THE REALITY CHECK

DR HEIDI HAAVIK

A quest to understand Chiropractic from the inside out

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graduating hands, hearts & minds

To Steffen, Sofie and Glenn, with all my love.

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also needs to go to those I have lost since this book first went to print. In particular my 93 year old Gran, Nola Calder who up until she passed walked her dog every day. She always put that down to a lifetime of chiropractic care from her father, son, daughter-in-law, granddaughter, and various others. Also I miss my beautiful black Lab Mr Darcy, who was my loving, loyal companion for seven years.

Finally, thank you to my Norwegian family (all of you!) and especially my parents, Kjell and Sally Haavik Nilsen, my brothers Anders and David, my niece Isabell, nephews Eric, Leo, Julian, their mothers, the gorgeous Maia and Veronica, my uncle Helge, my aunt Susanne and my little 'sisters' veslemor Alida and Josefine, you are my true North.

About the Author

Heidi Haavik was born in New Zealand but grew up in Norway. She is a chiropractor and a neuroscientist who has researched in the area of human neurophysiology for the past 15 years. She has used sophisticated brain science techniques to investigate the effects of chiropractic adjustments of vertebral subluxations on various aspects of brain function.

Dr Haavik graduated from the New Zealand College of Chiropractic in Auckland in 1999, and was awarded her PhD degree by the University of Auckland in 2008. She is the Director of Research at the New Zealand College of Chiropractic where she runs the Centre for Chiropractic Research. Dr Haavik is also an Adjunct Professor at the University of Ontario Institute of Technology in Oshawa, Canada, and is a member

of the World Federation of Chiropractic's Research Council. Dr Haavik has received numerous research awards and was awarded Chiropractor of the year in 2007.

She lives in Auckland, New Zealand, with her two children Steffen and Sofie, her fiancé Glenn Arthur, and their dogs.

heidihaavik.com

Forewords

We are fortunate to be living in a time of easy access to information - that from the ancients as well as from contemporary life. Yet many of us feel like the volume of information is overwhelming. It is like we are trying to drink from a fire hose!

The information is plentiful but a context with which to interpret the information and a guide to understanding the information are often lacking. For anyone hoping to understand more about how his or her body works, and an approach to putting that knowledge to work in a meaningful way for a happier, healthier life, The Reality Check is a remarkably powerful contribution to this quest. The power of The Reality Check is the product of the cutting- edge information presented, the ease and thoroughness with which it is explained and the usefulness of the insights offered. You will complete The Reality Check with a greater appreciation of the magnificence of the human body and your inborn, innate capacity to heal.

Heidi Haavik, D.C., Ph.D. walks us through some basic anatomy and physiology on the way to grasping some of the most current and empowering research on human neurophysiology. In the process she opens our thinking to a deeper understanding of the incredible master coordination and control system in our bodies, the nervous system. She goes

on to detail how the activities of our lives informs the nervous system and causes it to adjust to our every movement and thought. All this is accomplished to help persons, not trained in the human sciences, to understand data that is technical but not too technical and importantly is not dumbed-down. Dr. Haavik demonstrates the skill of a superb teacher and a compassionate guide.

Dr. Haavik brings her background as a practicing chiropractor and as a prolific researcher in neuroscience to help us learn more about how we work, about the remarkable design and control of the human body, and how chiropractic care plays a role far beyond simple biomechanics to influence and reshape the workings of our brain. When we start to grasp the significance of Heidi's research and the implications it holds to allow us to make our lives better, The Reality Check has hit home. As you proceed page by page through The Reality Check you will find a blend of hard science and compassionate humanism. Pleasantly neither is offered at the expense of the other. Dr. Haavik gracefully discusses health care matters of a practical and pragmatic nature while upholding her passionate commitment to rigorous scientific inquiry and application.

I am a chiropractor. As a youngster I experienced a profound recovery under the care of a chiropractor from a problem with my eyesight (I was declared legally blind and entitled to vocational rehabilitation) that every textbook of the time said could not be. Now over 45 years down the road in my career, through the work of researchers like Dr. Haavik and her exquisite explanations, I better understand what may have occurred, neurologically speaking, as I received those chiropractic adjustments as a young boy. Through The Reality Check I understand my recovery, my profession and the critical contribution to healing and health that chiropractic care gives us. My hope and prayer, and I think I can speak for Dr. Haavik on this point as well, is that you leave this read with a better understanding of what you can do to maximize your well-being and know who you can call upon to assist you on that journey.

Be well.

Gerard W. Clum, D.C., FICA

President Emeritus,
Life Chiropractic College West, Hayward, California, USA
Director, The Octagon, Life University, Marietta, Georgia, USA

I would like to congratulate Dr Heidi Haavik for her excellent book ‘The Reality Check’. It was a great pleasure to read, and in fact, I read the entire book in a matter of a few hours! I must say that Heidi has really hit the nail on the head in describing the processes of how chiropractic care may impact the nervous system, the possible benefits of this health care practice, scientific data supporting these benefits, and also the cautions to be taken. Well done indeed.

In reading this book I am sure that anyone wondering about these ‘spinal doctors’ will better understand what chiropractic has to offer them, so that they can greatly benefit. I am sure this understanding will come as a surprise to many, as indeed it was to me.

I first met Heidi several years ago at a neuroscience conference through mutual friends. She has a refreshing energy and I quickly discovered we share a curious fascination for understanding how the nervous system truly works. We met again at several other neuroscience conferences and our conversations led to us to collaborate in conducting research experiments involving chiropractic adjustments, both in her research laboratory in New Zealand and in mine in Turkey.

I must say that it has been a great pleasure working with Heidi and her team, investigating the possible effects of chiropractic care on muscle and reflex function. It was amazing to discover first hand that one session of chiropractic care alone generated so much change in the brain, and especially on the strength of subjects’ leg muscles.

Based on my more than 30 years of experience in this field of neurophysiology, I believe Heidi is quite correct in the information she has presented about what is currently known about the workings of the human nervous system, and that the theories and model she has put forward as a hypothesis for explaining the benefits of chiropractic care, is based on sound thinking and research.

I look forward to continuing the collaborative research with Heidi and her team, so that we can together in greater detail pin down the mechanisms underlying chiropractic care.

Kemal S. Türker, BDS, PhD

Professor of Physiology
Koç University School of Medicine
Istanbul, Turkey

Dr Heidi Haavik is a bright light in chiropractic neuroscience research. As a committed practitioner and researcher she helps the profession and patients understand some of the mechanisms that occur with chiropractic care. Her dedication to serious science in the quest for understanding, has advanced chiropractic research more in the past 5 years, then the past 25 years in chiropractic. This book offers a glimpse into neuroscience and the benefits of the chiropractic adjustment.

She is to be applauded and supported.

Dr Brian Kelly

President, Life Chiropractic College West, California

This book will forever transform our understanding of how chiropractic works.

Phil McMaster

DC, President of the New Zealand College of Chiropractic

Preface

“Imagination is even more important than knowledge. For while knowledge defines all we currently know and understand, imagination points to all we might yet discover and create.”

Albert Einstein

Chiropractic is a hard nut to crack. It has developed a thick shell from years of defending itself. But look beyond the politics of health care, and you will discover that chiropractic is full of goodness and love for humanity. It holds within it the potential to dramatically improve people’s health and wellbeing, if only it is allowed the conditions to grow…

Labelled an alternative health care option by many, or even ‘pseudo-science’ by some, chiropractic often exists on the fringe of health care. It is little understood, frequently criticised, and continues to survive by virtue of the overwhelmingly positive results chiropractic patients experience first-hand all over the world. But let’s face it, chiropractors are a little bit weird. I can say that since I am one of them. Chiropractors tend to be the black sheep, the fish swimming against the current. If you know one, you probably know what I mean. They tend to be opinionated, questioning, and unconventional. Over the course of my career I have had the opportunity to meet hundreds, if not thousands, of chiropractors. And, although I’m sure we have the odd rotten egg in our profession, as with all professions, most chiropractors I have met seem to share my genuine desire to make this world a better place; to help people live fuller, healthier, more satisfying lives. It is why we do what we do, and why we have persisted through some very tough times.

Since 2000 I have had the amazing privilege of working in the field of human neuroscience, specifically exploring the frontier of how the brain processes all the sensory information it receives, integrates this information, and then responds to it. My greatest passion and interest has been (and still is) to understand how the natural healing modality of chiropractic care impacts the function of the brain and nervous system, alters its processing, and ultimately improves or ‘tunes’ the way our brain controls our daily function. In this book my aim is to share with you what I, and other researchers, have discovered in this area, so that you too can appreciate the immense benefits of chiropractic care.

This book is my gift to you. It is an invitation to look under the bonnet of chiropractic, to understand why and how it works, and to explore how you can function at a higher, more interconnected level than you may ever have thought possible. This book is for those of you who have not yet tried chiropractic care, but who want to experience improved health

and wellbeing, and are looking for solutions. It is for those of you who may have tried it for a short time, but did not fully understand the benefits, or were perhaps discouraged by someone to continue, so that you can take a closer look at what this health care practice has to offer.

And this book is of course for all of you who, like me, do use chiropractic care on an ongoing basis, and would like to better understand the amazing changes you can feel in your body when a chiropractor adjusts your spine.

Dr Heidi Haavik

THE

REALITY CHECK

Reality check

n - an occasion or opportunity to consider a matter realistically or honestly

Introduction

A Personal Quest to Understand Chiropractic

To say that the chiropractic profession has had a turbulent history is an understatement. Perhaps it was for the best that I knew nothing of this when I entered the profession. As a fresh-faced chiropractic student, I was totally naive to the historical and ongoing political battles fought between my profession and other health care professions. Nor did I have a clue about the demanding course of study I was about to undertake, or the foreign world of chiropractic language, identity, and professional scope of practice.

All I knew then was that the chiropractic care I received as a young adult was transformative to my wellbeing, and that something about this profession felt 'right' for me. The care I received was not what I expected. In particular, I was surprised by the breadth of the approach to health and wellbeing the chiropractor took. My chiropractor would adjust my spine, discuss problem areas and give me exercises, talk about other possible options that would be appropriate for me, and discuss how best to prevent future problems from occurring. This chiropractor took a holistic view of what was going on for me that I really enjoyed and benefitted from.

My motivation to study chiropractic was also helped along by knowing that my great-grandfather, William Charlsworth Lawson, had been one of the first thousand chiropractors ever to have graduated from the first chiropractic college, Palmer College of Chiropractic, in the United States in the early 1920s. He practiced in Wellington, the capital of New Zealand, and my Gran loved to tell stories about growing up with such an 'odd ball' father.

So I stepped into the rabbit hole, or so it felt at the time, and what I discovered is that becoming a chiropractor is by no means a walk in the park. Years of academic study, endless hours of technique practice, and a very demanding two-year practical internship lead to a fulfilling vocation, but one that is often marginalised within the health care system. To become a chiropractor is to step away from the acceptance and comfort of mainstream medicine, and to step into the firing line with the knowledge that if you don't, and others don't, the world will be worse off.

Luckily, being a misfit was not unfamiliar to me. Growing up in Norway in a little village called Vikersund in the 80s and early 90s, I learned one thing very well, and that was not to stand out. Not to stick my head out above the crowd or to veer off the safe, conventional path. It has taken me most of my adult life to realise that I was doomed to fail at this from the very start. You see, my mother is a dental nurse from New Zealand, she spoke English and did not cook traditional Norwegian dishes. My

father is a medical doctor, with three medical specialties (when in Norway you are only supposed to have one) and was the lead medical doctor in the family owned business, Vikersund Kurbad, Norway's largest rehabilitation centre (established by my other great-grandfather, Hans Haavik).

I therefore spoke a second language better than my English school teachers, ate 'strange' food, and came from an influential family of over-achievers. I was self-conscious of these differences and tried my best to fit in… failing miserably.

I realise now the incredible power that cultural norms have on a person, and on society. They can hold us back from reaching our potential. Yet, our individuality and our life's purpose or mission remains inside us, waiting patiently until we are willing to listen. I knew something was up when I came to New Zealand as a 20 year old. I felt it in my whole body that I was here for a reason.

So as I set out on my path to become a chiropractor, and encountered first-hand the waves of resistance and criticism directed toward my profession, I was on familiar ground. I was able to accept and live with the discomfort of not fitting in, and simply channel my time and energy into improving my practice and understanding of chiropractic. And I have continued on this course throughout my career; taking criticism, debate, and questions into consideration as part of critical thinking, but not losing sight of what is important. It is for you, the receivers of our care, that I dedicate my time and attention. It is you who makes it worthwhile.

I known the chiropractic profession holds within it an incredible understanding about the importance of good spinal function for your wellbeing and overall health. They should in my opinion be the first port of call for anyone with spinal problems, even seemingly minor problems. In several countries around the world this has been recognised, and chiropractors are integrating into the health care system, to the benefit of you, the public.

I have chosen a vocational path that is not so much 'hands on'[i] as we call it in the chiropractic profession. Instead I have chosen to dedicate my working life to research; to pushing the boundaries of accepted scientific understanding in a quest to enable greater awareness and enlightenment for all those intelligent, open minded people who are willing to think for themselves, and who want the best out of life. Through building greater understanding of the practice and science of chiropractic, I hope to make it easier for you to access chiropractic care. And I hope to provide greater insight into what happens in your brain and body when you do receive chiropractic care.

I am a graduate of the New Zealand College of Chiropractic,

i With 'hands on' we in the chiropractic profession mean 'checking and adjusting patients' dysfunctional spinal segments' (i.e. literally with our hands on the patient).

located in the beautiful city of Auckland. I graduated in 1999. My class was the second class to ever graduate from the New Zealand College. Back in those days we were also required to do a Bachelor of Science in physiology or psychology at the University of Auckland as a part of our chiropractic education. I thoroughly enjoyed learning. I did not like the anxiety of exams but I loved listening to the passionate excited lecturers we had. We were very fortunate to have exceptional lecturers who had travelled from all around the world to teach at this enlightened chiropractic college in New Zealand. And there were also many University of Auckland lecturers that had a phenomenal ability to teach, to inspire, and to open my mind to all sorts of new opportunities and possibilities.

Because of this, and due to the encouragement of one of my chiropractic lecturers, I continued studying science, even after I had become a fully qualified chiropractor. So, while seeing patients at my first chiropractic clinic, and with a baby son in tow, I began a Post Graduate Diploma in Science.

Being a perfectionist and loving the process of learning, I maintained a very geeky grade point average and was accepted straight into a PhD programme. I was also awarded a prestigious Top Achievers Doctoral Scholarship from the Tertiary Education Commission of the New Zealand Government. Relative to the average earnings of practicing chiropractors this scholarship was not a lot of money, but it was enough to justify me doing this study. Between the scholarship and the ten hours a week I practiced, it was enough to pay our bills and survive. What I did not realise then was that I had begun a journey that would take over just about every aspect of my life.

Science holds a great power which I have the utmost respect for. Properly designed, properly executed, accurately and appropriately analysed experimental data can reveal ground-breaking new discoveries about the world we live in. This to me is incredibly exciting. More often than not, scientific experiments lead to more questions than you started with. That is also part of the fun of it. I was captivated by its lure very early on, and this lure has now grown into a great passion.

With this book I want to take a moment to reality-check what the essence of chiropractic is all about. I want to take this opportunity to look at chiropractic through the eyes of a neuroscientist, grounded in the critical thinking of science, and with insights referenced from rigorously conducted studies.

In this book, I have to the best of my ability, presented a fair and reasoned picture of what I believe to be the mechanisms of chiropractic care, specifically in relation to what happens when a chiropractor adjusts dysfunctional spinal segments.

Most chiropractors do far more than check and adjust the spine. Chiropractors are focussed on all aspects of spinal care, including advice on different treatment options, exercises and education about optimal spinal care that you can do at

home. They take into account risk factors for future problems to help you prevent dysfunction from developing in the first place. However, the focus of this book is one core aspect of chiropractic care only. This book's focus is about what happens in your brain when a chiropractor adjusts your spine. This has been the focus of my research for over a decade. This book is therefore based on my knowledge and insights from 15 years of chiropractic practice, and 15 years of work as a neuroscientist.

Video 1: Click here to watch "The Beginners Guide"

1 - The Vertebral Subluxation

"The ultimate measure of a man is not where he stands in moments of comfort and convenience, but where he stands at times of challenge and controversy."

Martin Luther King, Jr.

You may well be wondering what a 'vertebral subluxation' is... and why on earth you're being subjected to this weird terminology in chapter one. And fair enough, as this term could certainly do with a re-brand, or for that matter, a simpler, more straight-forward meaning.The thing is that in many parts of the world, this is the term that chiropractors use to describe the areas of the spine that they adjust. You could say that it is the problem we are looking to correct.

What chiropractors mean by the term vertebral subluxation is a dysfunctional area in the spine that negatively affects health and wellbeing, due to its influence on the nervous system. One key focus of chiropractic care is to detect and correct vertebral subluxations, in order to restore the healthy function of the spine and nervous system. This in turn enables the body to function at its optimal potential. I will to the best of my ability try to explain how this works in this book.

But, as important as this concept is for many chiropractors, I don't think there is any other term that has caused more controversy, debate, or heated discussions within and outside the chiropractic profession than the vertebral subluxation.

The term vertebral subluxation was used by early chiropractors because these dysfunctional areas felt "out of place" and "stuck" when they were palpated. It was therefore described as a subluxation, which actually means a "partial dislocation" or the old fashioned concept of a "bone out of place". With modern science, we now know that the bone is not partially dislocated. We know that a better explanation is that some of the small muscles that attach to individual vertebrae have become tight due to a variety of causes including injury, postural stress and overuse. The tight muscles twist the vertebrae so that certain parts of the vertebrae are more prominent and palpate as "misaligned" or "stuck". They are usually tender to the touch, and often cause pain when the person moves in certain directions, although they don't always experience pain at rest. Some chiropractors prefer to use other terms such as joint dysfunction or joint restriction to describe this entity. However, I will use the original term "vertebral subluxation" in this book, and I will cover this topic in greater detail later on.

I have spent much of my working life investigating and adding to the base of scientific research on this subject. Over the past decade and a half my research group has conducted a variety of experiments that have significantly contributed to our understanding of the changes that occur in the brain when chiropractors adjust the spine [1]. Chiropractors describe the way that they correct vertebral subluxations as 'spinal adjustments'. It is important to note however that in some countries and often in the research literature, the term spinal manipulation is commonly used to describe one type of spinal adjustment.

Within this book I will explain many of the studies that we have performed. And you will notice that I have also included the references for you. I have tried to keep the references as unobtrusive as possible, but they are there for you in case you want to follow up on anything I have written. The references are also there for you so that this book, and all of my claims within it, are fully open to scrutiny or formal evaluation.

For now, what you need to know is that most chiropractors don't just adjust parts of your spine at random. If you have been to a chiropractor you will have noticed that they touch and feel your spine, move it around, possibly test your muscles to see how strong they are, press on parts of your spine to find out if it is tender at particular points, and so on and so on. In the end they very carefully choose specific spinal segments[ii] to adjust. The segments that chiropractors choose to adjust will often have corresponding muscle tightness and tenderness if pushed upon [2, 3]. And the joint will have abnormal movement [4, 5]. These abnormalities, among others, indicate the presence

ii A spinal segment refers to a spinal motion segment, made up of two vertebrae in your spine and the joints that connect them.

of a vertebral subluxation in a specific location of the spine [6, 7]. Other professions may use different names for the vertebral subluxation such as 'spinal fixation', 'vertebral (spinal) lesion', or 'somatic dysfunction' [8].

From a research perspective, I am fascinated by, and interested in, understanding the effects we have on the central nervous system when we adjust a subluxation. I have come to realise that this term, although still used by many chiropractors, does not adequately explain the complexity of how the function of the different spinal structures impact normal daily function. The impact of spinal abnormalities on mobility and control of body function is not adequately explained by any single simple process. This is partially the reason behind this book. I want to share with you a simplified version of this complex process.

On the next page is an image of a spinal segment. A spinal segment consists of two vertebrae and the joints that connect them. There are generally three joints that connect two vertebrae in the spine. The biggest one is the intervertebral disc, or shock absorber, between the two vertebrae. The other two joints are called facet joints. If you have been to a chiropractor it is the release of gas within these facet joints that results in the popping sound you will often hear when you are adjusted [9].

The bony spinal column acts as a moveable protective armour for the delicate spinal cord. The spinal cord is like a nerve highway full of information flowing between the brain and the body. The spinal cord begins at the base of the brain in the skull and extends through the bony canal down the middle of the spine from the neck (cervical spine) to the lower back (lumbar spine). In the lumbar section of the spine it ends and becomes bundles of nerve fibres, a bit like spaghetti. At each spinal segment, where two vertebrae join, there are spinal nerves that exit from the spinal cord and carry information to and from the brain to various regions of the body.

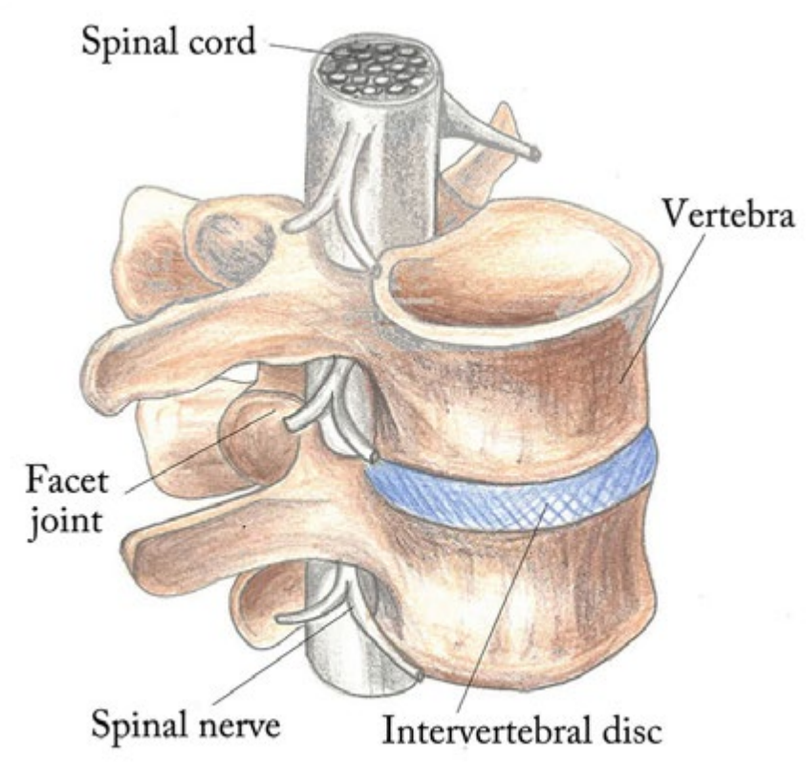


Figure 1: A spinal motion segment consists of two vertebrae

and the joints that connect them, i.e. the intervertebral disc and the two facet joints.

By understanding how the spine and the central nervous system are interconnected, the scene is set for exploring how dysfunction within the spine can lead to impaired health and wellbeing. So, take a deep breath and get ready for a wild ride through the human body!

2 - Discovering the Big Picture of Chiropractic

"Every organ in your body is connected to the one under your hat."

B.J. Palmer, son of D.D. Palmer

Chiropractic has been around for over a hundred years. It was founded back in 1895 by Daniel David Palmer, somewhat by chance. This is a fascinating story, as Palmer claimed to restore the hearing of a deaf janitor, Harvey Lillard, by replacing a segment in his spine that was 'out of alignment'. From this he came up with the concept that misaligned spinal segments interfere with proper nerve function, and that 'adjusting' these segments back to their normal position restores nerve function. His original theories were based on the idea that dysfunctional spinal segments were 'out of place', or misaligned, and that this put pressure on the nerves exiting the spine. We now know that this theory is not really the best way to describe what a subluxation is.

As discussed what we've come to understand is that we don't really put bones back in place when we adjust the spine. A

vertebral subluxation is not so much the condition of a bone being out of place; it is more that a bone is functioning or moving in a less than ideal way – in a manner that is not 'normal' for the body. Just how this affects a person's health and wellbeing will be explored in depth throughout this book. Today, over a hundred years on from that 'first' chiropractic adjustment, we know much more about how the brain and the rest of the central nervous system functions. And we are beginning to glimpse the big picture of how chiropractic adjustments really work.

Contrary to earlier beliefs within the scientific community, a recent wave of discovery has quite clearly revealed that the brain retains its ability to adapt to its ever-changing environment throughout life [10]. Furthermore, it is becoming clear to neuroscientists how important it is for our brains to maintain an accurate and up-to-date inner 'map', of the location of our muscles and joints in 3D space and relative to each other, and how detrimental a faulty inner map can be for an individual. If you think about it, it's really very simple. Most of what you perceive as reality is simply what your brain considers reality to be, or your brain's translation and interpretation of all the information it gets from its sensory receptors (in your ears, eyes, skin, muscles, etc.).

With this in mind, can you be sure that what you see is a complete and accurate reflection of what is in front of you? Neuroscientists know that this is not the case. For example, our eyes interpret the colour of an object based on what colour we think it should be, which is influenced by the colour of nearby objects. Our brain basically fills in the gaps, as needed, based on past experiences and expectations. You cannot really be certain that any of your sensory experiences accurately reflect what is going on within and around you! Your brain will not provide you with an exact translation of what its sensors tell it, but it will integrate this sensory information with its own expectations from the past, its intent for the immediate future, and in the context of the current situation. So, in reality, there is no one reality. All of your senses send information to your brain, and your brain will compute this information into your very own personal virtual reality. To give you an example that demonstrates how clever the brain is at filling in the gaps for you, try reading this:

"Ceoinsdr the pweor of the hmuan biran. It dseno't metatr in waht oredr the lrttees in a wrod are, the olny tihng taht is iproamtnt is the frsit and lsat ltetres are in the rghit pclae. The rset can be a tatol mses and you can sitll raed it."

It's amazing isn't it. One movie that eloquently depicts how these things are possible is 'The Matrix'. It's been a long time since it was released, but in this film, reality, as perceived by the characters in the film, is actually a virtual reality called 'the Matrix' which has been created by computers. This film struck

a chord with me at the time, and its core message remains true. Your own inner reality may not reflect what is really going on in and around you. But regardless of its accuracy, your inner reality is very real to you. This concept sparked my curiosity about how our brain's own bias impacts our experience of daily life.

As a chiropractor, having taken care of hundreds of patients with a wide variety of complaints, I am often amazed at the incredible changes that many patients experience, and how quickly these changes can occur when patients start to receive chiropractic care. I'm not just talking about symptomatic changes such as reduced pain; sometimes it is as if a patient's entire 'reality' shifts and they almost become a different person. I am greatly humbled to be able to share the gift of chiropractic with my patients, and I am in awe of the way that this gift can change people's lives. Seeing these so-called 'miracles' in practice has fuelled my curiosity to understand what actually happens when I adjust someone. I wanted to be able to answer simple questions, like 'How is this possible?', and, 'Why is chiropractic care not more readily available to people?'. I grew increasingly impatient and frustrated with the lack of scientific knowledge out there. My curiosity and frustration with the status quo provided the motivation for undertaking my PhD, conducting further research and now, writing this book. It has also provided the motivation to create the website therealitycheck.com, a site where the public can go to find out more research-informed information about chiropractic care. This site is also THE place where chiropractors and keep up to date with the current science of chiropractic.

As scientists exploring new ground, we need to imagine what the complete jigsaw puzzle may look like, and then test it one experiment (puzzle piece) at a time to see if the overall picture is indeed correct. However, along the way the results of our experiments may suggest that the big picture we had in mind is not correct because the puzzle pieces don't fit together in a coherent way. If that's the case we need to recreate or re-imagine a new overall puzzle picture, one in which the existing puzzle pieces do fit. While doing this we also need to keep in mind that sometimes the experiments that have been done may have been poorly designed, and thus inherently flawed, so we end up with a puzzle piece that doesn't really fit our jigsaw at all. As you continue reading, I will not only share with you the experiments or puzzle pieces we currently have in place for understanding the science of chiropractic, but I will also share the overall chiropractic puzzle picture, as I believe it to be, but which is still being assembled. If you are a chiropractor you can learn more about this material, and stay up to date with on-going reviews of a variety of relevant topics at therealitycheck.com.

I wish to be clear that although we have made significant and ground-breaking discoveries over the past decade or so, it is important to acknowledge there is so much more we do not yet know or understand. The full puzzle picture of

chiropractic requires thousands and thousands of individual puzzle pieces that we do not yet have. We are still testing models of chiropractic that are in development and have some way to go before the true 'picture' becomes really clear. We also do not yet fully understand how the brain itself works. What is becoming clear though is that chiropractic care seems to impact our brain's inner reality, by restoring the proper processing and integration of sensory information which alters the way our brain controls our body.

Within this book I have tried to simplify some very complex neurophysiology and reduce the complexities of chiropractic to their bare bones. I have also made some assumptions that are based on our current understanding of the research. Please forgive me if I have oversimplified certain concepts, or if some of my assumptions are proven incorrect by future research studies. That is the nature of science, and is not unique to neuroscience or chiropractic. I have shared with you my understanding of the big chiropractic picture at this time. As we continue to add puzzle pieces to the picture and it becomes clearer, I hope that this greater understanding of the science will help us create a better, healthier world.

3 - The Brain and Central Nervous System

"If the brain was simple enough to be understood - we would be too simple to understand it!"

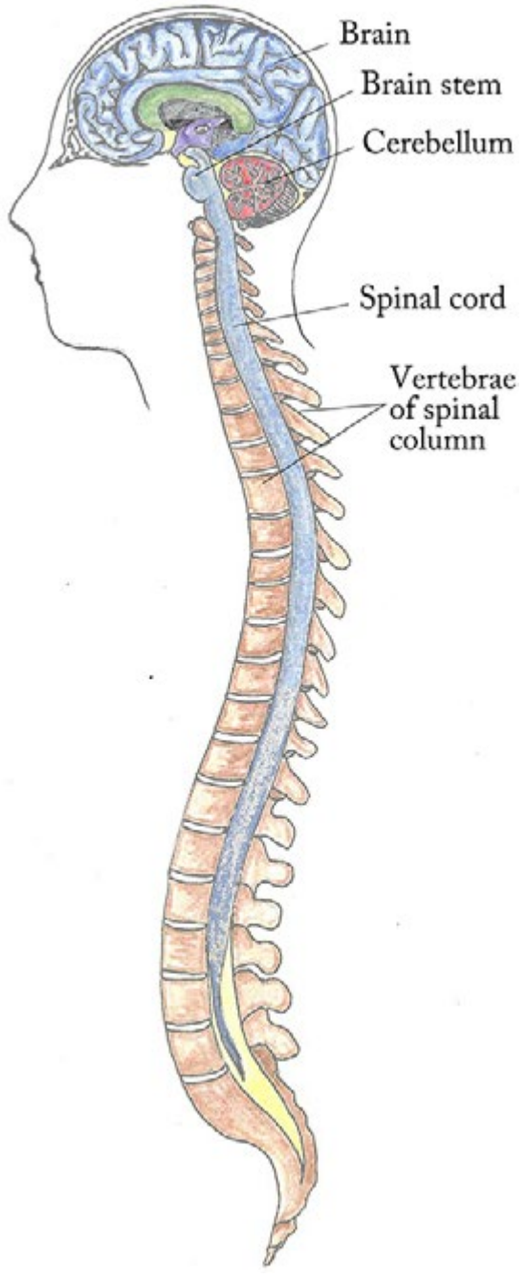
MA Minsky

To understand how chiropractic works, we need to take a closer look at how the brain and nervous system work. Our central nervous system (CNS) consists of the brain and spinal cord. Basically all the nerve cells inside the skull and spine. The peripheral nervous system (PNS) consists of all the nerve cells outside of the skull and spine.

We have billions of nerve cells that make multiple connections with each other (known as synapses). Very simply, these cells communicate with each other in the following way. If a nerve cell (also known as a neuron) is 'spoken to' loudly enough, it gets excited and sends an electrical message down one of its arms (called an axon) and it 'talks' to another nerve cell by releasing chemicals called neurotransmitters.These billions of nerve cells change the way they talk to each other based on the information the brain receives from its five senses. In this way the brain

continuously adapts to our ever-changing environment. This ability to adapt is known as ‘neural plasticity’.

Figure 2: The brain funnels into the brain stem and then is called the spinal cord once inside the bony spinal column. This is the central nervous system (i.e. brain, brain stem, and spinal cord). When the nerves exit out from the skull or spine they are part of the peripheral nervous system.



It is now well understood that the central nervous system can reorganise in response to altered external input [11-18]. Examples of increased sensory input[iii] that can lead to neural plastic changes include repetitive muscular activity [12, 19-24] such as typing or playing the piano, or repeated tactile sensory input such as occurs with blind Braille readers [25].

On the other hand, a similar central nervous system change or reorganisation may take place due to a decrease in behaviour or activity[iv] [15, 26-32]. For example, when people have a stroke, parts of the brain do not get enough blood-flow and die. Whatever parts of the brain that these dead cells once communicated with now no longer receive information from the dead cells. Because these dead cells have stopped 'talking' a whole lot of changes occur in other parts of the brain, both immediately and over time.

The changes that take place after an increase or decrease in sensory input to the brain involve actual changes in the structure and the function of nerve cells themselves [10, 33], which then impacts how they interact with other nerve cells. This results in the brain creating a different 'inner reality', which may or may not reflect what is really happening in and around us.

Put simply, brain cells change their behaviour based on how they're 'talking' to each other.

iii In the scientific literature this can be known as hyperafferentation. Hyper –meaning increased, and afferentation – meaning the afferent nerves, which are the ones that go to the brain with information.

iv In the scientific literature this is often called deafferentation.

The manner in which nerves 'talk' to other nerves can change in strength, a bit like turning up or down the volume dial on a stereo. A nerve cell can also change which other nerve cells it 'talks' to. Scientists call this a change in 'network activity'.

Let me give you an example. Nerves A, B and C may have originally talked a lot with nerves X, Y and Z (and only a tiny bit with nerves S, T and U). Then for whatever reason they may stop talking to nerves X, Y and Z and talk a lot more to nerves S, T and U. This would be a change in network activity.

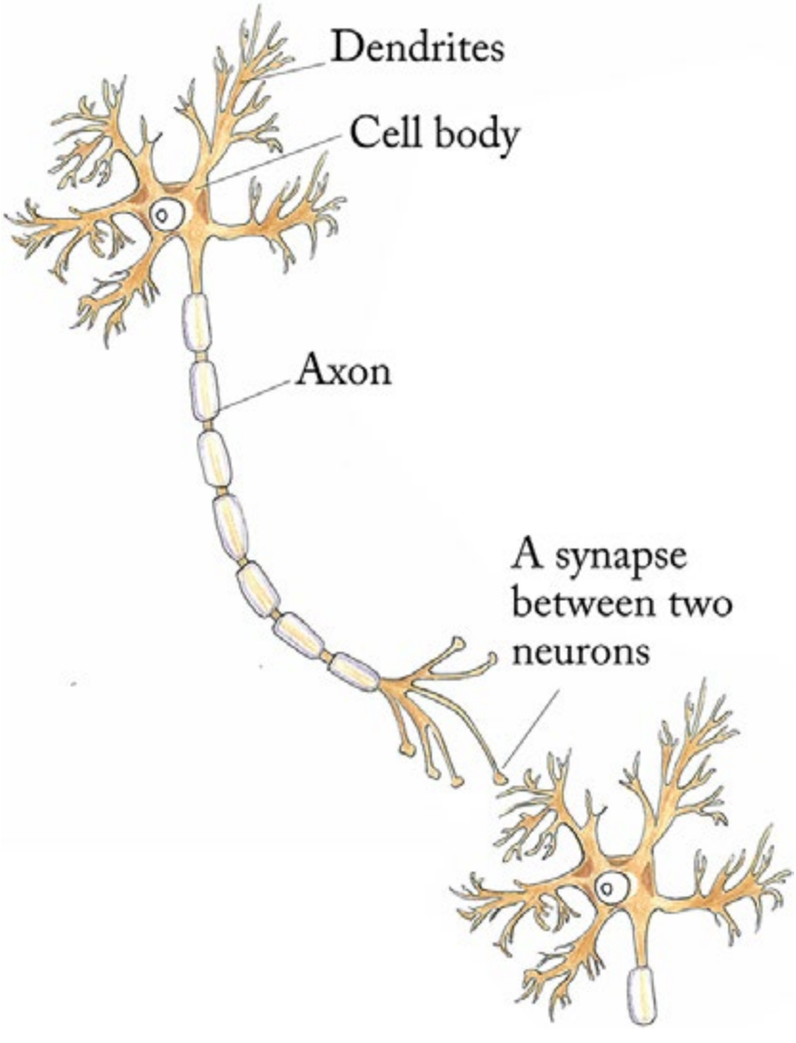


Figure 3: A typical nerve cell consists of a cell body, branch-like dendrites which receive information from other cells, and an axon which transmits information to another cell. The small gap where two cells connect and 'talk' to each other is called a synapse.

We know that the central nervous system is constantly reorganising in response to changes in sensory input. During every second of every day, our brain monitors and integrates all incoming sensory information. This allows it to accurately formulate and execute the motor commands it requires based on what you choose to do at any one point in time. This integration of sensory information to perform movements accurately is known as 'sensorimotor integration'.

Throughout our lives our activities, thoughts and behaviours will lead to specific molecular, biochemical, electrophysiological and structural changes in our brain and central nervous system. These adaptations and changes are in fact the mechanisms for learning, memory, and recovery from injury [10, 22, 29, 34]. These changes may occur within minutes to hours of an event occurring [30], or they may occur over longer periods of time. Longer term changes may be due to chronic deafferentation (long term decrease in information to the brain) from things like a stroke or amputation [15, 35-39,] or they may be due to a constant increase in stimulation which can happen when we're doing some type of motor training (repetitive movements) [40, 41]. These adaptations are not limited to the brain either. Neural adaptations have also been found in various brainstem structures [35, 38, 42-44,] and in the spinal cord [35, 38, 42].

So we've talked about how our inner reality is simply our perception of the environment via information from our sensory organs, interpreted by our brain with the filters of our past

experiences and learning, our expectations, and so on. And we've talked about how our inner reality constantly changes and adapts over time.

An interesting way to demonstrate how the brain's inner reality is indeed a perception is by using the classic checker shadow illusion, created by Edward H Adelsen from the Massachusetts Institute of Technology.

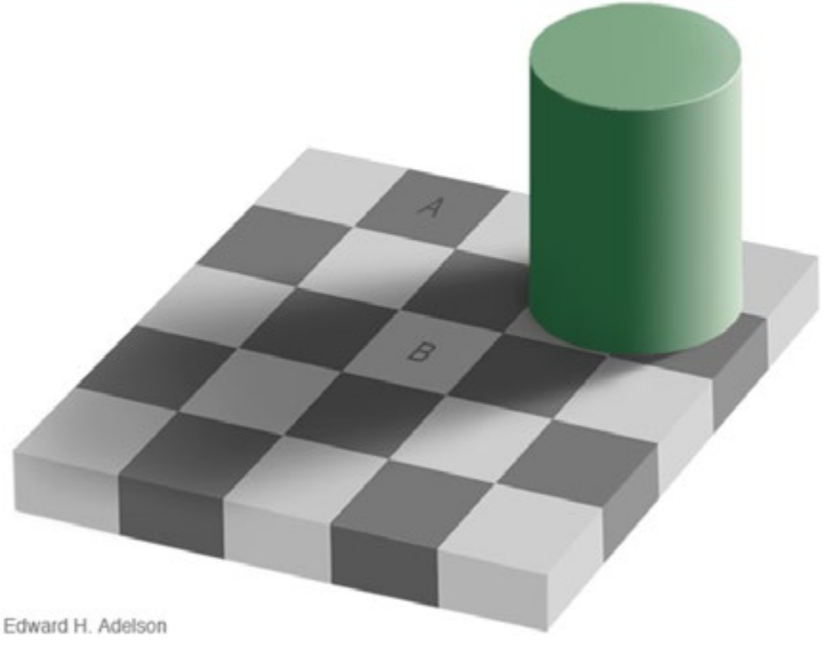


Figure 4:a Edward H. Adelsen's checker shadow illusion.

Which square is darker than the other, square A or square B?

The brain will take into account where you are, what you are doing, and what your intentions are. It will compute shadows and light sources, and only after all of these computations (which only takes the brain a few milliseconds by the way) will you actually 'see' what you see. In this case you see square A as darker than square B, because square B is in the shadow cast by the green cylinder, while square A is outside of the shadow.

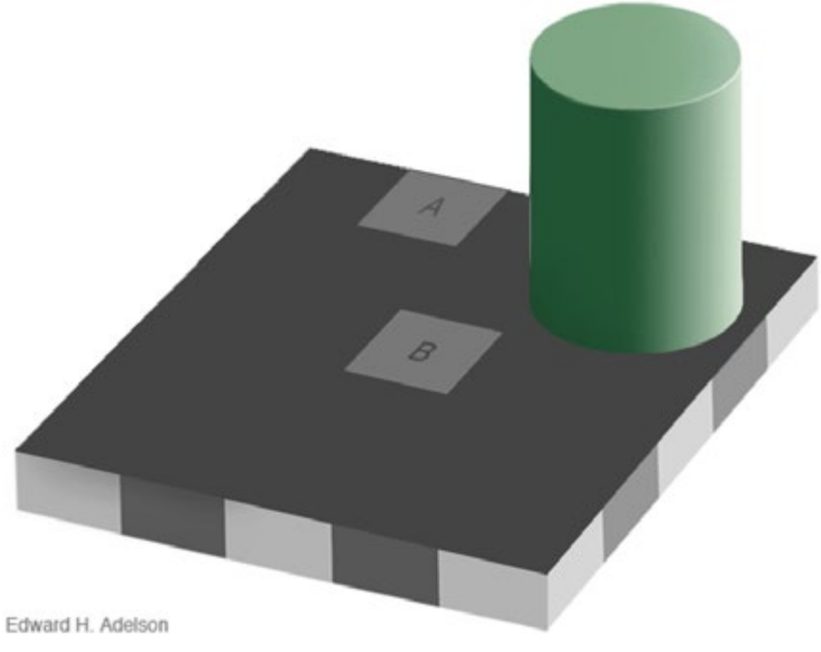


Figure 4b: Edward H. Adelsen's checker shadow illusion revealed.

Based on your brain's past experience it will 'decide' for you

that if a square in a shadow reflects the same amount of light as a square outside of the shadow, then it must be a much lighter shade of grey. So your brain actually alters your perception of the image. It changes your inner reality so that you see what it thinks is out there in the real world.

Video 2: Click here to watch "Perception of Reality"

As I mentioned earlier, another cool feature of the brain is that it will fill in the gaps, so to speak, if it is missing some information. A great example of this is how the brain can read words even though the letters have been scrambled (provided that the first and last letter remain at the beginning and end of each word). Another classic example of how the brain fills in missing information for you is the blind spot in our visual field. There is a part at the back of the eye that does not have photoreceptors because the optic nerve exits at that spot.

This means there is a part of your field of vision that your eye actually cannot see. It is small, but it's there, and it's called the blind spot. You can confirm this for yourself using the blind spot test. What your brain does instead of showing you a hole in your visual field in front of you, it fills in the missing gap.

The blind spot test

Instructions:

- Close your left eye and stare at the cross mark in the diagram with your right eye. Hold the book close to your face. You should be able to see the spot.
- Don’t LOOK at it; just notice that it is there off to the right. Keep your eye focused on the cross. Now slowly move the book away from you.
- Keep looking at the cross mark while you move the book slowly further away. At a particular distance (probably a foot or so), the spot will disappear (it will reappear again if you move even further away).
- The spot disappears because it falls on the spot where the optic nerve enters the eye, which is basically a hole in the photoreceptor sheet at the back of the eye.

So, as you can see, you have a pretty big blind spot, at least as big as the spot in the diagram. What is particularly interesting though is that you don’t SEE it. You don’t see a blind spot. What you see is something the brain is making up. The brain assumes that the blind spot area has the same colour as its surroundings. Keep in mind this is ALWAYS happening, not just when you are looking at a visual illusion. So what else are you not seeing or hearing of feeling? What else is your brain concocting every day?

4 - The Spine's Role in Brain Adaptations[v]

"The world as we have created it is a process of our thinking. It cannot be changed without changing our thinking."

Albert Einstein

One way to imagine the adaptations of the central nervous system (neural plasticity) is to liken it to the subtle changes of the riverbed in a flowing river. You can never really step into the same river twice; the water, stones and silt of the riverbed are constantly changing. Likewise, in the time that it took you to read the last sentence, your brain changed, and it will never be the same again!

Now consider this. The results of research studies have indicated that vertebral subluxations (those dysfunctional spinal segments) lead to changes in the information that the spine sends to the brain. To start with, instead of the brain receiving information that the subluxated spinal segment is moving as it should, it may get information that the segment is moving way more than 'normal', not moving much at all, or just moving differently to 'normal'.

That seems obvious, but for now, remember that any change in information to the brain can lead to changes within the brain itself. What's really interesting though, is that when a spinal segment doesn't move properly, it appears to influence how the brain perceives and responds to all other sensory information. Spinal function seems to be one factor the brain uses as part of its processing and integration of all information (like shadows and light sources in the checker shadow illusion above) to create your inner virtual reality. One hypothesis for why this may be is that your spine is being used by the brain as an indicator of your core body position. So for example, when the brain is planning to move your leg or arm, it also needs to take into account where your spine is to make allowances in the body for balance and stability.

We've established that the brain is forever changing. I'm sure you have experienced, not all change is necessarily for the better, so changes in the central nervous system are not always 'good' changes for the body. Sometimes the brain changes in ways that lead to uncomfortable, annoying, or even painful symptoms. Some scientists call these kinds of changes 'maladaptive' or negative neural plastic changes, as opposed to healthy adaptive or positive changes. I will come back to this shortly and explain this in greater detail.

v Brain adaptations are called 'neural plasticity' or 'neural plastic changes' in the research literature.

Pain, dysfunction and chiropractic care

Have you ever ended up in pain for no apparent reason? Pain that just sort of appeared one day? Well we now know that such an experience may not be 'all of a sudden' after all. Your pain (and also a whole lot of other symptoms) may in fact have been developing for some time without you knowing about it. It's all part of that background processing that you are not consciously aware of.

It's a bit like the thousand straws that break the camel's back. The camel is fine with 999 straws on its back, but one more tiny straw, and it will break.

Figure 5: Pain and conditions with other symptoms don't necessarily happen all of a sudden for no reason. They can slowly develop, without your awareness, a bit like the build-up of a thousand straws on the camel's back before it breaks. Only when the last straw is added and the 'camel's back breaks' do you feel or become aware of the issue.

The straws building up on your camel's back can include all sorts of things such as poor sleep, awkward postures, repetitive movements, lifting wrong, stepping off a curb unaware, negative self-talk and minor accidents. Subtle changes can be happening due to all of these things to the point where you reach your limit, your 999 straws. Then all that is needed is one last minor thing to go wrong and you end up with pain or other symptoms.

Video 3: Click here to watch "Symptoms"

The presence of pain itself has been shown to alter all sorts of aspects of how muscles are controlled by the brain, and therefore how they function [45-48]. So although the adaptability of the brain is a great thing that allows us to learn new skills, it can in some circumstances be a bad thing too[vi]. Put very simply, your brain can learn to function poorly and sense pain just the same way that it can learn to ride a bike or play the piano. We know for example that there can be major changes in the brain following an injury that very quickly alter the way the brain processes all other incoming sensory information [49]. It may be that the injured person's brain automatically goes on high alert as soon as they are in any kind of pain, as a protective mechanism. But if this goes on for a long time it may change the way their brain perceives the reality of what is happening in and around their body.

These kinds of maladaptive (bad) plastic brain changes are thought to be involved in the initiation of chronic pain conditions. Let's explore this with an example. Under normal circumstances if you wish to raise your arm or leg, your brain will first send messages to other muscles than the ones you consciously want to move, such as

the core abdominal muscles, to stabilise the body. In many painful conditions (such as low back pain) it has been found that the brain does not send these so called 'feed-forward' protective messages, and therefore does not stabilise the body, which in itself is likely to worsen the person's condition. We also know that for people who are not currently in pain, if their brain does not send appropriate protective feed-forward messages when they move, they have a higher risk of developing low back injury [93]. This makes sense because a lack of core stability means you're basically creating mini whiplash injuries to your spine each time you move around or lift your arm or leg. This problematic trait presents in many pain conditions and is one example of the way the central nervous system can adapt in a way that is not necessarily good for the person (i.e. a type of maladaptive plasticity).

Research has demonstrated that significant brain changes do occur in a variety of musculoskeletal pain syndromes [51, 52]. We know that patients with mechanical low back pain display alterations in the way their brains recruit their trunk muscles compared with people who do not have low back pain [53-55]. Abnormal ways of recruiting postural stabilising muscles also occur in other musculoskeletal conditions such as knee pain [56] and idiopathic[vii] neck pain [52]. I will get back to this in greater detail in Chapter Eight.

Based on this knowledge, several scientists have hypothesised that these changes in muscle recruitment patterns are an

vi One could of course argue that all adaptations by the brain are beneficial for survival of the individual. But we tend to classify maladaptive or negative changes as changes that are not necessarily comfortable for the individual, such as pain development. There are a number of conditions that are excruciating for people that are known to be due to maladaptive or negative neural plastic changes.

vii Idiopathic means we don't know the cause of it, so idiopathic neck pain means neck pain that we don't know the reason or cause of.

adaptation (i.e. maladaptive plasticity) due to underlying spinal instability; that is, spinal segments that are moving too much [57, 58]. The spinal segments may be moving too much due to ligament laxity. On the other hand it could also be due to damage to the ligaments that support the spinal movement segment. However, it can also be due to dysfunction of the muscles surrounding the segment, or even faulty control of these muscles by the brain. All these things can add up until that thousandth straw breaks the camel's back and you end up feeling pain.

I'll give you a simple case example. Many years ago before we met, my partner Glenn had pain in his right knee. It troubled him a lot. It just started one day and he did not know why. He put it down to all those years of playing rugby and rugby league. Over many years Glenn tried all sorts of treatments for his knee pain. He thought he had tried everything, even ending up with arthroscopic knee surgery to remove torn cartilage. But his knee still hurt. Many painful years later, and having given up on actually being able to fix the problem, he offered to help a mate who was going through chiropractic college who needed someone to practice on[viii]. Glenn started to receive chiropractic care. He had no expectations at all. He simply wanted to help his mate Chris. Glenn was utterly amazed when after a little while his knee pain disappeared – even though Chris did not directly treat Glenn's knee. He was simply checking and adjusting subluxations in Glenn's spine.

In my opinion this story demonstrates that Glenn's knee pain was likely due to altered neural control of the muscles around his knee that was caused by dysfunction in his spine or joints in his pelvis. It could be that Glenn's pelvis and neck were subluxated, causing changes in the way his brain perceived what was going on with his knee. This could have led to the brain controlling his hip and knee muscles in a way that left the knee joint constantly functioning in a less than ideal manner, causing ongoing micro-trauma and eventually pain.

I think that pain is just the brain's way of letting us know something is not quite right. Sorting out his spine and pelvis restored accurate communication from Glenn's spine to his brain. This enabled his brain to accurately perceive what was going on with his knee and correct the way it controlled the muscles in his leg. This reduced the ongoing stress on his knee joint, so the pain disappeared. Naturally Glenn was delighted. He thought he was just 'getting old' and would have to put up with it. Having thought he would have to give up sport years ago, Glenn still plays soccer twice a week.

Maybe you are sitting there thinking "Hang on! How can the neck have anything to do with the knee?". What the research has shown us is that dysfunction in the spine, including the neck,

viii In New Zealand to become a chiropractor you need to train for five years. You first learn all the basic sciences of anatomy, pathology, physiology, neurology and so on, and in your final two years of study you practice chiropractic under the supervision of qualified chiropractors to achieve a minimum of 500 patient visits, with a wide case mix (i.e. different ages, different complaints, etc.).

disrupts the brain's ability to sense what is going on accurately in the rest of the body [84, 136]. Keep in mind that the brain is constantly trying to pick up on thousands of different bits of information from all around the body. It needs to judge what is important and try to ignore non-essential information. The dysfunction of the spine appears to cause a distraction for the brain that makes it harder for it to accurately 'see' what is going on in other places, like the knee in Glenn's case.

We know from the research studies that muscle impairment or dysfunction occurs early in the onset of spinal complaints [59]. The muscles around the spine don't work properly early on in the development of spinal pain. We also know that this kind of muscle problem does not automatically resolve even when pain symptoms improve [59, 60]. This has led some scientists to suggest that the lack of the brain's awareness about what is going on in the spine, and the resulting faulty control of the muscles surrounding the spine, rather than the feeling of pain itself, may be the main factors defining the clinical picture and chronicity of various chronic spinal pain conditions [61, 62]. They are basically proposing that the heart of the problem is that the brain does not accurately perceive what is going on. If the brain does not accurately know what is going on, then it can't control muscles properly, like in Glenn's example above.

This makes perfect sense to me. This is what I believe a subluxation is, a breakdown in the way the brain perceives and controls movement of the spine. And this spinal dysfunction does not just affect how the brain then perceives and controls the spine, but also how it perceives and controls the rest of the body too. Such dysfunctional spinal segments therefore become self-perpetuating problems in themselves and can influence the development and perpetuation of various chronic pain conditions.

As discussed, the function of the spine impacts how the brain organises and interprets sensory information from the rest of the body [1, 63-66]. It also impacts how the brain controls muscles throughout the body [67-69]. With the brain appearing to include spinal function in its background processing, this can be an even bigger problem than it at first sight appears to be.

This can explain why seemingly unrelated symptoms and conditions can clear up coincidentally when people start chiropractic care, such as with Glenn's example. Of course I don't think it is a coincidence. Rather it is due to the improved communication between the spine and brain influencing the accuracy of your brain's inner reality about what is actually happening in your body.

Let me explain this a little better. But to do that I need to first remind you about the movie 'The Matrix.'

5 - Chiropractic Changes the Matrix of Your Brain

“What is real? How do you define ‘real’? If you’re talking about what you can feel, what you can smell, what you can taste and see, then ‘real’ is simply electrical signals interpreted by your brain.”

Morpheus, The Matrix

If you have seen the movie The Matrix you will remember Thomas Anderson, a computer programmer who maintains a double life as the hacker Neo. He is intrigued by the cryptic references to the Matrix that appear on his computer. He eventually meets up with the infamous hacker Trinity who informs him that a man named Morpheus can tell him what the Matrix is. And in the end Neo meets up with Morpheus and confirms that he wants to learn more about the Matrix by choosing an offered red pill. After swallowing the pill, Neo abruptly awakens in a liquid-filled vessel, with his body pierced with cables that connect him, along with billions of other people, to an elaborate electrical network.

From this place he is rescued by Morpheus, who goes on to explain to Neo that humans are fighting against intelligent machines that were created in the 21st century and have since taken control of the planet. Humans polluted the sky to cut off the machines’ solar power, but the machines adapted by using human bioelectricity as a power source. Enslaved humans are kept docile within the Matrix, a simulation of the world as it was in 1999. Neo has lived in this simulated world since birth. In reality, the year is closer to 2199. Morpheus explains that he and his crew belong to a group of free humans who ‘unplug’ others from the Matrix and recruit them to join their rebellion against the Machines. So basically Neo’s whole life has been a simulation, a lie, created by the intelligent machines plugged into his central nervous system.

How does the ‘Matrix’ concept relate to us here and now?

Our brain creates our own virtual reality or ‘matrix’ via our five senses. Through these five senses our brain computes environmental information and integrates this with its own wishes and desires. It then carries out a whole lot of background processing that we are generally unaware of, and creates for us a virtual reality in our minds about what is going on in our own bodies and the world around us.

Scientists have learnt that when the nervous system is subjected to unaccustomed or new inputs, changes occur

in the way the system processes all subsequent inputs [11-18]. Research has shown that brain adaptations partially serve as an explanation for how people can recover function after damage to the nervous system, such as the damage that occurs with strokes.

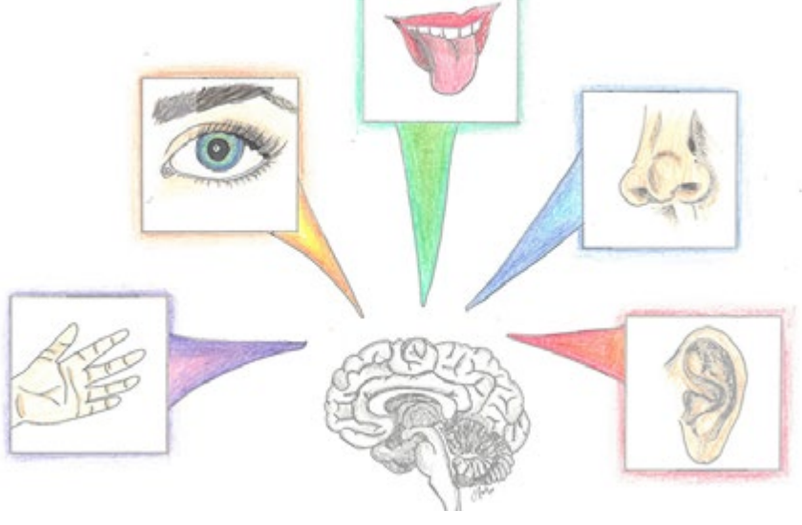


Figure 6: The brain has to integrate or merge all the sensory information it gets from the five senses, and from this it creates a virtual reality of what is going on in and around you.

Over the past ten years several research groups have demonstrated that spinal adjustments can change various aspects of nervous system function, including muscle reflexes, reaction time, and the speed at which the brain processes information. My research colleagues and I have been heavily involved in this type of work. All the references regarding this research is detailed in Chapter Six. We have hypothesised [1, 63, 64] that maladaptive neural plasticity (i.e. negative brain changes) occurs as a result of segments in the spine that are not moving in an ideal or 'normal' manner. We have further proposed that through spinal adjustments we can restore normal movement patterns in these spinal segments and therefore restore a more natural pattern of input from the spine to the central nervous system. This in turn will allow the spinal cord, brainstem and brain to process incoming information in a more coherent and meaningful way. We believe this to be the mechanisms by which adjustments of vertebral subluxations can improve nervous system function, as observed daily in chiropractic practices all around the world. Since the inception of chiropractic, patients have reported improvements in areas of nervous system function following an adjustment of their spine. Understanding how this might occur is of essential value to us all. Better scientific explanations for how chiropractic care improves function will have far reaching effects on scope of practice, funding for, and access to chiropractic care.

To help you understand this better I will now cover some of the basic science discoveries about how the brain and central nervous system work, and link this with greater detail to what I have outlined above regarding the mechanisms of chiropractic care.

The ‘eyes’ within the body: Paraspinal muscles and muscle spindles

One key component in the proposed theory of how chiropractic care works (i.e. through influencing brain function) [1, 63, 64] is the functional role of paraspinal muscles. To understand this you need to understand the role of the muscle spindle. I will therefore cover the basics of this here. Bear with me if this information is a lot to take in – over the next few pages I will explain the scientific side of what happens in the body, and I will then bring it to life with some simple examples.

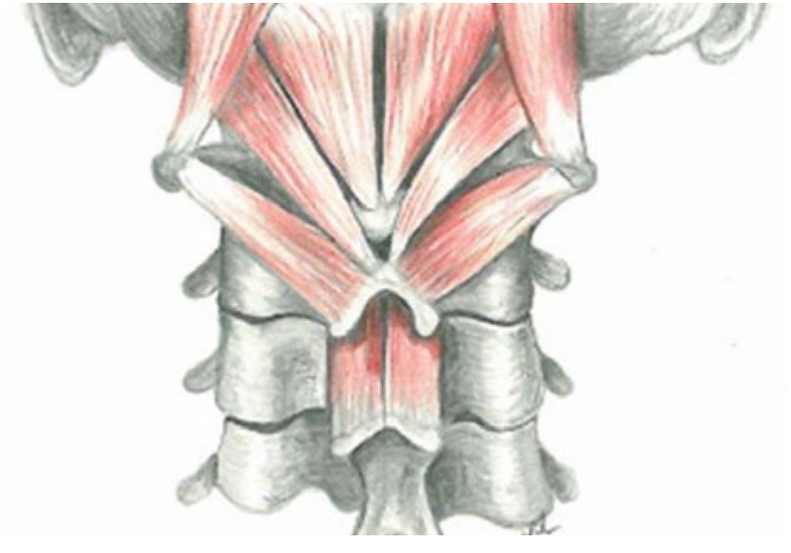


Figure 7: Image of the back of the skull and spine showing the deep upper cervical paraspinal muscles that attach between the upper spinal vertebrae and the skull.

Muscle spindles are tiny little stretch sensors found inside the muscles. They play a very important role in sensorimotor integration and most likely also play a very important role in the mechanisms of spinal adjustments. Remember that sensorimotor integration means the brain’s ability to integrate the sensory information it receives and adapt the motor command (muscle response) based on this information. This enables us to perform ‘perfect’ movements (i.e. without making mistakes). Every time your muscle is used or is ‘stretched’ in any way, the muscle spindles tell your brain about it immediately. Basically, the muscle spindles are your brain’s ‘eyes’ within your muscles. Even if you close your eyes your brain knows where your arms and legs are, and you can accurately move about. This ability to feel where your body is (without seeing it) is called proprioception, and muscle spindles play a very large role in your proprioceptive ability.

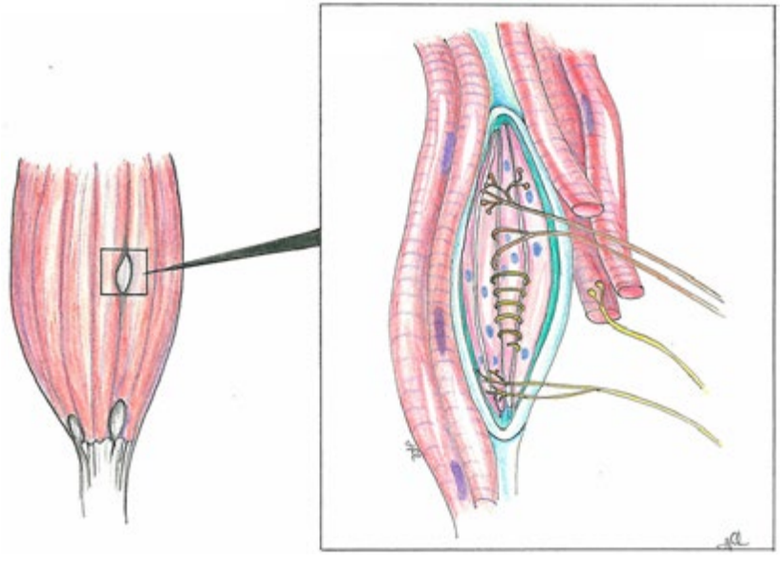


Figure 8: Image of the muscle spindle found within muscles themselves. Inside the muscle spindles there are nerves that wrap around parts of the muscle. These nerve cells respond to stretching of the muscle.

Interestingly, scientists have shown that the number and density of muscles spindles are remarkably high in the deep small upper neck muscles (in particular the suboccipital deep paraspinal muscles shown in Figure 7) [70-73]. This has led some of them to propose that the role of these deep upper neck muscles is to act primarily as proprioceptive sensors in the body, rather than playing any significant role in actual movement of the head and neck.

Let's explore this in a bit more detail. One group of scientists that studied the number and density of muscle spindles commented that because these deep upper neck muscles are very small, they seem incapable of bringing about any significant head movement [71]. The same researchers also noted that they have a mechanical disadvantage because they are inserted very close to the joints between the skull and vertebrae in the neck (craniovertebral joints). This is compared to the large powerful rotator muscles of the head which attach further out to the side of the head [71]. These researchers proposed that due to the very high muscle spindle content of the deep upper neck muscles, this makes them ideal candidates to act as sensors of the position and movements of the craniovertebral joints [71].

Others have suggested that from a proprioceptive perspective, the small muscles required for fine motor control have large spindle densities, whereas those recruited for overall movements are comparatively devoid of muscle spindles [70]. This is interesting as fine motor control obviously requires a high level of awareness and communication between the moving part of the body and the brain.

The effects of chiropractic adjustments on spindle activity

When chiropractors apply an adjustive thrust to the spine it stretches the paraspinal muscles. One group of scientists found that muscle spindles in the paraspinal muscles in anesthetised cats responded to forces applied to the vertebrae that are

similar to the forces delivered during spinal adjustments [74,75] (my apologies to cat lovers). Another group of scientists have shown that spinal adjustive thrusts can evoke short lasting electromyographic (EMG) responses in paraspinal muscles [76, 77]. These studies demonstrate that chiropractic adjustments are felt by the paraspinal muscles - which will then feed this information back to the brain.

Another scientist and his collaborators developed an animal model for studying what the different parts of the nervous system would do when you move a vertebra out of its natural alignment [78, 79]. They found that if you do move a vertebra ever so subtly, this small displacement is signalled to the brain and central nervous system from nerves arising from deep muscles that run between the vertebrae (intervertebral muscles). In particular, both the speed of vertebral movement and the relative position of the vertebral displacement appeared to be encoded by nerve activity from intervertebral muscles. This again supports the idea that the deep muscles close to the spine are sensors for the brain that tell the brain what is happening in the spine. This work also supports the theory that joint dysfunction (vertebral subluxations) leads to altered input from deep intervertebral muscles to the central nervous system.

As discussed, we know that the central nervous system continuously reorganises in response to altered input from the rest of the body [11-18]. So, knowing all of this, we hypothesised that a subluxation is likely to alter the input to the brain from the deep paraspinal muscles. This may lead to ongoing maladaptive plastic changes in the brain.

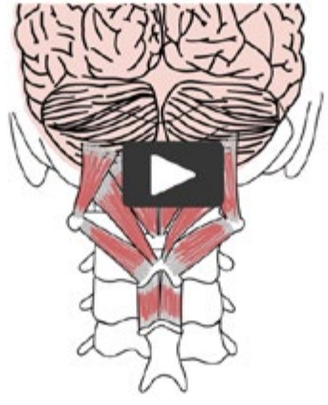
Put very simply this means that if there is a stuck joint in the spine, the muscles around the joint don't get stretched, which means the brain will not receive information about what is going on at that segmental level. And what does the brain do if it does not get information? It will tend to fill in the gaps based on past experience and surrounding information. This may not be 100% accurate and could mean that it sends less than ideal messages to the muscles around that joint, which then could cause ongoing problems.

Let me give you an analogy to make it easier to understand. Imagine that you have lived in a house all your life, and in this house there is a long corridor with no windows or natural light. At the end of this corridor is the electrical fuse box. Now imagine that the circuit breaker to the lights in that corridor blew and you were pitched into complete darkness. Would you be rendered completely helpless? Or could you walk down that corridor, in that house you have lived in all your life, and turn the circuit breaker back on? Of course you could. You have lived there all your life. You would know roughly how long the corridor was and how wide it was. You would be able to get down there and turn the lights back on. Your brain is just as smart as that.

It can function even if there are parts of your body that are

in the dark, parts of your body that it cannot 'see'. It can still function based on previous experience. But now imagine that before those lights went out, your kids had left a bicycle in that long corridor that you had not seen before the lights went out. What would happen in that scenario? You would likely fall and hurt yourself. And that, I think, is what happens when the brain is not fully and accurately aware of what is going on somewhere in the body.

When you are subluxated, the paraspinal muscles may not be moving as much, so your brain's 'eyes' in the spine are now in the dark and cannot 'see' what is going on, like in the dark corridor analogy. The brain can still function, but it is guessing what is going on based on past experiences, and may get things wrong as it cannot 'see' the potential problems, like the kid's bike in the corridor. And this can lead to mistakes and accidents. For example, you may now start knocking your elbow on door frames because your brain has misjudged exactly where your elbow joint is compared with the door frame.



Video 4: Click here to watch "The Brain, Body & Spine"

Chiropractors have known for over a hundred years that movement is important, and now we better understand why that is. It's not just because exercise is good for you, which of course it is. But movement feeds the brain with information about what is going on in your body. You cannot see inside your body and you don't watch everything you do. Your brain relies on all sorts of information arriving from all around your body to have a clear picture of what is going on and to make the right decisions about how best to respond.

When we talk about vertebral subluxations, we generally think of segments that are not moving enough. So what about segments that are moving too much or just in a different

way to normal? In these situations the different or excessive information that the brain receives may act as background noise in the system, making it harder for the brain to accurately perceive what is going on and respond appropriately.

We know for example that older adults appear to filter less background sensory information, meaning they experience more baseline 'noise'. This results in a need for greater integration of sensory information than younger adults, even when they are selectively attending to a sensory stimulus [80, 81]. This increased background sensory noise may not be a good thing because it may cause distractions for individuals and may therefore lead to accidents [81 82].

As outlined already it appears that spinal sensory information is important for the brain to integrate other sensory information. In one study the researchers set out to investigate the influence of neck pain on sensorimotor function in older adults [83]. They concluded that the older adult participants with neck pain had altered information going to their brains. It originated from the cervical spine, and they believed this altered neck-to-brain information caused greater sensorimotor disturbances compared to older adults that did not have neck pain. The researchers claimed that these sensorimotor disturbances would influence the ability of these people to maintain balance and prevent falls.

In their study, they ran a large number of sensorimotor functional tests and took into account actual age and other conditions. These scientists were pretty much saying that the altered information from the necks of these older adults who had neck pain was disturbing their brains' ability to integrate and process all other sensory information. This in turn potentially affected their balance and increased their risk of falling.

I would add to this that you don't actually have to have pain for there to be altered information from spinal segments. As mentioned earlier, dysfunction can be happening in the body behind the scenes well before the pain shows up (and sometimes pain will not show up even when the internal problem is severe). The implications of the study involving older adults with balance issues are likely to apply beyond people with neck pain. Many others without neck pain may also be prone to poor balance and coordination due to vetebral subluxations, without any obvious symptoms at all. My research group recently conducted a study which looked at sensorimotor function that is linked to falls risk in people over the age of 65.

The study of sensorimotor integration is vital to improving our understanding of normal physiological function, as well as to provide important insight into how and when adaptations of the sensorimotor system malfunctions. A better understanding of these maladaptive or negative adaptations will help to unravel the complex interactions occurring when a spine is not functioning properly, and could shed light on how best to provide appropriate chiropractic care for affected people.

6 - The Research of Chiropractic Care

“Cutting off fundamental, curiosity-driven science is like eating the seed corn. We may have a little more to eat next winter but what will we plant so we and our children will have enough to get through the winters to come?”

Carl Sagan

Let’s start with a re-cap. Based on the results of our research findings over the past 15 years, my colleagues and I have proposed that areas of spinal dysfunction, i.e. subluxations, represent a state of altered input to the brain. This may be responsible for ongoing maladaptive or negative brain changes and the development of symptoms [1, 63, 64]. Furthermore, we have proposed a potential mechanism which could explain how chiropractic adjustments can improve body function, reduce symptoms, and even prevent conditions from developing in the first place.

We have proposed that the abnormal feedback to the brain from an area of spinal dysfunction alters the environment or inner reality into which subsequent feedback from the rest of the body will be received and processed. This leads to altered sensorimotor integration of new incoming sensory information from the body and the world around us [1, 63, 64]. When a chiropractor adjusts these dysfunctional spinal segments we believe that we normalise the incoming information from the spine, which makes it easier for the brain to accurately know what is going on in and around the body, and therefore respond more appropriately and accurately [1, 63, 64].

This processing, i.e. sensorimotor integration, is a central neural function that appears vulnerable to altered input from the spine [1, 64, 83]. We have shown this in multiple experiments [1, 64, 65, 67, 68, 84]. The combined implications of this are very significant. In this chapter I will give you more of an overview of the research that shows the effects of chiropractic care on the brain’s sensory processing, muscle control, functional performance, and sensorimotor integration. This body of work helps to explain how an initial episode(s) of back or neck pain may lead to ongoing changes in input from the spine, which over time leads to altered sensorimotor integration of input from the spine and limbs, and potentially the development of chronic problems. Increasing this understanding may provide a neurophysiological explanation for many of the beneficial clinical effects reported by chiropractors and patients in day to day practice.

One of the long term aims of our research is to identify

indicating brain factors[ix] which may enable us to predict which types of people will respond best to various types of chiropractic care, and whether someone has had a sufficient amount of care to properly resolve the dysfunction. It may be that some people do not get enough chiropractic care (i.e. they drop out of care too early) and that this may lead to the reoccurrence of problems that could be avoided or that could have been prevented from becoming chronic in the first place. You see, when pain shows up there has likely been a long period of time in which dysfunctional changes have been occurring in the body before the final straw is laid and the camel's back breaks. And so with chiropractic care it may be that pain itself is quickly 'fixed' and so the patient stops receiving care; but the bulk of the problem remains under the surface, disguised by the lack of symptoms, but ready to surface again with just a few extra straws.

With the growing burden of musculoskeletal pain syndromes in our lives and on our health care systems, this is a very important area for future research. I must admit that when we first started to do this research, my PhD supervisor, Professor Bernadette Murphy and I were really looking for spinal reflexive changes. We hypothesised that spinal adjustments worked locally at the spinal cord level, somehow reducing pain and increasing function.

I also believed at this early stage in my career that there were many chiropractors who saw their clients too much. Our scientific discoveries have since changed my opinion. Bernadette and I have many times laughed about the fact that science has a tendency to set us on a more difficult and controversial path than we had planned. But our work is, and always was curiosity driven. I just wanted to understand how the science worked, because I had seen chiropractic bring about incredible results for so many of my patients. I had also felt it in my own body and health and seen changes with my two babies.

I knew at the time science had no real explanation for some of the things that I had seen or experienced. I did not have an attachment to what the outcomes of the studies would be. I was just on a mission to discover the truth. And so we set about designing a series of research projects that could explore this area further. We wanted to know what effects a single session of chiropractic care would have on the human nervous system. We looked at how chiropractic care affected the way the nervous system sensed information (i.e. 'felt' things), how it integrated this information before sending out motor commands to the muscles, and how it controlled the muscles themselves. Based on these studies we formulated a theory, a model for how it might work. All the research that we have been conducting since this time all relates to the over arching research model shown in Figures 9 and 10.

ix What scientists would call 'objective neurophysiologcal markers'.

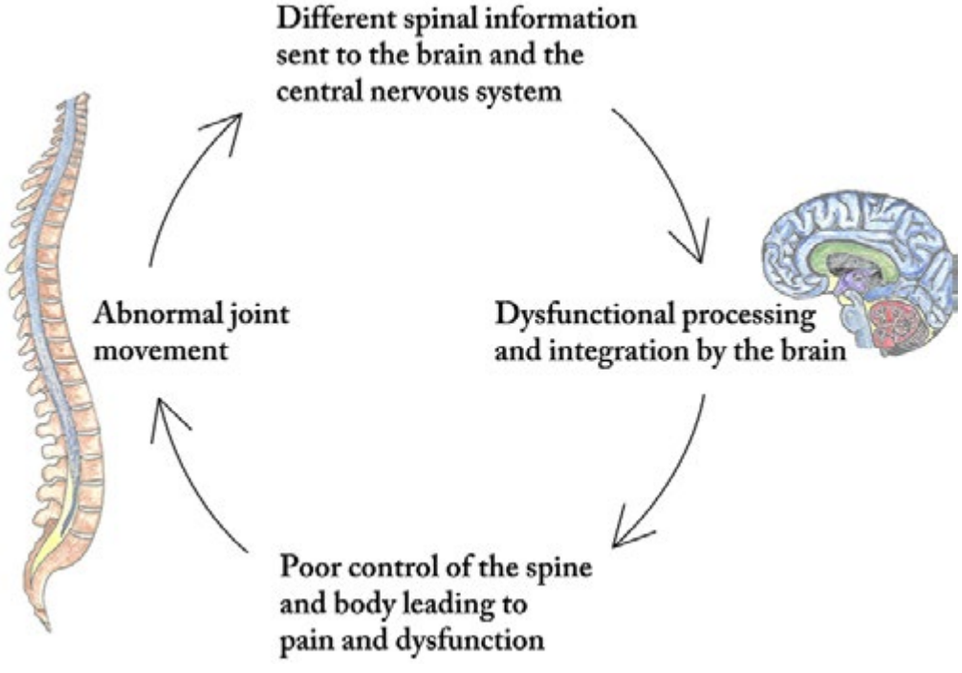


Figure 9: The hypothesised effects of spinal dysfunction (subluxations) on the brain and central nervous system function, and the wider consequences for the body

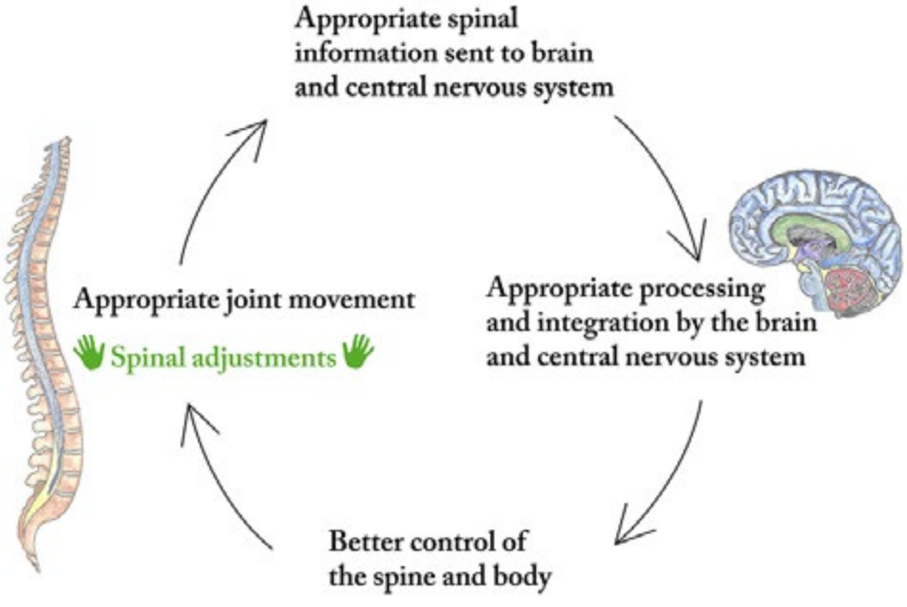


Figure 10: The hypothesised effects of adjusting subluxated spinal segments to restore proper brain and central nervous system function.

These models offer an explanation for the broad range of changes that have been reported following chiropractic care in studies that my research group, and other researchers, have completed over the past 15 years. These studies have suggested that chiropractic adjustments can trigger changes in the body that are as varied as:

- improved or altered visual acuity and visual field size [85,

- reduced joint position sense error[x] [84, 136]
- decreased reaction times [87]
- altered brain processing [64, 87]
- changes in the way that our brain integrates sensory and motor information [64, 65, 68]
- altered spinal cord reflex excitability [45, 46, 77, 89]
- changes to specific messages that get sent to muscles from the central nervous system [68, 90, 91]
- increased muscle strength in the legs [69, 92]
- reduced (or prevented) muscle fatigue developing [69]

Our theory and the above model provides a potential explanation for the link between chiropractic care and all of these changes in sensorimotor function [1].

The most interesting thing that came from all these experiments is that chiropractic care, adjusting the spine to restore spinal function, actually changes the way the brain functions.

Does chiropractic care improve spinal function?

Several researchers have shown that chiropractic care improves spinal function [94-99]. This in its own right is important because spinal dysfunction is known to result in reduced postural control [62, 83, 100-109]. The link between the function of the neck and postural control has been well documented in people with chronic neck pain or neck muscle fatigue[xi], cervicobrachial pain syndrome[xii], cervical root compression[xiii], cervical myelopathy[xiv], head injury and whiplash injury [62, 83, 101, 102, 104-108]. Recently an association between neck osteoarthritis and postural stability has also been reported [100].

It therefore appears that there is a strong link between neck function and accurate proprioceptive processing, and thus postural control. In other words we know from all of these studies that if the neck is not functioning properly this makes it difficult for the brain to know what is going on in the neck (obviously making it difficult to control the neck muscles properly) and this is known to negatively affect our brain's ability to stabilise the body, making it easier to trip or fall over.

Even the lower back has been implicated in poor postural control. People with low back pain or lumbar disc herniation are less steady on their feet [110, 111]. This again suggests that spinal function influences how the brain controls balance.

x Joint position sense refers to the brain's ability to know where your arm or leg is even when you close your eyes.

xi In people with neck muscles that get tired very fast, as if the neck muscles are just not strong enough to even hold their head up.

xii These people have terrible pain radiating from their neck down their arms.

xiii This is similar to cervicobrachial pain syndrome, but in cervical root compression there is documented damage to the nerves that exit from the neck, i.e. the nerves as they exit the spine in the neck are compressed, for example from a bulging disc.

xiv With these people the damage to the nerves is happening inside the spinal cord from a variety of causes and also often leaves the sufferer with neck and arm pain.

Subclinical pain

When designing our studies I wanted to know what happened when we adjusted someone. I specifically wanted to know what happened when we corrected the spinal segmental movement patterns.

One of the problems I faced was that we know pain itself can also change all sorts of processing within the central nervous system. And chiropractic care is well known for its ability to reduce pain. Adjusting the spine may relieve pain for individuals suffering from neck pain [112, 113] back pain [113, 114] and headaches [115]. So if I adjusted our research participants who were in pain, and their pain reduced or went away, then it would be impossible to know if any changes we found in central neural processing were due to the improved segmental movement pattern or simply due to the reduced pain. We agonised over this for a while until we came across a group of people that other scientists were exploring; a group called subclinical pain sufferers.

Subclinical pain refers to recurring dysfunction such as mild pain, ache, and/or stiffness, with or without a history of known trauma. Individuals with subclinical pain do not have constant symptoms and have not yet sought treatment for their complaint. There is an increasing interest in subclinical pain in the scientific literature because individuals who fall into this category provide a unique opportunity to explore neurophysiological dysfunction without the complications of current pain, which by itself is known to alter sensory processing and motor control [116].

Another reason why this particular group of people is interesting is because gaining a better understanding of the features characterising members of this group may help to improve sub-grouping of actual pain patients. This will help us to identify the best way to help each person with pain to improve. Based on their specific type or 'group' of pain we may discover how best to take care of them, and for how long they need care so that it is less likely to reoccur or become worse.

The scientists who explore sub-clinical pain patients (such as us) also wish to be able to identify objective brain markers that indicate when altered sensory processing is taking place. This could aid in determining which individuals are showing evidence of disordered sensorimotor integration, and who may need an intervention (such as chiropractic care) to prevent the progression of neck pain to more long-term pain states [117]. Such brain markers may also help us determine if an intervention is working, and for how long such an intervention may be required. For these reasons we specifically chose to explore what went on in people who had subclinical pain syndromes when we adjusted subluxated spinal segments.

It was in these people that we found that a single session of chiropractic care alters all sorts of sensory processing, sensorimotor

integration, and how the brain controls muscles, increases the strength of muscles, and reduces muscle fatigue [1, 63-69, 84].

Does the speed or skill of the adjustment matter?

We know from recent scientific publications that chiropractic care can alter the brain's control of muscles and proprioceptive function in patients with neck and back pain as well as in subclinical pain individuals. We also know that spinal function will influence how we 'feel' things distant from the spine. For example, cervical spine adjustments have been shown to produce changes in pressure pain threshold in lateral epicondylalgia [118] (people who have painful elbows). These people are often 'over-sensitive' to touch, so normal touch can feel painful to them. This study showed that adjusting the neck reduced their over-sensitivity to touch, so touch did not hurt as much as before the adjustments. We also know that spinal adjustments can change the way muscles are controlled. For example a group of scientists found that lower back adjustments in asymptomatic individuals (people not reporting pain or other symptoms) significantly influenced brain to spine communication and reflex activity in the spinal cord [119].

Interestingly, in another study where asymptomatic individuals received slow stretches to muscles rather than the fast adjustments, no neurophysiological changes were found [120]. This perhaps suggests that the fast adjustments, as distinct from slower stretching like mobilisation, induces unique physiological changes. We know too that it takes time to become skilful at adjusting the spine. Just as it takes years of practice to be skilled at any sport, it also takes years of practice to be able to deliver a fast yet gentle spinal adjustment. Several studies have shown that it takes two to three years at least to be able to deliver the adjustment at a rate fast enough to induce physiological reflexive changes in the body [121-123]. An adjustment needs to be delivered in under 200 milliseconds to induce the types of physiological changes I have discussed in this book. Anything slower than that and it will have a different physiological effect on the body.

7 - Pseudo-symptoms

"We often preoccupy ourselves with the symptoms, whereas if we went to the root cause of the problems, we would be able to overcome the problems once and for all."

Wangari Maathai

Understanding the reason behind symptoms is very important. I believe that symptoms are usually there to tell you something is going on, that if you continue down the same track that you are on it is going to cost you. However, sometimes the brain may mislead us. Sometimes the symptoms you experience are 'false' symptoms, or 'pseudo-symptoms'. Let me give you an example. I'm sure you would have met or heard of people who suffer from phantom limb pain. These people feel sensations (symptoms) and even pain in an arm or leg that they don't even have. In some cases it can be excruciating pain that is debilitating for the person.

The pain is a very real experience for the sufferer, even though the limb is not even there. This is an extreme example of a pseudo-symptom, meaning a symptom (pain in an arm) that is false, because the arm does not exist. The pain is created by the person's brain and central nervous system, like an illusion. This person's brain has created an inner virtual reality that includes pain in an arm that they do not have. There are many, many other examples of this as well. Another example is tinnitus, i.e. people who hear ringing in their ears when there is no external source for what they 'hear'. Their brains have created the perception of sound when there is nothing outside of them causing these sounds.

Pseudo-symptoms can also occur on a smaller scale, and may accompany other 'real' symptoms or conditions, making them appear better or worse than they actually are. One scientist who has done a lot of work in this area is Professor Lorimer Moseley. I would highly recommend you have a look at his short online video called 'Why Things Hurt'. In this video Moseley explains how he can change the way the brain experiences symptoms by altering various sensory inputs.

What the work of Moseley and others has shown us is that our brain's inner reality can be altered by other sensory input such as vision, sound and touch [124] so what we think is happening in our body through the experience of symptoms may in reality be quite different. Add in our own work which shows that spinal function also influences the brain's inner reality, and it's a wonder the brain gets it right as often as it does.

It's incredible, don't you think, that with every single movement you make, your brain is processing millions of

sensory inputs, taking into account what it knows from your past experiences and what you wish to do. During every movement you make your brain compares the actual sensory feedback from stretching skin, the movement of clothes, and other muscle and joint receptors to the expected sensory feedback based on previous experience and the goal the brain has in mind for the movement. If the real and expected feedback does not match exactly, the brain automatically corrects the movement to make it more precise and accurate.

Wow! I bet you never spent much time thinking about the amazing job your brain does for you every second of every day. What we can take from this understanding of inner reality is that symptoms are not always a reliable indicator of what is going on in your body. Symptoms may be your brain's attempt to tell you that something is not right, that there is some underlying dysfunction, or they may mean that your brain is struggling to make sense of the information it is receiving from your body or the environment. The key is to understand the root cause of the symptoms, which is often easier said than done.

8 - The Painful Facts of Abnormal Movement Patterns

"There is a looming chasm between what your brain knows and what your mind is capable of accessing."

David Eagleman

As mentioned in earlier chapters, recent research has demonstrated that changes in muscle activation patterns occur in the presence of pain. This can result in imbalances in the way various muscles are controlled, as well as abnormal recruitment and sequencing of muscles during functional movements [45-48]. This can for example be a problem if it affects muscles that produce opposing movements when they contract. Muscles that cause opposing movements are known as antagonistic muscles.

For example, the muscles on the front of your thigh, your quads, will extend and straighten your lower leg (like when you kick at a ball), and the muscles on the back of your thigh, your hamstrings, cause your leg to bend at the knee when they contract. These thigh muscles, the quads and the hamstrings, are antagonistic muscles to each other. What happens do you think if you contract both sets of muscles at the same time? This

causes a very stiff leg that can neither bend nor straighten. So usually you want your brain to send messages to these muscles to contract at different times, not both at the same time. You obviously cannot both bend and straighten your leg at exactly the same time, but if your brain gets this a bit wrong, you may end up with a 'stiff' leg and have less movement in your leg.

This actually happens if you have had a stroke that damages the brain's ability to control your muscles properly, resulting in contractions of both sets of antagonistic muscles causing a very stiff limb that you can no longer use properly. However, this can also happen on a smaller scale. Scientists have discovered dysfunctional sequences of muscle activation in people who suffer with pain (even subjects with experimentally induced pain). What they find is that people who are in pain recruit muscles in the 'wrong' order compared with people who have no pain [48, 50, 125, 126].

In addition to dysfunctional sequences of muscle activation, imbalances between antagonistic muscles have also been identified in people who suffer from pain [127, 128] . Some scientists think that pain is the initiating factor that causes the abnormal muscle control [129]. It may be that the brain adapts to the pain by altering the way it sends messages to muscles to reduce movement of this part of the body.

Altering the way the brain sends messages to muscles may be a protective adaptation. The problem is that other scientists have shown that such altered patterns of muscle control (i.e. imbalances between antagonistic muscles and altered recruitment sequences) may even occur before the onset of pain. It has therefore been suggested by some that faulty neural muscle reflexes may predispose people to the development of pain and/or injuries [6, 91, 130-132]. It's the classic problem of the chicken or the egg – which came first?

Regardless of whether the initial cause of the issue was the pain itself or the dysfunctional recruitment pattern of muscles, adjusting the spine appears to be a bit like rebooting the computer.

The small glitches you were having trouble with prior to the re-boot just disappear. It seems that the short, rapid stretch of spinal joints caused by a chiropractic adjustment re-establishes the correct connection between the central nervous system and sensory organs (including the muscles), so the brain accurately knows what is going on, and that this influences the brain's control over the rest of the body.

Professor Bernadette Murphy and a graduate student of hers at the time conducted a very cool study [91] where they showed that adjusting the joint between the bottom of the spine and the pelvis, the sacroiliac joint, could influence the so called feed-forward activation of the deep abdominal muscles.

Remember these deep abdominal muscles are part of your core stabilising muscles, and they need to be 'turned on' before you lift your arms, so that you remain stable while doing this. In a healthy state these abdominal muscles are activated by the brain before you move your limbs. This happens very fast and without your conscious awareness. So if you decide to lift your arm up, your brain will first send a message to your abdominal muscles to activate them milliseconds before you move your arm. The time it takes to do this (i.e. it normally happens before you manage to activate your arm muscles) is so fast that we know it has to be a part of the brain's subconscious plan to move the arm (as opposed to a reaction or reflex because the arm is moving). This is why it's called 'feed-forward' activation, because it is 'pre-planned' by the central nervous system to ensure healthy movement of the body, without injury.

What is so interesting about this study is that they found that in a group of 90 healthy asymptomatic young men, 17 of them could not pre-activate their abdominal muscles before they moved their arms. So these guys, without the protective pre-activation of their core stabilising abdominal muscles, may have been more prone to injury. Fast-forward six months, and they managed to get hold of 13 of these original 17 young men. They retested their ability to pre-activate their abdominal muscles when they lifted their arms, and found that they still couldn't do it. So nothing much had changed after six months of daily living. However, when these young men were assessed, they all had tightness and restriction of the sacroiliac joints in their pelvis. When the participants were given a single session of sacroiliac adjustments there was an almost 40% improvement in their ability to pre-activate their core abdominal muscles!

This study is really important because we know that people who have low back pain have delayed activation patterns of their core abdominal muscles with various movements or perturbations [xv] [48, 50, 125]. We also know that six months of daily living for these active young men did not make a difference to this protective postural function. Yet one single session of pelvic adjustments made a dramatic difference to the way their brain controlled their core stability and potentially reduced their risk of future injury. How many budding athletes would function better if they had chiropractic care?

We also know that if you have altered core abdominal muscle recruitment patters you are more likely to have a low back injury in the future [93].

xv A small change in a physical system, caused by an outside influence.

Video 5: "Chiropractic care may prevent injuries"

This study to me highlights what I think is just the tip of the iceberg. How many more people walk around with similar glitches in their central nervous system function? Glitches that may over time lead to more serious problems. Low back pain is a major problem for society because it is so difficult to treat. It is a multifaceted problem, and has most likely developed over a long period of time, like the thousand straws building up on the camel's back. Scientists know that many of the straws involved in the development of low back pain include emotional and psychological components [133, 134]. So once that camel's back has broken it is a huge job to fix it. I think it's about time we started to take greater responsibility for our health and wellbeing by placing far greater emphasis on prevention than on cures!

9 - Sports Performance and Injury Prevention

"You can't put a limit on anything. The more you dream, the farther you get."

Michael Phelps

Many athletes have discovered the benefits of using chiropractic care as part of their performance optimisation regime. The best thing is that it is drug free, and yet it provides an edge.

There are a growing number of scientific studies that have shown that chiropractic care can alter and enhance muscle function in the general population [67, 68, 92] and also in some people with particular types of pain syndromes [45].

Interestingly, studies have shown that adjusting dysfunctional segments in the spine can not only improve spinal function [94-99], but can also improve the way we sense our environment, process information in our brain, and control the muscles in our arms and legs [1].

The amazing thing is that we know these nervous system changes can in many instances take place after a single session of chiropractic care, even in people who appear to be healthy and are not in pain at the time of the research study. Interestingly, some of these findings that have been observed following a single session of spinal adjustments are similar to what has been observed following three weeks of strength training [137]. Knowing this, I suppose it's no wonder athletes use chiropractic as part of their overall approach to performance enhancement.

These findings are very encouraging with respect to the ability of chiropractic care to enhance human performance in the general population. However, what is not known yet for sure scientifically speaking is whether chiropractic care can also enhance performance in top athletes. An athlete's body is not exactly like yours or mine. Athletes have spent many years exercising, which causes their muscles and nervous system to adapt and change [138, 139]. These changes are generally beneficial, but due to the physical nature of various sports, some detrimental changes to sensory and motor control may also occur [140]. If studies demonstrate that top athletes respond to chiropractic care in the same way as the general population and their proprioception and muscle function is enhanced, this could be a vital, safe, and simple way to improve their sports performance. The fact that many top athletes choose to have ongoing chiropractic care would suggest they feel that they do benefit from it. However, from a research perspective we still want to explore this further with properly designed studies. We may then be able to identify how best to care for top athletes and what particular combination of chiropractic care and other approaches to training are best suited for optimal sports performance.

Chiropractic care may also play a role in preventing injuries in athletes by improving their core stability, improving their proprioception, and increasing the accuracy of their brain's control over their muscles. We know that the ability to activate the core abdominal muscles appropriately is essential for low back health and the prevention of back injuries. This is especially true for athletes who have to make rapid movements and responses during the course of a sporting event. One group of scientists found in a study of 303 college athletes that a delayed ability to activate core abdominal muscles in response to sudden trunk loading significantly increased the odds of them sustaining a low back injury [93]. They specifically conclude in their study that this delayed ability to activate the core abdominal muscles appropriately appears to be a pre-existing risk factor for developing a low back injury [93]. And as you now know from the study by Bernadette Murphy and her colleague, some individuals lack the ability to stabilise their core before performing rapid movements, but this ability can improve dramatically after a single session of chiropractic care [91].

Chiropractic may also reduce injuries because we know chiropractic care can improve our proprioceptive ability [84, 136] and change the way the brain sends specific messages to our

muscles [68, 90, 91]. If the brain is more accurately aware of where our arms and legs are, and exactly what they are doing, it will obviously be better able to know what messages to send to the various muscles (and to the stabilising muscles) to perform the types of fast movements it requires and prevent unnecessary injuries. Can you think of any sports person that would not benefit from naturally improved reaction times [87], increased muscle strength [69, 92], and the prevention of muscle fatigue developing? [69].

Video 6: "Chiropractic care may make you less clumsy"

If you use a computer this is a must read for you!

Early on in my research career I knew I wanted to examine the influence of chiropractic adjustments on how the brain controlled muscles. I was particularly interested in this because of my experiences with people I have adjusted in practice. I would usually test people's muscle strength before and after adjusting them. It astonished me how often they would appear weak before being adjusted and then all of a sudden, after being adjusted, their muscles were much stronger. Having a questioning mind I wondered if maybe I was just pushing harder before I adjusted them? So I decided to put it to the test.

Bernadette and I designed several studies to measure scientifically what happened to the messages the brain sends to muscles and compare what happened before and after adjustments [67, 68]. First of all I read a lot of existing studies around this topic. We call this doing a literature search on the topic before you design your study, so that you fully understand what has previously been done. That way you can avoid repeating studies that have been done before, and you learn what is known about the various research techniques that can be used. From this literature search I discovered our brains appear to have several gas pedals and handbrakes for every single muscle in our body [141-144]. Your ability to move a muscle is controlled by your brain either pressing harder on the gas pedal, or releasing the handbrakes, or a combination of both [145].

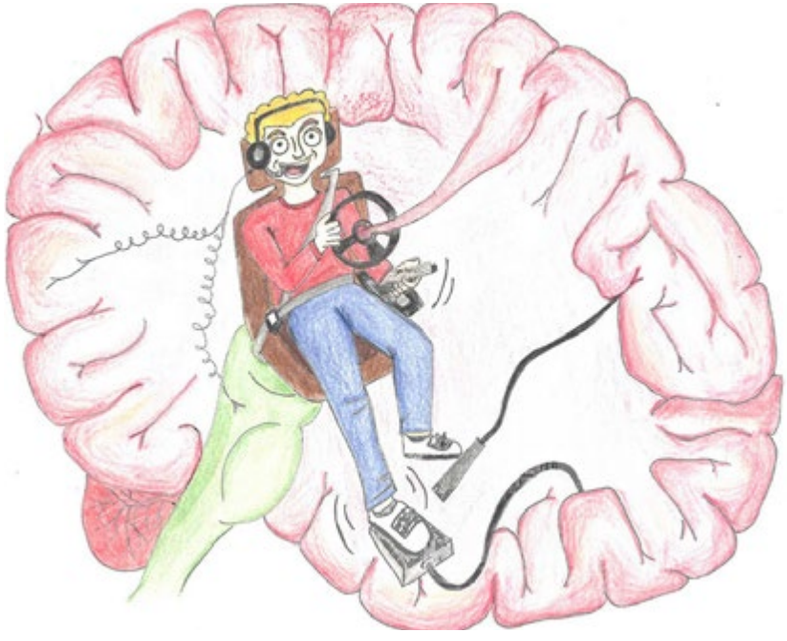


Figure 11: Our brains appear to have several gas pedals and handbrakes for every single muscle in our body.

You can scientifically measure the degree to which your brain is pressing various gas pedals and handbrakes for a particular muscle. I knew that many of my patients in practice had tight and sore forearm muscles that would often relax after I adjusted their spines. So we designed a study to look at one forearm muscle and one hand muscle and measured the degree to which the subject's brain was sending muscle contraction commands (i.e. pressing the gas pedals) or muscle relaxation commands (i.e. pulling the hand brake). What we found was very exciting. After one session of adjustments we found that the subjects' forearm muscle would receive larger relaxation commands and smaller muscle contraction commands, and we found the opposite in the thumb muscle [68].

So what does this really mean? Basically, the brain changes the way it controls your muscles depending on the function of your spine. Adjusting subluxations can change the way the brain sends messages to your muscles, in a muscle specific way. So from one spinal adjustment session, it can change the signals it sends to one muscle in one way and the signals to another muscle in another way. So if you think that some of your muscles suddenly feel stronger after you have seen your chiropractor, we now understand what is likely to be happening. It is probably because your muscle is receiving greater drive from your brain to activate the muscle, making it easier to perform a stronger contraction of the muscle than before.

We have repeated similar studies using different techniques and found the same thing, that the brain can increase its drive to your muscles which allows you to contract them at a greater level than before [69]. Through the study described above [68], we also now know that if you get very tight and sore muscles because you sit and type a lot on a computer, that getting your neck checked and adjusted can help relax those tight forearm muscles. If you type a lot, your brain is constantly sending messages to those forearm muscles to keep contracting.

Over time this may end up creating too much tension, as if the gas pedals to these muscles are too strong, and there are

not enough of the brake messages. Adjusting the spine and re-booting the system appears to re-establish better background contraction and relaxation messages going to our muscles.

10 - Multisensory Integration

“All we have to believe is our senses: the tools we use to perceive the world, our sight, our touch, our memory. If they lie to us, then nothing can be trusted.”

Neil Gaiman

In the past it was thought that humans perceived each of their various sensory modalities (e.g. vision, audition, proprioception, etc.) separately. It was thought that each of these sensory modalities operated independently of each other [147]. However, we now know that this is not the case. Scientists have found that our brains create our very own inner matrix made up of information from all our different senses which is integrated together to accurately and efficiently represent what is happening in our body and in our environment [147-150]. Scientists have shown that integrating information from multiple senses enhances our ability to interact with the environment [149-153].

Basically, the brain uses all the different sources of information, but has to very efficiently merge (or integrate) them to form a coherent and accurate perception of what is going on within the body and its environment. The mechanisms that the brain uses to achieve this and merge information from

the senses are complex. Scientists have shown that when the brain is able to combine and integrate sensory information from a number of sensory modalities, and when this is merged with its own prior knowledge, then the accuracy and robustness of the perceptions are enhanced [154]. The accuracy of multisensory processing relies on appropriate function of both peripheral sensory organs (in your eyes, ears, skin, muscles, etc.) and different parts of the brain [81].

Two of the brain structures involved in this process are the basal ganglia and the cerebellum. The basal ganglia are a network of neurons in the middle of the brain and brain stem. The cerebellum is a structure at the back of the brain. When we choose to do something that requires movement, this invariably involves the creation of or use of existing "motor subroutines", i.e. automatic motor output in response to particular sensory input. These motor programmes also get continuously modified or 'updated' as they are used [155]. This is thought to be an essential process involved in motor skill acquisition [40, 156, 157]. The basal ganglia is thought to play an important role in this process [158] by 'filtering' sensory input.

The cerebellum is also thought to play an important role in the changes that take place in the brain when it adapts due to repeated movement. We know that the cerebellum is heavily involved in learning new muscle behaviours [157]. Let's say that you decide to learn how to play the piano or learn a new sport. As you practice and play, the cerebellum in your brain will be very much involved in learning the new muscle behaviours that are required. There are studies that indicate the cerebellum plays a role in the plasticity and adaptation of neural control of muscle function [159, 160]. In particular the cerebellum is thought to facilitate the development of motor learning by fine tuning and coupling sensory signals with motor responses [161]. So as you are learning a new skill, your brain picks up on chunks of sensory information and pairs this with automatic muscle responses, meaning that as you get better and better you don't need to concentrate so hard. Once you have learnt how to ride a bike it's easy right? When you sit on a bike, even if it's years since you rode one last, your brain immediately feels the sensations of sitting on a bike and automatically plays the 'ride the bike' messages to your muscles.

The study of multimodal[xvi] and sensorimotor[xvii] integration has increased dramatically in recent years, with emerging evidence that maladaptive plastic changes in sensorimotor integration is implicated in various movement disorders, such as overuse injuries [22, 23, 162] dystonia [163-169] and Parkinson's disease [169-172]. The research we have done [173] seems to suggest that we can impact or alter the way the cerebellum influences the motor cortex, the part of the brain that directly sends messages out to muscles. What I suspect we will find in future studies is that this ability to influence the way the cerebellum impacts the motor cortex may explain why muscles get different signals from the

xvi Mulitmodal integration refers to the integration that occurs between two or more of the five senses.

xvii Sensorimotor integration specifically refers to the how the brain integrates sensory information to help it make meaningful movements.

brain when we get adjusted. I think these things are linked, and explain the improvements in performance that people claim is occurring in their bodies when they receive chiropractic care.

What may be happening is that there are glitches in the muscle routines that your motor cortex gets from the cerebellum. You may experience that you are having an off day. Maybe you keep stubbing your toe. Maybe you knock your elbow on the door frame. Maybe you just cannot hit that golf ball like you know you usually can.

Your brain should know exactly where your big toe is, and your elbow, and it should be giving your toes and elbows messages that prevent you stubbing your toe or knocking your elbow. Adjusting the spine seems to correct the in-house communication and the clumsiness goes away.

Multisensory integration and falls risk in the elderly

Falls are a major problem. They are a significant cause of death and injury in older adults [174-177] and make life very difficult for those who have experienced a fall. Approximately 30-40% of older adults who still live independently suffer from at least one fall per year, and this number rises exponentially with increasing age [178-180]. In my opinion the role that chiropractors may play in preventing falls in their patients has not yet received the kind of attention it deserves. A few studies have investigated how chiropractors and other manual therapists may influence the risk of falls [181, 182]. However, as you now know, there is also a growing understanding about how chiropractic care can impact our brain's ability to know where the arms and legs are (without looking) and how our brain controls the muscles of the body. These sensorimotor functions are also very important for maintaining balance and preventing falls.

Knowing the importance the role chiropractic care may play in preventing falls, a very bright young researcher and chiropractor, Dr Kelly Holt commenced his PhD studies at the University of Auckland. He wanted to find out whether a 12 week period of chiropractic care would be effective in improving sensorimotor function specifically related to fall risk in 'community-dwelling' older adults (i.e. those that live in their own homes as opposed to living in a supervised institution). Kelly ended up conducting a very cool study (called a pragmatic randomised controlled trial) that compared the effect of chiropractic care to 'usual care'. He recorded proprioception data (ankle joint position sense), postural stability data, a multisensory integration measure called the sound-induced flash illusion (which I will explain soon). He also used a broad measure of sensorimotor function that tested the research participants' ability to move their feet in response to a sudden lighting up of a panel on the floor. Finally he measured the participants' self-perceived health-related quality of life using a questionnaire. All of this was recorded at the beginning of

chiropractic care (or usual care for the control group) and again after four and 12 weeks. Sixty older adults from Auckland took part in the study. Kelly and I, and Kelly's other supervisor from the University of Auckland, were all amazed at the generosity of local Auckland chiropractors who offered to provide the chiropractic care free of charge for the study participants.

Over the 12 weeks of the study, the group receiving chiropractic care showed a significant improvement in ankle joint position sense. This means that the participants' brains were more accurately aware of what was going on at their ankles without having to look at their feet.

After 12 weeks of chiropractic care they were also able to react and move their foot onto an illuminated panel faster than before they started chiropractic care. A group of researchers had previously developed a device that measures voluntary stepping reaction time [183] that Kelly used in his PhD studies. This device involves an individual standing on a platform with two panels in front of them, one in front of each foot, and one panel beside each foot. These panels can be individually illuminated, and the study participant is asked to place their corresponding foot on the illuminated panel as quickly as possible as soon as it is lit up. This particular type of stepping reaction time has been assessed in research studies and has been shown to be a significant, independent predictor of falls in older adults [183-185]. The time taken from the panel lit up until the foot is planted on the panel is called the 'choice stepping reaction time'. This was significantly reduced after 12 weeks of chiropractic care. None of these changes were found in the control group!

Older adults that find stepping difficult are more likely to experience a fall, most likely because they will find it harder to appropriately respond to some unexpected challenge to their balance [186]. If you have the ability to take a step fast, this is your best chance to regain your balance and avoid a fall. To be able to do this you need all aspects of sensorimotor function to be working properly. For example, your brain needs to be able to detect your instability, then rapidly plan and execute an appropriate response. Several scientists have claimed that older adults may be less able to execute appropriate compensatory responses due to age-related changes in sensorimotor function [183, 186, 187].

After 12 weeks of chiropractic care the participants were also less susceptible to the sound-induced flash illusion. This particular test was specifically chosen because we know that the way the brain processes and integrates information from different sensory modalities (multisensory processing and integration) changes as we get older, and these changes are not always beneficial.

One recent study suggested that altered multisensory processing may be associated with an increased risk of falling in older adults [188]. This experiment investigated the susceptibility of older adults with a history of falling to a visual illusion that

is induced by sound. Their susceptibility to the illusion was compared to older adults with no history of falling, as well as healthy younger adults [188]. This visual illusion is called the sound-induced flash illusion [189]. It involves flashing a white light once or twice on a black background approximately 50 milliseconds apart, and accompanying the flashes with one or two beep sounds, spaced at similar intervals apart. When a single flash is presented with two beeps, the person being tested often incorrectly reports seeing two flashes. When flashes are presented with no sounds, or an equivalent number of beeps to the number of flashes, the person being tested usually correctly reports the number of flashes that has been presented. The sound-induced flash illusion has been used extensively in studies over the past ten years [148, 150, 188, 190-198].

What we do know now is that older adults who are at risk of falling are much more susceptible to this illusion compared with young adults or older adults who are not at risk of falling. These differences are thought to be due to differences in their brains' ability to process multisensory information. The fact that 12 weeks of chiropractic care (on average 24 visits) can improve this measure is important for people to know, particularly since scientists have not previously been able to reduce someone's susceptibility to this illusion by much.

It was also great to discover that after 12 weeks of chiropractic care the participants' physical component of health-related quality of life had improved significantly. This was by then no surprise to us as Kelly had already received multiple letters from the participants thanking him for conducting the study. It turns out they had experienced all sorts of improvements to their health that had not been documented, because we had not been looking for them. These improvements included reduced dizziness, less hip pain and improvements in chronic migraines amongst others. One participant even reported that they were better able to swallow their food after receiving chiropractic care!

So what does Kelly's study tell us? It shows that 12 weeks of chiropractic care improves sensorimotor function related to falls risk in community dwelling older adults. This may well mean that chiropractic care can help to reduce the number of falls that older adults suffer. The results also indicate that the participants themselves experienced a greater physical quality of life after as little as three months of chiropractic care. We were particularly intrigued by the fact that some changes occurred faster than others. The changes in ankle joint position sense occurred early on during chiropractic care, but the improvement in choice stepping reaction time took the full three months of care before we saw significant improvements. This may mean that more complex issues take longer to improve.

11 - Safety

“Status quo, you know, that is Latin for the mess we’re in”

Ronald Reagan

In some countries around the world there has been a remarkable amount of scaremongering about the safety or risks associated with chiropractic care. In particular there have been numerous claims of chiropractors causing strokes. And for some reason there have been claims that chiropractic care is dangerous for children. I am not going to speculate as to why this has been the case, but I do want to set the record straight.

Chiropractors have been accused of causing strokes by the media and some researchers [199]. These people have suggested that when chiropractors adjust someone’s neck, they may cause a tear in the vertebral artery that runs through their neck. However the research clearly shows that people go to chiropractors with pain from a stroke in progress as opposed to the chiropractor causing the stroke [200]. If someone is unfortunate enough to suffer a stroke due to a tear in the vertebral artery, they usually suffer from very severe head and neck pain. And many people with head and neck pain go to their chiropractor, because it is widely known that we are good at helping people with head and neck pain. So when someone turns up at a chiropractor’s office suffering from head and neck pain, and that pain is due to a torn vertebral artery, the chiropractor is at risk of being blamed – as has happened a number of times. Blame has even been attributed to a chiropractor who provided no treatment at all, but had called an ambulance after assessing the patient and realising that the patient was having a stroke in progress!

A very large study was conducted in Canada a few years ago that investigated the relationship between chiropractic care and strokes. Every person who goes to a health practitioner in Canada is documented. Every visit is coded. Every symptom is coded. Every stroke is coded. So a group of smart scientists looked back through thousands of patient visits to doctors and to chiropractors and found that in fact, statistically, patients were at higher risk of having a stroke after seeing their medical doctor than from seeing a chiropractor. And as we know, a medical doctor usually does not touch a patient’s neck. Knowing all of this, the scientists proposed the following reasoning for why a correlation exists at all between chiropractors and stroke risk [200]:

- Some people have a stroke in progress.
- This causes pain in the head and neck for some of them.
- They don’t know that they are having a stroke, but seek help for the excruciating pain.
- Some go to their doctor while others go to their

chiropractor.

- If you happen to be young and well educated you are more likely to go to a chiropractor for your head and neck pain (as shown by the Canadian data [200]).

So knowing this, what can we do? There is not a lot we can do.

We know that the various diagnostic tools that were developed to screen for someone who is having a stroke in progress are not sensitive enough to pick up only the real cases. This means that these diagnostic tools also pick up a whole lot of cases that are not stroke cases. Many of them are in fact people who are suffering with pain, dizziness and other symptoms that are caused by dysfunctional neck joints and which can be relieved by chiropractic care.

The only thing we can do, which we train every chiropractor to be able to do, is to always be aware of the possibility and to recognise indications that a stroke may be taking place. For example, if a person has a stroke in progress he or she would usually experience a worsening of symptoms after being adjusted by a chiropractor, as opposed to feeling relief of their pain. What needs to happen then is to arrange for urgent admission to a hospital. There is medication and other acute hospital procedures that can be used to reduce brain damage from a stroke.

Although very rare, some people do have a preexisting connective tissue disorder that could predispose to having a stroke from being adjusted by a chiropractor. However to put this into perspective, the following situations have also been associated with people who have developing a stroke due to this rare condition [201]:

- Backing out the car
- Having hair washed at the hairdresser
- Painting the ceiling
- Playing basketball, tennis or softball
- Swimming, walking, or kneeling at prayer
- Household chores
- Sexual intercourse
- Wall papering
- Washing walls and ceilings
- Archery
- Yoga
- Turning head while driving
- Looking up
- Sneezing
- Going on a fair ride
- Violent coughing

Scientists really don't know exactly why some people in these situations have a stroke, but they think it has something to do with the head position and sudden movement, and the rare predisposition that makes the arteries in their neck susceptible to damage.

Chiropractors are trained very well to look out for and, as best they can, screen for anyone or anything that could potentially result in a person having a detrimental effect from being adjusted. Every single person who sees a chiropractor is screened for what we call contraindications to receiving spinal adjustments and we have many alternative ways to take care of you to improve your spinal function.

Another thing you also need to consider is the risks associated with alternative options for pain relief. Did you know that hundreds of thousands of people die from properly prescribed and properly taken medication every single year [203]? Does this stop us from going to see our medical doctor when we need to? Does this stop us from taking medication if we have to? No! And I have nothing but respect for the medical profession and their endeavours to save lives.

Two of the people I love and respect the most on this planet are medical doctors, my father and my younger brother. Medicine and medical doctors are great when you have a serious illness or accident. What I am trying to point out is that when it comes to life, health, and function you may derive great benefit from chiropractic care.

12 - Chiropractic for Kids

"The best way to make children good is to make them happy."

Oscar Wilde

I don't think there is any other group of people who benefit more from chiropractic care than kids. If I had any doubts early on in my career, they vanished pretty quickly in practice.

I was, and still am, one of those who struggle to say no if asked for help. Particularly if asked to help with chiropractic care, and especially when it comes to children. In practice I was often unable to say no if a parent asked me to have a quick look at their child for whatever reason. There is no quick look at anyone, but kids need a functioning spine just like their parents, even if they are not in pain, so I always said yes. One thing that astonished me was that it would not take many visits for a child as young as 18 months to climb up on the checking bench the next time they arrived with their parent (for the parent's appointment). This would speak volumes to me. The kids intuitively felt the benefits and wanted more.

We don't adjust a child's spine the way we do with an adult.

When a baby is born their spine is not yet fully mature. The bones of their spine are softer, so when I adjust a child I don't apply more pressure than what you would do if you press on your eyeball. I'm sure that you don't press your eyeball all that often, but give it a go! You don't apply much pressure do you? It's more of a gentle hold over dysfunctional segments. Gentle cranial (skull) care can also be fantastic for a baby (as well as for adults). If cranial bones or spinal segments are not moving properly, the child does not thrive. I have seen this myself and have no doubts about it whatsoever.

But since I am a scientist, let's also have a look at what the research tells us. It tells us that babies cry less if they receive chiropractic care [204]. It tells us that there has not been one single serious adverse event caused by chiropractic care for a child anywhere in the world for the past twenty years [205]. Not one! There have been false claims for sure. But these are purely scaremongering. And when it is discovered that in fact there was no adverse event for any child from a chiropractor this is not considered newsworthy. A great example of this happened recently in Australia, where it was headline news that a chiropractor had broken a baby's neck [206].

It turns out that the person looking at the scan of the baby's neck got it wrong. There was no broken neck, it was a genetic malformation of the neck bone that the child had since in utero. The sad thing is that this caused major public fear and an outcry that chiropractic was dangerous for children and should be banned, when the truth of the matter is quite the opposite – and so children miss out on safe, effective health care.

Children and babies need an accurate inner reality just as much as adults do. Their brains' need to know what is going on in their bodies and their environment just like we do. I suspect that kids who constantly fall over and knock themselves have an inaccurate body schema, hence all the accidents.

It always amazed me that my kids (who got adjusted regularly) never had accidents, never hit their heads, never broke any bones, and never seemed to trip over their own feet like other kids did. My kids still ask for an adjustment every week, sometimes twice a week, and they are only eleven and fifteen years old. Their hand-eye coordination is superb, their balance and sports skills they take for granted. But I suspect with time and more research we will discover this is no coincidence, but rather due to a life-time of chiropractic care.

But for the time being many kids go without chiropractic, simply because their parents don't know about the benefits.

If you are lucky enough to be born in Rotorua, in New Zealand, you would most likely be referred straight to the local chiropractors. Drs John Funnell and Margie Bishop-Funnell have made such a reputation for themselves in Rotorua that

many midwives and obstetricians will refer pregnant women and new born babies to the Funnell's to have their spines checked and adjusted. I hope I live to see the day when this is commonplace everywhere.

13 - Text Neck The Power of Posture

"The age of a man is not measured by years but by the flexibility of his spine."

Old yogic saying

Our posture has become, I think, a forgotten aspect of our health. Due to my role as a scientist I am often interviewed on television or for newspapers, and many of the questions I am asked are about posture. Not many health care professions focus all that much on your posture, so you may mistakenly think it's not that important. But let me tell you that is far from the truth.

First of all, let's take a few minutes to practically test for ourselves how important posture CAN be for your health. Try this at home while reading this book. Sit up straight, wherever you are. Sit (or stand) tall and straight and take a deep breath in. Then let it out, and take in another deep breath. Notice what it feels like, how deeply you can breathe. Then slouch, really slouch, so your chin is almost resting on your chest and your back is hunched over. Then try to breathe again, and notice

the difference. Isn't it incredible! This little test really shows just how much of a difference correct upright posture has on your ability to take a deep breath.

And this alone has very important health implications. People who end up with chronic neck pain often have respiratory, or breathing, difficulties which will impact their daily lives and functional ability.[207] And the problem does not end here, because the way you breathe also has a very important influence on posture and spinal stabilization.[208] Breathing pattern disorders have been shown to contribute to pain and motor control deficits, which can result in dysfunctional movement patterns. So basically, if for some reason you develop bad posture, this can negatively influence your breathing patterns, and these poor breathing patterns can negatively influence how your body moves and even the development of pain. So you see, poor posture is not just about the way you look, it's also very important for good health.

But it does not end there. There have been some very interesting research experiments in recent years that have looked at the effects of posture on various other aspects of health. For example, a group at the psychology department at the University of Auckland, New Zealand looked at the effects of up-right posture (as compared to slouched posture) on young healthy peoples' resilience to cope with a stressful reading task.[209] The study results clearly showed that when these people were held in an upright 'good' posture they could cope with the stressful task much better than if they were held in a slouched position during the task. In addition to this, the scientists found that the good upright posture also resulted in the participants displaying and feeling higher self-esteem, better mood, and lower fear, compared to the slumped posture situation. Yes, you read that correctly, good up-right posture is not only good for healthy breathing, but it can also make you more self-confident, feel better mood-wise, reduce feelings of fear, and it helps you to be more resilient when dealing with a stressful situation! That alone makes me nag my children on a regular basis to sit up straight.

Other scientists have specifically looked at what happens when you have what is known as 'forward head posture,' where your head is not resting directly on top of your spine, but instead the centre of your head is in front of your spine. If you look at a person side on you can tell reasonably easily if their head is perfectly positioned on top of the spine, or if it is instead perched out front of their body. Often on x-rays these people will have what is known as a reversed curve of the neck. And people who have this often have neck pain and/or headaches.[210]

Something that is quite concerning is that the number of people who are showing up with this forward head posture is increasing dramatically! It is becoming so common it's been given the name 'text neck,' because many people believe we are seeing such a rapid rise in young people developing neck pain due to the increased use of our smart devices, such as smart

phones and tablets. Studies are showing that developing neck pain is not something we should consider like 'growing pains'. It is not likely to go away all by itself,[211] so you should try your best, for your children's sake, to nip it in the bud, and fix the problem early so it does not become a life-long problem for them. We know that kids who develop pain in teenage years go on to become adults with pain.[212] Teenagers with pain in multiple regions become adults with pain in multiple regions, and so on.[212]

So you may be wondering what you can do about text neck and forward head posture. There are many things you can do. You can keep a close eye on your children and teenager's habits. Do they sit or stand texting, playing or reading on their smart device with their head down. If they do, this has to change. You can also make easy and simple spinal exercises as normal in your house-hold as brushing your teeth. If you go to straightenup.org.nz you can find some simple 2-5 minute spinal exercises that everyone in your family can do twice a day. They are super simple, like star jumps, and there is a kids section also to help encourage your children to do these every day.

Another simple solution for little kids with smart devices is to make sure they lie on their stomach when they are using them. This makes it impossible for them to hang their heads forward. The weight of a normal sized head is about 3kg (about 6.6 pounds). Which is like having a bowling ball perched on top of your spine. Your spine is designed to hold that up without any problem at all, but if it's hanging forward, then there is a 3kg weight hanging off your muscles, ligaments and connective tissues in your neck. This is not a good thing for your spine and increases the burden, strain and stress that your spine has to cope with.

Of course there is one more thing that you can do to help your children deal with the stress and strain that is placed on their spine through everyday life, and in particular the use of smart devices… and that is to ensure that they have their spine checked by a chiropractor. Remember that once you reach the thousandth straw, the camel's back breaks and you end up with symptoms. Be proactive when it comes to posture and don't wait for symptoms to occur before you do something about it.

14 - So Where to From Here?

“I know where I’m going and I know the truth, and I don’t have to be what you want me to be. I’m free to be what I want.”

Muhammad Ali

I believe that changes are needed in our health care system. I think we need to be willing to look beyond the solutions of traditional medicine, to take a fair and open look at other options for health care. Maybe our first option should not be drugs or surgery. Maybe our first option should be far more conservative, with a proper healthy diet, greater exercise, and chiropractic care.

Having your spine checked regularly, to ensure your brain is accurately aware of what is going on in and around your body, should be just as common as exercising every day and brushing your teeth. Everyone should have access to chiropractic care right from birth through to the day they pass away. I believe a lot of suffering could be prevented if this was the case.

I think greater integration of chiropractors into the health care system is sorely needed. I know in countries where this occurs, there have been great benefits to you the public. Ideally you would have access to chiropractors everywhere from hospitals and schools to nursing homes. I realise this would require enormous changes in our health care system, but I genuinely believe mankind would immensely benefit as a result. I also think that it’s time to ramp up the scientific investigations we are performing into the health benefits of chiropractic care. We now know that there is something really significant that happens when we adjust dysfunctional spinal segments.

It has been demonstrated by a number of rigorously conducted research studies. We know the function of the spine impacts our brain’s ability to interpret other things that are going on in and around us. The better we understand this through continued neuroscience research, the better we will be able to take advantage of this under-utilised resource.

There is still so much we do not know. For example, there are so many different chiropractic techniques available that have yet to be scientifically studied. I have spent fifteen years of my life just looking at the effects of adjusting subluxations. But what about the cranial work we do, or the multiple low force techniques? What combination ultimately produces the best outcomes for various people? How often should we get adjusted? And is ongoing care required? Furthermore, what can we do to help ourselves? What is the effect of the spinal stretches we can do at home? I could write another book just outlining what we do not yet know and understand about

chiropractic care.

I am sure it has come through loud and clear that I am very biased when it comes to chiropractic care. This is very true. But I am also just as passionate about science. I take my role as a scientist just as seriously as I do my role as a chiropractor. Solid, top quality honest research is fundamental. As a scientist I take the utmost care to ensure that my personal bias in favour of chiropractic does not influence my research outcomes. My research team and I make absolutely sure that we use the best possible research designs we can manage. And I have made great efforts to find others to collaborate with who are not chiropractors, and thus don't have the bias I have. By doing this I can eliminate myself from being able to unconsciously influence the outcomes. I have grown to enjoy these collaborations immensely. I so thoroughly enjoy watching these scientists become astounded by the results we get.

I no longer collect the data, nor do I analyse it. I only design the studies, supervise the collection and analysis to ensure all the rigorous ethics guidelines and protocols are strictly adhered to, and I do a lot of the manuscript writing. I also usually provide the chiropractic care for the research participants. This is something I also treasure. This degree of involvement with the research studies is a very conscious choice, so that I know for a fact I cannot even unconsciously affect the data we record, because it is not done by me.

Over the past few years I have thoroughly enjoyed watching the bioengineering students we have had working in my research laboratory collect chiropractic intervention data. They have come out from a data collection session mumbling amongst themselves about the unbelievable brain changes they have observed in the subject during that session. And it is even more fun when I find a neuroscientist who is keen to test out my theories about chiropractic. These guys are like walking encyclopaedias of neuroscience knowledge.

I know I will forever be fascinated by the amazing human brain. And I will never tire of my quest to better understand how and why chiropractic care helps people function better. I intend to spend the rest of my life investigating how chiropractors can do an even better job and serve humanity in the best way possible.

In reading this book you've gone on a journey across the frontiers of evolving neuroscience and chiropractic science, and through the complex interconnections of the human body, to discover that your inner world is indeed not always what it seems. So what does this mean? And where to from here? The purpose of this book is simply to provide you with information to better understand the inner workings of your body, so you can make a more informed choice about your health care.

What this book means for you is that the function of your spine will be impacting the way your brain processes sensory

information from your body and the environment, which will influence your inner reality. It means you cannot be 100% sure that what you experience as reality is reality.

It means that you may well benefit from seeing a chiropractor. You don't need to be in pain. Spinal dysfunction, or subluxations, can be present without any pain symptoms. I have shared with you multiple studies where this was the case. It means that adjusting your spine can improve the accuracy with which your brain perceives the world and controls your body. All kinds of weird and wonderful changes can take place.

Give it a go and enjoy!

Glossary

Adjustment	A procedure in which a chiropractor uses their hands or a small instrument to apply a quick, controlled force to a spinal joint, in order to restore the joint's proper movement (or as you may hear chiropractors say, to correct a 'vertebral subluxation'). An adjustment is often referred to as a 'spinal manipulation' in research literature.
Antagonistic muscles	Muscles that produce opposing movements of a jozint.
Axon	The long thread-like part of a nerve cell along which nerve impulses are conducted from the cell body to other cells.
Basal ganglia	A group of structures in the brain that are important for coordinating movement (among other things).
Blind spot	A part of the retina in the eye that provides no visual input to the brain.
Brainstem	The area at the base of the brain that connects the brain to the spinal cord. This is an important structure that acts as an information highway between the brain and spinal cord. It also contains important structures involved in things like cardiovascular system control, respiratory control, pain sensitivity control, alertness, awareness and consciousness.
Central nervous system	The brain, brain stem and the spinal cord. Essentially everything inside the skull and spinal bones.
Cerebellum	The part of the brain at the back of the skull which is important for coordinating and regulating muscular activity (among other things).
Cervical myelopathy	Damage to the spinal cord in the neck.
Cervical root compression	Damage or compression of the nerves as they exit between the vertebrae in the neck.

Cervicobrachial pain syndrome	A combination of pain in the neck, shoulder and arm.
Contraindication	A term used in health care, meaning a reason that makes it inadvisable to employ a particular procedure or treatment with a given patient.
Craniovertebral	Between the skull and the vertebra at the top of the neck.
Deafferentation	Decrease in information to the brain (can be long term or short term).
Electromyographic (EMG)	The recording of the electrical activity of muscle tissue.
Facet joints	There are two of these joints between each spinal segment – they exist to guide and limit movement of the spinal segment.
Hypothesise	To assert or suggest something may be true in the absence of certainty at that time.
Idiopathic	A disease or condition that arises spontaneously or for which a cause is unknown.
Intervertebral	Between the bones in the spine.
Intervertebral disc	Any of the discs between the individual vertebrae in the spine that act as shock absorbers.
Lateral epicondylitis	Also known as tennis elbow. This condition involves painful inflammation of a tendon in the elbow resulting from overuse of lower arm muscles.
Maladaptive	Brain adaptations that are not considered positive.
Mobilisation	Low velocity (i.e. slow speed) movements done by a practitioner that aim to improve movement of joints.
Multimodal integration	The integration that occurs between two or more of the five senses.
Muscle spindle	Small stretch sensors in muscles that signal muscle movement to the brain, so your brain knows at any given time where your core body, arms and legs are, even when you close your eyes.
Musculoskeletal	Relating to the muscles and the skeleton.
Neural plasticity	Changes within the nervous system which are due to changes in behaviour, the environment, or neural processes. Put very simply, neural plasticity involves adaptation within the brain.
Neuron	A nerve cell that transmits nerve impulses.
Neurophysiology	The branch of physiology that deals with the function of the nervous system.
Neuroscience	Any of the sciences that deal with the structure or function of the nervous system (including the brain).
Neurotransmitters	Any of several chemical substances that transmit nerve impulses between neurons across a synapse.
Paraspinal	Alongside the spinal column.
Perception	The way in which something is perceived, regarded, understood or interpreted.
Peripheral nervous system (PNS)	The nerve cells outside of the brain and spinal cord.
Photoreceptor	A sensory cell in the eye that responds to light.
Physiology	The branch of biology that deals with the normal functions of living organisms and their parts.
Pseudo-symptom	A symptom that is false and is not due to physical damage in the corresponding area of the body.
Psychology	The scientific study of the human mind and its functions, especially those affecting behaviour in a given context.
Proprioception	The ability to sense the position, location, orientation and movement of the body and its parts.
Sensorimotor integration	The integration of sensory information in the brain in order to perform movements of the body accurately.
Spinal manipulation	Refer to ‘Adjustment’ above.
Stroke	Loss of brain function due to disturbance in the blood supply to the brain.
Subclinical	When a disease or condition is not severe enough to present definite or readily observable symptoms.
Suboccipital	Under the base of the skull at the top of the neck.

Synapse	The junction between two nerve cells where nerve impulses are transmitted and received.
Vertebra	Any of the bones or segments composing the spinal column.
Vertebral subluxation	A joint in the spine that is not moving correctly, and which is negatively impacting health and wellbeing.

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