up. No gym fees either. You can also do much deeper brain exercise as well. One example is graded motor imagery and we discuss this in detail elsewhere.[215,216,217,218]

Virtual body exercises are like retraining the orchestra to help it play more harmonious notes, to exercise the trumpets without the strings interfering, to revive old tunes not played for years and to compose some music for the future. Some of the movements aim to activate brain areas that are usually activated in a pain experience, but without igniting pain (ie. the pain neurotag – see "Pain relies on context: Part 2"). In Section 1 we discussed how powerful context is in the pain experience. Context changes can also be used in training.

For example, you could perform a movement in a different to usual position or environment, or you could look or not look at the moving part. Once you get the idea, you will be able to invent endless virtual body exercises that particularly suit your needs.

Of course, while you are experimenting with movements there could be some pains evoked. This is OK – remember, if you understand your pain and know that it won't harm you, then there will be minimal stress responses.

For the purpose of this exercise, we have selected the frequently painful activities of bending forwards and turning your head. Let's see if we can work out together what can be altered.

Bending forwards

We are aiming here to re-learn the movement of bending forwards without the orchestra snapping into the pain tune.

1. Imagined movements – activate the brain neurotags but don't move the actual body

Imagined movements activate many of the same brain areas as actual movements. If you think about the movement you know to be painful, or watch someone else perform that movement, movement neurotags in the brain will be activated but the pain neurotag probably won't. Sometimes, if your pain is very chronic and severe, even imagined movements can be painful,[eg.219] in which case you could initially imagine performing part of the movement. What you are doing here is helping the orchestra to play a gentle movement melody without playing its accompanying pain tune.

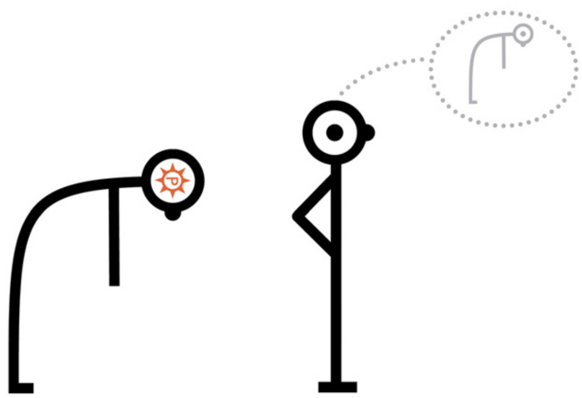

Figure 6.7 *Bending forwards – imagine the movement*

2. Alter gravitational influences

Sitting on the floor with your legs straight out in front of you is the same body formation as lying on the floor, face up, with your legs in the air, or standing bent over at the waist, leaning on a table – it's the gravitational force that's different in each case. Changing gravitational influences allows you to run brain representations of the movement in similar but slightly different and novel ways.

If you lie on your back and pull your knees to your chest (one knee, if it's too sensitive to do both) – the back has been bent in the real and virtual body. You could try it lying on different surfaces too (eg. cold floor, warm rug), just for some different inputs into the brain. Brains love variety. If this is painful, perhaps just lying flat on your back on the floor and flattening your back with your knees bent is your appropriate level of activity. You can flex forward while sitting on a chair. Performing movements in water is another way to alter gravitational influences. Altering gravity also alters levels of movement security. There is greater security leaning on a wall and bending than bending without support.

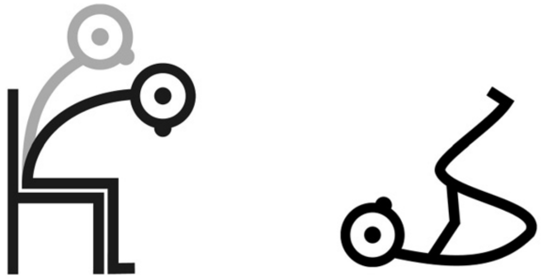

Figure 6.8 *Alter gravitational influences – try sitting, lying, standing*

3. Add varying balance challenges

The forward bending movements could be performed sitting on a fitness ball and bending forwards, rolling the ball under you as you bend. A further progression would be to bend forwards with your arms up to the ceiling or pointing down to the ground and moving your legs to one side and then the other. These inputs will also provide some virtual body changes via distraction.

Figure 6.9 *Balance challenges – try balancing on a fit ball*

4. Vary visual inputs

Performing a movement with your eyes closed usually means a greater challenge for the virtual body. If you can perform a movement, say bending forwards from the waist on a chair without igniting a pain neurotag, try to look at your body while you are doing it, so perhaps do it in front of or side-on to a mirror. The visual input to the brain reinforces the message that a movement, which the brain 'knows' to be painful, doesn't have to be.

5. Alter the environment of activities

You could perform forward bending movements in the comfort and security of your home, or be adventurous and do them in the park like the Tai Chi groups, or even at work or where the injury happened. Performing movements in water allows environmental inputs from variations in balance, temperature, smells, other people around and wearing different clothing. You can stand in a pool up to your chin in water, lift one knee up and pull the knee towards your chest. This will bend your back a little, but the virtual back bending in your brain will be very different to the one you ignite when you bend your back in the therapist or doctor's office.

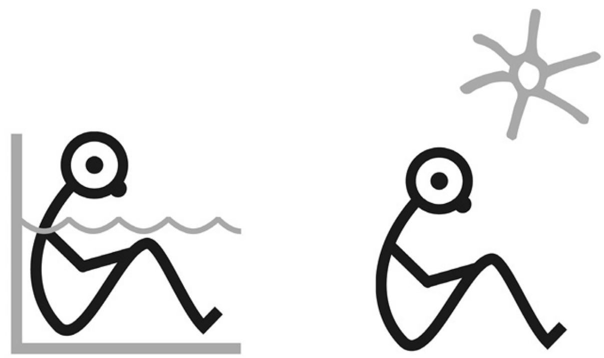

Figure 6.10 *Alter environmental context – try excercising in water or venturing outdoors*

6. Do the movement in different emotional states

We tend to put exercise and activity off when we are feeling a bit down, but if you were to perform activities such as those listed above in various emotional states, it would give the virtual body a richer context of representations in which to run. You are now teaching the orchestra to play some pretty sublime and new-age tunes. The better the orchestra becomes, the more harmoniously it will play together and the more it will be able to remember new tunes. Also the less it will tend to snap into that old familiar pain tune.

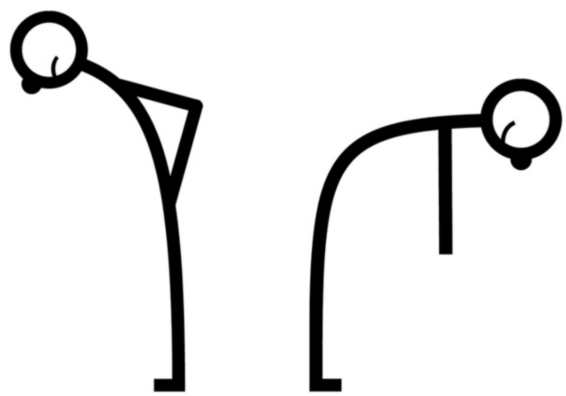

Figure 6.11 Perform the movements in different emotional states – it is good to excercise when you are feeling down

7. Add distractions

Distraction is a powerful way to disable the pain neurotag. Distraction removes key ignition nodes ("Figure 2.7 A possible pain neurotag"), such as nodes which are activated when you concentrate or focus on something (such as pain). You could use music, meditation, visualisation or you could even alter the environment of exercise. Music which is conducive to getting moving and changing rhythm would be useful. Doing artwork which allows you to go into aspects of the pain experience but without igniting the pain experience would be therapeutic in itself. Distraction is not a simple pain reliever – combine it with some creative activities for added power.

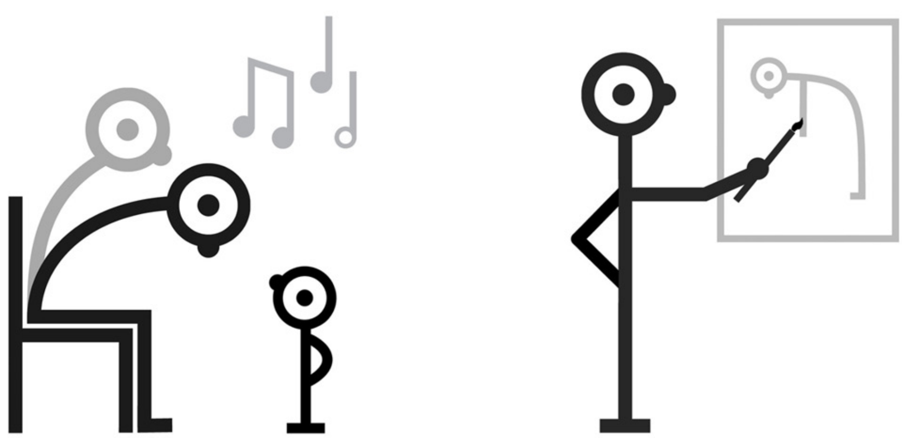

Figure 6.12 Stepping up the activity by allowing in distractions and exploring the experience through artwork

8. Plan functional activities which involve bending the back

When a part of your body hurts, your brain will accept movements that it knows are familiar and necessary to your comfort and survival – meaningful movements. While some meaningful movements can hurt if they bring back memories of pain, many are gratefully accepted by the brain. We flex our backs when we lie on our sides to go to sleep (on either side). We bend our backs to put on shoes, to pick something up off the floor and to speak to children.

9. Break down functional movements that involve the back

People who have persistent pain lose their quality of movement – they perform activities such as rising from a chair or picking up an object from the floor in very regimented ways. See if you can perform the activity in different ways. For example, when you rise from a chair, try it with one foot forward then the other, lead with the head, with eyes open or closed and try performing the routines at different speeds. Feed some quality varietal movement to the brain.

10. 'Sliders'

'Sliders' are techniques that encourage total body movement.[220] An example of a slider is when you lie on your back with your knees bent and feet on the floor, and flatten your back (thus flexing it up a little) and at the same time tilt your chin upwards. This allows distraction plus movements which are unlikely to aggravate sensitive alarms in your low back. Another slider is to sit upright in a chair and sag your back, hold under your thigh and extend your knee while tipping your head back. Think about kicking your head off!

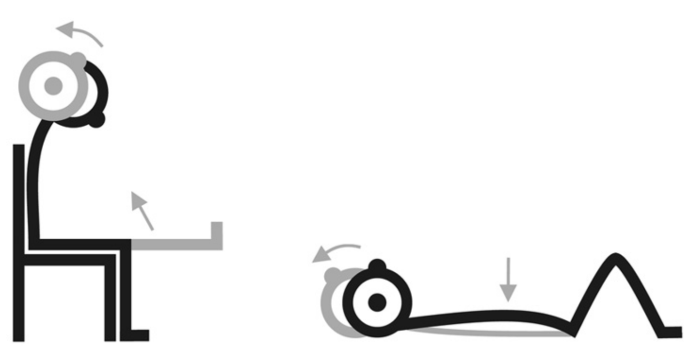

Figure 6.13 *Slider exercises for total body movement*

11. Perform movements with neighbouring tissues in a ‘friendly’ state

Sitting in a chair, if you bend forwards and have your chin tilted forwards it will slacken some of your nerves in the back. Bending forwards when sitting means that some of the tension is taken away from the tissues in your hips and legs. You may need to look back at “Tool 2: Pacing and graded exposure” to incorporate these movements into a pacing process that will work for you without making your pain flare up.

12. Playing with your ‘glitches’

Glitches are the ways we have all learned to wriggle and adjust when we perform a movement. They are often caused by memories of painful movement. For example, you may know that the best way to bend forwards is to hold your back in a certain position, lean on your knee etc. Methods that you use as a helper to make the movement easier for you. These glitches may be little memory boosters to the pain neurotag. See if you can work out ways of performing a movement without the glitch. Sometimes sliders (moving another part of the body when the glitch occurs) can remove them. Maybe you can take a thoughtful approach to it and ask yourself – ‘do I really need to have that glitch’ and try to move without it.

13. Let your mind go

You could bend on the pew or on a bar stool, bend when there are different smells or playing the fool, bend with the arms up or by your side, bend when it’s noisy or while holding your breath, or do it in the nude or in your Sunday best.

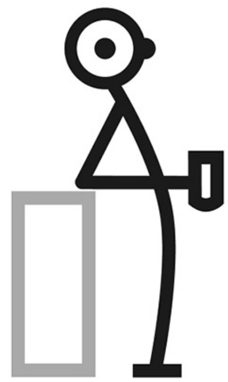

Figure 6.14 *Let your mind go...*

Turning your head

If you use the categories above, you should be able to construct virtual exercises for any part of the body. Simply: work out ways to move and use the painful part of your body without activating the pain neurotag.

Turning your head often hurts if you have a painful neck. Here are a few specific head turning examples:

- If you sit on a swivel chair, look at a fixed object and rotate your chair while looking at the fixed object, you are performing a neck rotation but in a different context.
- If you fold your arms and shrug your shoulders a little you are slackening nerves which may enable a better head rotation.
- Stand close to a wall and write your name or play an imaginary game of noughts and crosses on the wall with your nose. Try it standing on one leg, or with your eyes closed.
- You could rotate your head with your tongue, jaw and mouth in different positions.
- It is usually much easier to turn your head when you are lying down.
- You could turn your eyes to a point on a wall and then follow them with your head.
- Make noises while you perform movements.
- Learning to juggle may help your neck as well.

Make the neurotag curious, make it wonder ‘what’s next’. You be the master.

RECAP

Recap section 1

- All pain experiences are a normal response to what your brain thinks is a threat.
- The amount of pain you experience does not necessarily relate to the amount of tissue damage.
- The construction of the pain experience of the brain relies on many sensory cues.
- Phantom limb pain serves as a reminder of the virtual limb in the brain.

Recap section 2

- Danger sensors are scattered all over the body.
- When the excitement level within a neurone reaches the critical level, a message is sent towards the spinal cord.
- When a danger message reaches the spinal cord it causes release of excitatory chemicals into the synapse.
- Sensors in the danger messenger neurone are activated by those excitatory chemicals and when the excitement level of the danger messenger neurone reaches the critical level, a danger message is sent to the brain.
- The message is processed throughout the brain and if the brain concludes you are in danger and you need to take action, it will produce pain.
- The brain activates several systems that work together to get you out of danger.

Recap section 3

- Tissue damage causes inflammation, which directly activates danger sensors and makes neurones more

sensitive.

- Inflammation in the short term promotes healing.
- Tissue healing depends on the blood supply and demands of the tissue involved, but all tissues can heal.
- The peripheral nerves themselves and the dorsal root ganglion (DRG) can stimulate danger receptors. Normally, pain initiated by danger messages from the nerves and DRG follows a particular pattern.

Recap section 4

- When pain persists, the danger alarm system becomes more sensitive.
- The danger messenger neurone becomes more excitable and manufactures more sensors for excitatory chemicals.
- The brain starts activating neurones that release excitatory chemicals at the dorsal horn of the spinal cord.
- Response systems become more involved and start contributing to the problem.
- Thoughts and beliefs become more involved and start contributing to the problem.
- The brain adapts to become better at producing the neurotag for pain (the ‘pain tune’).
- Danger sensors in the tissues contribute less and less to the danger message arriving at the brain.

Recap section 5

- Modern management models incorporate the current scientific knowledge and do not focus solely on tissues.
- These models recognise the importance of alarm system sensitivity, fears, attitudes and beliefs in a chronic pain state.
- How you understand and cope with pain affects your pain as

well as your life.

- Many people with persistent pain relate to ‘avoid pain’ or ‘try to beat pain’ (boom-bust) approaches. While understandable, these approaches are not helpful and lead to drastic limitation of activity and meaning in life.

Recap section 6

- Education and understanding are critical for you to overcome pain and return to life.
- A key is to understand why your hurts won’t harm you and that your nervous system now uses pain to protect at all costs, not to inform you about damage.
- By being patient and persistent, you can use smart activities to gradually increase your activities and involvement in life.
- Purposefully seek out activities that produce danger-reducing chemicals.
- You can quickly learn to exercise the virtual body as well as the actual body.
- By mastering your situation and then planning your return to normal life, you will be able to do so. The research shows that it can work.

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“The clinical decision-making model”

“Ideally, health professionals should be able to give you an answer to all the following questions:”

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[“Amazing pain stories: Part 3”]

disc

"Get to know your LAFTs"

DNA

“Vital sensor information” *(Point 4)*
“Helpful nerve knowledge” *(Point 3)*
“Some interesting features of the DRG”

enzymes

“Figure 3.4 The nail in the foot: inflammation in the tissues is essential to the tissue repair process”

God

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"Sensors in the neurones to the brain"

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"Amazing pain stories: Part 2"

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“Here are some interesting things about the immune system which are relevant to pain:”

muscle

nerve

nervous system

pain

internal pain control system

"Sensors in the neurones to the brain"

war

“Figure 1.8 WWII: pain doesn’t always equate to damage but is influenced by context”

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- Noijam facilitates findings from science into clinical decision making.
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- Noijam brings researchable ideas from the clinic to the fore.

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