1990

Articulating changes

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Order Number 1341669

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San Jose State University, 1990

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ARTICULATING CHANGES

A Thesis

Presented to

The Faculty of the Cybernetic Systems Program

of the Department of Cybernetics and Anthropology

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

By

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August, 1990

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ABSTRACT

ARTICULATING CHANGES

by Lawrence Wm. Goldfarb

This thesis presents a cybernetic model of the Feldenkrais Method of neuromuscular re-education. Examining the relationship of perception, action, and intention in human movement. It proposes an understanding of how movement limitations, physical disabilities, and chronic pain can be successfully addressed by an educational approach. A systemic approach to movement evaluation is presented and used to reformulate the definition of common problems. Cybernetic theory provides the basis for understanding the functioning of the sensory-motor loop and the role of perceptual learning in rehabilitation. A specific case study is interwoven with each chapter to provide a concrete illustration of the theoretical issues discussed. The case studies also serve to illustrate the application of Conversation Theory to movement re-education.

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ACKNOWLEDGEMENTS

This book would have been impossible without the direct and indirect contributions of many people, especially my teachers and colleagues in the fields of movement re-education and cybernetics.

Moshe Feldenkrais taught me the method that I practice and, more importantly, inspired my appreciation and understanding of movement. I am particularly thankful for all I learned from him, especially during those conversations in the kitchen, late into the evening, where I learned so much and where he gave me the idea for this book. Others have made invaluable contributions to my understanding of movement and cognition, particularly the teaching of Gerda Alexander, Judith Aston, Bonnie Bainbridge-Cohen, Richard Bandler. Marjorie Barstow, John Grinder, and Ilse Mittendorf.

During the middle of my training, Dr. Feldenkrais became too ill to continue and Anat Baniel, Jerry Karzen, Myriam Pfeffer, Yochanan Rywerant, Chava Shelav, Mia Segal, and Gaby Yaron guided the completion of my training. My colleagues of the Bay Area Feldenkrais Teachers Study Group have supported my ongoing learning and provided a place to try out my ideas. Elizabeth Beringer, Nancy Denenberg, Jill Feigal, Dennis Leri, Marcia Margolin, David Moses, Sarnell Ogus, and Edna Rossenas, my friends and colleagues in the Method, have spent many hours conversing with me, helping me clarify my thoughts, giving valuable suggestions, and providing the support that made writing this text possible.

Heinz von Foerster has served as my mentor in the field of cybernetics, for which I am most grateful. Besides guiding my reading and learning, he generously read and commented on all the drafts of this text. Good fortune has provided me with the oppportunity to follow my reading of Herbert Brun, Ernst von Glasersfeld, Lynn Hoffman, Louis Kauffman, Humberto Maturana, Gordon Pask, and William Powers with invaluable, in-depth conversations. My colleagues in the field--Christoph Berendes, Brock Bernstein, Jere Confrey, Rodney Donaldson, Elizabeth Dykstra, Gail Fleischaker, Kevin Kreitman, Paul Pangaro, Encarnita Figueroa Santiago, Elin Whitney Smith, and Mark Sullivan--have all contributed to my understanding of cybernetics and helped me face the difficult task of writing.

Much of the theoretical material in this book evolved from my workshops to physical and occupational therapists, and from presentations at conferences and to the Somathematics training. The feedback and suggestions from the participants in those events have proved pivotal in refining my ideas. The case studies are based on my experiences with my private clients, each of whom has served in his or her way as an important teacher.

Finally, I want to express my gratitude to Livia Calice, Jill Dorfeld, Karen Diaso-Serrett, Elizabeth Dykstra, Carl Ginsburg, Jan Hunter, Dennis Leri, Nancy MacAllister, Michaela Roessner-Herman, Devayani Smith, and Heinz von Foerster for reading drafts of the manuscript, offering advice and giving me ongoing encouragement. Michaela Roessner-Herman has contributed the illustrations for the chapters and has done a beautiful job bringing the case histories to life with her exquisite sketches. Andrew Costerus, Stephen J. Cotton, Nancy Hug and Becky Taylor were kind enough to serve as the models for these illustrations. To these people, and to my friends and family, who have whole-heartedly supported me through the long process of writing, and to many others to whom I owe so much to but have not the space to mention, my thanks.

INTRODUCTION

The following thesis, submitted in partial completion of the requirements for a Masters in Cybernetic Systems at San Jose State University, offers a theoretical framework for understanding the method developed by Israeli scientist Moshe Feldenkrais. Feldenkrais was already a renowned judo expert when he re-injured one of his knees, about fifty years ago, and caused serious damage to the ligaments. Facing an operation that could not promise freedom from his excruciating pain and that might permanently disable him, Feldenkrais opted out of medical treatment. Instead, he chose to find another route to recovery. In the following months, he studied his own movement and applied his knowledge of physics to human anatomy, building on the practice of studying movement that he had begun while studying and teaching Judo. Feldenkrais utilized this knowledge, in conjunction with his highly refined awareness of motion, to teach himself a new way of walking and moving. His success with his own problem led him to begin to assist his colleagues and acquaintances with theirs.[1]

Harnessing his keen mind and scientific training, studying other approaches, including those of Elsa Gindler and F.M. Alexander, and applying

[1] Alon Talmi, "First Encounter with Feldenkrais: A Reminscence," Somatics 3:1 (Autumn 1980): 60-61.

the most experimental findings in neurophysiology,[2] Feldenkrais developed a broad understanding of how human beings move and learn to move. He worked with people individually, and in groups, assisting the process of recovery from various forms of physical limitation by teaching them to move differently. His work has benefited individuals with chronic back problems and neuromuscular diseases, recovering from strokes and serious car accidents, suffering unexplainable pains and unclassifiable ills. As his reputation spread with his success in assisting people with previously unsolvable problems,[3] people from the world over found their way to his small office on Nachmani Street in Tel Aviv. During the final years of his life, Moshe Feldenkrais continued to develop his method, successfully assisting infants with cerebral palsy to gain new movement abilities. In the late nineteen-sixties, Feldenkrais began training others to practice his approach. I was fortunate enough to participate in the last training that Feldenkrais conducted before his death in 1984.

When I studied with Feldenkrais, he demonstrated a dedication to applying the findings of scientific research to practical matters of everyday movement and individual learning. At the heart of his Method was an ability to turn abstract concepts from physics, anatomy and neurophysiology into the concrete experiences that formed the very foundation of the lessons he taught.

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[2]Moshe Feldenkrais, Body and Mature Behavior (New York: International Universities Press, 1949).

[3]Jon Keller, "His Methods May Seem Bizarre but Thousands Swear by this Mind-Body Guru, Moshe Feldenkrais," People Magazine (September 7, 1981): pp-87-88.

His approach to teaching was experiential and metaphorical. However, when it came to bridging the gap in the other direction, from concrete experience to abstract conceptualization, Feldenkrais was better at warning of the inadequacies of prevalent forms of explanation, such as the dangers of what he called "cause and effect reasoning," than he was at articulating an alternative.

As demonstrated by his writings, Feldenkrais never developed a straight-forward, systematic explanation of his approach. The Method he created lacks, to this day, an explicit, abstract model. The difficulty in developing such a model arises, in part, because Feldenkrais had applied specific scientific findings in a unique approach based on circular, rather than linear causality. His general approach to teaching, along the specific methods he developed, was based on an implicit, experiential understanding, an understanding which he repeatedly expressed was difficult to put into words and talk about. It was as if Feldenkrais' Method was based on a language that profoundly moved people, one that he spoke with ease but one of which he could never quite convey the rules and structure.

This state of affairs has made for a difficult situation, in which practitioners of Feldenkrais lack a way of explaining the logic of the Method or of articulating it with clarity when talking with others. This lack is particularly problematic when it comes to communicating with members of the medical, educational and scientific professions. In order for the application and the acceptance of the Method to grow, in order for the Method to fulfill its potential in improving the quality of people's lives, it seems to me that it is becoming increasingly necessary to develop explicit ways of explaining what a Feldenkrais teacher does and how what we do works. Until we have a way to talk *about* what we do that fits with *how* we do it, we will not be able to make the work available to all who can benefit from it.

When I began to study cybernetics and systems theory, in part as a result of Feldenkrais' suggestions to read Gregory Bateson, I recognized a theoretical perspective that could be true to the spirit of the Method. Cybernetics promised the possibility of explicit, abstract explanations of the Method without the loss of what is unique and beneficial about it. Indeed, cybernetic explanations of circular processes fit the kinds of phenomena that Feldenkrais thought were so important to take into account. This text is an initial attempt to offer such explanations and to demonstrate the kind role they can play in understanding the Method. As such, the purpose of this text is to offer an explicit model for understanding the implicit logic that underlies how Feldenkrais lessons work.[4] My intent is for this text to present a way of talking about the work my colleagues and I do, a way that can clarify how Feldenkrais teachers perceive movement and understand learning. By making explicit the systemic and dynamic presuppositions at the heart of this approach, I hope to facilitate communication with members of related professions--including athletic trainers and coaches, bodyworkers, dance and movement teachers, movement scientists, physicians, physical therapists, occupational therapists, and teachers of all kinds--and with interested members of the general public. This is, of course, not the only form of explanation possible and I can only hope that it sparks better, more useful

[4]Since the Feldenkrais Method is an educational model, the phrases *student, teacher,* and *lesson* are used rather than the medical terms patient, therapist, and treatment.

models for understanding this incredibly gentle and incredibly powerful approach to developing human potential.

To bridge the gap between abstract and concrete, and to encourage the reader to go back and forth between theory and practice, a specific case history is interwoven into each chapter. Each case study, set off from the rest of the text in *italics type*, is presented in several sections braided into the theoretical discussion. Each case study is based on a specific client with whom I have worked but the name and specific, personal details have been altered to protect their privacy. Please note that while the case study begun in Chapter One is concluded in Chapter Five, the rest of the chapters each present a unique case history.

Though the case presentations do not mirror the accompanying text point for point, they do illustrate the theoretical points made in the surrounding chapter and, thus, are meant to expose my reasoning as a Feldenkrais practitioner and movement teacher.[5] My intention has been to relate stories that reflect the it conversational dialogue that underlies a Feldenkrais lesson and to provide a concrete way of integrating theory and practice, thereby allowing the reader to step into the thinking process that informs this kind of interaction while also getting a sense, a taste, of the Method *in action*.

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[5] Please note the case histories present a certain style of Feldenkrais lesson, one that is very cognitive and explicit. This is not necessarily the most appropriate kind of session for every student nor is this the way that I teach *all* the time. However, to serve the purpose of the book, to help clarify the reasoning behind the Feldenkrais Method, and to make it easier for a reader who has minimal experience with the Method, the lessons are presented in this way.

The overall plan of the book is as follows: the first chapter begins by examining the human potential for graceful, efficient movement and suggests that this potential, and the problems that interfere with it, can only be understood by viewing the body dynamically and by appreciating the importance of the mover's experience of moving. The second chapter contrasts the standard, reductionistic, medical model of problems in functioning with a systemic approach, offering a new way of conceptualizing these kinds of problems. A discussion of the role of intention in movement leads to a basic cybernetic model of self-regulating systems and its application to movement in the third chapter. Chapter Four discusses the consequences of this model in relation to understanding perception and the role of perceptual learning in overcoming movement limitations. The fifth and final chapter presents an interactive model of education and illustrates its application to understanding the Feldenkrais Method.[6]

By taking advantage of the double meaning of the word "articulate," the title of this work, Articulating Changes, points to the thematic (and often problematic) relationship between movement and language. When we move, we move at our joints, which are also known as articulations. Thus during movement, it is our articulating that changes. And when, in response to some trauma or illness or in the course of a movement lesson, we learn to move differently, our ability to articulate, to move, changes. Interestingly enough, as

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[6]Readers familiar with cybernetics may recognize that this format more or less recapitulates the development of the field, starting with systems theory and progressing through first-order cybernetics to second-order cybernetics and conversation theory.

will be discussed in the coming pages, it not just our movement that changes, but our ability to articulate our experience of moving, to put it into words, that changes. Finally, since this book is about developing a way of talking about this process of changing how we move and how we experience movement, the title speaks to articulating how these changes come about.

Chapter One

The Forgotten Senses

"We are reminded again of the oneness of the human body. Its trillions of cells and its "institutions" of tissues, organs, and systems have their own identities and functions, but their survival depends equally upon their relationship to the whole organism. It is important to remember this as we proceed to analyze the structure of the human body."

James Crouch

Grace. Fluidity. Poetry in motion.

There is something we all recognize in the ice skater, the Olympic gymnast, and the circus acrobat. We notice a quality of ease and beauty in movement, a quality brought to the foreground of our attention by a noticeable absence of extraneous motion or effort. The whole person moves as one, each muscle doing its job so that every bone's motion is orchestrated in perfect harmony. We marvel at the person who moves with ease, effortlessly, without preparation, without hesitation.

Our ability to recognize this quality is an aesthetic we share, an appreciation of human motion when it reflects the grace and agility of gazelles, jaguars, and dolphins. Perhaps it is all the more striking to see humans move with such animal ease since for us it is a developed agility rather than an inherited trait.

The ability of the whole body to work fluidly as an integrated whole, and the potent, easy quality that comes from moving that way, cannot be attributed to any one physical attribute nor can it be ascribed to the mere possession of athletic ability. This almost magical coordination is a potential available in our everyday actions--opening a door, brushing your teeth, or doing the dishes--as well as in feats of great strength and agility. Nor can this ability to move gracefully be eliminated by physical impairment; for example, the wheelchair athlete playing championship basketball whizzes down the court while dribbling the ball, pivots to a quick stop, and, with a flick of her wrists, sends the ball spinning in a beautiful arc into the hoop.

Grace arises from how the mover faces the challenge of moving; every example of graceful movement is a clue to the potential inherent in the design of our human anatomy, a potential intrinsic to the very way in which you and I are physically constructed. The prowess of efficient movement offers a glimpse at a possibility that is all but forgotten in our everyday lives, especially in the lives of those of us who face physical impairment or chronic pain: the possibility that the human body is designed for easy, coordinated movement. By the phrase "designed for easy and coordinated movement" I mean that we are capable of more than just getting from here to there, we are each capable of moving with uncanny coordination.

In order to be able to understand this possibility, and to understand what interferes with it, it is imperative to *see* the body in motion. There is something almost mysterious about graceful movement, something that can't quite be explained by the ways we normally look at the human body. The scientific study of the structure of the body presents a problem to the study of movement. The very acts of identifying and naming the components of the body obscure the whole body coordination that gives rise to the kind of movement we are trying to understand.

The ability to recognize patterns inherent in the body's motion runs counter to the historical trend in the study of anatomy, from the time of Vesalius's classical study, **De Fabrica Corporis Humana**, in 1543, to the present. Historically, anatomical distinctions were generated by the human eye as the edge of the scalpel[7] disassembled a cadaver, separating different types of tissue from one another, creating boundaries, and mapping a previously unexplored territory. Anatomy, which literally means "separating the parts," charted inner space by differentiating, making distinctions among, the body's structures and shapes, tissues and organs.

What is known about the mechanisms of movement has, necessarily, been derived from the study of cadavers.[8] The application of anatomical distinctions to human motion requires extrapolation from one domain of

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[7]Michel Foucault, The Birth of the Clinic (New York: Vintage Book Editions, 1975), p. 14.

[8]Berndt Yager, "A Historical Perspective on the Study of Anatomy," lecture at Somathematics, 10 July 1987 (on videotape, San Francisco: Somathematics, 1987).

knowledge to another, from the motionless body to the body in motion. Understanding the anatomical structure of the human body is necessary, but not sufficient, when it comes to understanding human movement. A reductionist anatomical perspective obscures as much as it reveals: the parts are made visible and the whole disappears.[9]

Therefore, to understand how the body is designed to move, what is needed is a way to understand the body as a whole, as an integrated mechanical **system** engineered for movement.[10] A system is an integrated whole, a unity, comprised of interdependent parts working together in a unified fashion.[11] Indeed, the way the parts of a system are organized as a closed network of relationships determines the system's nature, its very identity. Another way to say this is that a system is **structure-determined**: what a system does is determined by how its components relate to each other not simply by what they are.[12] When we look at the relationships between the parts of the body, a design emerges.

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[9]Heinz von Foerster, "The Cybernetics of Cybernetics," The Cybernetician 3, (November 1973): 32.

[10]This idea, of the body as an integrated mechanical system, unites many approaches to bodywork and movement education, including Structural Integration (Rolfing), Aston Patterning, and the Alexander Technique. See Ida Rolf, Rolfing: The Integration of Human Structures (Santa Monica: Dennis-Landman, 1977); Thomas Hanna, "Somatics Interview with Judith Aston," Somatics 3:1 (Autumn, 1980): pp. 8-10; and F. Matthias Alexander, The Use of the Self, with a Preface by Marjorie Barstow (Downey: Centerline Press, 1984))

[11]The body, considered as a biological organism, often serves as the archetypical example of a system.

[12]Humberto Maturana, "The Biology of Language: The Epistemology of Reality," Psychology and Biology of Language and Thought (New York: Academic Press, 1978), p. 35.

Consider the body as a whole; this structure has a very unstable design. The heaviest parts--the head, chest, and pelvis--are placed high above a relatively small base of support, our feet. With a high center of gravity (the pelvis) relatively far above the standing surface, the **static stability** of the human body is very precarious.[13] Compared to all the animals that walk on land, the ratio of the height of the center of gravity to area of support is highest for humans beings, meaning humans have the least static stability. While learning to walk, toddlers seem to automatically adjust for this instability by standing with their feet wide apart.

Viewed from the perspective of stillness, the instability inherent in the body's design could be considered a disadvantage. In order to maintain a static posture, constant adjustments of the activity of individual muscles and whole groups of muscles are necessary. Since it requires continuous muscle effort and ongoing neurological monitoring to maintain balance, it might seem that this instability is inefficient.

Instability, or, better yet, **dynamic stability**, is a small price to pay for its enormous advantage; our human instability endows us with the ability to initiate movement with a minimal amount of effort. A body supported by such a small base goes off-balance easily. It takes only a small motion of the higher, heavy parts to easily generate movement. Like the rock at the top of a hill, the body has a high potential energy, meaning that it requires little added energy to produce movement.

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[13]Moshe Feldenkrais, Higher Judo (London: Frederick Warne & Co., 1951), p. 27.

From a systemic point of view, we can now redefine standing as a dynamic activity, due to the continuous regaining of an **unstable equilibrium**, rather than a static posture. Reconsidered from this standpoint, a posture becomes the resting place that a person returns to between movements. As such, a posture is the launching pad for each newly begun movement. A neutral posture is one that allows for utilization of the body's inherent potential for movement: the ability to move in any direction that the environment permits with equal ease.[14]

Posture, or stillness, is then viewed in the context of movement. Rather than being a snapshot of a person's ongoing movement, rather than being an abstraction from the ongoingness of lived experience, rather than being a thing-in-itself, posture is considered in the context of activity. A *position* or a *posture*, how a person is sitting or standing, is the result of what someone **does** rather than a *place* someone holds. This shift from a static to a dynamic frame of reference is a necessary consequence of, and prerequisite for, adopting a systemic approach.

Look at the layout of anatomical components, the blueprint for our muscles and bones. The largest muscles--the muscles of the lower back, abdomen, inner pelvis, and legs--are located in the pelvic region; a direct corollary to this axiom: the thicker a muscle, the more centrally it is located. The pelvis is the largest boney mass and the basin for everything above it that rests upon it. This means that the arrangement of the muscles coincides with the

[14]Moshe Feldenkrais, The Elusive Obvious (Cupertino: Meta Publications, 1981), pp. 51-52.

layout of the skeleton. Muscles are arranged so that the larger a muscle is, the more mass it moves.

To generate the force required for a movement, without creating any sensation of undue effort, each muscle must supply a force roughly proportional to its size (specifically, force proportional to its cross-section). When the central musculature of the pelvic region initiates the movement, the biggest muscles of the body provide the major impetus for motion and the smaller, more peripheral muscles are needed only to guide the movement. Thus, the action of the pelvis, even in a motion that is small relative to the overall movement of the body, is integral to efficient action.[15] When the muscles of the pelvis initiate the movement, the biggest muscles do the work of moving the largest mass and no muscle in the body need contract with greater intensity than any other. This mode of action, central to all efficient movement, is called **coordinated action.**[16]

Coordinated action, movement where no muscle needs to contract more than the rest, is the key to efficient movement. This definition concretizes optimal human performance in any activity. As a measure of human performance, coordinated action offers a concept of strength different from the one held by the current aesthetic of muscle building. The fitness boom's standard of strength evaluation is the shape and size of individual muscles. (A more rigorous

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[15] This musculature plays an equally important role in refined movements of the hand, as found in calligraphy and the playing of musical instruments, by providing the central support for movements of the arm and hand.

[16] Feldenkrais, Higher Judo, pp. 35-39.

equation would read that strength equals a muscle's ability to generate force.) The notion of coordinated action suggests strength also can be defined as an attribute of the coordination of the whole body, rather than measured only as one particular muscle's ability to contract.

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"I don't know how you can possibly help me."

Patrick leans forward, slowly pulling his weight off the wall behind him to rest onto his cane, "The neurosurgeon says I have a protruding disc in my lumbar spine and that it's the root of my pain. He referred me to you so you could teach me to move differently. If surgery won't help and therapy hasn't helped, how can learning to move make me feel better?"

As we begin to talk, Patrick tells me of his first episode of back pain that occurred when he was working as a grocery stocker and bag boy in high school. He hurt himself moving a shipment of canned goods but didn't report the incident because he was afraid of getting in trouble and didn't want to have his mom fussing over him. Patrick pretended to have the flu and, after spending a few days in bed, the soreness went away, more or less. Since then, Patrick has suffered regular bouts of stiffness and pain in his lower back. As he has become more successful in his career, computer programming and systems analysis, and the stress associated with work has grown, he's found it increasingly difficult to sit for long hours. Despite regular exercise, his back has been uncomfortable every day and lately the frequency of spasms, with the severe bouts of painful
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stiffness they bring on, has been increasing. Patrick has just finished telling me how frustrated he is about not getting better, not wanting his day-to-day life to depend on medication and fearing that his health might continue to deteriorate.

After listening to Patrick's history, I begin to explain how I can be of assistance by saying, "Whenever you have an injury, accident or illness, there are two kinds of problems you face. The first problem is whatever physical damage your body suffers. With this problem, medicine has a role to play, assisting your body in the process of healing itself. As soon as you are hurt, you not only begin to mobilize your resources to repair the damage but you also adjust your movement to minimize the pain and discomfort. The second category of problems arises out of these compensations, out of your body's unconscious attempt at damage control and pain reduction following an injury."

I pause, watching as Patrick cautiously shifts his weight to lean back onto the wall again. "For instance, after someone breaks a leg, it's very common to develop a limp. That limp is an example of the second kind of problem I'm talking about. This kind of problem arises from how someone alters how he or she moves in order to decrease discomfort after an accident or injury; I guess you could say that is a consequence of how someone responds to an initial affliction. At first, limping can help by keeping you from putting weight on the injured leg but, after a while, this new way of walking can lead to other problems. For instance, when I was working at the physical therapy clinic in the Podiatric Hospital I saw many women who had developed low back problems months or years after having operations to remove bunions."

"Yes, but what does that have to do with my back?"

"Well, there are many ways to limp. I guess that while it's easy to see how a limp could cause someone to hurt her back, it's more difficult to see how your back pain fits with this notion of limping. It's just that this kind of response can happen every time you are hurt; we have a name for it when you hurt your foot but we don't have a name for the same phenomena when the injury is elsewhere. But wherever someone hurts him- or herself--breaking an arm, sustaining a neck injury in a car accident or whatever--he or she learns to accommodate, to adapt, to the injury, figuring out what hurts the least and changing every movement accordingly. This is what limping is all about."

"You mean, like, when you favor an arm after you've injured the shoulder?"

"Exactly. In the long run, you can create secondary problems. Sometimes these problems show up as restrictions in mobility, sometimes they appear as pain or soreness. And these secondary problems don't necessarily mean that part of your body is broken; they may mean that because of the way you adapted to one problem, or because of the way you learned to move in the first place, you are stressing one area while favoring another."

"Are these problems like the side effects of the compensations you make?"

"Yes, you could call them that, just like you call the unwanted consequences of certain medicines 'side effects.' In both situations, they are the unintended results of an attempt to correct a problem. But though they are

labeled 'side' effects, because they are unwanted, they are usually just as central and just as inevitable as the so-called 'main effect.' As far as your situation goes, ever since you were a teenager, you've made changes in how you move to minimize the strain on your back. Like most people, after you were hurt you tried to reduce the discomfort by limiting your movement in certain ways. Without any education in how your body is designed to move, you made these changes based on the simple criteria of eliminating any movement that felt uncomfortable or dangerous. And those ways of moving and, especially, of ***not*** *moving, of holding still, became habitual, automatic. These unconscious accommodations led to your stiff back and to the inefficient ways you move."*

"Are you saying that my problem was caused by what I did over twenty years ago?"

"No, I'm not. It's not as if there's a direct cause and effect relationship. You learned to move in order to protect yourself, which led to changes in how you moved. Because of the restrictions you imposed on how you moved, you made yourself stiffer and, thus, became less mobile and more prone to hurting yourself. When you continued to experience problems, you continued, unconsciously, to impose limitations on how you moved. I'm saying that the discomfort you're feeling now is, at least in part, ***a result of how you're moving now****. How you're moving is a result of how you learned to move after your injury and over the years. The problem is that you're not aware of how you're moving; instead you're aware of the consequences of how you're moving."*

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The immediacy of movement conceals a mystery. When you decide to read a book, you simply pick it up and open to the first page, and then, focusing on the first word, you begin. How you reach for the book, grasp, lift, and open it, seems evident because you *just do it*. There is a simple expediency of action that obscures the intricacy of how we move, an intricacy that is rarely, if ever, appreciated or understood.

The act of reaching for, and grasping hold of, a book incorporates many simultaneous events. Your eyes move to locate the book, perhaps your head and torso move as well. When you reach for the book, the spatial configuration of your body changes and, since the weight of your arm is enough to throw you off-balance if you don't compensate, the distribution of your body weight also must change. You make continuous adjustments as your hand moves in coordination with your eyes. Your hand moves more or less smoothly, quickly or slowly, as you guide yourself, with or without deliberation, with or without effort, toward the book. Your arm, shoulder blade, and collar bone follow your hand along, moving either as a solid unit or an intricately articulated mechanism, probably unnoticed. The even smaller movements of your ribcage, spine, and pelvis may go entirely unheeded. When your hand reaches the book, when your fingertips touch it, you take hold of it, almost instantaneously adjusting the amount of effort called into play by your almost instantaneous assessment of the weight of the book.

The ease with which you accomplish this intention, or any other, is usually taken for granted. In everyday life, with our awareness focused on the action that we are engaged in, on what we are doing and accomplishing, you and I may barely notice **how** we're moving. We are engaged in an activity--cooking, driving, reaching, and so on--and we attend to that activity, usually noticing only whether or not our intention has been achieved. This ease of action, of turning intention into achievement, is all the more remarkable considering how we accomplish a goal without accounting for how it comes about.

With our attention so firmly locked on what we are accomplishing, we have little or no idea how we go about achieving our aims, how we move. The act of reaching for a book--the speed of your hand and arm, the accuracy of reaching the exact place where the book was set, and the precise finger movements--demonstrates our nervous system's incredible facility for performing complex actions with little conscious attention to the means whereby we perform them.[17] Our embodied knowledge of movement is barely conscious and our awareness of our movement so elusive that questions about how we move catch us unawares. The answers are just out of reach at the edge of our awareness.

We have a difficult time examining our experience of moving, let alone explaining it. Indeed, most of us lack any but the most minimal awareness of what happens within the envelope of our skin as we move. Just thinking a movement through can easily become a riddle. For example, how do you get in and out of a chair? Where does the impetus for the movement come from? Do

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[17]F. M. Alexander was perhaps the first person to point how little we attend to the *means-whereby* we move, as shown in Alexander, The Use of the Self, pp. 50-60.

you push down on your thighs when you start to stand up? Are you contracting the muscles in the back of your neck? At which joints are you moving? What would be the easiest way *for you* to do this movement?

When teaching bus drivers or gardeners, secretaries or janitors how to prevent on-the-job injuries, I often begin the first class by asking people to tell me how they perform an everyday action, like standing up from sitting, without using their hands or body to demonstrate. Usually participants stammer and mumble, giving vague descriptions of the movement based on what are, more often than not, wildly inaccurate ideas about anatomy. The annoying difficulty of accomplishing this seemingly simple narrative task gives the class a visceral experience of how little we understand movement and a graphic illustration of just how uneducated we are about our own movement. This experience makes it easier to understand why we hurt ourselves so often at work and at play. Without some idea of how we are actually moving, let alone without any idea of how we ***can*** move, how can we modify our actions to prevent injuries or recover from them?[18]

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"Can you explain how my problem could be a consequence of how I move?"

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[18]Moshe Feldenkrais was fond of saying "If you don't know what you're doing, you can't do what you want" (Moshe Feldenkrais, Amherst Training Videotapes, New York: Feldenkrais Foundation, Summer 1981).
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"I think so. Maybe it's best if I show you rather than tell you. How about walking around the room a bit?"

Patrick begins to stroll the length of my office, a room about twelve feet wide by twenty-five feet long. His gait is very stiff, his trunk moves rigidly above his legs and his arms are held stiffly at his sides.

As I walk over to him, I ask, "Would you please stop and stand still, as comfortably as you can, for a moment."

Standing to Patrick's left, I gently run my hand up and down his back, allowing my hand to conform to the contour of his back as I slowly move from the back of his head down to his pelvis and back to his head. "Where do you feel discomfort?"

"Here," he answers, pointing to his middle back and the lower part of his ribcage. "And I also get pain here, in my right buttock, and down my right leg."

"As you probably know, the pain you feel in your mid-back isn't caused by the structural problem in your lower spine. Because of the arrangement of the nerves, pain from a bulging or ruptured disc travels down the body from the site of the damage, never up."

I pause, letting him consider what I said.

"What do you notice about how you're standing? Can you tell me where on the bottom of your feet you feel the weight of your body resting?"

"I notice most of the pressure on my heels, way at the back of each of my feet. Is that right? Where should it be?"

Illustration 1. Gently running my hand down Patrick's back.

"For right now, let's emphasize your noticing what you ***are*** *doing, rather than what you* ***should be*** *doing. With your weight back on your heels, you've got to do a lot of muscular work to do just to hold yourself up. It must be pretty tiring to stand."*

"Absolutely. Tiring and painful. But what do you mean by saying a lot of muscular work? Don't your muscles hold you up?"

"Your muscles' job is to move you, your bones are designed to hold you up. If your muscles are doing the work to keep you standing, or sitting, then they have to work constantly. This leads to exhaustion, discomfort, and, eventually, pain.[19] *If your muscles are working to keep you in position, it also means that they're already engaged, already contracted, so they can't do their primary job, which is to move you. Let me show you what I mean. Please look down at your feet for a moment. What do you see?"*

"My belly."

"How can that be? You're a skinny guy. Yet when you bend forward you see your belly. Does that make sense to you?"

"I've never thought about it before but, now that you mention it, it does seem a bit odd. How come that's happening? Is it because my stomach muscles are weak?"

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[19] Thomas Hanna, Somatics (New York: Addison-Wesley, 1989).

"Here, feel how much work your abdominal muscles are doing," I say gently pressing on Patrick's stomach.

"They're really hard."

"That's right. Because you're leaning back, arching your mid-back so that the weight of your torso is falling behind your midline, you're relying on the muscles of your abdomen and the muscles here, in the front of your thighs," I say, touching the front of his upper legs, "to hold you up, to keep you from falling. Can you feel how tight and hard these are? If these muscles were to let go, the back of your head would hit the floor."

Moving around to Patrick's front side, I put my hand on his breastbone, asking, "Do you feel the angle of the front of your chest? Rather than being perpendicular to the floor, it's sloping backwards."

I gently rest my hands on his shoulders, slowly pressing straight down toward the floor. At first he tightens his torso and legs to resist my force and then, a moment later, his pelvis buckles, pushing further forward. "Do you notice what happens when I press on your shoulders? I'm adding a little bit more force along the line of gravity, adding a little bit more pressure to the force that already presses on you all the time. Testing your response to this vertical compression lets us see how you deal with gravity and, as you may notice, your response to the increased pressure makes you feel worse. First, you generate a lot of muscle effort to keep standing and then you have to lean a little further back to *counteract my force. And you notice how this puts pressure on the very part of your back that you said was the sorest."*

"Yes, I could feel the pain starting to come back right before you stopped pressing."

"Is this interesting to you? I'm showing you what I notice so that you can understand how the way you move is important. You know, none of this is meant as criticism, don't you?"

"Yes, of course. Please continue, I'm very interested in what you're saying."

"Okay, good. Let me just point out one more thing. Please start walking again. With your weight leaning backward like this, you'll notice that you have to overcome inertia every time you take a step forward. There are two extremes in walking. One is the toddler's walk, where you lean forward, letting weight come in front of your body. You sort of fall forward and catch yourself with each step." Patrick has stopped walking and he's watching me demonstrate as I continue to explain, "At the other end of the continuum is what I call the Mr. Natural walk. Remember Mr. Natural? He is the cartoon character with the long white beard who's associated with that famous phrase, 'Keep on Trucking.' Anyway, Mr. Natural would lean way back and stick his feet out in front of him when he walked."

"I walk like Mr. Natural, don't I?

"Yes."

"Now I know why walking is so tiring. But why haven't I ever noticed any of these things before? I mean, I've known that I'm a little stiff for years, but I had no idea just how inefficient my movement is nor what serious consequences it's had."

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Just like many of us do not think about how a car engine works until it breaks down, movement usually does not lose its obviousness, and the complexity of movement is not brought into the foreground, until we experience a performance barrier or until the ability to move becomes restricted or limited.[20] Until an athlete wants to improve his tennis game or a bus driver wants to recover from her shoulder injury, the importance of the involvement of the arm, the shoulder blade, the collar bone, etc. in the movement of the hand is rarely considered. Not until someone incurs a back injury, and the continuous, minute changes of the body's configuration become so painfully obvious, does he or she consider the importance of the spine in everyday movement. And, usually it is only when chronic or acute pain, or a stroke, cerebral palsy or other neurological problem, interferes with the easy ability to convert intention into complex actions that we consider just how it is that we can move at all.

The limits in our understanding of human motion become more than an interesting or frustrating riddle for individuals confronted with limitations in their

[20]The concepts of breakdowns, as borrowed from Heidegger, is taken from Terry Winograd and Fernando Flores, Understanding Computers and Cognition (Norwood: Ablex Publishing, 1986), pp. 36-37.
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movement abilities due to accident, injury or disease. What so many of us take for granted as simple acts--opening a book or a door, bathing and dressing, carrying the groceries into the house and preparing dinner, and so on--are made difficult or impossible by the obstacles of pain, stiffness, and immobility.

But, whatever our individual level of functioning may be, for most of us there is the gap between our ability to move and our ability to understand--to feel, see and speak--about how we move. As with many other mindbending enigmas, the nature of human movement does not seem to yield easily to logic or common sense. Indeed it is made all the more invisible and elusive by attempts to reveal its secrets. **We are inarticulate about how we articulate our movement.**

The two meanings of this one word, articulate, not only identify what's missing in our understanding, but also hold the potential for, and the promise of, bridging this gap between our ability to move and our ability to understand movement. On the one hand, this word signifies the ability to express an idea cogently, that is to say, with clarity and intelligence. Alternately, when something is said to be articulated, we understand that to mean that it consists of segments joined by moveable connections or joints. Bringing together the two fundamental meanings of the word "articulate"--to distinguish with clarity and to move at joints--suggests that there may be a language for experiencing and expressing movement.

Yet the very nature of this language is often forgotten, left out of our everyday appreciation of how we work. Ask any child, ten years or older, to tell you how she knows what's going on--to name her senses--and the answer is very predictable: "I have five senses: taste, touch, smell, hearing and seeing."

This list is terribly impoverished. The five senses we list in answer to this question are all **exteroceptors**, senses that notice what is going on outside the skin. If the human nervous system were so poorly equipped, you would be unable to tell whether your elbow was straight or bent and you would be unable to know when you're hungry or happy, exhausted or energized, hot or cold, sore or strong. The list of five senses leaves out the internal senses: the ability to sense temperature, the visceral (or organ) senses, and, most importantly for our concerns, the kinesthetic senses[21]. The word, "kinesthetic," comes from the roots *kin*, meaning movement, and *aesthetic*, referring to sensing or perceiving. Therefore ***kinesthesia*** is the sense of movement.

Kinesthesia is the poor cousin to the other senses, often ignored and forgotten. While kinesthesia has been referred to as the sixth sense and the secret sense[22], it conveys a myriad of perceptions related to movement: muscle tension, joint movement, pressure, position, direction, acceleration, balance and so on. The nervous system relies on sensors located throughout the body--in muscles, joints, tendons, and the inner ear--to perceive movement and stillness.

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[21] All these senses taken together--temperature, visceral and kinesthetic--are referred to by the more general term **proprioception**, which means "self-perception."

[22] Charles Sherington, The Integrative Action of the Nervous System, 2d ed. (New Haven: Yale University Press, 1947).

While we each have the potential to sense our own movement with great refinement and while our bodies are designed for easy, graceful movement, few of us have realized our potential in perception or in action. It is *as if* we have forgotten how to sense movement, how to move with ease. Yet this ability to articulate our experience of movement, and its double, the ability to articulate our movement, have never benefited from education, never been cultivated. The following chapters demonstrate how movement education can have profound effect on those of us who face physical impairment, pain and other limitations.

The focus of physical education has for too long been on competition and sports, rather than on developing coordination and efficient action. Perhaps one day movement education will be a central aspect of childhood learning, so that each of us will learn to utilize the human body's fantastic design for movement. Yet it is imperative to remember that the lessons to be learned are just as applicable to making the way each of us moves (as adults) easier and more comfortable as they are to improving the physical education of the young.

Chapter Two

An Anatomy of Possibility

"I am a devout listener of my three-dimensional body."

Deborah Hay

Pain is a symptom, a sign, an indication.

Modern medicine decodes pain by determining what is causing it and finding out where the cause is located. As such, the experience of pain is interpreted as a signal of pathology: physiological damage or malfunctioning. In the case of a back problem, for example, the list of likely causes include a torn ligament, a pulled or strained muscle, an infection, spinal stenosis (a narrowing of the spinal canal), spondylolisthesis (a slipping vertebrae), arthritis (inflammation and, possibly, accompanying deterioration of a joint), degenerative disc disease or, perhaps, a protruding or ruptured disc.[23]

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[23] Marion Steinman, The American Medical Association Book of BackCare (New York: Random House, 1982) pp. 51-103; and Augustus A. White, III, Your Aching Back (New York: Bantam, 1984), pp. 33-64.

Medical diagnosis is the process by which the sign reveals the signified, the symptoms identify a disease. This disease, in turn, must have its origin in some place, at some specific location or locations. Like a detective following the clues to determine the cause of a crime, the doctor follows the symptoms to identify pathology and diagnose disease.

For example, consider an individual who has back pain and also suffers from sciatica, a pain that travels down the leg, often shooting "jolts of electricity" to the foot. By means of various diagnostic tests--physical examinations and technological assessments--the back pain and sciatica are traced back to a herniated disc in the lumbar vertebrae. The discs between vertebrae act as shock absorbers and maintain the space between the bones of the spine to allow free movement. A herniated disc, damaged in a sudden injury or over years of repeated strain, bulges and impinges on the nerve going to the leg, the sciatic nerve. The sciatic nerve, the largest nerve in the body, leaves the spinal cord in the lumbar spine, the vertebrae of the lower back, and travels through the leg to the foot. Thus the cause of the pain is said to be the herniated disc.

The logic of this medical detective work is based on two presuppositions: first, that the cause of the pain can be localized and, secondly, that the origin of the pain (or, more generally, of the disease) can be found by tracing backward along a continuous path of events, from the effects back to the specific causal site. Once the location is determined, the cause can be found and vice versa.

The idea that the source of physical maladies can be pinpointed, or localized, is historically and methodologically the foundation of modern medicine.[24]

For instance, a primary cause of leg pain associated with back problems was not identified, and labeled as sciatica, until the completion of the clinical and microscopic studies, in 1934, that located the problem of the herniation of a disc and its resulting pressure on the sciatic nerve.[25] Once the origin was identified, surgical and therapeutic interventions could be developed to deal with that specific cause. The development of successful, reliable treatment was dependent on identifying the site of the problem.

Therefore, the practice of medicine requires identifying a local cause. In Patrick's case (discussed in the previous chapter), after the diagnostic process traced the cause of the symptoms back to a pinpointed cause, a surgical remedy had been considered and deemed inappropriate; the various types of therapy that had been used--manipulation, massage, heat, exercise and so on--proved ineffective.

When the origin of the pain cannot be diagnosed, that is to say, no specific physical cause can be found, as in the case that will be presented in this chapter, or when the origin is found but does not respond to treatment, as in Patrick's case, the situation gives little hope for cure. Here we reach the limitations of the medical model. Beyond the boundary of orthodox diagnosis

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[24] Foucault, The Birth of the Clinic.

[25] Steinman, The American Medical Association Book of BackCare pp. 53-58.

and treatment is a kind of limbo. Healthcare practitioners become frustrated by their inability to alleviate their patients' woe. If there is no response to therapeutic intervention then the patient's experience and motivation is called into question and all sorts of convoluted psychological explanations are proposed.

In my years of practice, I have worked with few individuals who suffer from purely psychosomatic pain or who I thought were malingering. By and large, I have encountered a multitude of individuals who suffered from real, physical limitations--back problems, chronic pain syndromes, headaches, and so on--and whose situation simply did not fit the physician's diagnostic categories or whose problems did not respond to surgery or standard therapies.

The greatest tragedy here is the hopelessness that results from looking for a cause and not finding one. In these puzzling situations, where no cause can be found, no treatment can be prescribed. Without a cause, the medical act of removing the cause cannot be performed. The person in pain begins to accept that nothing can be done to help; resignation sets in as a grim acceptance of an intolerable situation develops. Self-doubt, disappointment in the unrealized expectation of a quick solution, frustration with the lack of progress and distress take hold.

This bleak prognosis is the common fate not only of people who face chronic pain, but also of the others whose situations are beyond the reach of successful medical intervention because they suffer from one of many incurable neurological problems, such as childhood polio, cerebral palsy, or brain damage, or because their condition falls outside the domain of so-called "medical problems." This latter category includes athletes who have reached a performance plateau, dancers who repeatedly suffer minor injuries in route to major catastrophe, musicians who endure constant discomfort and physical distortion, and even those unfortunate individuals who are beleaguered with a lack of easy coordination and seem to possess no natural athletic abilities.

When pain, disability or movement limitations arise, it is most common to turn to the body to ask, "How is it broken?" and "What needs to be fixed?".[26] These questions arise directly from the diagnostic reasoning, which is based on the logic of the body as machine. In this analysis, any dysfunction is directly caused by localized damage to the physical structure or by a specific defect in the ongoing operation of the mechanisms of the body. To ask "What is broken?" is to presuppose that pain and disability must, necessarily, be the consequence of a malfunction in the machinery of the body.

The reductionistic view of the body, and of movement, requires that each of us takes how we feel and how we move as a given; that is to say, this view requires that you have no alternative but to resign yourself to accepting that this is how your body "***is***." Whether clumsy or graceful, in athletic peak or out of shape or physically disabled, young or old, you are to take the situation as given, attributing your abilities and limitations to inheritance, fortune or fate.

For instance, after beginning an exercise program to improve her flexibility, a friend of yours complains she has begun to experience discomfort in

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[26]A similar point is made in reference to psychotherapeutic approaches by Richard Bandler and John Grinder, Frog Into Princes (Moab: Real People Press, 1979).

her upper back, between her shoulders, which is aggravated every time she returns to class. She has no history of injury or prior problems. The exercise instructor refers your friend to her doctor. If the subsequent X-rays yield evidence of arthritic deterioration of the thoracic vertebrae, your friend is told to take it easy, perhaps given a few gentle stretches, and counseled to learn to live with the inevitable limitations that come with this finding. If no such culprit can be found and the problem is attributed to poor physical condition or old age, the advice is to take it easy. Either way, the result is the same: how she is moving is not considered and the problem is investigated no further.

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"I'm scared. The doctors that I've consulted haven't been able to explain this and it only seems to be getting worse. The acupuncture helped, it stopped the downward spiral and the constant aching in my arms has decreased. But now it seems that I am able to do less and less." Agnes finishes speaking, brushes the grey hairs from her face, and falls back into the chair, sighing.

She looks at me, her eyes asking questions she hasn't yet voiced. I recognize Agnes as a librarian from the Main library's reference desk and as a well-known ecological activist. It's difficult for me to imagine this exhausted, frail woman as the vibrant political activist and rabble-rouser that I've read about so often in the local paper.

Speaking slowly, Agnes recounts her story. Several years ago, she noticed her arms felt numb at the end of the day. Over the months that followed,
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the sensation worsened until Agnes began to awaken with an aching numbness in both arms. She can no longer fully straighten her arms; at first, reaching over her head was uncomfortable, but now it has become painfully impossible. Thoroughly engaged in her job and community work, Agnes ignored her plight until the insistence of her colleagues convinced her to pay a visit to a doctor. Her doctor couldn't find any explanation for Agnes' symptoms; however, he was concerned enough about the potential seriousness of the symptoms to refer her to a neurologist. The neurologist ordered a battery of tests but could not determine a specific cause for her problem. Though no disease was identified, the doctor prescribed a course of physical therapy treatments to deal with restrictions in Agnes' movement. The therapy proved very painful; not only were the stretches and exercises unpleasant but the sessions caused bouts of increased pain that lasted for several days.

As Agnes' situation worsened, her concern grew. Though she continued to work, it became increasingly difficult for her to do the simple things that her job depended on until it was impossible for her to take a heavy book down from a shelf or sit at her desk to write for more than a few minutes.

Acknowledging that her problem was not responding to a standard medical approach, the neurologist told Agnes of recent articles in medical journals that reported applications of acupuncture with various chronic pain syndromes and he recounted the successful experiences his other patients had had with Chinese medicine. With the doctor's encouragement, she subsequently made an appointment with a local acupuncturist and, much to her surprise, the treatments helped. Agnes' situation stopped deteriorating: the pain stopped *worsening and some normal sensation returned to her arms. As the acupuncturist continued to work with Agnes, her situation showed signs of steady improvement until, several weeks into the treatment, Agnes reached a plateau. No matter what the acupuncturist tried, Agnes got no further benefit. Unsatisfied with this stalemate, the acupuncturist referred Agnes to me, telling her that his personal experience with the martial arts led him to believe that further progress was being limited because of how she moved.*

"Do you think that this pain and numbness, this immobility is somehow related to the way I move?" she inquires.

Nodding, I ask Agnes to stand. Standing a few feet in front of her and placing my hands in front of my chest, I ask if she could comfortably place the palms of her hands against mine. She tells me that the height of my hands is as high as she can possibly lift her arms without pain. Asking her to put her hands palm to palm with mine, I watch as she gingerly raises her arms, her elbows bending out to the side as her hands reach toward mine. My hands face her, my fingers pointing directly toward the ceiling and my elbows pointing toward the floor. She struggles to line her fingers up with mine, her elbows bent like wings, each pointing out to the side. I ask her to gently push on my hands, only increasing the pressure within her range of comfort. As she pushes into my hands, she leans toward me. Her body remains so stiff that she can only bend at her ankles, her trunk moving forward slightly and her elbows lifting until her arms begin to tremble.

Telling Agnes to stop pushing, I ask her to sit on the edge of the low, padded table in the center of the office. She sits on the edge of the table, slouching, looking crumpled, defeated. Sitting across from her on a stool, I gently take hold of her right hand with my right hand and her right elbow with my left hand. Her arm is very tense and her fingers are stiff. I ask her to allow the weight of her arm and hand to rest in my hands.

She says she hadn't noticed that she was holding her arm. I then ask her if she could purposefully hold the weight of her arm without moving it. She responds that she can, lifting her arm slightly out of my hands. Next, I ask her to let her arm go so that I can support it. Some of the weight of her arm drops into my waiting hands.

We continue in this way, with her alternately holding the weight of her arm on her own and then letting herself rest into my hands. Each time she allows more of the weight to rest into my hands, each time the muscles of her arm relax a bit. She takes a deep breath.

"I didn't realize I was holding my arm up," she says, again allowing the fingers of her right hand to curl a bit and her wrist to bend slightly.

I glance over at her left hand and arm. No similar change has occurred, the hand is still stiffly placed palm down on her left thigh, her fingers held so rigidly straight that the fingertips aren't even resting on her dress.

Using only minimal effort, I slowly move her hand at her wrist in both side-to-side and back-and-forth movements. Then I move her forearm, gently turning *her forearm and then bending her elbow. She actively resists anything more than the slightest movement, stiffening her arm and hand again. I wonder aloud, "Do you realize that you're resisting the movement? Are you afraid that this will hurt?"*

Agnes looks at her hand and then at me, her eyes moving back and forth several times. "I could feel I was fighting the movement . . . I'm not doing it intentionally. I'm sorry. I guess I'm afraid that it will hurt more. Every exercise or manipulation that's been tried has only made me feel worse."

"I'm not going to do any manipulations," I say. "And this isn't an exercise. I'm simply evaluating how your arm moves, finding out in which directions you allow yourself to move most easily and noticing in which ones you're preventing or interfering with movement. When I find the direction of ease, I follow that motion a little, riding along with you. For example, notice how your right elbow lifts away from the side of your torso. Gently now, try not to get ahead of me . . . yes, that's better. Can you feel how the movement is easy until we get your elbow to about forty-five degrees away from your body? There, did you notice how your arm got stiffer?"

I wait until she nods before I proceed. "Now if I lift your arm higher, do you feel the pulling on the inside of your arm and in the front of your chest? If we try to go to ninety degrees, notice how the resistance increases and you may begin to sense some discomfort in the muscles around the top of your shoulder. Do you notice how your arm starts to veer backward rather than continuing up?"

"What stops my arm from lifting any higher? I know that it hurts terribly every time I try to lift my elbow above my shoulder. Do you know how come?"

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Diagnostic questions, that is to say, questions about what is wrong or broken, lead away from the person in motion. This is the greatest handicap of any strictly reductionistic approach: looking for the geographic site of the problem prevents us from looking any further than a direct causal link between symptom and pathology. Pain, fortunately, serves a more complex function than signalling a mechanical breakdown; unfortunately, the other ways of understanding the role of pain are more elusive. In order to construct an alternative to the "What's broken?" perspective, we must be willing to relinquish the primacy of the etiological chain reaction and its essential cascade from cause to effects, asking instead, "How is this person moving?"

Think, for example, of the myriad of ways people walk: while each of us engages in the same basic activity, utilizing the same basic structural components, we demonstrate a considerable range of nuance and variety. The human body offers a wide range of movement possibilities, an incredible array of options to be utilized for any activity, each of which is more or less efficient and each of which has different consequences in terms of preventing or creating stresses and strains. Problems such as pain and limited mobility need not be due directly to damage in the person's physical structure. These difficulties, and others, can arise because of how the body, the structure, is
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organized, that is to say, by how the body-as-movement-system accomplishes a particular movement.

To make sense of this kind of systemic organization, of the way a person as a whole is moving, a way is needed that allows us to sort through the complexity of movement and see the underlying patterns. The most common approach to analyzing movement, a muscle-by-muscle analysis, breaks a whole body movement into the separate action of separate parts thereby making it difficult, if not impossible, to identify an overall pattern of motion. The emphasis on the action of muscles also misses a key factor in the kinematics of human movement: while the muscles are the engines of movement, they do not give rise to the shape of movement. The muscles generate motion by contracting and moving the bones to which they attach. Without bones, the contraction of muscles would resemble the quivering of jellyfish. It is the layout of the skeletal system--the shape of the joints and the length of the bones--that shapes our movement.

Interestingly enough, there is a muscle for each movement structurally possible at every axial joint.[27] In other words, any movement allowed by the anatomical design of a joint can be controlled by the muscles around that articulation. Given a detailed and accurate understanding of where the joints are and how they move, it becomes possible to evaluate any particular

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[27] Axial joints are freely moveable, or synovial, articulations as compared to articulations which allow minimal or no movement, such as the sutures of the skull or synchondrosis of the ribs and costal cartilages. (An exception would be the syndesmoses of the radius and ulna or of the tibia and fibula, where considerable movement is allowed). James E. Crouch, Functional Human Anatomy, 3d ed. (Philadelphia: Lea & Febiger, 1978), pp. 92-96.

movement. Such an evaluation is comprised of assessing which joints are moving and, of the joints that could be participating in the action, which ones aren't. The number of components to be kept track of has thus been reduced from over 650 to 210. The complexity of movement analysis can be reduced further because of the 210 bones in the human body, fewer than 180 have axial articulations. Furthermore, the majority of these articulations only permit movement in one or two dimensions, reducing the complexity even more.

Unfortunately many people are rather squeamish about bones, especially human skeletons. Just talking about the skeleton brings up unpleasant associations: the skeleton symbolizes the figure of death. Hidden behind a closet door, it hints of dangerous secrets and hidden dangers. A skull and crossbones warns of poison and recalls the atrocities of marauding pirates.

This view of the skeleton as a symbol of death incorporated into the living human body, though understandable, is fundamentally mistaken. Every body has a skeleton consisting of living cells, cells that die and are continuously replaced. Over the years, bones actually change shape, meeting the stresses and strains imposed by daily movement by altering their structure.[28] The skeleton is the bony structure that supports the weight of the entire body, provides flexibility at the joints, transmits the forces generated by the contraction of muscles, protects the internal organs, serves as a shock absorber, and houses the cells that produce red blood cells.[29]

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[28]Wolfe's law.

[29]Crouch, Functional Human Anatomy, pp. 83-84.

Skeletal models, even those that are comprised of real bones, don't faithfully reproduce the movement of the living skeleton. Because of the inaccurate connections made at the joints of model skeletons, models fail to illustrate correct joint action. This artifact of an inexpensive and expedient design makes it difficult to recognize the multi-directional patterns inherent in the body's structural organization and makes it nearly impossible to recognize the necessary involvement of the entire skeletal system in any movement. This is a result of not asking what the skeleton is designed to ***do***, which, in turn, results in the singular lack of appreciation of the integrated mechanical design of the body.

From this analysis of the configurations of bones, the observer can then extrapolate back to muscular activity and to what is happening with the body-as-motion system. Following the movement of the bones not only simplifies the task of analyzing movement, it specifies the domain of possible movement. Movement at the joints defines the body's **absolute constraints.** In other words, as a system, the body's **potential range of motion** is restricted by the shape of the joints. Remember the amazing flexibility of acrobats and gymnasts. These marvelous feats demonstrate the utilization of the body's full potential for motion.

Yet, for most of us, there is a considerable margin of difference between how we ***do*** move and how we, ideally, ***can*** move. The design of the skeletal structure defines an anatomy of possibility but we only utilize a subset of the possible configurations that are available. Each person's movement is an expression of that person's **relative range of motion**. The relative range of motion is found by comparing someone's **actual** motion with the human **potential** for movement.[30]

The definition of a relative range of motion is useful because it allows an observer to specify limitations in another person's movement. Barring any limitation due to heredity or accident, a person's relative range of motion is due to the organization and coordination of muscular activity; the activity of muscles is the most common source of interference in the flexibility of joints. Muscle tightness can inhibit the movement at an articulation, coupling two bones together so their relative motion is limited. Chronic muscle tightness means that the muscles are engaged in maintaining a constant level of contraction. Chronically contracted muscles cannot perform their primary function--that of contracting to move bones--because they are already contracted. Besides just limiting the range of motion of a particular articulation, muscle contraction acts as a damper, absorbing motion rather than allowing it to pass through the skeleton.

It is imperative to remember that the skeleton doesn't move haphazardly, willy-nilly. If there is no interference, a movement of one part of the skeleton flows sequentially through the entire skeletal structure. There is a sequential entailment of bones that is reminiscent of twisting the links of a dog leash. Holding one end of a leash and gently turning the first link initiates a chain

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[30] Any notion of optimal motion must take into account the structural limitations imposed by the human frame and developed over each person's lifetime, such as a joint fused by arthritic degeneration or by surgical intervention. By taking into account these individual variations, this definition of optimal avoids the dangers inherent in chasing after an unattainable ideal.

reaction: the first link twists freely until it engages the next link. As the first link continues to turn a wave of motion is propagated down the chain.

Linkage is the determinate relative motion of two resistant bodies, or elements, in a machine. Elements are considered linked if their motion is constrained such that the motion of one piece results only in the reciprocal and pairwise motion of its mate.[31] The skeletal mechanism for motion is not limited to such restricted movement relationships--I can move my hand without my shoulder moving--but rather, inherent in the body's design, there are many potential paths or linkages.

The determinate path of force through the entire structure forms a **kinematic linkage.**[32] The kinematic linkage is the level of organization that emerges from the connectivity of the various boney components and from how this connectivity forms ordered dynamic relationships. Another way to say this is that these pathways are a feature of the body-as-motion-system that emerges when looking at how the bones fit together, like the elements of a machine, to transmit force through the skeleton. In analyzing movement, kinematic linkage is the interconnection of the bones in such a manner as to modify and direct motion along a specific path.

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[31] F. Reuleux, The Kinematics of Machines (London: MacMillan and Co., 1876).

[32] The term "kinematic linkage" is coined here to designate potential paths of motion through the skeletal system. It is derived from standard nomenclature in mechanical analysis--kinematic chain and linkage--and in orthodox kinesiology--kinetic chain.

A constrained kinematic chain is formed when two links are connected to a third in such a way that every alteration in the position of one link is accompanied by the alteration in every link in the kinematic chain relative to the first. To form a kinematic chain, one of the bones must initiate the movement so that the other bones, constrained by the shape of the joints, necessarily move in one specifiable pattern. Since a moving structure may have as many links as it has pairs of linked elements, and since pairs of links can be connected so that motion travels through the ensemble, it is this potential for linkage, for sequential movement through the skeleton, that defines optimal pathways for movement.

This means that muscle tightness not only restricts one joint's motion but also interferes with the skeletal substrata of coordinated action. Returning to the analogy of the dog leash, it is as if the links are rusted together. This would require more work to generate the greater force necessary to move the larger mass. Instead of a sequential chain, the movement "kerchunks" or stops. The situation of muscular tightness is more complicated than a simple rusted chain because chronically contracted muscles contract further when contradictory movement is introduced[33]. Whatever the cause of muscle tightness--self-protective muscular tightening following an injury, inefficient organization of motion, neurological disease, chronic tension, or the uneven development of

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[33]Vladimir Janda, "Muscles as a Pathogenic Factor in Back Pain," The Treatment of Patients: Proceedings of the fourth Conference of the International Federation of Orthopedic Therapists (Christchurch, New Zealand: n.p. 1980).

muscle--chronic tightness interferes with the kinematic linkage and the coordination of action.

Tracing the path of motion along the bones reveals a new picture of the skeleton, one no longer thought of simply as a collection of isolated levers, each acting independently. The intricate living machine of the human body can be seen as an integrated system of levers, a system that contains pathways for transmitting and modifying the mechanical energy generated by the muscles. The articulations are not just the places where one bone moves in relationship to another; they modify the path of force and direct motion through the bones. As such, joints are nodes that both restrict and allow movement. Taken in its entirety, this system of nodes forms a **network** that shapes the path of motion through the body.

The configuration of the body, its shape in motion, emerges from how the interaction of the bones at the joints guides the force generated by muscles. A particular configuration of the body in motion can be initiated from different bones along a pathway. For example, the motion of reaching can be started from the fingertips, from the elbow, from the chest, from the pelvis, or from the foot. It is the direction of the initiating force, not simply the point of initiation, which determines the pathway.

The point of initiation, rather than the path of the force, determines the amount of force required for the chain to be propagated through the skeleton. If insufficient force is provided the motion will stop without additional muscular work. The function of muscles is to generate the force necessary to move and stabilize the skeletal structure. Muscles serve to initiate the kinetic chain, to propagate it, and to make fine adjustments in guiding the execution of a movement. The pelvis is considered the optimal point of initiation for most movements; it is the largest mass and the largest muscles originate in the pelvic region. When the pelvis moves, the rest of the skeleton follows.

However, the body can interfere with its own motion if the muscles of the trunk are continuously engaged in maintaining a certain configuration (as in Patrick's situation) or if they don't participate in generating the force of the movement (as in Agnes' case). In a less drastic fashion, most people learn to depend overly on the muscles of the arms and legs. If these muscles are made to create the prime force of motion, then the muscles of the trunk must be relegated to stabilizing the body so that the limbs can move *against* the torso. This means that the trunk muscles will counteract the movement of the limbs instead of participating in the motion. Such uncoordinated action will not feel easy and comfortable. Whatever the circumstances, if the central muscles of the body participate in the movement and the appropriate kinematic linkage is utilized, then the peripheral muscles need act only to guide the movement. This movement is not only efficient, but also comfortable and easy.

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Slowly moving Agnes' arm, I bring it to rest on her right leg. I begin to touch the muscles around her shoulder. "Do you notice how these muscles, in your upper arm, your chest, and around your shoulder blade are tight?"

"Yes. I've always carried all my tension in my shoulders."
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"The tension in these muscles is inhibiting the movements that support the motion of your arm and hand. With this tension, the rest of your body is prevented from participating in and supporting the movement of your arm. This counteracts the way your arm is designed to move. Look at this picture of the human skeleton," I say, pointing to one of the charts on the office wall. "The arm is connected to the torso here, at the shoulder joint. As you can see, the shoulder joint is composed of the shoulder blade, the collar bone and the humerus, the upper arm bone. The human shoulder blade is not directly attached to the spine, allowing the arm a considerable potential for motion. By the way, this means your shoulder is a part of your arm, not a part of your back. The tension in your shoulder girdle muscles is holding your shoulder blade still and preventing it from participating in movement."

"Are you saying that it's really the way I'm **not** *moving that's creating my difficulty?"*

"Yes, that's a good way to phrase it," I answer. "It's not a matter of 'carrying tension' in your shoulders, as if tension were like sand in a bucket. While this may be a handy way to talk about what's happening, it is, in fact, misleading. What you feel is a result of how you've been moving,"

"I think I understand this concept, but I'm not sure if I really understand, in my body, how it applies."

"If you'll place one of your hands on my shoulder blade, I'll demonstrate. If I make my shoulder muscles tight, can you feel how my shoulder blade doesn't move? Then it becomes difficult for me to raise my arm above shoulder height. Eeehhh, it feels uncomfortable when I do it, too. Now, notice what happens

when my shoulder becomes involved in the motion of my arm. Can you feel it move? Do you notice how much more my arm can move?"

"Certainly."

"That isn't quite a complete picture of what happens when your arm moves. Do you know which bone is the most commonly broken?"

"No, I don't. Does that have anything to do with the pain in my arms?"

"The collar bone is the most commonly broken bone in the body. This is important because it illustrates something else about how your arm works. The collar bone connects the arm to the central skeleton, facilitating efficient movement by transmitting the force from the center of your body to your fingertips. The collar bone is also designed to act like the physical analog of a circuit breaker. If you are about to fall and you reflexively put your arms out to the impact, then when you hit the ground, the force of the fall will be transmitted through your arms into your torso. If your shoulder blade were attached to the spine, the force would be transmitted directly into your back. If this were so, you could easily damage your spine, break a rib, and probably endanger your vital organs. Following a high impact fall, the collar bone would break, protecting the trunk and vital organs." As I'm talking to Agnes about these ideas, I am helping her feel my arm, shoulder, collar bone, and spine. "This arrangement enables your arm to move through a wide range while protecting the integrity of your torso. Without excess muscle contraction, the collar bone also moves with the arm. In fact, it's useful to think of the arm as starting where the collar bone attaches to the breast bone, here, in front, at the top of your chest."

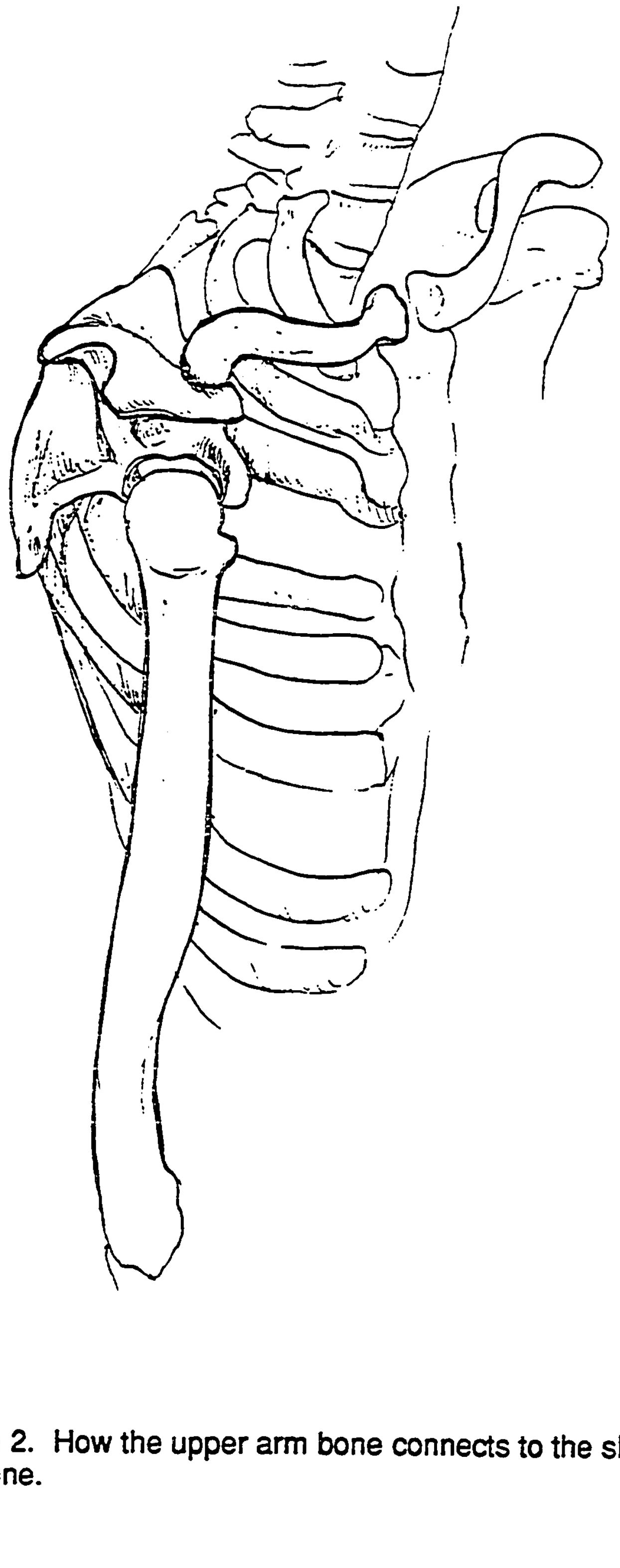

Illustration 2. How the upper arm bone connects to the shoulder blade and the collar bone.

"That's an unusual idea. I've never thought of my arm moving that way. You know, if what you're saying is true, then I'm actually fighting myself moving my arm the way that I do."

"That's right."

"Very good. I think I'm starting to understand what you're telling me," she says, smiling.

"Now, if I can help you understand this experientially as well as intellectually, you may be able to eliminate that tension and alleviate at least some of your discomfort. Place your left hand on the muscles of your chest, right there, below your right collar bone. Now let the fingers of that hand relax a bit and allow your hand to soften. That's good. By letting your entire left hand rest there, comfortably, you create a larger sensing surface. That way you'll be able to feel what happens better than if you just used your fingertips. Now, very gently, without straining, reach for the book on that table, there, next to where the phone is resting."

Agnes' arm straightens stiffly, moving toward the book. The rest of her body sits rigidly on the edge of the table, solid and unmoving. She can't quite reach the shelf. "The muscles under my fingers are tensing. Oooh, now they're very hard. If I try to reach any farther my arm starts to hurt."

"Okay. Stop and let both your hands rest on your lap again." I pause for a moment, waiting for her to place her hands down and look up at me. "Now

would you be interested in finding a different way to do that movement, one that won't hurt?"

"Do you think I can learn to move differently?" She says, answering my question with other questions, "Will it hurt? What kind of exercises will I have to do?"

"Yes, you can learn to move differently. Right now. Without pain or exercises. Let me show you."

Lifting Agnes' right arm, I rest her right hand inside my right elbow and hold her right elbow with my right hand. Then I place my left hand on her right shoulder blade. I slowly move her right arm, initiating just the very beginning of the action of reaching. "Do you feel how your shoulder blade isn't moving?"

She nods her head. I hold her right arm still for a few moments while using the fingers of my left hand to guide her left shoulder blade gently away from her spine. Slowly, I let my fingers help her find out what the movement of her shoulder blade feels like. Reaching over her shoulder, my fingers provide hints of the small associated movements of her chest and upper back. Then I take over the work of the tense muscles, holding her shoulder still with my left hand as I move her arm, with my right arm, in small circles, using the movement of my pelvis to initiate the movement of her arm. At no point do I try to force movement in any direction, I always stay within the range of ease and smoothness. After a few minutes of exploring the various directions in which her arm can move without involving her shoulder blade, I begin to move her arm while guiding her shoulder to participate in the movement. Agnes responds immediately, allowing her *shoulder blade to participate more fully in her arm's motion. Slowly, I continue to move her hand and her shoulder, using a directional touch[34] to help her feel the connection between the movement of her hand and her shoulder blade. I stop for a moment. The tension in the muscles of her right arm, shoulder, and chest has decreased noticeably. Her right shoulder is hanging slightly lower than her left. I can even see an asymmetry in her facial muscles; her right eye is more open then her left and the jaw muscles softer on the right. When I move her arm again, the shoulder blade and collar bone respond automatically.*

"I can feel my shoulder blade beginning to move. My arm feels so much more relaxed. Can I try the movement without you?"

"Yes. Just be very gentle."

Agnes reaches for the book once again. This time the movement is much easier and she can actually touch the book. "That's amazing," she exclaims. "I can reach so much further."

Before I can stop her, she grasps the book and tries to lift up the book. She gasps and drops the book, grabbing hold of her right shoulder with her left hand. "That hurt. But . . . you know what, I felt the muscles of my arm and shoulder tighten up again. Will I ever be able to do that without hurting myself?"

"Yes. In order to pick up the book without pain, the larger, more central, muscles of your body will have to participate in the movement. Right now, since

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[34]Directional touch refers to using a gentle touch to communicate a sense of direction, of moving in a certain orientation, by slightly stretching the skin and moving underlying soft tissue.

these muscles are already chronically contracted they can't contract to assist you in the lifting motion. A muscle must lengthen before it can contract again; if it stays contracted then it can't participate in motion. When these chronically contracted muscles learn to tighten and lengthen as needed, then they will be able to join in the motion. From that moment on, your shoulder blade will move and the excess tension that you became aware of will be eliminated. The muscles of your upper chest and arm will no longer bother you because they'll no longer be overworking; they'll be able to participate in your movements. Now, even though they aren't designed to carry the strain you are burdening them with, these muscles are trying to do all the work. Pain is a complaint, a signal that you're not moving well."

"I don't understand what you mean about how my body should move."

"I'm not talking about how you **should** *move. There is no moral imperative here. My comments are meant to direct you to how you* **can** *move, to your potential ease and comfort. Rather than explaining further, if you'll please lie down on the table, I'll help you feel what it is like to experience what I've been talking about."*

In response to my request, Agnes lies down on her left side. Using folded towels, I support her head off the table at the level she finds comfortable. In order to assess the configuration of her tightness and to help her feel where her muscles are tight, I gently touch her right arm, shoulder, back, neck, pelvis, and legs. I move her here and there, observing how the motion travels through her body and where it stops. Her chest and pelvis are coupled by muscle *contraction, prohibiting the motion from traveling along the skeletal paths of optimal motion. I think about the connections that make up the kinetic chains of reaching and lifting; I decide to guide her in noticing how her arm is connected through her shoulder and clavicle to her back and pelvis.*

Moving her from arm, shoulder, or chest, I can feel how far my gentle pushes or pulls travel through her skeleton, noticing where she is tightening unwittingly and thereby restricting movement from traveling through her body. Whenever she begins to tighten up or resists, I yield. Rather than insisting, I explore the range in which her movement is easy, allowing her to comfortably discover a connection, a pathway. As I continue to touch and move Agnes, her range of motion gradually increases. As her collar bone and shoulder blade begin to participate more fully in the movement of her arm, the previously rigid muscles begin to soften. Her arm moves more smoothly, with greater ease. First, the muscles attaching her shoulder blade to her back and pelvis become responsive to the movement of her arm. Once this happens, she can lift her arm above her head. Then her arm can move in increasingly bigger circles. Finally, I can gently pull on her wrist and the pull travels along her arm and through her body, moving her pelvis and even her legs. Almost thirty minutes have passed since I began working with Agnes; I say that we're finished and help her sit up again.

"My goodness, I feel different. I'm sitting up more erect," she says, her eyes sparkling. She looks in the mirror and laughs, "You mussed up my hair."

She looks to her right and spots her purse on a nearby shelf. Her left hip raises slightly as her right hand reaches toward the purse, her body turning to the right as she reaches. As her arm extends fully, the increased mobility of her *upper back, collar bone, and shoulder blade are quite visible. She takes hold of her purse and picks it up, her left hip moving ever so slightly toward the table as her right shoulder blade moves in toward her spine and down toward her pelvis, counterbalancing the weight of the purse as she lifts it. Her left hip continues to move until it touches the table as she brings the purse to rest on her lap. Only then does she stop and look at me. "I don't believe it. My arm didn't hurt at all. I'm not numb any more, the aching has gone away. And that movement was so easy, so natural."*

"Do you feel how all of you participated in the motion?"

"Yes," she replies, giggling. "Finally, I won't have to lower my head to my hand to brush my hair because I won't have to worry about the pain of lifting my arm. You know, for the first time in months, I'm looking forward to brushing my hair."

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Over the years of working with a wide range of people--from a dancer who wants to improve her arabesque, to a taxi driver who wants to rid himself of back pain, to a child with cerebral palsy who wants to improve her walking--I have come to recognize a common thread in how we habitually look at the body as broken, a common problem that is conceptual rather than physical. What I have seen is that the problem of which each person complains--whether it be a lack of mobility, or discomfort and pain, or difficulty performing certain movements--usually arises *from how this person is moving,* from function rather than from malfunction. The problems my students bring to me are usually a
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Illustration 3. Her range of motion gradually increases.

result of how they are moving (and they usually haven't any idea of what they are doing to bring this about). In other words, when I observe how someone moves, what I notice is that what the student is asking me to get rid of is a **consequence** of the way she or he is moving.

This way of understanding problems in functioning does not supplant or replace medicine; instead it provides a much needed adjunct to standard diagnosis and treatment. Rather than adopting the perspective of illness, rather than looking at structure as the cause of a problem, this approach seeks to understand how a symptom, pain or impaired movement, can be correlated to how a person moves. This requires a perceptual shift: from understanding a symptom as a sign of malfunctioning to seeing pain and other problems as an indication of how the body-as-movement-system is functioning. This is a shift from a reductionistic model to a systemic one, from one-way cause and effect chain to circular mutual causality; the cause of the problem may not be a localizable malfunction but rather an unlocalized coherence of factors contributing to the person's habits of moving. This kind of problem could well be called a **system effect**, a consequence of how the body-as-movement-system is working.

Looking at the way a person moves simply as a result of physical structure and any abnormalities that may develop, makes the role of the nervous system, and therefore of learning and cognition, invisible. In diagnostic procedures, the role of the nervous system is usually considered only when there is evidence of a neurological disease, such as cerebral palsy or multiple sclerosis. Yet it is the nervous system that regulates muscle action and controls the coordination of movement.

This is particularly significant for all of us because, as human beings, we must learn how to move. The performance of all complex movements is not innate; coordinated human movement is not "pre-programmed" but rather it develops over several years of developmental maturation. Unlike a baby goat that can amble up the side of a rocky slope a few days after its birth, a human baby is not able to move about in its environment on its own so soon after birth. The growth and refinement of our movement abilities, which means the development of the nervous system's ability to coordinate movement, occupy the months and years of infancy.

As we develop, we adapt how we move to the physical, emotional, and cultural situations in which we find ourselves. How each of us moves--the flexibility and range of motion we have available, the ease with which we move through life, the refinement of action we manifest in our everyday activities--reveals the state of functioning of the nervous system and the kinds of learning we have incorporated. Looking at the wide individual variation in the ways people move and the permutations across cultures, we can conclude that what is natural about human movement is that we learn to move; that is to say, other than the constraints imposed by the blueprint of the human frame, learning is what determines how we move.[35] We move only as well as we've learned.

[35] Strangely enough, it seems to me that most children learn to move fairly well if they have an unhampered development as infants. I believe that it is the constraints imposed later by socialization into family and culture, along with adaptation to environmental structures and compensations for injuries, that account for many of the learned limitations that we experience.

This conclusion necessitates an appreciation not only of how the body is designed to move and an ability to see the body in motion, but also of how the nervous system is the guidance system of the body-as-motion-system. Without understanding how movement is guided and controlled, we cannot hope to facilitate the processes of learning and changing. Within the nature of that guidance lies a possibility for understanding what learning is and how it occurs. The next chapter introduces the basic notions necessary for understanding how the nervous system guides the body in motion and the chapter following that relates these notions to the processes that comprise learning.

Chapter Three

The Wisdom of the Body

"I you say and are proud of the word. But greater is that in which you have so little faith, your body and its great reason that does not say I, but does I."

Freidrich Nietzsche

Every movement is the consequence of the mover's intent; every action expresses an intention: walking across a room to answer the phone, sitting down on a bleacher and watching the baseball game, posing for a photograph, hitting a golf ball or a tennis ball, picking up a child, turning the steering wheel; blowing a kiss, carefully washing fine crystal; signalling someone into a parking space, dancing with joy, saying hello in sign language. At any one moment, movement fulfills at least one of many aims: changing the mover's location, maintaining the mover's position, imparting motion to an object, controlling the motion of a person or an object, or expressing a certain idea, emotion or quality.

Descriptions of movements as the action of muscles and the motion of bones miss this key factor: **the dimension of intention.** Anatomical models address only the mechanical organization of the human body in motion. While biomechanical models describe the constraints and possibilities inherent in anatomical structure, these models cannot explain how our movement is organized. A billiard ball's motion is determined by the forces acting on it, the impact of the cue stick and the effects of friction. Though human movement can be defined in terms of physics, our ability to move cannot be reduced to such simple terms. Though movement is constrained by anatomical structure, gravity, and three-dimensional space, voluntary action is not caused by some external force. In order to understand movement as a self-generated and self-regulated phenomenon, we say that the mover has a **purpose.**

The purpose of the notion of purpose is to allow us to describe an action, getting from point A to point B, without stipulating the trajectory the action took.[36] As such, purpose reflects our experience of intention: I can decide to stand up and then *just do it*, without figuring out every step along the way. Purpose serves as an explanatory device.[37] Whether movement is *really* purposive or not, is undecidable; I can only say that the description of movement as intentional is fundamental to my experience of my actions. The concept of intention is useful because purpose gives fluidity to our descriptions, allowing us to talk about an end without specifying its means.

Purpose is a cause that exists in the future, one that is driving action in the present. The purpose of a movement is the achievement of a desired state of affairs that does not yet exist. A purpose is also called an aim, a goal, a target, or a destination. Watching someone in the middle of an action, such as

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[36] Heinz von Foerster, "Cybernetics," Encyclopedia of Artificial Intelligence (Boston: John Wiley and Sons, 1987).

[37] Gregory Bateson, Steps to an Ecology of Mind (New York: Ballantine Books, 1972), pp 38-40.

walking across a room, it is impossible to determine what the purpose of the action is while the action is still in progress. As such, the purpose, the desired outcome, of a movement is invisible to the observer. It can neither be directly observed nor measured. Purpose can only be inferred to a mover by an observer or reported by its author.

Indeed, the study of purposeful activity requires its own branch of science, which is called **cybernetics.**[38] This field was named by the mathematician, Norbert Wiener, who based the name on *kybernetes*, the Greek word for "helmsman." He defined cybernetics as the science of "control and communication in the animal and the machine"[39] in recognition of the common processes that underlie all purposeful activity. Control refers to the regulation of activity necessary for any kind of system to achieve a purpose. It is only with the notion of purpose that the idea of control can make sense, because without a purpose, what is controlled? The system's regulation of activity (and achievement of a goal) requires up-to-date information about its progress toward the goal, hence the term communication. In order to apply cybernetics to the specific domain of human movement, it is necessary to first delve into the abstract workings of cybernetic thinking.

The seafaring root of the word cybernetics points to navigation as the archetypical example of the phenomenon of control. The job of the helmsman, or steersman, is to keep the ship on course; without the helmsman guiding the

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[38]Norbert Wiener, Cybernetics, 2d ed. (Cambridge: Massachusetts Institute of Technology Press, 1948).

[39]Ibid.

progress of the ship, it would never arrive at its destination. Once the journey has begun, the helmsman is charged with counteracting the various disturbances, such as the changing tides, the wind, and the weather, which can cause the ship to deviate from its course. The success of this process is dependent upon the helmsman's ability to notice any divergence from the ship's course and to perceive any disturbance that would take the ship off its route. The helmsman tracks the ship's progress by assessing the ship's location, comparing the difference between its present position and its destination. Assessing this difference not only allows the helmsman to perceive the ship's course but also makes it possible for him to effectively control the ship's course by acting to reduce, and eventually eliminate, the difference. Though the means of correcting the ship's course and the methods for determining its location changed over the centuries, navigation requires both.

Every purposeful system is analogous to the archetypical helmsman. Cybernetics formalizes the process of navigation by identifying and naming the functions that comprise it. Like the ship that has a destination, a cybernetic, or control, system has a **goal**. In order to achieve this goal, the system also must have a **sensor** that determines its present state, a **comparator** that compares the present state to the desired state of affairs (or goal), and an **effector** that is capable of altering the system's action so as to keep it on track.[40] In the example of navigation, the helmsman carries out all these functions: *sensing* the boat's location, *comparing* the boat's location to the desired destination and *effecting* the boat's progress towards the destination by changing its course.

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[40] Heinz von Foerster, "Cibernetica ed epistemologia: storia e prospettive," ed. G. Bochi and M. Ceruti, La sfida della complessita (Milano: Feltrinelli,1985): pp.112-140.

The control system compares its present state to its goal to arrive at a discrepancy. (In the example of navigation, the discrepancy is the distance from the ship's present location to its destination.) In order to achieve its purpose, the system acts to reduce, and eventually eliminate, the discrepancy. One attribute of cybernetics is that the system's present condition is due, at least in part, to its own actions. The system's previous action, or output, along with the environmental consequences of that action, becomes its next input; i.e., the result of the effector's activity is sensed by the sensor. This is a loop: the result of the system's action is sensed and compared to the goal, giving rise to the system's subsequent actions. This kind of circular, or recursive, process is called a *feedback loop.*[41]

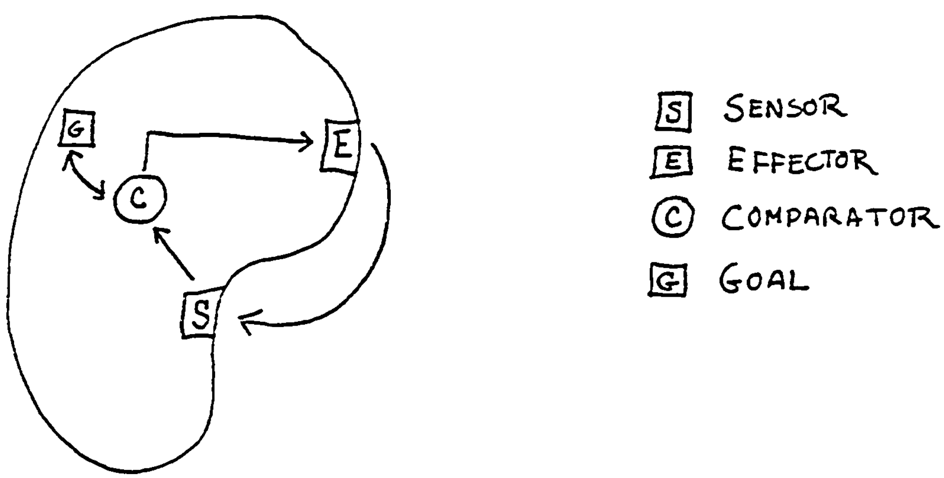

Illustration 4. Control system diagram.

[41]Wiener, Cybernetics, pp. 6-7.

If, as time goes on, the system reduces the difference between the desired and present state, the feedback loop is said to be *negative.*[42] Negative feedback establishes a loop because the error signal becomes the basis for the production of subsequent action, which is aimed at eliminating the deviation (the difference between what the sensor senses and what the goal is).[43] This loop illustrates the circularity of control systems: the system senses, compares what it senses to its goal, acts to bring itself closer to the desired state, senses again, compares again, acts again, and so on. The process of assessment and correction continues, in this recursive fashion, until the goal has been reached and there is no discrepancy.

If, on the other hand, the system increases the difference between the initial state and the subsequent states, the feedback loop is said to be *positive.*[44] Positive feedback establishes a loop because the output becomes the basis for the production of subsequent action, which is aimed at increasing the discrepancy or difference. Positive feedback is said to be deviation-amplifying[45] as compared to negative feedback, which is deviation-reducing. Whereas negative feedback narrows the system's behavior to a goal, positive feedback escalates or collapses.

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[42] Ibid., p. 96.

[43] In other words, in a negative feedback loop, more is less and less is more.

[44] Magoroh Maruyama, "The Second Cybernetics: Deviation Amplifying Mutual Casual Processes," <u>American Scientist</u> 51 (1963): pp. 164-179.

[45] In a positive feedback loop, more is more and less is less.

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Dirke is a strong, athletically built man in his early twenties. In high school, he was a champion swimmer. While finishing college, he worked as a lifeguard at the local beach. Dirke suffered a serious whiplash injury in a car accident a few months before coming to me.

"The accident happened early one morning, at the beginning of summer, as I was driving down to the beach. I stopped at a crosswalk to allow a father and his two small children to cross the street. Looking in the rearview mirror, I saw the car behind me hadn't slowed down and was fast approaching my car. I can remember thinking it through . . . if I moved the car, the pedestrians would be injured, but if I didn't move, I would be hit. I froze. I can still remember watching the car zoom towards me in the mirror. And then I remember hearing the impact; there was a loud thud followed by a crunching sound that seemed to last for several minutes. I was thrown backward, against the seat and headrest." Dirke's eyes defocus as he recounts the story of the accident and his body shudders as he describes the impact.

He pauses before continuing, "I can't turn my head very far without discomfort. And my head aches constantly, right at the top of my neck and, here, in the back of my skull. Sometimes the ache travels over the top of my head and even the back of my eyes start to hurt. My neck and my upper back have been stiff since the day of the accident. I can't swim at all. The worse part isn't just that I didn't make any money this summer for next semester's tuition. The worst
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part is that I just can't do what I enjoy the most . . . This tightness is so damn persistent. It just won't go away. I feel as if I've lost control of my body. It just doesn't respond to me any more . . ."

I am so caught up in Dirke's frustration that it takes a few moments before I can begin to speak. The tightness in his upper back and neck muscles is due to a reflexive spasm. The explanation for his problem runs through my mind: this kind of stiffness is caused by spasms known as muscular splinting. Splinting is a very common response to injuries, acting as the nervous system's automatic self-protection device. After an injury, splinting prevents the body from further damage by immobilizing the injured area.

After I explain the nature of the spasms, Dirke asks, "Why are the spasms still happening?"

"I don't really know. My best guess is that you are still engaged, unconsciously, in protecting yourself. It's like you're caught in a moment of time, the moment of the accident. It's as if you're still protecting yourself because, somehow, you don't know that the danger has passed."

"One of my friends told me that this problem was caused by muscle memory. Is that what you mean? Are you saying my muscles remember the trauma of accident?"

"No, muscles don't remember. They don't remember or tighten or even relax on their own. They can't. Muscles are stupid. Muscle activity isn't individual or independent, it's controlled by your nervous system."

"That would mean something is going on with my nervous system that I'm not controlling. But, I'm not keeping my upper back tight on purpose; I can't get rid of the stiffness even if I try. How come it won't let go?"

"Your muscles tightened up automatically at the time of the accident to protect you. When you tried to move your neck after the accident, the pain got worse because you pulled against spasmed muscles. The already tight muscles automatically tightened more to protect you from further injury."

"But after the accident, even if I tried to stretch those muscles, I hurt. In fact, the more I tried to move, the more I hurt. And the more I hurt, the tenser I became. No matter what I do to stretch those muscles, I seem to only get more tense."

"You're discovering what has been called the ***pain-tension cycle,*** *" I say as I draw a picture on my notepad:*

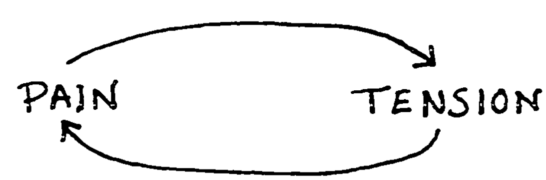

Illustration 5. The pain-tension cycle.

and go on to explain, "An increase in pain leads to increased tension. Increase in tension leads to increase in pain. And so it goes, round and round. It's a vicious circle."

"When does the cycle stop?"

"That's hard to say. Often the pain and tension go away once the physical trauma has healed. Unfortunately, this isn't necessarily the case. Sometimes, it can take months, even years, for this kind of spasm to go away. I think of it as an example of one of the problematic consequences of human learning. As is the case with phobias, one brief event makes an impression that lasts for a long time."

"What can I do to stop my pain from chasing its own tail?"

I explain to Dirke that the only way to stop the pain is to break the cycle. Even the slightest increase in pain or tension can initiate the whole cycle again. Standard approaches to chronic problems try to break the cycle by either getting rid of the pain or reducing the tension. That's why pain killers and muscle relaxants, on the one hand, and massage and manipulation, on the other, often work. The pain-tension cycle is an example of a positive feedback loop.

In Dirke's case, as in many others, the chronic pain seems directly related to an unconscious splinting response. He is unable to voluntarily control the upper back and neck muscles, which are engaged in the reflexive spasming that underlies the pain-tension loop. Rather than treating either the pain or the tension, in and of themselves, the various approaches to movement education, *such as the Feldenkrais Method, address regaining voluntary control of chronically contracted muscles.*

I ask Dirke, "How about if you could become aware of what you're doing with your upper back and neck? What if, even as we speak, you could regain the option of conscious control of those muscles that are so tense and so uncomfortable?"

"I've already tried to stretch out those muscles. And I've also tried to relax them. Nothing seems to work."

I begin to tell Dirke about Moshe and about how the Feldenkrais Method came to be. I talk to him about Moshe's experiences learning Judo as well as about his studying the Alexander Technique and other movement education approaches, saying, "In Judo, in Alexander's work, in every successful approach to movement learning, the theme of awareness keeps surfacing. Each of us moves, often unaware of exactly how we move, only aware that we have moved."

"Many of us," I tell Dirke, "are asleep to how we move. Moving is like driving home late at night when you're very tired. Sometimes you pull in the driveway and you realize that you can't remember anything that happened from the instant you got off the highway to the moment you got home. There are no branches on the bumper, no bloodstains on the car. You obviously made it home alright, but you have no idea, no recollection, of exactly how you did it. It's like you had the automatic pilot on.

"Moving is analogous: you get where you're going with very little, if any, idea of how you got there." I pause for a moment to allow Dirke to contemplate what I've been saying before I continue, "The point is that **without refining your sensory perception, without an awareness of how you move, you can't control how you navigate through the world."**

"The first step is to notice exactly what is going on. Here, use this hand mirror and look at how you're standing in the wall mirror over there."

Dirke takes the small mirror and stands in front of the wall mirror. After a few moments of adjusting the mirror and his position, he tells me that he can see his head is thrust back, behind his shoulders. He says, "My upper body looks like it's arching backwards. I guess I see my whole upper body leaning backwards."

"Are you standing up straight?"

"Well, that question is a bit complicated. If you had asked me before I looked in the mirror, I would have said yes. Looking in the mirror now, I can see that I'm not. But I still feel as though I am."

"Do you notice how your chin is tilted up a bit?"

"Yes."

Touching Dirke gently with my hand, I ask, "And can you feel how the muscles all along the back of your neck and upper back are very stiff? Good. Do you also feel how the muscles between your shoulders are so tight? And can *you feel how tight your abdominal muscles and the muscles in the front of your thighs are?"*

"Yes. I wasn't even aware that all those places were tight until you directed my attention to them. I mostly felt the tightness and discomfort in my neck. Now I can sense how tight my other muscles are . . . My whole body is involved in this, isn't it? It seems strange that I didn't notice how tight I was before you touched me."

"It's not that strange. The nervous system is known to adapt to constant perturbations. After a sensation is constant for a while it fades from your awareness. For example, a short time after you dress in the morning you stop feeling your clothes touching your skin. Otherwise you would be constantly aware of your clothes, and other similar long standing sensations, continuously. As we used to say in the small town I grew up in, you don't smell the manure on the farm."

"You know, it's interesting, looking in the mirror and talking about what I see. It looks sort of like I'm stuck in the position of the whiplash."

"That's exactly what it looks like," I say, nodding in agreement. When Dirke first walked into my office, I noticed that his head was locked in the thrust back position so common with people who have been in whiplash accidents. I'm glad Dirke noticed this on his own. Though post-traumatic holding patterns are often directly pointed out to people, I'm wary of doing this and leading students to feel all the more victimized by what "the accident did" to them. I've found that it is better to help students notice these configurations on their own, in the

context of finding out what they were previously unaware of, and then learning what can be done.

"Would you like to find out what happens if you stand up straight?" I ask.

"Yes, but I'm not sure I can," replies Dirke as he struggles to stand more erect.

"Let me help you," I say. Using my hands to provide gentle hints of how to rearrange himself--sliding his shoulder blades slightly away from his spine, dropping his breastbone toward his pelvis, lowering his chin toward his chest, and so on--I assist Dirke in finding a more vertical standing position.

As Dirke strains to maintain this placement, I can see that he's holding his breath and that the muscles around his jaw are clenched. He looks at me and says, "This is very uncomfortable; I feel like I'm falling forward now."

He stops straining and returns to his former position. "You know, though I know this isn't good posture, it feels much more comfortable than that position you put me in. Even though I know that it looks like I'm leaning back and even though I can feel that most of my weight is on my heels, it still feels like this arched position is vertical. What's throwing me off so much?"

"Here, bend forward, very gently, and move in the direction of touching your toes. Slowly. Allow yourself to keep breathing while you move. And don't strain. That's it, go only as far as is comfortable."

Illustration 6. Dirke bending forward.

"Damn, I can't even touch my ankles," he complains as his hands reach just below his knees. "You know, before the accident I could put my palms on the floor! Do you think if I keep stretching, even though it hurts, that I'll be able to stretch out my muscles? I don't care if it hurts as long as I get better."

"I doubt that it would help. You see, the "No pain, no gain" approach would just make you try harder. But the harder you try, the more it will hurt. The more it hurts, the tenser those muscles become. The tenser the muscles become, the more difficult the movement becomes. Therefore, the harder you try, the less likely you are to succeed."

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In The Wisdom of the Body, the book from which the title of this chapter was borrowed, Walter Cannon discussed how human physiology can be understood as utilizing various kinds of error-correcting processes. The survival of each of our bodies depends on its ability to maintain certain variables--the body's temperature, the amount of oxygen in the blood, the underlying contraction of muscles and so on--within very narrow ranges. Cannon recognized that this constancy was due to an ongoing process, a process that counteracts any perturbations affecting these variables. He called this process *homeostasis.*

At first glance, such homeostatic processes may seem a peculiar example of cybernetic processes. How does the human body's ability to maintain a relatively constant body temperature resemble the prototypical
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example of navigation? These two seem very different: navigation has to do with getting somewhere, while homeostatic temperature regulation has to do with maintaining constancy, with staying somewhere.

The body acts to maintain temperature within a certain narrow range by counteracting various perturbations and disturbances. This narrow range is the system's goal. The body maintains its temperature around 98.6° Fahrenheit, continually making adjustments for changes in metabolism, physical activity, and external temperature. The physiological process that regulates body temperature has all the functional components of a control system: sensors in the skin, spinal cord, viscera, and brain, a comparator in the hypothalamus, and a complex network of effectors, which not only includes the autonomic, endocrine, and non-voluntary skeletal muscles but also includes voluntary behavior.[46] Therefore, homeostasis is a special case of negative feedback control. Temperature control, taken as a homeostatic process, illustrates how maintaining constancy in a control system is an *activity.*

The level of underlying muscle contraction, called *muscle tonus*, is controlled by a similar, homeostatic process. The central nervous system--the brain and the spinal cord--regulates muscle tone by way of a reflex known as the *myotactic*--or *stretch--reflex*. Muscle spasms are at the extreme range of muscle contraction, maintained by the same process that regulates the body's low level of normal tonus. Perhaps an understanding of the homeostasis of muscle tone will provide a clue to the rationale behind my response to Dirke's

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[46]Kandel and Schwartz, Principles of Neural Science, pp. 451-453.

spasms. The nervous system's control of the muscle activity, and the processes of communication between sensor and effector that underlie that control, must be understood in order to comprehend the maintenance of muscle tonus. Can this explanation be accomplished by applying the formal terms of cybernetics to movement? Obviously, muscles are the engines, the effectors, of movement. But how are the effectors controlled? Where is the sensor? The comparator? What is the goal?

Muscles consist of bundles of two different types of muscle fibers. What we normally think of as muscle is called *extrafusal muscle.* This muscle is the workhorse, providing the contractile power of muscles for the movement and stabilization of bones. The total potential strength of a muscle is directly proportional to the cross section of the muscle, that is to say, strength is proportional to the muscle's thickness. The actual strength of any particular muscular contraction is due solely to the number of extrafusal muscle fibers contracting and the frequency of their contraction. The extrafusal muscle is the effector, not the sensor.

Another kind of fiber, called the *intrafusal muscle fiber,* acts as the sensor. The intrafusal fiber, which is also called the *muscle spindle,* lies in parallel with the extrafusal fiber and contains receptors that are sensitive to stretch. (Receptors in the tendons, called *Golgi tendon organs,* and receptors in the skin also respond to stretch and influence muscle tone.) Though the spindle cannot contract with the same force as the extrafusal fiber, it does contract enough to be able to match the extrafusal muscle's changes in length. The separation of sensor and effector is a central feature of the neurological control mechanism of muscle tonus.

When the central nervous system sets a certain level of muscle tone as a goal, it signals the muscle to contract, simultaneously activating the extrafusal muscle and the intrafusal muscles. Co-activation allows the nervous system to monitor and control the length of the extrafusal muscle by comparing the length of the extrafusal and spindle fibers. The spindle adjusts its length to maintain its sensitivity over a wide range of extrafusal length. The spindle's length sets the sensitivity of the sensor in the control of muscle tonus.

The physical difference in the length of the two kinds of fiber provides the comparison that makes this control possible. If the muscle spindle is shorter than the extrafusal muscle it is parallel to, it is stretched. (This stretch is known as **loading** the muscle spindle.) The spindle responds to the stretch, sending a signal that loops, via the spinal cord, back to the extrafusal fiber and causes it to contract. If, on the other hand, the spindle is longer than the extrafusal muscle, there is no stretch on the spindle fiber. In order for the spindle to be loaded, the extrafusal muscle would have to decontract. A sudden or unexpected perturbation, such as the tap of the doctor's rubber hammer below the kneecap, elicits the *phasic* component of the stretch reflex. The tap of the reflex hammer stretches the quadriceps muscles on the front of the thigh and, due to the control loop, the muscles then reflexively contract, making the lower leg jerk forward. The slower, *tonic* component of the reflex is less intense but

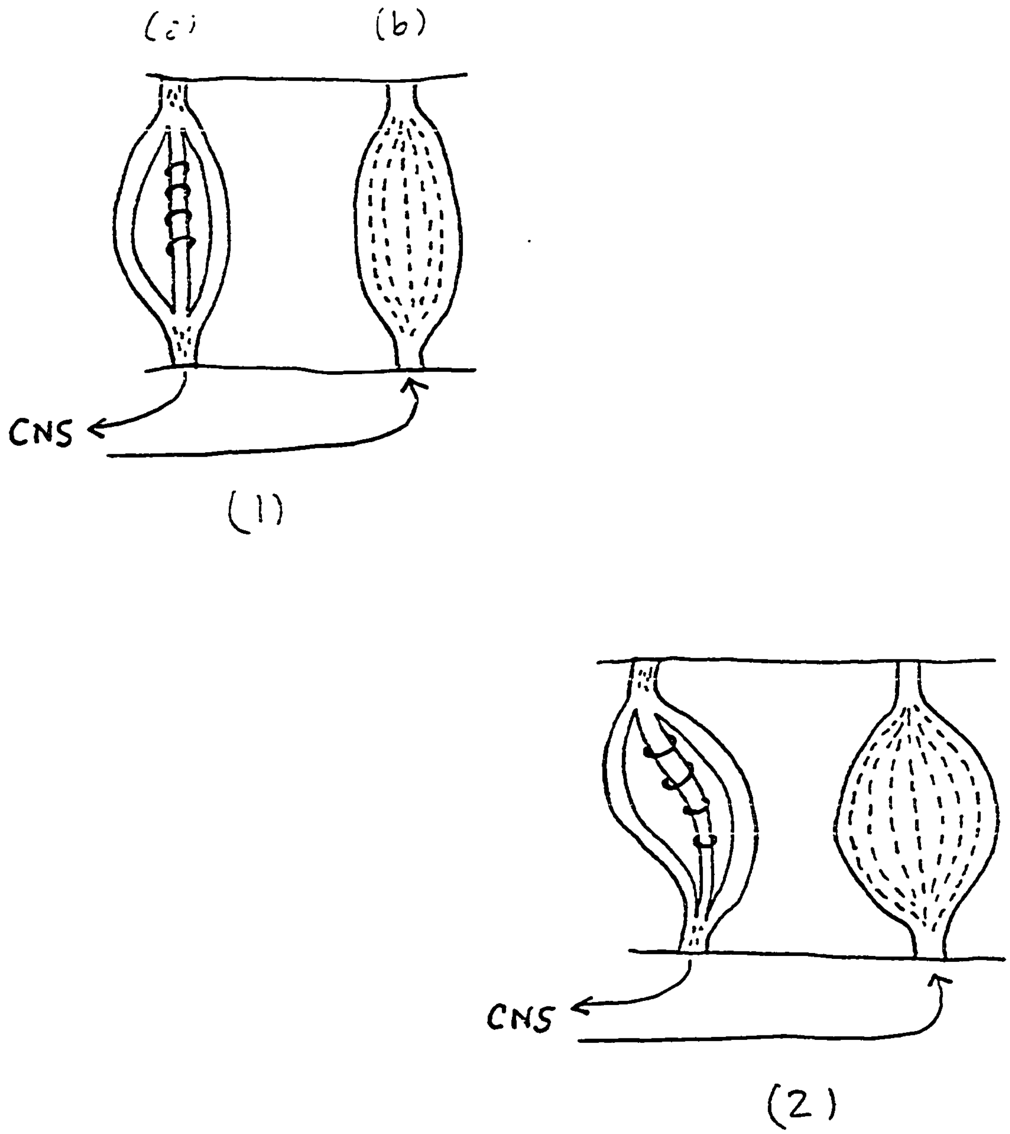

Illustration 7. (1) When the muscle spindle (a) is stretched, it fires. The central nervous system then signals the extrafusal muscle (b) to contract.

(2) When the extrafusal muscle contracts, the spindle becomes lax and stops firing.

lasts longer; it is thought to play a role in the maintenance of posture.[47] It is important to note that while the stretch reflex responds to the *stretch* of the spindle, it functions to control the *length* of the extrafusal muscle. It can therefore play a role in the maintenance and regulation of a specific configuration of a joint or group of joints even as the body assumes different orientations in space and participates in various activities.

The stretch reflex illustrates the circular functioning of the *sensory-motor loop*. A stretch of the muscle spindle causes a change in the activity of the spindle receptor, the sensory component. This leads to a change in the activity of extrafusal muscle, the motor component, which subsequently leads to a change in the activity of the sensory component. When Dirke tried to no avail to stretch his tight muscles, he experienced the tenacity of the stretch reflex and the efficiency of the sensory-motor loop. The recursive nature of this process mirrors the circularity of assessing and adjusting that underlies all navigation, all purposive behavior.

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I ask Dirke to gently reach for his toes again. As he bends forward, I touch the muscles along his spine and ask, "Do you notice how tight these muscles are?"

"Yes."

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[47] Ibid., pp. 299-303.
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"Even when you bend forward the muscles of your back stay stiff and contracted. Stand up again . . . The muscles, here, along the back of the spine," I say as I run my hand along Dirke's back, "are called extensor muscles and they arch the spine backward when they contract. Now the muscles in your abdomen and in front of the spine are called flexors and they round the spine. If all the flexors contract at the same time, the back rounds and the body assumes a fetal position. If all the extensors contract at the same time, the back arches, like the cobra position in Yoga. If both the flexors and the extensors co-contract, the back is held rigid."

"Then, my upper back muscles shouldn't be staying tight when I go to touch my toes, should they?"

"Not if the purpose of the movement is to reach your toes."

"If I'm following your explanation, you're saying that my back muscles are involved in arching even though I'm trying to round my back. That means my muscles are actually trying to round and arch my back simultaneously. Is that right?"

"Exactly."

To help him further understand the significance of what he had just grasped, I explain a basic idea from neurophysiology. "To touch your fingers to your toes, the extensor muscles must let go so they can lengthen. The work of the muscles in front of the spine, the flexors, and that of the extensors is *coordinated by a neurological phenomenon called* ***reciprocal inhibition****. This reflex is designed to allow for the cooperative action of opposing muscles."*

"To demonstrate this," I continue, "hold your arm, either arm, up. Put the back of your hand against the wall and, while keeping your arm almost straight, gently push the back of that hand against the wall. Notice how the triceps, the muscle on the back of the upper arm, the one which straightens the elbow, hardens and bulges. Meanwhile the biceps, the muscle here in the front of the arm, remain relaxed. The complementary action can be demonstrated by holding onto a doorway, with that same hand facing toward your face and your arm partially bent. Yes, that's it, not straight but not bent all the way either. Keep your body still and attempt to bend your arm further. Now the biceps muscles, the flexor of the elbow, contracts and the action of the triceps is inhibited."

"That's just what ***isn't*** *happening in my back? What's wrong with my back?"*

"There's nothing wrong with your back. *This cooperative action does not, necessarily, have to occur. There are other neuromuscular patterns besides reciprocal inhibition, other ways that your nervous system can organize the activity of your muscles. One other way of organizing muscle activity is called co-contraction. It can be demonstrated when you "make a muscle" with your biceps. In that instance, the triceps muscle contracts at the same time as the biceps. This co-contraction stabilizes the elbow and provides the resistance against which the biceps can tighten. The biceps and triceps are then engaged in competitive activity, working against one another. This is exactly like what's*

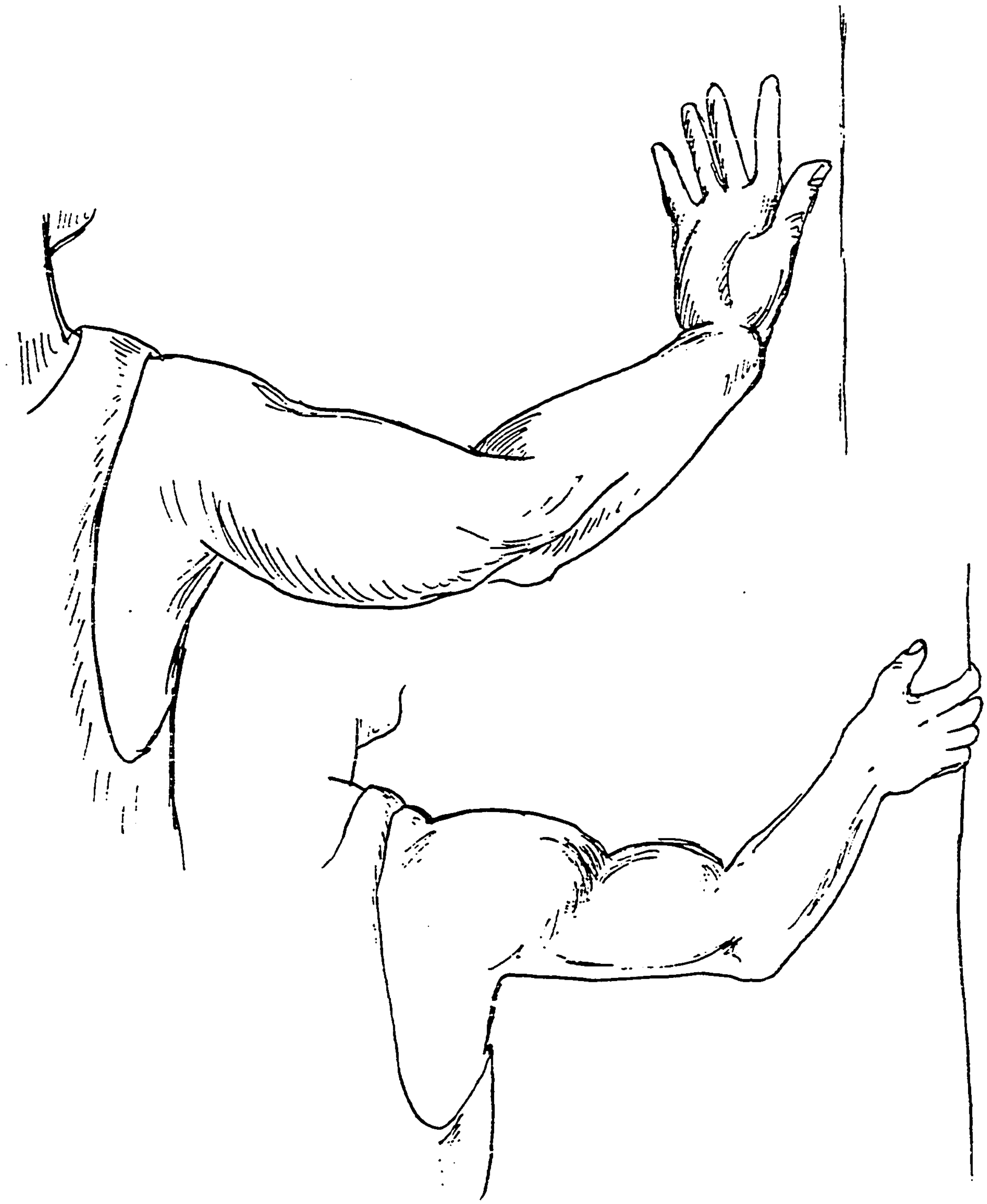

Illustration 8. Demonstrating reciprocal inhibition by pushing against the wall and pulling on the doorframe.

happening with your back: the muscles in the front and back of your spine are co-contracting and keeping your upper back stiff."

"So I'm actively interfering with my flexibility and range of motion. I keep trying to move my back while, somehow, I'm simultaneously keeping it still. Now I can you see why you said that trying harder wouldn't help. But what can I do to get these muscles to let go, to get my back to be able to move again?"

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Our ability to perform various movements, whether relatively simple reflex activity or complex fine motor coordination, can be understood as being regulated by the negative feedback of the sensory-motor loop. In his early studies, Wiener recognized the application of cybernetics, in general, and the notion of feedback, in particular, to movement. In Cybernetics, he wrote:

> "When we desire a motion to follow a given pattern the difference between this pattern and the actually performed motion is used as a new input to cause the part regulated to move in such a way as to bring its motion closer to that given by the pattern."[48]

Wiener illustrates the importance of feedback in the control of motion by referring to the clinical example of *tabes dorsalis*. *Tabes dorsalis* is a syphilitic infection of the central nervous system, now relatively rare. It causes *ataxia*, a neurological condition characterized by a staggering, wavering kind of motion. Ataxia is due to the difficulty of guiding movement in a condition where infection has greatly diminished or completely destroyed the kinesthetic sense conveyed

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[48]Wiener, Cybernetics, pp. 95-96.
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by the spinal nerves. When attempting to voluntarily pick up a book or pencil, a person who has ataxia overshoots the mark. This person *sees* the movement missing its goal and initiates a feedback in the other direction to attempt a correction. The motion overshoots further and the person goes into uncontrollable oscillation (or "*hunting*").

Although the control of the motion of reaching, or any other movement, can be modeled as a system with a single feedback loop, the complexity of the nervous system's coordination of motion can take many levels of feedback.[49] Control is constituted by feedback loops that are nested, one within another, such that the activity of one loop can govern others. For example, spinal reflexes coordinate many, potentially conflicting, muscular activities including the maintenance of tonus, reciprocal contraction and release, and activation of synergistic muscles. Recent experimental evidence suggests that perhaps even complex locomotor activities, such as walking, may be controlled by spinal reflexes[50]. Spinal reflexes can cause the musculature to assume and maintain severe spasticity or flaccidness. For example, in individuals with injuries to the spinal cord there is no mediation from the various control centers of the brain and spasticity results. It is the activity of the cerebellum, the motor cortex, and other parts of the brain that controls these spinal reflexes, activating and inhibiting them in order to carry out a specific motion or maintain a certain position.

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[49] William T. Powers, Behavior: The Control of Perception (Chicago: Aldine, 1973).

[50] Yakov Mikhailovich Kots, The Organization of Voluntary Movement (New York, Plenum Press, 1977), pp. 181-229 and Kandel and Schwartz, Principles of Neural Science, pp. 316-321.

Between intention and action, the organization of the nervous system allows for multiple, partially overlapping circuits of control. As Dirke's case illustrates, the control of movement does not require that we consciously attend to sensory information or the actual movement in order to be able to perform a motion. It is enough, often, simply to choose a destination and the body then seems to reach that destination on its own. Since the volitional control of bodily processes is only partial, this automaticity is quite beneficial. To the relief of many a mother, it is impossible, no matter how determined or angry a child may be, for her or him to commit suicide by refusing to breathe and intentionally holding the breath. At some point the child will faint and begin to breathe automatically. For breathing, and other physiological movements as well, conscious control is neither necessary nor absolute.

The strangest thing about human movement is this dual nature: the voluntariness and automaticity of movement. When we become expert at a specific action or motion, we can do it without paying attention to it, without even knowing exactly how we do it. We become habituated to an action when it is learned, whether it was learned in an instant or after many years of practice. Whichever, this activity is now a skill and is something that is known, like a dear friend's phone number. It happens without our attending to it and continues to occur after it is no longer necessary; when the friend moves, the intention leads to the learned behavior, dialing the old number, and so the whole action must be relearned.[51] What has become automatic is often difficult to explain, or to even pay attention to. So the control of movement is only somewhat conscious at any one given moment.

Since the muscles are the final common pathway for all movement - related nerve impulses, the control of movement is constrained at the effectors, which act as a bottleneck. Outgoing signals from every region of the nervous system ultimately converge on the same, limited, set of effectors. But muscle activity is such that certain actions cannot co-occur: the elbow cannot bend and straighten at the same time. The complementarity of muscle action is due to both anatomical constraints (muscles engaged in holding the body in a certain configuration are not available to participate in movement) and neurological ones (muscles engaged in one activity will counteract an opposing activity). This was clearly illustrated in the case study in the previous chapter where the muscles of Agnes' shoulder girdle were being kept so tight that they interfered with the movement of her shoulder blade. Given potentially conflicting purposes and the constraint of the effectors, conscious intention does not necessarily control movement.

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"Now please lie down on the table, on your back." Once Dirke is on the table, I ask him to pay attention to how his body makes contact with the table's

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[51] A similar phenomenon occurs when using a rotary phone rather than one with push buttons: the number may have been memorized based on the pattern on the keyboard and cannot be recalled.
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surface. "Do you notice how you're lying on the table? Can you tell how arched your upper back is?"

"Now that you ask, I can feel that my upper back, between my shoulder blades, is lifted away from the table. I'm also feeling a lot of pressure under the back of my head."

"Okay. Now, very gently, without straining, try to flatten your back against the table. What happens?"

Dirke grimaces, saying, "It takes considerable effort to bring my back down, and it hurts." He sighs and stops making an effort. As soon as he stops pressing, his upper back pops up and returns to its previous arched position.

I begin to touch Dirke, pointing out that this arched position is the same configuration that he noticed when he was looking in the mirror. "Even when you're lying down, and the table is there to support you, you hold yourself up, off the table, maintaining this extraneous muscle contraction."

I place my hands under his raised back, touching the tight muscles so he can identify exactly where the contractions are. His upper back, shoulder and neck muscles, and the surrounding tissue feel very dense and contracted. In some places my fingers find tiny kernels of tension; in others, I discover large knots. Trying gently to move his shoulder or roll his head, the rigidity I had seen in Dirke's movement becomes palpable.

Continuing to touch Dirke, I begin to gently take over the work of these muscles, providing just enough force to hold him in the arched position. I *approach the arch of his upper back from different angles: holding the left shoulder and then the right, gently putting both of my hands under his neck for a few minutes, then lifting his head ever so slightly, and finally sliding my hand behind his upper ribcage to lift there. Each place I touch, I lift until Dirke releases the weight of that part of his body into my hands.*

Dirke sighs and begins to breathe more easily. After a few minutes, he asks, "You're touching me so gently and it's having such a powerful effect. How does this happen?"

"I'm taking over the work of the muscles that are holding you stiff. If I start providing the work that holds you in the position you're stuck in, the work of those muscles becomes superfluous. Your nervous system senses this and the muscles stop contracting."

"It feels like you're doing the opposite of stretching."

"Exactly. This is a ***No pain, More gain*** *approach."*

While I continue to touch and move Dirke, I talk to him about Moshe again, saying, "Moshe adopted one of the principles of the gentle martial arts and adapted it to teaching movement. Moshe talked about how Judo teaches that instead of fighting someone's attack, you go with it. If you struggle with your opponent's attack, the attack only becomes more earnest and you become engaged in a battle of strength. If, rather than confronting the force of the attack or resisting it, you utilize the attack then you can take over the attacker's momentum and gain control. Moshe realized that there was a similarity in what *happens with muscle tightness. Because of the stretch reflex, the more you fight a contraction, the more it resists being stretched. So instead of fighting what your muscles are doing, I help them. Since there is no resistance, they can let go."*

I notice that Dirke's upper back is still slightly raised. I begin to lift it with my left hand while applying very slight pressure on his breastbone with my right hand, directing the pressure in the direction of his feet, taking over the little bit of lifting that remains. As I touch his breastbone and chest in various places, I feel his back begin to lower onto my fingers. Since his back is still somewhat elevated, I ask Dirke to purposefully raise and hold it for a few moments. I then ask him to let his back return to my fingers. As I guide Dirke to hold and release his back from various places, he begins to let go of the last little bit of tightening. With my left hand on his forehead, I start to gently roll Dirke's head slowly from side to side. His shoulders are no longer held with tension; his upper spine can respond to my touch with easy movement.

"My neck feels so much better; it doesn't hurt anymore."

"Feel how your back is now resting more fully on the table?" After Dirke nods a yes, I ask him, "Do you remember the position you were in when we started, about a half hour ago?"

"Definitely."

"Please go back to that position."

"Do I have to?"

"Of course not. But please do arch your back again, on purpose. This is an important part of learning, to be able to contract those muscles intentionally is necessary if you want to get rid of the tightness and regain control of your muscles."

"Alright."

"Do you feel how much work you're doing to hold that position?"

"Yes . . . it's very uncomfortable. Can I let go now?"

"Certainly. Now you can feel all the work you were doing before; it's no longer an unconscious spasm. You can stiffen your back on purpose and let it go on purpose. Before, you couldn't even feel that you were contracting those muscles, you just knew they were tight because you couldn't move and they hurt. Now you know what was happening because you have a comparison between holding your back tight and letting it go. With that comparison, and the awareness that comes with it, you've regained conscious control of your upper back."

Dirke slowly stands up. After a few quiet moments, he turns to me and says, "That's quite an improvement. I can still feel some tightness but the pain is almost gone; I mean, it doesn't hurt like it did before. And I feel so much taller." He looks in the mirror, exclaiming, "I can hardly believe it; I'm standing up straight."

Illustration 9. Gently rolling Dirke's head.

"Are you ready to bend forward and reach for your toes? Okay, just go very slowly, without forcing. That's it, very gently."

Dirke slowly curls down, his finger tips just touching his toenails. He gently comes back up to standing, "That's a lot better. I can feel a bit of tightness in my upper back but, overall, I feel a lot better. Will I be able to keep this improvement?"

"Yes, of course. However, after the first lesson, you probably won't keep all the improvement. What you have is a feeling and, like all other feelings, it will change. The important thing is not to be able to keep a feeling, but being able to keep finding a feeling."

"How do I find it?"

"This is just the first lesson. I like to call the first lesson the "possibility lesson" because it's about finding out that it is possible to feel different. Until you know that how you feel can change, it's useless to try to convince you that it can. Before this lesson, you were very frustrated that nothing you had tried had worked, right? Now that you know your situation is changeable, we can address the question of how you are going to learn to do this, to find this difference, on your own."

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This case study illustrates an important consequence of any self-regulating activity: as soon as a system defines certain kinds of reference,
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everything changes around it. Whether the reference is a constant to be maintained or a goal to attain, it becomes the axis around which the activity of the system revolves. That is to say, certain references or goals become dominant and other aspects of the system's functioning become subordinate. This phenomenon is observable after an injury or accident when the nervous system adapts by making adjustments in movements to avoid pain and, whenever possible, by compensating for limitations in mobility in one place by relying on motion someplace else.

Thus this kind of automatic response, such as Dirke's and Patrick's muscular splinting, has an overriding influence on movement, interfering with voluntary control of movement and with the pathway of motion along kinematic linkages. These protective habits are a form of powerful, primitive learning that affect our abilities to move and to sense ourselves in motion.

For example, Dirke felt like "his body" was doing one thing, as if on its own, while he was trying to do another. Not only was his movement very restricted, but Dirke also demonstrated a considerable, though not uncommon, lack of awareness of what he was doing. *He was inarticulate.* Because he could neither voluntarily move nor say what was causing the immobility, Dirke couldn't articulate himself in words or action. His voluntary intention was being countermanded by this reflex pattern of muscle contraction, which led to immobility.

Dirke only noticed the consequences of this spasm; he did not perceive the configuration that caused the immobility and pain. It is this sensory distortion, this lack of awareness, which is so central to the ongoing nature of Dirke's problem. Without awareness of this pattern of tightness, his perception was unreliable and he lacked voluntary control of his movement. As Feldenkrais was fond of saying, "*If you don't know what you're doing, you can't do what you want.*"[52] In terms of the cybernetic model that I've introduced in this chapter, it is easy to understand that the control of movement depends on the sensory-motor loop and the ability to compare what is sensed with what is desired. Without sensory perception of what is happening, comparison is impossible and the ability to voluntarily control movement is unavailable.

As long as the student has no idea what is being carried out automatically, and is only aware of the consequences, voluntary control is impossible. In the case study it is easy to see that as long as the spasm continued, Dirke's sensory experience would be distorted and he would not have control of the movements of his back. Until he could distinguish between having his upper back relaxed and keeping it arched, he did not have any control of what was happening. But until the spasm stopped, he could not feel exactly what he was doing; not feeling it, he could not control it.

Voluntary control--the ability to choose--is based on comparison and comparison is based on the ability to perceive a difference. Notice that choice presupposes a distinction; without a difference, there is no choice. But where does this difference come from? If stretch (or any other intervention that

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[52]Moshe Feldenkrais, Amherst Training Videotapes (New York: Feldenkrais Foundation, 1983).

attempts to counter what is happening) is perceived by the sensory-motor system as a disturbance to be counteracted, how does a change come about?

In order to break a cycle of pain and tension, we must interrupt the process of habituation. The habituation I am speaking of here is complicated because it includes two levels of adaptation. To explain this notion of second order habituation, let me start with an example from the visual system: the experience of brightness. The neuromuscular system of the eye acts to maintain the amount of light reaching the sensors of the retina within an optimal range. If too little light is present, then color vision is impaired and if too much light is present, the sensors responsible for vision, the rods and cones of the retina, are endangered. The amount of light is regulated by contracting or relaxing the circular ciliary muscles of the iris.

If you look around for a moment, you will be able to ascertain the amount of light, the brightness, of your surroundings. How do you do that? If the iris contracts or relaxes to keep the amount of light entering the eye more or less constant, how can you tell how bright it is? Because there is a second loop, the sensor of which senses the activity of the effector in the first loop, the ciliary muscles. Therefore, your experience of brightness arises in part because you're sensing the efforts in the ciliary muscles that keep the amount of light hitting the retina at a constant.[53]

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[53]Heinz von Foerster, "Experiencing Brightness," The Cybernetician 4, (February, 1974): 36-38.

Now to return to the domain of movement and kinesthesia. Assume you are holding this book in a certain position in space and that you wish to continue doing so. Let's say that I place a second book on top of the one that you are holding and you manage to keep both books in the same place. You can feel how much heavier the two books are than the one book was alone. How is this possible? Your arm and shoulder muscles contract to keep the book in the same place, involved in the kind of interaction between extrafusal muscles and spindles that I described earlier. This system functions to maintain a constant length and can only report whether the spindle is being stretched or not. Adjusting the amount of effort to compensate for the second book is analogous to the iris adjusting the opening of the eye to compensate for increased brightness; the sensation of weight and of brightness are similar in that they are second order experiences. To sense increased weight, you must sense increased effort. To sense effort, you must rely on second order sensors, which report the activity of the spindles.

Thus the case study presents an example of second order habituation: not only is Dirke habitually maintaining the muscles of his upper back at a constant length but he has habituated to those muscles constantly working. The second order sensors were not working--not letting him know how tight his muscles were--because they were adapted to the constant effort and the sensation had therefore disappeared. The simple strategy of going along with how Dirke was unconsciously holding himself, by supporting him in the over-arched position, took the strain off the muscle spindles. The muscle spindles stopped contracting and the extrafusal muscle could then stop contracting. This changed the signal to the second order sensors, eliminating the error signal that drove the sensory-motor loop and that had kept the muscles spastic. Thus Dirke could begin to notice where he was working and how much he was working, and with that awareness came the possibility of no longer continuing the tightness.

While this explanation elucidates the process by which Dirke could get his chronically shortened back muscles to lengthen, it leads to intriguing questions and notions about the nature of perception, in general, and kinesthesia, in particular. Our perceptions seem to be rather unreliable, especially when sensing ourselves and our movement. This is challenging to any simplistic notions that what you and I feel is what ***is***. The cybernetic explanation of movement as controlled by the sensory-motor loop requires further investigation of the sensory component, of perception. The following chapter delves into this topic.

Chapter Four

Perception as Action

"By my body's action, teach my mind."

William Shakespeare

During a movement lesson, many changes occur. The overall level of muscle contraction throughout the student's body decreases and equalizes. Muscles which moments ago were tight become relaxed. A shoulder or hip, once contorted and rigid, untwists and becomes moveable. A back that resisted any effort to stretch, or a spastic arm that simply wouldn't bend, each somehow yield to gentle touching.

These changes are palpable and observable. Hardened muscle softens, the range of motion of a joint measurably increases, the path of force through the skeleton changes, and movement becomes smoother, easier, more continuous. Yet no matter how dramatic a lesson may look, what is most noticeable for the student is how these changes **feel**.

After his lesson, Dirke finds himself more flexible and mobile, able to intentionally release his formerly spastic back muscles. Agnes says that she not only regained the movement of her shoulder but that she felt as if she had *regained her shoulder.* In each case, the person not only increases movement and decreases pain, but he or she also learns to make sense out of the experience of moving, to articulate movement, in a new way. Prior to the lesson, Dirke and the others were not aware of how they were moving. Each had some aspect of motion that had become habituated and was no longer under voluntary control. During the lesson, each student learned to make new kinesthetic distinctions. With this enriched kinesthetic awareness, they gained choices about how they move, choices they simply did not have before the lesson.

There are many ways to describe what changes during a lesson: in terms of anatomy, kinesiology, or kinesthetic experience. Yet any third-person description of behavioral or perceptual changes can miss one crucial aspect; if movement is intentional, then it is *the student's ability to carry out an intention that changes.* To understand how this change comes about, we must return to the sensory-motor loop and an examination of the role that perception plays in the coordination of movement.

After working with students who can no longer perform what I used to consider simple movements--such as opening a door, buttoning a shirt, or walking down the street--I have come to appreciate the precision of my ability to act intentionally. What if, for instance, I were to stop writing for a few moments to take a sip of tea? The ability to carry out an intention can, ideally, be so very precise: I reach for the cup without passing it by entirely and, usually, I grasp it without knocking it over. Sometimes, I cannot help but wonder: how did I manage to reach the cup so easily? How do I keep myself on track? How do you? How do you know when you're going to miss the target? And how do you know to correct yourself when you get off course? What do you do when you realize you're going to miss but it's too late?

Here a closer examination of perception and purposeful activity may prove useful. For example, my intention to drink tea is an intention *to have something occur that hasn't yet happened.* According to the cybernetic model, in order to make something which I desire happen, I must monitor some certain set (or sets) of variables so that I can track my progress and correct for any deviations. As I move my hand to reach the teacup, my nervous system automatically attends to the motion of my arm and to the location of the cup, comparing where the cup is and where my hand is, as if it's asking "Am I there yet?" This question defines the operation of the feedback loop so that the *there* in the question is my goal, to be holding the cup. I rely on my ability to feel--my hand moving through the air and my trunk moving in support of my arm--and to see--where my arm is and where the cup is--when I navigate my hand through space until I grab hold of the cup's handle. By comparing where I am with where I want to be, my nervous system keeps me on target.

In the cybernetic model, the system acts *until* the reading at the sensor matches what is specified by the intention or goal. That is to say, the system generates behavior (it moves) *so that* what it senses will fit with what it wants to sense, with its intention. It is behaving *in order* to match the activity at the sensor to the state of affairs defined by the goal. But the implications of this model, as pointed to by the words *until*, *so that*, and *in order to*, proved difficult for me to appreciate for a long time. It used to make sense for me to think that my hand kept moving *because* I had not reached the cup and that I wanted to drink *as a result of* being thirsty; I was so used to thinking that it was my perceptions (of my hand moving and of where the cup is in space) that *guided* or *caused* my behavior.

But this kind of cause-effect description just doesn't take into account the intentional nature of movement and its role in the circularity of the sensory-motor loop. I have come to realize that I move my arm and hand this way *so that* I may reach the glass and attain my goal: *what I sense* guides my action and my intention (where I want to go) guides my perception. Here is the core of the circularity of perception and behavior: the cause of my behavior is my goal, something that I *intend to* experience in the future. If movement is purposeful, then perception serves that purpose: I am acting *in order to* perceive.

Therefore, by having a goal or an intention I specify a perception that I am aiming to *attain*, such as grasping a teacup or a book, or to *maintain*, including certain physiological variables such as temperature and oxygen level. What I perceive in route to achieving my intention--the distance between my hand and the glass, the experience of being thirsty--is the discrepancy between the where I am and where I'd like to be. Technically, this discrepancy is, unfortunately, also called an ***error signal.***[54] It is this discrepancy which a negative feedback system acts to eliminate.

Behavior controls for a perception,[55] one that is specified by the goal. Whether the goal is to reach the teacup or to quench my thirst, I act *until* my experience matches the perceptions that the goal specifies. When I move, I am coordinating what I do, in comparison with what I want, *until* what I notice matches what I want. I continue to move my hand, arm and trunk *until* my fingers are around the cup, *so that* I will bring the fluid in my body to certain level. *Until* then, I experience thirst.

From the perceptual aspect of the process, a self-regulating system's ability to carry out an intention is therefore limited by two factors: by the kinds of sensors the system has and by the terms in which the goal is defined. In order to maintain a reference, such as keeping a certain posture, or to attain a goal, such as crossing the street or the room, the body-as-moving-system must have sensors to perceive progress as it navigates toward the goal. Perception is fundamentally constrained by the structural limitations of the nervous system[56]: I cannot see behind me, I cannot see ultraviolet or infrared light, I cannot hear those special whistles designed for dogs, I cannot feel my brain, and so on. The

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[54]The word "error" can be inappropriate when referring to the difference between a newly chosen goal and a present state, which does not match the new goal. It would hardly seem correct to label this discrepancy an "error."

[55]Powers, Behavior: The Control of Perception.

[56]Humberto Maturana, "The Biology of Language: The Epistemology of Reality," Psychology and Biology of Language and Thought (New York: Academic Press, 1978), p. 35.

absolute constraints of perception are determined by the kinds of sensory receptors we have and by their locations and interconnections. Kinesthesia depends on sensors in the joints, muscles, tendons and skin to report such sensations as effort, tension, direction, vibration, and joint angles.

Within the domain defined by these absolute constraints, the ability to coordinate our movement is dependent upon the relative constraints on our ability to notice: those constraints developed in each of our individual processes of learning. Developmental psychologists argue that the ability to attend to, and, literally, to make sense out of the activity of millions of sensory neurons is learned.[57] As we saw in the last chapter, habit necessarily interferes with both movement and perception. Thus learning, especially when what has been learned has become automatic, can limit perception by interfering with the ability to sense what is happening. On the other hand, learning can expand perception, making new distinctions possible.[58] When I ride my bicycle along the bike path in Golden Gate Park on Sunday afternoons, I can feel which of my muscles are working, interpreting sensations of effort and pressure in the context of my knowledge of anatomy. The absolute range of my kinesthetic experience, and yours, is determined by our biological heritage. The scope of each of our abilities to articulate our experience, within that range, is a result of our learning.

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[57] Ernst von Glasersfeld, The Construction of Knowledge (Seaside: Intersystems Publications, 1987), pp. 95-118.

[58] Moshe Feldenkrais, The Case of Nora (New York: Harper and Row, 1977), p. 82.

But the ability to have different kinds of sensory experience is not enough to ensure that a self-regulating system will be able to achieve a goal. The goal must be defined in such a way that the comparator can make the necessary comparisons and can keep the system on track. In other words, the goal must be translatable into terms that are comparable with those variables reported by the sensor. For example, in order to maintain a constant temperature, the body must have sensors capable of reporting the temperature and the desired state must be defined in terms that the comparator can weigh in relation to the signals reported by the sensors.

A corollary to this second condition is that a self-regulating system's ability to carry out an intention is determined by how well the goal is specified. By "specified," I mean how well the aim is defined in sensory-specific terms that are appropriate to the desired outcome. If the goal is to be able to do a certain dance step or a specific baseball pitch, my ability to succeed is determined by my knowing what to notice *in order* to perform the correct motions with my limbs and torso.

One major problem of most approaches to movement education is that they rely on imitation, on a watch-and-do approach to learning. If the student cannot make the appropriate kinesthetic distinctions, cannot convert what he sees into what to **feel for**, then demonstrating a movement, whether at baseball practice, in martial arts training or in a ballet class, is not sufficient. This type of demonstration can leave the student feeling incompetent and frustrated since the coach or teacher seems to perform the action so easily and the student doesn't have an inkling of how to reproduce it.

The central insight here, that movement is driven by a perception that is aimed for, is the basis for the emphasis on kinesthesia in the cybernetic approach to movement education. If the goal of teaching is for the student to move in a new way, then the teacher's job must be to guide the student in learning what to notice, in particular, what to feel for *in order* to move differently. To do this, the teacher must first be able to translate the description of what she or he *sees* into a description using variables within the student's kinesthetic experience.

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Let me tell you about the conversation and impromptu lesson that I had with my friend Emily. Emily has Cerebral Palsy. She walks with considerable difficulty, her taut leg muscles keeping her heels from touching the floor and preventing her knees from fully straightening. Emily's arms are stiff and she has difficulty controlling her hands in refined movements. She speaks with considerable difficulty, pushing her words out with an uneven delivery. By the time of this story, I have known Emily for six years, since she was six years old. In that time she has benefited from physical therapy and from Feldenkrais lessons, and from her family's love and encouragement, learning to walk without a walker and developing her independence in everyday activities.
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One evening, while visiting her family, I notice Emily is walking up and down the hallway with crutches. I ask, "What are you up to?"

With excitement, she explains, "Since I've started Junior High, I've been walking from one classroom to another between class sessions. Even though most of the teachers give me a head start and let me leave early, I've been having trouble making it from one end of the school to the other in time for my next class. I can move around the house on my own but it's really hard at school. So I got these new crutches and I'm practicing walking with them."

Unlike common crutches, this new pair is a set of Canadian crutches.[59] *Each one consists of a long tube with a handle about half way up and a partial cuff a few inches above the handle. Emily can slip her arm through the open side of the cuff and grasp the rubber grip of the handle with her hand.*

Emily looks at me over her shoulder. I'm sitting on the couch watching her walk up and down the corridor. Her arms do not move smoothly; they are stiff and the crutches follow an erratic path as she lifts each crutch to her side with her elbow held straight. With every step Emily's face contorts and she holds her breath. Her arms are quavering so much that I guess just moving the crutch must be quite difficult. With each step the large rubber knob at the tip of the crutch hovers momentarily an inch or two above the floor and then thuds down.

"Are you looking at how I'm using these crutches?" she asks.

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[59] These are also called Loftsrand crutches.

"Yes"

"What do you notice?"

"I think you're working very hard," I respond.

"I'm not used to them yet. It's hard for me to get them to go where I want. They feel heavy."

"Would you like some help?"

She stops, looking at me and smiling. "Sure."

"Keep walking. Just slow down a little and tell me what you notice about your walking."

"This is so new, it's not easy for me to tell exactly what I'm doing."

"Take your time. Maybe you could slow down a little more."

"My arm shakes when I lift up the crutch. "

"What else?"

"I am moving a lot. My whole arm and shoulder lift up when I lift the crutch."

"Can you tell how you lift your arm up to the side each time you lift the crutch? You're not swinging the crutch forward, you're moving it through a very roundabout path. And do you feel how you keep your elbow very stiff?"

"That's because they're so heavy."

"As you take your next step, listen to the crutch when it touches the floor. What kind of sound does it make?"

Emily slowly takes another step, watching her right arm lift the crutch through the air. Her elbow is straight; the muscles of her upper arm and forearm are clenching. The tip of the crutch wavers up and to her right, then the crutch moves forward until it is in front of her right leg. The rubber end hovers momentarily an inch or so above the floor before it drops.

"It thumps."

"Exactly. Would you take a few more steps, continuing to listen?"

After walking down the hallway and returning, she says, "Each time I put the crutch down it goes thump."

"Do you know how come it thumps?"

"It's so heavy. I have a hard time moving the crutch to where I want. I guess at the last second I sort of let go of my arm and drop the crutch."

"Right. Can you put the crutch down without making any sound?"

Emily leans to her right, using her right crutch for additional support. She lifts and lowers her left arm, slowly bringing the crutch down onto the floor. She inches the tip toward the floor.

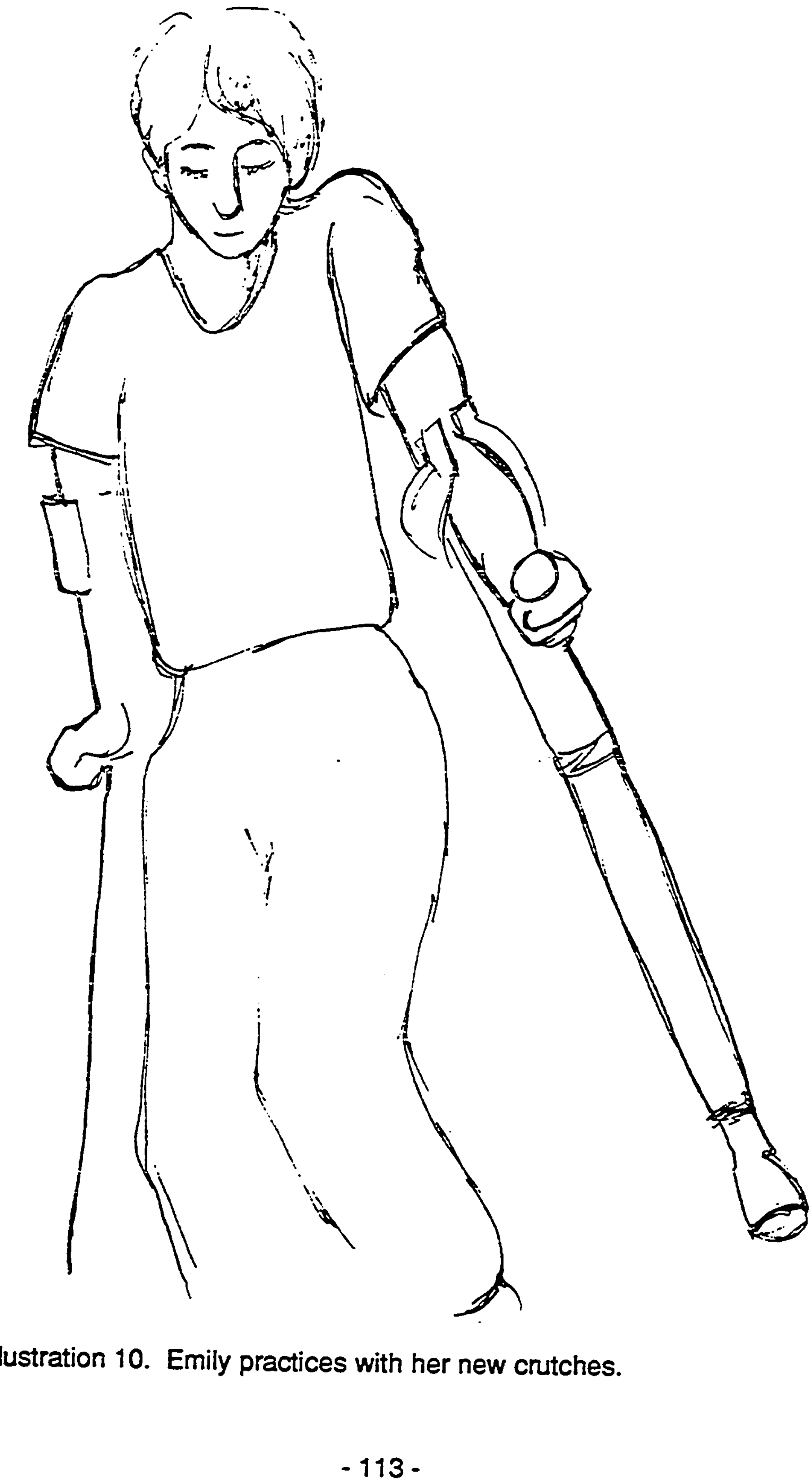

Illustration 10. Emily practices with her new crutches.

Thud.

She tries again. This time she almost reaches the floor when her arm jerks and the tip of the crutch crashes suddenly to the floor.

"The crutch is too heavy. It makes me shake. I can't control it."

"I think that the way you're holding the handle is part of the problem. You start out with the handle pointing toward your hip and your knuckles facing forward. When you lift the crutch, you turn the handle outward, to the right, and you stiffen your arm. That means you have to use a very stiff arm to guide the crutch." Emily lifts the left crutch several times. "See what I mean?"

Each time she lifts the crutch, her wrist and forearm turn, the back of her hand faces backward, and her elbow snaps straight. She is left clutching the handle and lifting her arm straight and stiff.

"Now let's see if we can make that a little easier. Start by lifting the crutch a little and turning the handle in toward you, then forward. Good. Go very slowly and let your shoulder participate in the movement without stiffening. Now turn the handle out, to the right, and then, slowly, backwards. Put it down and rest a moment . . . Now repeat that movement a few times, turning the handle backward and forward in a little circle. Can you feel what happens with your arm and shoulder?"

"Yes."

"Rest a moment."

"My arm gets very stiff and my shoulder gets very tight when the handle is pointing out to the side, away from me."

"That's right. Next time you lift the crutch, turn the end of the handle so that it's pointing toward your hip."

Emily lifts the crutch again. The tip of her handle turns toward the front the instant the crutch leaves the ground. Steadying herself on the other crutch, she turns to look at her hand. With slow, faltering movements, she rotates the crutch to turn the handle toward her. She beams at me.

Her arm is still held very tightly. I move from the couch to a small stool. Sitting beside her, I gently place my hands around her arm, my right hand below her elbow and my left above. "Do you feel how tight your arm is?"

She nods yes.

"Do you know how the position of your hand is related to what's happening with your elbow? When your arm turns so that the handle points toward you, you can let your arm muscles soften and you can bend your elbow a little." As I talk, I am touching the muscles of her forearm and upper arm. I begin to guide her through some gentle movements, first rotating her forearm and then moving her arm through slow figure-eights. At first her shoulder tightens when I move her arm, resisting the motion. I move my left hand to her shoulder, beginning to move her arm and shoulder together as a unit. As I feel her arm and chest muscles begin to decontract in my hands, I again move just

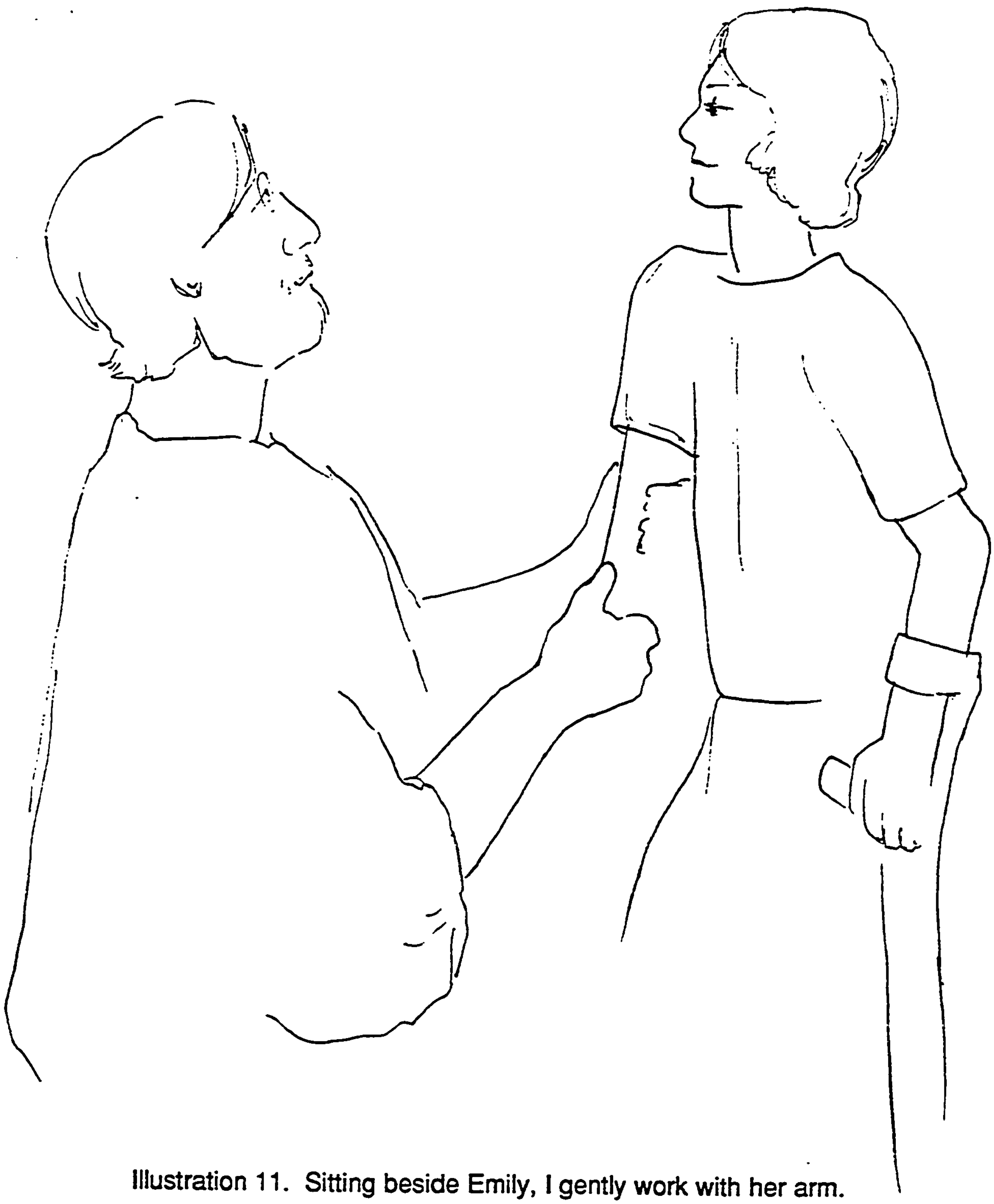

Illustration 11. Sitting beside Emily, I gently work with her arm.

her arm. Her shoulder moves more freely, no longer interfering with the movement of her arm. My hands begin to move slowly at right angles to one another, suggesting the bending of the elbow. As she follows the suggestion of my fingers, the muscles of her forearm and hand begin to soften. "That's right. Now can you loosen your grip on the handle?"

The tonus of Emily's arm muscles have decreased considerably. Indeed, her breathing has grown easier and her face looks more relaxed. Satisfied with our progress thus far, I say, "Now practice turning the crutch handle to the front and then toward your hip again. Can you find where it's easiest to lift the crutch, without stiffening your arm? Repeat this movement several times, making it easy."

Emily turns the crutch handle, rotating her arm along its length. Her arms start to quaver.

"When your arm starts to get tired you can put the crutch down."

Emily puts the tip of crutch on the floor. It barely makes a sound. I doubt that she notices because she has already turned her attention to her other arm, lifting it and repeating the same movements.

"After you've got the feel for the movement, maybe you would like to walk again."

Emily nods. She repeats the movements a few more times on each side and then she begins to walk the corridor again. The movement of the crutches *has become considerably smoother. She is not lifting them so high or moving them so wildly. Though she still drops them at the last moment, she is getting the tip much closer to the floor and it makes a softer landing.*

"The crutches feel lighter."

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Perception is active. Perception arises out of the coordination of action and intention. Noticing has direction and serves a purpose. Yet perception is rich, it is not strictly limited to the control of movement. Even when I am intent on the matter at hand, it is possible for me to notice the unrelated and the unexpected. Even if I don't do anything I can't help but be engaged by noticing when a draft cools my neck, the phone rings, or a bird flies by.

It is as if the nervous system can ask--and answer--questions other than the purposive "Am I there yet?" The sensory system is also able to provide reports by answering questions such as "Where am I?" and "What's happening?" or by comparing two movements and answering questions such as "Which is larger?" or "Which is smoother?" Indeed, noticing could be thought of as a kind of goal, an end in itself.

Yet noticing is not only an end. Noticing is an activity, it is something that you and I *do*. In retrospect, I can say that I *had* a certain experience--of the movements I felt or of the sounds I heard--but, in the moment, in the present, *experience* is not something I have nor is it something that happens to me.
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Rather, *perceiving* is something I do--I feel myself opening the door or I listen the to notes of the guitar. I engage in noticing and am engaged by it.

To reduce noticing to that which is noticed, to turn the activity of perceiving into a thing, is to reify an ongoing process, to make a fossil out of lived experience. To nominalize perceiving into perception (to turn the verb into a noun) is to separate my act of noticing from what I notice and, most importantly, to separate *what* I notice from *how* I go about noticing it. Learning requires the ability to shift attention from where we're going to how we are getting there. Without the ability to engage in noticing, without the ability to direct our attention, learning would be impossible. Once perceiving is frozen into perception, we are at the effect of experience rather than being at the cause; we are no longer the authors of our stories.

Most of the time, language gives us the means to recognize the difference between the process of noticing and its products: we distinguish the act of listening from what we hear, the act of looking from what we see. However, this distinction is next to impossible to make when it comes to kinesthetic experience. This is because English uses the same word for the activity and its consequences: the act of feeling is linguistically indistinguishable from what it is that I feel. To report a sensation, such as "I feel the tension in my shoulder muscles," is to give a necessarily ambiguous report. It is impossible to discern whether I notice what is happening or whether what I notice is a result of how I notice it.

Thus, more often than not, you and I talk about our feelings as if they happen to us, as if we are the merciless victims of bodily sensation, rather than recognizing that *what* we feel emerges from *how* we feel. To talk of feeling as a *thing* is to forget the ongoingness, the circularity, of the sensory-motor loop, to forget that what you and I perceive about our movements is a result of how we move and of how we go about noticing how we are moving.

For example, Emily experienced great difficulty walking with her new crutches: the crutches felt very heavy and made it difficult for her to move her arms. Emily knew that the movement should be smoother but she did not know what to notice in order to make it so. By actively feeling the crutch at the various angles, Emily began to feel a variation in the effort required to lift the crutch. By feeling how I moved her arm and shoulder together as a unit, or separately as independent parts, she began to feel the effort in the muscles of her arm. By discerning the different degrees of tension in her arm, she began to feel her effort. By learning what to notice, Emily's ability to move changed. Once how she moved changed, what she noticed ("how she felt") changed.

To feel is to feel a difference, to make a distinction. Feelings are distinctions that make action possible;[60] feeling is the activity of making those distinctions. By learning to make more refined distinctions, we are better able to specify a goal and better able to achieve it because we can make more refined comparisons.

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[60] This is an application of Flores' concept of words as possibilities for action, in Fernando Flores and Michael Graves, Education (Berkeley: Logonet, 1986), p. 3.

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"But I'm still thumping."

"Well, now that the crutches feel lighter, you can work on putting them down even more gently. Do you want to rest for a few minutes or are you ready to continue?"

"Let's keep going."

"Okay. Can you draw a square on the floor with the tip of your right crutch? From where the tip is, move it to the right and then back. Good, now move the tip to the left and then slide the tip forward. Keep going, tracing around this square."

Emily follows my instructions exactly. During the segment of the tracing from the back to the front, the tip of the crutch skids on the floor. Now that she is holding the tip of the handle toward her hip, she presses along the length of the crutch into the rubber tip and the resulting friction is greatest as she slides the tip forward. "Do you notice how the forward movement is the most difficult? Can you feel how the friction of the rubber tip is making that movement of the crutch more difficult?"

"Yes. The end of the crutch is rubbing against the floor and it's sticking."
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"If you lift the crutch a little it might be easier. Maybe you can make the tip hop over the sticky part. It's not a big hop, just a tiny one. Let your elbow bend so that you only have to lift the tip a little."

"Good idea," she says. The movement is easier now; she can lift the tip ever so slightly off the floor and replace it smoothly. "That's much better."

The movement of the crutch has become smoother. Yet Emily still seems to be struggling a little. "I think maybe you're holding your breath when you lift the crutch for the little hop. Can you breathe as you move?"

Emily repeats the movement but is still holding her breath. "I don't think I can breath when I do this movement. It's too hard."

"Then let's try something different. Hold your breath on purpose."

"That's easy."

"Good. Now repeat the movement again, only breathe when you do it. Is it easier to inhale or exhale?"

"It feels weird to exhale when I do this movement. It's easier to inhale when I lift the crutch a little."

"Now do the same movement and hold your breath again. Can you tell the difference that breathing makes?"

"Yes."

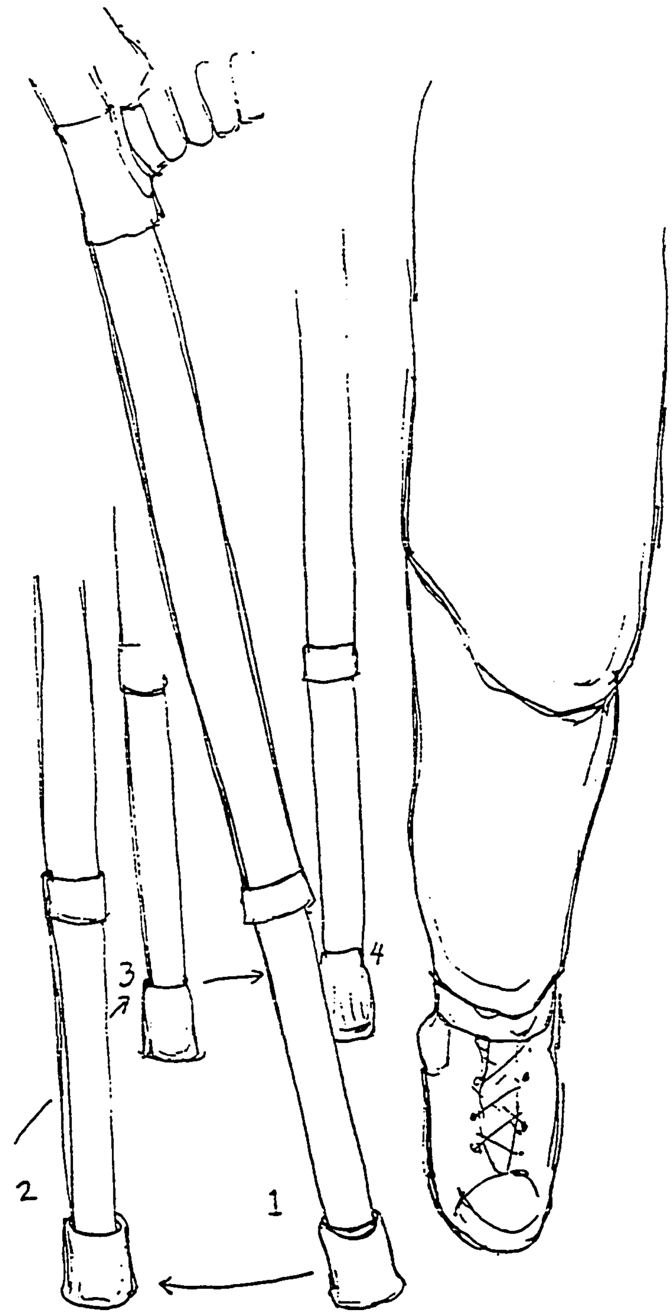

Illustration 12. Emily draws a square with the tip of her crutch.

She switches sides and begins to draw a square with her left crutch. At first, she has the same difficulty as with the right arm; the crutch catches in the forward movement. She begins to lift the tip slightly and the movement with her left arm improves rapidly.

"Are you getting tired?"

"Yes."

"Take a rest." I stand and Emily sits on the stool.

"When you're ready to start again, stand up."

After a few quiet minutes, Emily comes to her feet and begins to walk down the hallway. The lifting of the crutches has become much smoother, her arm now stays slightly bent and she places the ends of the crutches down on the floor noiselessly.

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Emily's experience during the lesson is not only that the movement becomes easier, but she also feels the crutches become lighter. If we were to naively understand perception as detecting the world *as it is*, Emily's change and Dirke's change in feeling vertical alignment would be difficult, if not impossible, to account for. After all, neither the actual weight of the crutches nor the line of gravity changed. Rather, in Emily's situation, the way she moves has changed and, with that change, her experience of the weight of the crutches
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has been altered. Again, we return to the sensory-motor loop to understand how this is possible.

All that you or I can notice are changes of sensation. Kinesthetic sensation is determined, at least in part, by our own movement. The diagram of a cybernetic system shows that sensation is connected, via the effectors, to the system's internal goal. In principle, it is impossible for us to differentiate whether the loop connecting the muscles (the effectors) with the spindles (the sensors) lies inside or outside the self.[61]

There is nothing inherent in a sensation that lets us know whether what we are experiencing is "reality" or "hallucination." Though we can *measure* the weight of the crutches with a scale, this datum will not change how heavy or light they may *feel*. We only perceive the effort required to lift the crutches; we never directly experience their weight. The perceived weight of the crutches, or of any object, has more to do with how we move than with how many pounds the crutches weigh.

Biologically, in terms of neurophysiology, the connection between the sensors--those in the muscles, in the joints, and in the skin--and the effectors lies within the confines of the nervous system. Since the nervous system only has access to varying states of its own activity, sensory information arises *within* the operation of the nervous system's sensory-motor loop. The sensory-motor loop circles in on itself, defining the **closure** of the nervous system.

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[61] This closure provides an elegant way of understanding the effectiveness of the visualization of movement in Feldenkrais lessons and in ideokinetic facilitation (Mabel Ellsworth Todd, The Thinking Body (New York: Paul B. Hoeber, 1937) and Lulu Swiegard, Human Movement Potential (New York: Harper and Row, 1974)).

This notion, of the closure of the nervous system, makes it possible to reconsider the nature of the relationship between environment and perception. Much of the work in sensory psychology assumes that there is a cause and effect relationship at work, as if the world is the cause and experience is the consequence. An alternate view, following the notion of the closure of the nervous system, is that *experiencing is the cause and a world is the consequence.*[62] We sense changes in our sensors, changes within our nervous system, rather than directly apprehending the world *or* our bodies.[63] We do not feel the weight of an object we hold; rather, we feel the effort it takes to hold the object as our sensors respond to the perturbations made by the object.

Information is the difference that makes a difference.[64] This definition of information requires that we identify two differences in the operation of the sensory-motor loop. The first difference is the difference at the sensors. But how do we know which sensory differences to attend to and, once we attend to them, what meaning to give to those differences? It is at the comparator that the second difference arises: the difference that makes a difference is the discrepancy between the goal and what the sensor senses.

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[62] Heinz von Foerster, "Apropos Epistemology," Family Process 24 (March, 1985): 517-520.

[63] This means that our nervous system actively *constructs* our experience out of the changes at our sensors.

[64] Gregory Bateson, Mind and Nature: A Necessary Unity (New York: E.P. Dutton, 1979), p. 228.

What the sensor senses is tied, by way of the effectors, to the system's goals. Thus experience arises from the perception of distinctions, of differences. When it comes to movement, the distinctions that make a difference are the distinctions that make action possible. That is to say, the distinctions that make it possible to compare the present state of affairs with the desired state (to compare what is happening with what could be happening) are the differences that make movement possible.

For example, it would be misleading to think of the muscle spindle[65] as an objective *detector* of information. The spindle's sensitivity depends on its

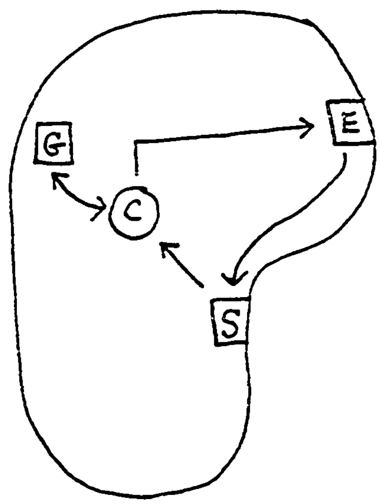

Illustration 13. Closure: from within the system, it is impossible to tell whether the loop connecting the effectors with the sensors lies inside or outside the boundaries of the system.

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65 The spindle is one of the types sensors involved in the nervous system's control of movement, as discussed in the previous chapter.

length and its length is set according to the goal for the extrafusal muscle's activity. Therefore, the spindle's sensitivity is not absolute; it depends upon what is already going on in the nervous system. So Emily's sensation of the crutch's weight was dependent on how tight the muscles of her arm and shoulder were, and their tightness depended, in turn, on how she was organizing herself to move her arm. Dirke did not sense his posture in comparison to an absolute vertical line. He compared the distribution of the weight on his feet, the tightness of his muscles and the spatial configuration of the segments of his body with his learned reference, which served as Dirke's definition of what it meant to be standing straight.

Information, therefore, cannot be said to exist by and for itself. It is not a commodity that can be transmitted from one person to another, like a radio signal from a transmitter to a receiver, or apprehended passively from a world around us. For example, what we hear depends on how we listen. Even information about our bodies, our selves, is not a simple report of what *is*. Sensory information is constructed within the nervous system, arising out of the operation of the sensory-motor loop. The root of the word "information" reflects this kind of meaning: it comes from the Latin root, *in-formare*, which means "to form within."

In light of cybernetics, my body *as it is* becomes my body *as I sense and move*. My perception of the body, of my body, is not simply given, it is not my perception of myself as I am. Perception is active. Out of the circle of noticing and doing, I construct my experience of my body, of myself.

Chapter Five

Conversation for a Change

Movement has a grammar and syntax.

Moshe Feldenkrais

During a movement lesson the student's experience of moving changes. That is to say, the lesson leads the student to making new sensory distinctions, both about aspects of present movements, which were previously outside awareness, and about new ways of moving and, therefore, of experiencing movement. The case histories presented thus far--Patrick, Agnes, Dirke and Emily--illustrate that what changes during a movement lesson is the student's kinesthetic perception. Thus the student's knowledge of his body, of her movement, changes.

Can we explain how this change in self-knowledge comes about? Where do these new distinctions come from? If you are willing to come along with what I've proposed thus far about information being, as the Buddhists would say, "*no-thing*," then you will agree that we cannot talk about a lesson as the teacher somehow transmitting information to the student. Rather, the teacher's role is to *somehow* assist the student in kinesthetically informing herself or himself. In other words, the teacher *somehow* interacts with the student in such a way as to guide the student in the process of making new distinctions, especially those distinctions that make it possible for the student to, literally, *feel* different and, therefore, to be able to move in new ways.

But what is the "somehow" of how the teacher interacts with the student? This question goes to the heart of the cybernetic approach to movement education, in particular, and to education, in general. Students, as well as those people who have observed lessons, often remark on the gentleness with which a movement lesson proceeds. This gentleness is evident whether the teacher guides the student through a sequence of movements manually--such as when I lifted Agnes' shoulder taking care to move smoothly and to fully support her--or whether the teacher uses words to focus attention and direct movement--when I encouraged Emily to make her movements as flowing and continuous as possible. So little effort is made and yet such dramatic changes occur.

The profound effectiveness of this gentleness is impossible to understand if the body is viewed only reductionistically, as a mechanical system, albeit a biomechanical one. The various approaches to massage and "bodywork," as well as those approaches to physical therapy which view the body as a mechanical system, orient their treatment to directly affecting the components of the system and their interrelations. The clinician accomplishes this by adding physical energy to the body in any number of ways: either by applying heat or ice, by strengthening and stretching, by manipulating bones and joints, or by massaging muscles and other soft tissues. Whatever the modality of treatment, the therapy is viewed in the context of a straight line of cause and effect; the therapeutic effect is caused by the practitioner's intervention.

But the gentleness of a movement lesson precludes explaining the changes that occur as the result of some form of physical energy applied by the therapist or teacher. Rather these changes can be understood only in terms of the mover as a self-regulating system, in terms of the teacher interacting with the student so as to alter the ongoing coordination of the student's sensory-motor loop. Since the student only has access to his or her sensory experience, a movement lesson must be the kind of interaction in which the student learns to make new perceptual distinctions and, therefore, develops the ability to move differently. An interaction in which one person guides another in making new distinctions can best be called a **tutorial conversation.**[66]

Distinctions arise in conversation, in the consensual coordination of coordinations of action.[67] Words, for instance, are distinctions that make it possible for us to coordinate our actions.[68] Distinctions serve as tokens for ways we can notice and ways we can act. As such, distinctions are not limited to the language of words but also can include pictures such as a traffic sign and

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[66] Gordon Pask, "Conversational Techniques in the Study and Practice of Education," British Journal of Educational Psychology, 46 (1976): 21-23.

[67] Maturana, "The Biology of Language", pp. 51-52.

[68] Flores and Graves, Education, p. 3.

a wall of hieroglyphics, gestures such as a pointing finger or a threatening fist, sounds such as a whistle or a baby's cry, and various ways of touching such as a caress or the guiding hand of the leading partner in a dance.

In order to understand the type of tutorial conversation in which movement learning occurs, it is important to ask what is the currency, the language, of such a conversation? It is only by answering this question, in terms of the model of the sensory-motor loop and the notion of closure, that we can understand how the nervous system participates in a tutorial conversation. Once again we can draw upon another fundamental notion in the cybernetic theory: self-regulating systems can be sub-divided into two kinds of systems--**taciturn systems** and **language-oriented systems**--each of which has characteristic ways of acting.[69]

A taciturn system cannot set its own goals; the purpose *in* a taciturn system is based on an evaluation by an observer of the taciturn system's goal. This purpose is then taken as the purpose *for* the system. This is simple and straight-forward when talking about a thermostat or the cruise control mechanism in a car: the purpose built *into* a mechanical system, the one that the system is fabricated to accomplish, is the purpose *for* which it serves. When the system in question is not a manufactured artifact but a naturally occurring system, such as the ecosystem of a pond, then the matter of goal(s) *in* the system, or purpose *for* the system, becomes a matter of the observer's

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[69]Gordon Pask, "The meaning of cybernetics in the behavioral sciences (The cybernetics of behaviour and cognition; extending the meaning of "goal")," Progress of Cybernetics, ed. J. Rose (London: Gordon and Breach, 1969), pp. 23-29.

assertion.[70] A taciturn system can neither describe its goals nor can it be given new kinds of goals.[71] That is why these systems are called taciturn: they are uncommunicative, they are silent about their goals.

Language-oriented systems, on the other hand, are communicative: these systems can respond to requests to adopt new goals and they can, at least in part, articulate their goals. This means that language-oriented systems are **adaptive control systems**, systems that can change what they control for and that can change what their goals are. Language-oriented systems communicate in what is technically called an **object language**. An object language consists of the terms in which the system can accept new goals and describe present ones. Computers and people fall into the category of language-oriented systems. Please note, however, that the distinction drawn between language-oriented and taciturn systems is not inherent in the system; an observer will identify a system as taciturn when she or he does not know the object language and, therefore, cannot communicate with the system.

The object language of the body-as-movement-system is the set of distinctions that allow us to describe and accept goals. Unlike a computer, for which we would have to read the manual in order to understand its object--or *programming*--language, when it comes to movement we rely on our experience of moving and our conversations, with ourselves and with others, *about* our

[70] For elucidation of this idea, see Brock Bernstein and Lawrence Goldfarb, "ECOSET: Understanding How Ecosystems are Defined" (Ojai: EcoAnalysis, forthcoming).

[71] You can set the speed on the cruise control of the car but this is not giving it a new *kind* of goal. You are simply changing the value of the goal, one that the system was built to accomplish, within a pre-determined range of values, rather than changing the kind of goal the system accomplishes.

movement in order to understand the object language. While the absolute range of potential distinctions in our conversations about movement is determined by the types of sensors the nervous system includes, the language we use to experience and describe movement arises out of our conversations.

This idea of an object language can be related to the model of the self-regulating system. As you may recall, in order for the comparator to do its job of guiding the system to its goal, it must be able to compare the present state with the desired state. In order to accomplish this comparison, the system must specify the goal in terms that relate to the sensor's reports. The easiest way to do this is to describe the goal in sensory terms; that is to say, the most direct way to describe a movement goal is to describe it in terms of kinesthetic experience, in terms of what the mover must *feel for* in order to perform the motion.

So a movement lesson can be said to be a conversation in the language of kinesthetic experience, one in which the student learns to make distinctions about moving in order to be able to move in new ways. A movement lesson is a conversation in which the student learns to articulate movement and to move more articulately. A lesson is not about learning a particular movement; rather a lesson is about learning the distinctions necessary to perform a movement.

It is the movement teacher's responsibility to relate the student's description of a problem--usually a list of symptoms and limitations--to the pattern underlying how the student is moving. Once the problem is redefined in terms of how the student is moving, and *not moving*, the teacher can then figure out how to change the student's movement such that the pattern changes and the problem no longer occurs. The teacher must then translate the new movement from an observer's description of behavior into the subjective, kinesthetic language of the mover. This means that the lessons are about the student making a set of sensory-specific distinctions and applying those distinctions to learning a new way of moving. In other words, each lesson is a conversation in which the student learns to make the distinctions necessary to coordinate his or her activity in a new way.

The process of learning is developmental and the progress of a tutorial conversation must reflect the sequential unfolding of learning. The first thing a student learns in a lesson is that it is *possible* to feel different. Once the student can feel differently, can feel a difference, then the student can become *aware* of how she is moving and how that way of moving relates to the complaints that she has. This is one of the unique aspects of the Feldenkrais Method: it allows the student to have a new experience of moving, of being embodied, which breaks cycles of habituation and leads to the awareness from which learning can proceed. Thus the lesson moves from possibility to awareness.

With awareness, comes the experience of difference and the possibility of choice. Each student must *apply* the new distinctions to action and, thereby, practice incorporating the new distinctions into her sensory-motor vocabulary. This is the third phase in the progression of a lesson, the phase of *application.* An important type of action is called **teachback**, where the student applies what she has learned by teaching it back to the teacher.[72] A tutorial conversation, whether during the course of one lesson or over a series of many lessons, recursively follows this sequence--from possibility to awareness to application--for each distinction that is to be learned.

Please note that what is "practiced" during the course of a lesson or at the end of lesson is a new awareness, a new set of distinctions. Contrary to popular advice, practice of a movement, in and of itself, without awareness, does not make perfect: practice only makes automatic.

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The first day he came, Patrick was in the midst of a serious episode of spasm and pain. During that first session we had managed to relieve most of the spasm and he left feeling encouraged. Over the next three sessions we worked on his becoming aware of his habitual stiffness and his learning to move with greater flexibility and ease. With each lesson Patrick has regained some of his potential for movement. Today he enters my office for his fifth lesson, moving stiffly and looking very tired.

"I'm feeling lousy," he says, frowning. "The pain came back two nights ago. And I haven't slept since. This is so discouraging. I thought maybe that this stuff we were doing was going to help but I'm right back in the middle of agony again."

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[72]Gordon Pask, "Styles and Strategies of Learning," British Journal of Educational Psychology 46 (1976), pp. 133-34.
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"Have you been doing the movement sequences I gave you to do on your own?"

"No. I was feeling so good after the last session that I kinda forgot to do them and I've been feeling so bad since the pain came back that I haven't wanted to do anything."

"Would you do me a favor? Just take a short stroll around the room."

"Okay," he says as he slowly begins to walk stiffly around my office.

"What do you notice about how you're walking, about how your torso is moving?"

Patrick stops walking to report, "I am very stiff. My back muscles are grabbing and my whole torso is tight. I'm so stiff that I feel like a box on legs."

We both chuckle at his funny, yet accurate, self-description.

"Damn," he says, "I'm so tight that I even hurt when I laugh. Do you mind if I sit back down for a moment?"

"No, not at all. Let's evaluate the movement of your spine while sitting."

Patrick nods consent and we slowly go through the various movements of the spine--rounding, arching, bending to each side, and turning right and left. As he slowly performs these movements, it is quite clear that Patrick's mid- and lower back are extremely rigid.

I ask him, "What do you notice as we go through these movements?"

"I'm stiff."

"Can you be a little bit more specific than that?"

"Yes, no matter what movement you ask me to make, I'm only moving my upper back. It's almost as if the bottom half of my rib cage and my pelvis had been welded together. Up till the last few days, I was feeling like that area was starting to move again."

"Well, let's find out if we can help make you pain-free again and help unlock those muscle spasms. Please lie down on the table, either on your right or left side."

Patrick lies down on his right side. I place a bolster under his head for support, asking, "Does that feel like the right height for your head?"

"Yes. That's fine but the lower back feels strain in this position."

"Please bend your knees up so that your knees and hips are at ninety degree angles. Is that better?"

"A little. But it still hurts."

I reach for a small pillow. After gently lifting Patrick's left knee off his right, I slide the pillow between his knees.

Patrick sighs, "Much better."

I move so that I am standing alongside the table, behind Patrick. I put my right hand on his left hip and slowly move the hip a tiny bit forward and then a tiny bit back, asking, "What do you notice as I do this?"

"Not much movement."

"That's exactly right. There is none of that flexibility, that natural ease of movement, that we've been working on. Can you tell what happens to your left shoulder when I move your left hip?"

"I see what you're talking about. When you move my hip, my shoulder moves along with it. I guess my little joke wasn't too far off; my torso is like a box."

"Do you notice the tightness in these muscles here, along your spine, at your waist, in your belly, in your buttocks, and in your legs?"

"Yes, I do. And they are very tender."

"I'm sorry, was I pressing too hard?"

"No, but when you touched me I became aware of how tight and uncomfortable all those muscles feel. What can you do to help me let go of this tightness today?"

I answer Patrick's question by moving to sit on my stool at the head of the table. Reaching down along Patrick's back to the base of his spine, I begin to feel along the muscles of the spine, gently touching every muscle along the way.

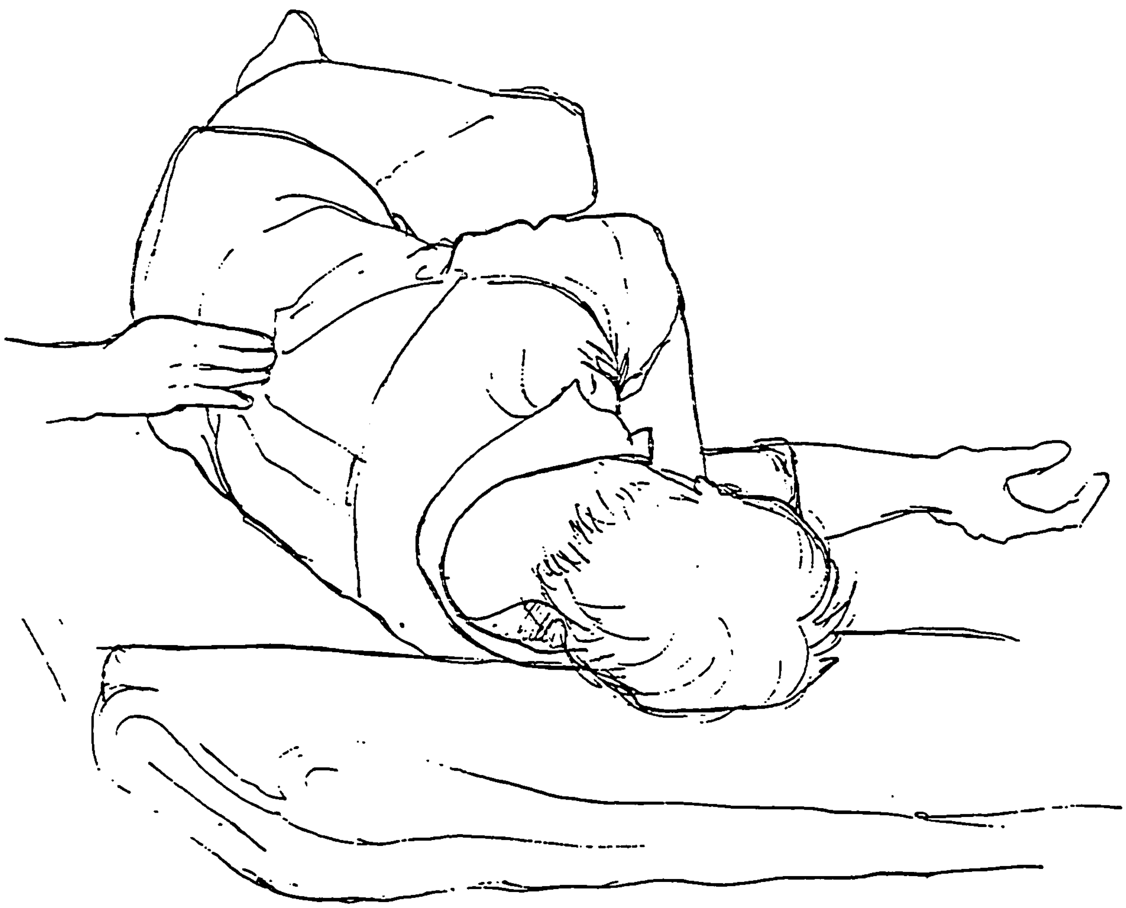

Illustration 14. *"Do you notice the tightness in the muscles here, along your spine?"*

The fingers of my left hand are curving to gather the muscle and skin, taking up some of the contraction, and then slowly straightening to supply a gentle hint of decontracting. My hand then moves to his left shoulder, beginning gently to guide his shoulder through various small movements.

"Damn. Even my shoulder is tight."

I notice that the easiest direction of movement for his shoulder is retraction; that is to say, his shoulder blade slides in toward his spine most easily. After moving in the direction of ease and back to the starting position several times, I begin to alter the movement slightly, guiding the shoulder a little down toward the hip or a little up toward the head. With each new alteration, I go only as far as I can without force, waiting at the place just before the movement stops and giving Patrick the opportunity to allow his shoulder to move further.

"That is so strange. I can feel my muscles relaxing and my shoulder starting to move more. How do you do that?"

"The best way to explain is to say that I think about the way I touch you and the way you respond as a conversation. My touch can ask different kinds of questions like, 'Do you feel how tight this is?' or 'Can you feel the difference between this muscle and this muscle?'" As I ask each question, my hand acts out the query. "I also can ask you to move a in different direction just by varying the direction of my touch. For instance, when I am holding your shoulder blade like this I can gently suggest that you move it toward your head, like that, or toward your hips, like that. Can you feel what I'm talking about?

"Yes, that's very clear."

"I also can take up the work of one of your muscles by bringing the ends of the muscle closer together," I say as I slide his shoulder up toward his ear and lift his head to bring his ear toward the shoulder. "This is like asking a tight muscle what it would feel like if it didn't have to work."

Patrick sighs, his trunk muscles softening noticeably in my hands.

"Once I've asked a question, I wait for your response. Sometimes, like just then, your muscles lengthen a little. Sometimes nothing happens. Just like in any conversation, the next thing I do depends on the response you just gave."

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The student and teacher can enter into a tutorial conversation with words or with touch. Either way, the teacher must describe what the student is *to notice for*, what the student is to *attend to.*[73] As we saw with Emily's case, the teacher asks the student to notice how she is moving, shifting attention from completion of the movement to the process of carrying it out, from the end to the means whereby it is accomplished.[74] In effect, the teacher is redefining the goal in dynamic terms, directing the student's attention to the ongoingness of *moving* rather than to the completion of *a movement.* This transition is

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[73]Though grammatically clumsy, these phrases best describe the sense of active perception discussed in the previous chapter.

[74]F. Alexander, The Use of the Self, pp. 50-60.
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necessary for it allows the student to make a transition from accomplishing a goal to noticing the process, from moving to learning to move.

This process of shifting attention is one of recalibrating, of fine-tuning. When the student is moving on her own, she slows the movement down to be able to notice how she is moving. This is necessary because, as is true of all real-time cybernetic systems, it takes time for reports from the sensory outposts to reach the comparator. A slow movement, known in neurophysiology as a **ramp** movement, happens slowly enough for the central nervous system--the spine and brain--to receive signals from kinesthetic sensors and slowly enough for the mover to be able to adjust the course of the movement. A fast, or **ballistic,** movement is based on sensory information that was gathered before the movement was begun and the movement happens too quickly to receive feedback and alter the movement's course.[75]

The greater the effort used, the less sensitive the student is; the less sensitive the student is, the less likely he will be to make new distinctions. This insight is grounded in one of the central principles of psychophysiology called the **Weber-Fechner law.**[76] The Weber-Fechner law refers to the minimal change in intensity of a sensory experience that a person can notice, demonstrating how sensitivity depends on activity. This minimal change is called a **just noticeable difference** (JND). The JND is expressed as a ratio of

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[75] T.L. Teuber, "Movements and Motor Programs," Brain Research. 71 (1971).

[76] Frank A. Geldard, The Human Senses, 2d ed. (New York: John Wiley & Sons, 1972), pp. 6-8.

the already occurring intensity.[77] For instance, in terms of vision, we can notice a difference in brightness of one two-hundred-and-seventieth of the already present illumination. In the realm of kinesthesia, we can sense a difference in a change of one fortieth the effort we are making. In other words, you would not be able to feel the difference between a box weighing forty pounds and one weighing forty-and-a-quarter pounds but you would be able to feel the difference between a box weighing forty pounds and another weighing forty-one pounds. Thus, in order to be more sensitive to how she is moving, the student must calibrate her effort, using the minimal amount of effort to perform each movement.

During a hands-on lesson, such as the one in this chapter with Patrick, my touch helps the student calibrate directly to muscle tightness and to limitations in mobility. When I, as teacher, move a student, I support wherever I'm holding fully and guide him slowly, without forcing, so that he can feel safe and can attend to his experience without protecting himself. Any guarding would interfere with the movement and, therefore, with his ability to notice. By fully supporting whichever part of the student I may be holding, I take over some of the work of the muscles. In this way, the student can begin to sense, and then to decrease, any extraneous effort his muscles may be making, thereby increasing his sensitivity. Once the student allows me to initiate movement without resisting, I can begin to help him notice the range of motion of various joints, assisting him in calibrating to his movement potential. Beginning to

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[77] While the ratios of the Weber-Fechner law have since been replaced by a more accurate logarithmic scales known as Steven's Power Law, the basic insight still holds. Ibid. p. 8.

sense movement at joints that were held still up until that moment leads to profound changes in the student's experience of where he can move and of how he is articulated. This kind of interaction is **consensual**; it is as if we are dancing together and I am leading. At first, I am the student, "listening" and learning which movements the student allows. Once I have begun to sense how the student moves, and doesn't, I can begin to help him notice how he is moving. The student's role in this kind of moving together is not passive; rather, it is **collaborative.**

Whether I am initiating the movement or whether the student is moving entirely on her own, there is no need to force movement beyond the range of ease, beyond what I have come to call the "comfort zone." After all, a lesson is not about pushing limits, a lesson is about making new distinctions, about building contrasts. If the movement goes beyond the comfort zone, then the student is likely to tighten up and protect himself, thereby making it more difficult to notice the fine differences that the lesson is pointing him towards. The teacher's respecting the student's comfort makes it possible for the student to learn to listen to himself, to feel attentively, and to begin to trust what he feels.

As the lesson unfolds the teacher begins to trace a line of motion through the skeleton.[78] The pattern of restriction and holding that was interfering with the student's movement begins to loosen and unwind as the student develops a new way of moving. It is not enough to simply loosen tight muscles, to beguile

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[78] While this is not the only basis for a lesson, it is the most rudimentary and therefore the one I have chosen to focus on here. For an example of another approach, see Feldenkrais' description of teaching a student how to recover her ability to read after a stroke, in Moshe Feldenkrais, The Case of Nora (New York: Harper and Row, 1977), pp. 55-72.

chronic contraction and compulsive holding into giving way; the teacher must replace an inefficient or damaging way of moving with an easier, healthier movement. The goal here is not to impose a correct movement on the student nor to enforce some ideal pattern, but rather to follow the path of motion through the student's body and to develop, in the course of this tutorial conversation, a new way of moving that is optimal for the student's particular situation.

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My hand returns to Patrick's left hip. Once again, I move his hip forward and back very slowly. There is a little bit of independent movement in Patrick's upper back and neck. I then move his shoulder forward and back. Now when his shoulder moves, his upper back can move a little. His shoulder and upper back move backward much more easily than they move forward.

"My back feels a little looser. But my lower back is still pretty stiff and painful."

I continue to move Patrick's left shoulder, moving backwards and then returning it to its original position several times, allowing the movement of his shoulder to engage his upper back each time. I go only as far as I can without encountering resistance. I then hold his shoulder drawn back about half as far as it will go easily and begin to touch Patrick's breastbone. I am gently hinting with my fingertips, suggesting that his breastbone and ribs might follow the shoulder and allow the upper back to turn further. When I return his shoulder to
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its initial position and repeat the backward motion, Patrick's upper back and chest turn twice as far as before and now his head also turns.

Moving my stool to sit behind him again, I use my right hand to guide Patrick's shoulder forward, sliding his shoulder blade away from his spine as his shoulder rolls forward. After doing that movement a few times, I begin to use my left hand to ask Patrick to feel how each of his ribs can resist this movement or can follow along with it.

When I was moving his shoulder forward, I had noticed that Patrick's head did not move. My left hand moves to Patrick's shoulder and my right hand moves to his head so that I can gently hold his head still as I continue to move his shoulder forward. A few moments later, I am using the finger of my right hand to encourage Patrick to let his neck turn as my left hand rolls his shoulder slowly forward and back. As I perform these movements, I pause occasionally to let Patrick feel where the movement stops. I move slowly enough for him to answer the implicit question about which configuration--his head moving with his shoulder and upper back or his head staying still--is easier.

Moving to the head of the table, I reach down for Patrick's left arm and bring his upper arm to rest against his left ear. Cradling his arm and head together, I lift them as one unit, thus preventing him from moving his neck. By doing this I add a temporary **constraint** *to his movement, as if asking him, 'If this isn't allowed to move, where else can you find movement?' Slowly, I move his head and arm together in a small circle, first counter-clockwise and then clockwise, always following the path of least resistance. After this movement* *becomes smoother and easier, I begin to move Patrick's arm and head forward and back, and then up and down; with each new movement I wait until the muscles of his mid-back and chest decontract and follow along.*

When I replace Patrick's head on the bolster and put his hand back on the table in front of his chest, his breathing has noticeably improved. Where before his breathing was so shallow that it was difficult to see, now his ribcage and breastbone expand easily with each inhalation.

I move to the left side of Patrick's pelvis again, holding onto his left hip with my left hand and gently moving it forward and back, up and down. His pelvis barely moves at all except in the upward direction, toward his left shoulder. So I move his hip up toward his shoulder a little and then begin to move it backward and forward. Here the movement of the pelvis is freer, a little easier. I move my right hand into the small of Patrick's back, sliding it up until I come to the floating ribs. These lower ribs are called "floating ribs" because, unlike the other ribs, they do not attach to the breastbone in front. With my right hand at the bottom of his ribcage I can assist Patrick's spine and chest in moving with his pelvis or in countering the movement. Out of the contrasts between these two possibilities, he can begin to differentiate his pelvis from his ribcage and, in so doing, he can begin to let go of the effort of the muscles that were holding it welded together.

After several more minutes of moving the pelvis in various ways, both with assistance and with interference from other parts of his body, I begin to move his shoulder forward and his pelvis back. This allows him to feel the increased

Illustration 15. I begin to move Patrick's shoulder forward and his pelvis back.

range of movement in his back and chest. Patrick's mobility has increased so that I can now, slowly, begin to move his pelvis and his upper back in opposite directions. Taking my hands off him for a few moments, I give Patrick the chance to feel how he is now resting. Then I replace my left hand on his left hip and slowly move him forward and back. The movement of the pelvis begins a wave that gently rolls up his spine to his head. His head and shoulder move in response to the movement of his pelvis but not simultaneously with it: now it takes some time for the movement of the pelvis to wind its way along the chain of the spine up to the head.

"I'm not a box anymore!"

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This case study, like the ones in earlier chapters, illustrates how an understanding of the circular relationship between perception and action can lead to a new way of working with physical limitations; a way of working based on engaging the student in a process of making new distinctions. To summarize, this process of making distinctions is one in which the student and teacher **converse**, interacting verbally and/or non-verbally in such a way as to make it possible for the student to notice how the problems experienced are a consequence of how the student habitually moves.

The teacher must be able to **convert** his or her third-person perceptions of how the student is moving into kinesthetic distinctions, especially those distinctions that will facilitate the student's becoming aware of habits and
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possibilities. This is accomplished by the teacher getting the student to **calibrate** (or, to be more accurate, to re-calibrate) to the various aspects of the experience of moving: effort, speed, direction, place of initiation, and so on. During Patrick's lesson, my questions about how he moves as he walks, about how his torso responds to the small movements I initiate at his pelvis, and so on are asking him to calibrate, or fine-tune, his kinesthetic experience.

At the heart of this educational conversation is the process of the student learning to **contrast** ways of moving and, thereby, beginning to make distinctions. The student moves from undifferentiated movement, and an undifferentiated experience of moving, to more refined, more articulate, perception *and* action. To facilitate this process of making distinctions, the teacher's approach is to **conjoin**, to go with the habitual pattern of motion the student demonstrates in order to break the habituation without eliciting self-correcting resistance. Sometimes the teacher can **constrain** the student's movement in some way, making a distinction by taking away a choice. (For instance, I held Patrick's pelvis still and moved his upper back in relationship to it so that he could sense how it was possible for him to move in the middle of his back.) As the lesson progresses, the teacher can **correlate** the new distinctions to one another, demonstrating how movement in one place leads to movement in another.[79]

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[79]This description provides a rudimentary introduction to the "Seven C's of Change" (Converse, Convert, Calibrate, Contrast, Conjoin, Constrain and Correlate), an explanatory device that I developed for describing the ways Feldenkrais teachers interact with their students.

This way of working is profoundly different from orthodox approaches to bodywork and physical therapy, which are based on a reductionistic theory and which rely on interventions designed to directly impact the body's physical structure. The sensory-based method presented here, a systemic and dynamic approach, provides another path to regaining function and increasing human abilities, a path based on the central role the nervous system plays in regulating movement and on the central role that perception, especially kinesthetic perception, plays in regulating the nervous system. Relating perception and action, giving voice to kinesthetic experience, and affecting the feedback loop are central notions in this educational approach. This path to improving human movement and perception is an important addition to existing approaches to physical education and physical rehabilitation; that is to say, this approach is not an alternative to other approaches, it is an adjunct. By adding this way of learning to our lives, we can add a marvelously gentle and effective way for each of us to develop our inherent potential for grace and comfort in motion.

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