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On Plasticity and Paraplegia
Some Clinical Observations on the Ability
to Recover from Severe Injury
to the Spinal Cord
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*Two remarkable instances where paraplegia begins to be overcome
by force of will and sensory awareness.*

Two cases are reported here of partial recovery from severe spinal cord injury involving fracture dislocations of the lower thoracic vertebrae. These are remarkable instances, since each of the two women involved had been totally and near totally paralyzed from the waist down for about ten years. The general medical view of such injury is that recovery is unlikely and is impossible after two years post injury. Medical research into recovery methods is very scanty although Brudny has reported two instances of partial success using a biofeedback approach with quadraplegics, and some research is being done now with electrical stimulation of the spinal cord. In the Soviet Union there is more research being done on how to stimulate spinal cord growth and repair. Some of this work has been reported in the popular press.

The two women whose achievement is recorded here are not, however, the recipients of some new modern medical miracle. On the contrary, the achievements in recovery they made were the result primarily of their own efforts as encouraged by a group of therapists and teachers using various non-medical approaches which had the effect of stimulating self-recovery. These approaches included the Feldenkrais method, practiced by myself and somewhat emphasized in this report, biofeedback and imaging, practiced by Michael Leffert, Rolfing, practiced by William Zimmer and acupuncture practiced by J. Michael Moore. All four of us worked primarily to promote the phenomenological aspects of the recovery process and to support our clients at each step of the process with as much positive energy as we had to offer. Behind our efforts were the inspiration of our teachers. I would like to give particular acknowledgement to my own teacher, Moshe Feldenkrais, who so clearly pointed the way during my training with him. Without his example I would never have attempted the seemingly impossible or encouraged anyone to do so.

The recovery process as described in these two cases involves, from a biological point of view, the ability of the nervous system to adapt at a structural level and create circuitry where apparently nerve tissue had been damaged or destroyed.

Carl Cotman in the preface to a recent monograph, *Neuronal Plasticity*, which he edited, comments,

“The concept of a highly static and immutable nervous system posed a serious limitation for understanding behavioral plasticity and phenomena such as recovery of function after injury. Recent findings, however, clearly show that neuronal circuitry is highly adaptable at a structural level even in the mature nervous system.” (p.v)

In the same monograph Goldman and Lewis note that recovery of function following brain injury “does not necessarily occur spontaneously but rather depends on the opportunity that the environment provides for stimulation during the course of postoperative development.” (p. 291)

Recent findings clearly show that neuronal circuitry is highly adaptable at a structural level even in the mature nervous system.

Watching Moshe Feldenkrais working with a paralyzed woman during the summer of 1977, I became aware how important it was to start with the most basic things. Feldenkrais had his student lie on her stomach across his fourteen inch high work table with her legs and hips dangling over the edge. Her legs were completely lifeless and made little contact with the floor, the knees barely touching. In this demonstration Feldenkrais pointed out that his student with her atrophied legs and pelvis could not feel and did not know where her body was below the point of injury. Thus even if some motor impulse could get through, it would be lost in the total confusion of his client’s sensory image below the point of injury. He also pointed out that if you want some weakened muscle to move it would receive only a tiny fraction of an impulse from the central nervous system. For anything to work it must be effectively weightless. That is why he placed his client with her legs dangling.

In this instance, plasticity was induced by sensory awareness of bodily movements.

Feldenkrais proceeded to help his client restore her body image by touching her back and down her leg, asking her what she felt and whether she knew it was the right or left side, whether his hand was on the front or back, etc. He would move her leg and ask, “Am I moving your knee forward or back?” As he checked with little tests, having her imagine parts of her body, he would know when she had accomplished some restoration of her body image. At the end of the lesson there was a clear change in the leg: where before it dangled, it now touched the floor. Feldenkrais showed us that something had changed in her hip, and that she now knew how to bring her leg forward. This small change was exciting to watch. Feldenkrais predicted that within a day his client would experience tingling and creeping sensations in her legs.

In this instance, plasticity was induced by sensory awareness of bodily movements. But an important part of the process was the integrative activity of image formation. And of course Feldenkrais was engaging his client in each part of her learning. So it is not just environmental stimulation that is involved here but the organizational processes that are part of our biological inheritance and the self direction we can give these processes. I will elucidate this theme further at the end of this paper but let me present now the two stories of our clients Suki H. and Lorie L.

II. SUKI H.

Suki H. was first referred to Michael Leffert for paraplegic pain. Michael and I and William Zimmer, a Rolfer, have shared an office complex since I first came to Albuquerque, New Mexico. Michael uses the modalities of autogenics and biofeedback in his work, and Suki was referred primarily for biofeedback training to see if she could learn pain control. In his initial sessions with her, he noted that although she was diagnosed as completely paralyzed from the waist down due to a fracture dislocation at T11,T12, she had some control of the right quadriceps muscle in the front of her leg. Using his EMG biofeedback equipment and connecting his electrodes first to this muscle group and later to the adductor muscles on the inside of her leg he asked her to increase the meter readings on his instrument, thus teaching her to increase activity in these muscles. Within a relatively short time she could move her right leg and with some practice in transferring this learning to the left side she managed some weaker but significant movement on this side too.

Although she was diagnosed as completely paralyzed from the waist down she had some control of the right quadriceps muscle in the front of her leg.

The irony of this discovery by Michael Leffert was that just previously Suki had seen a neurologist about her leg and hip pain. His advice after a cursory examination was that by recutting the spinal cord she would never be troubled by pain again. Fortunately, Suki sought out other alternatives.

I first saw Suki some time after she had begun biofeedback training and was seeing William Zimmer for Rolfing sessions. Suki had developed severe contractures at the back of her legs restricting her ankle motion and had some structural difficulties as a result of sitting in a wheel chair for ten years. The Rolfing work was designed to help Suki with these difficulties, but it was also anticipated that the deep tissue manipulation involved could stimulate the muscle fibers and reduce the adhesions and some of the rigidity of connective tissue in her long unused leg muscles. But Suki's immediate problem when she first came to see me was severe pain in her left hip resulting from her attempts to move her weaker left leg. Discovering that she strongly contracted every partially usable muscle around her hip in attempting to move her leg, I helped her differentiate her leg movements from that of the hip, and consequently the painful spasm disappeared. She now felt that Feldenkrais Functional integration work could contribute to her therapy program and arranged to work with me while continuing her work with Rolfing and biofeedback.

Suki gave the impression right away of having a lot of strength. She organized herself beautifully in such tasks as moving from her chair to my table or to her automobile. She could creep on her hands and knees. She handled the daily tasks of her life easily from her wheelchair. These tasks included taking care of her three year old daughter and her household as well as going to the university where she was majoring in art education. Her own efforts in her recovery included regular swimming and gym workouts.

Suki also had a strong desire to regain movement in her legs. Immediately after the accident that paralysed her some ten years ago, she had assumed she would learn to walk again. In fact she did improve, regaining some bowel and bladder control and the small control she had attained in the right quadriceps muscle, as Michael Leffert had observed. She had been a healthy and athletic person before her injury. To some degree she seemingly set limits as to how much disability she could tolerate. While in the hospital she insisted on removing her catheter and discovered she had enough sensation of her bladder to restore bladder control. She later regained bowel control through a training procedure that resulted in an increase in sensory awareness.

I helped her differentiate her leg movements from that of the hip, and consequently the painful spasm disappeared.

In the subsequent years after leaving the hospital she lived for a while at home. Here she settled in, accepting her disability, losing touch with her previous determination to recover. But marriage, a move to New Mexico, and contact with new possibilities, reawakened the old desire to walk.

In my second lesson with Suki, I addressed the problem of standing. I discovered right off that her spine did not respond at all to my pushing gently on her feet as she lay on my table. Of course I knew her spine was stabilized with a Harrington rod alongside the injury at T11, T12. The problem was not just the rod, however. Let me digress a moment at this point to describe “function” as used in the Feldenkrais sense and to point out the unique contribution this concept adds to the process of recovery.

The functional viewpoint looks at the parts and the whole and the synergy between them.

Although most people who are interested in movement are aware that to carry out an intended action the whole nervous, muscular and skeletal system including the connective tissue is activated, there is a tendency to describe only the most obvious moving part of the action. Yet to stand and move one’s arm to the right means that the entire left side of the body will compensate for the shift of weight in gravity. Of course this happens below conscious awareness for most of us. Yet each part of the compensation must work smoothly for the action to be easy and well coordinated. The functional viewpoint looks at the parts and the whole and the synergy between them. When I pushed Suki’s right foot, for example, I simulated the action, function if you will, of standing on the right foot. If the function is complete, I will see the hip, the spine and the head move directly with my push so that the force of the push, given a clear direction through my hands will be carried through to the head. I can feel with my hand as well as see if some part of the spine or the hip does not cooperate and thereby disturbs the function. If the function is disturbed in this way with the person lying on the table, it will surely be disturbed when the person stands in gravity. In Suki’s case she had only stood infrequently with braces since the accident and had forgotten how to organize her spine and hips and neck for normal standing. These braces also threw her body forward with her hips hyperextended. In addition, though her side muscles were not paralysed she had forgotten how to use them to push or pull her leg. So my first purpose was to induce her to restore the missing function herself, helping the parts cooperate with guidance from my hands until she herself restored the sensation of how her spine worked. I then had her push and pull her leg towards or away from my hand until she remembered again how to do this movement,

all the while reminding her that to push with her right foot meant contracting her left side. As Feldenkrais has often observed, we frequently do not know what we do, even in the simplest action and this lack of awareness only becomes apparent when an injury or illness renders the action seemingly impossible. For Suki it was a revelation to realize that she could push her foot with her hip and that the push was really a pull on the opposite side.

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Once I saw there was some semblance of a standing function in the working parts of Suki's body I felt we could move to actual standing. Of course I did not expect Suki to be able to stand. But Feldenkrais had shown us a simple way to get a paralyzed person up in gravity. Once up in this position, one could then check to see, for example, if the quadriceps muscles responded even in a small way to the pressure of the body weight on her feet. I had Suki put her knees against mine as she sat facing me with her arms around my neck, and we stood together, my body providing the force of straightening and my knees serving as the fulcrum against which her legs straightened. After a few tries she organized this process well enough so that I instructed her on how to do the same standing at home with her knees braced against a chair and using the chair back to pull herself up. With her husband's help she fixed a chair to aid herself in this way and practiced regularly. A few weeks later I had Suki stand with me in the office while Michael Leffert checked for reflex activity in the quadriceps muscles. On both sides a response was present, stronger, however, on the right.

Suki's injury did not result in strong spasms in her legs, although there were contractures about her ankles and her big toe on each side had been fixed with a rod during her hospitalization to prevent the toe from curling. Also there was a good deal of atrophy about the pelvis, thighs and especially the lower legs. As Suki practiced standing it became obvious that the contractures in the back of her lower legs prevented her heels from fully touching the floor. The tissue of these muscles had become tough and inelastic. It took many months of Rolfing work and gentle movement before her ankles had enough flexibility for proper standing.

In the many lessons that followed we worked with numerous functions and movements. Each time we began a new movement I would have Suki try a movement to see how she would initially do it, not using the correct muscles. These movements had to be inhibited if she were to regain connection with the unused muscles, and of course this was the most difficult part of the task. When something fails to work we try everything else to accomplish the goal. But the compensation overwhelms the tiny possibility of doing the desired function. Yochanan Rywerant has elucidated this situation very nicely in an article describing his work with a flute player who had lost the use of his hand though a gun shot wound. Rywerant describes this compensation "...as an effect of the *regression* the system undergoes when suddenly thrown into a state of infringed capabilities." (p.27)

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To avoid compensatory action I would have Suki first just imagine the movement. Suki would do this through visualization at first. As she saw herself move she would begin to imagine the feel of the movement. This was often difficult as her injury also disturbed her body image so that she could not know at first where to feel even in her imagination. But her previous achievements were a great help in giving herself a pathway towards the desired kinesthetic image. The first movements she would achieve were often so small I could barely be sure she had made them. Each movement we tried was made in a situation in which there was the least possible resistance. This way she would not be overwhelmed by trying hard. Sometimes a complex differentiation had to be achieved. As an example let me cite a particular instance.

Suki could use the adductor muscles of her thigh to move her knees to the inside while sitting. But lying on her back she could not rotate her hips inward. What would happen was that in her attempt to carry out the action her feet would actually turn the opposite way from her intention. To correct this function she had to learn to differentiate the action of the short adductor muscles. But one does not do this by merely knowing which muscles to use, but rather by the different internal feeling of the movement. I therefore held her leg bent at the knee and rotated outward at the hip and asked her to lift her knee. At each step I asked her to lift while slowly straightening her leg each time she successfully lifted. When at last her leg was straight Suki knew what it was to rotate her hip to the inside.

During the course of our work together Suki began to dream that she was walking again.

During the course of our work together Suki began to dream that she was walking again. Sometimes in her dreams she walked with difficulty and at other times with the ease she had before her injury. She told me that during the last few months she never dreamed of herself being in a wheelchair. She also has reported that at times she has had the impulse to just get up from her wheelchair and walk. And in fact she now is beginning to walk using parallel bars for support. She had done this before with braces on both legs, but now she discards the right leg brace and finds that her right leg supports her. She is talking about moving on to a walker and is looking for a model with enough stability.

I would like to complete my description of Suki's progress with some description of her sensations of the changes she had undergone. The return of sensation and body image is strongly coupled to the return of motor function. Suki had always had sensation in her right thigh and in fact her skin on the front of the thigh was hypersensitive. It was also her right thigh muscle that moved initially. The rest of her legs, however, were dead, "like a couple of pieces of furniture," to quote her metaphor.

Now she describes both legs as being "awake."

Her first experience of sensation came with sexual orgasm. Afterwards she would experience tingling and sometimes itching down her legs. At the time she began to see me she could feel her right leg down to the knee. Now she describes both legs as being "awake." A recent left ankle injury produced intense tingling whereas previously she could feel nothing. But Suki has never been entirely clear in her own mind about the

direct relation between these internal feelings and the consequent return of function. When a new function became apparent to her she would more likely say, “Oh it works. I never knew that,” and not know precisely how the function got there. Lorie L. whose case I will discuss next is much clearer about feeling and movement. But Suki is very clear about the effect of imaging and the imaging processes. She carried out these processes at the direction of all three of us, Michael Leffert, William Zimmer and myself, and many times experienced her “Oh it works” as a consequence.

III. LORIE L.

Lorie L. was referred to me by a massage therapist who knew a little of the Feldenkrais work. When Lorie came to my office for her first visit, she explained that she had decided that after ten years in a wheel chair she was ready to walk again and that she needed help in re-learning. I noticed that she had driven herself to my office, moved well from car to wheel chair, and I asked her to lie on my table. I immediately observed her legs. They looked like sticks and were bowed by contractures behind the knees. Her pelvis looked hollow; there was so little musculature left. In relation to Lorie’s stated goal to walk again the situation looked absurd. But her energy was strong, her desire to walk obviously not a mere fantasy of the moment nor a desire of desperation. Her eyes were bright and her spirit alive and well. Atrophy had taken a great toll in ten years but who knew what was really possible? We agreed to work together for a few months to see what could happen.

Lorie’s injury at the tenth thoracic vertebra occurred in an auto accident ten years earlier. At that time Lorie already had a scoliosis of the spine and the injury occurred at the apex of the curve. An attempt was made to fuse the spine from T8 to T12 by removing one of Lorie’s ribs and placing it along side the injured area but the fusion failed. Some natural fusion occurred later. On x-rays it was impossible for me to interpret the confusion of bone at the injury site. To the touch the injury site protruded more than a quarter inch on the left side of her back and felt massive and immovable. As a consequence of the curve, the lower ribs on the right side fell below the crest of the pelvis when Lorie sat in her wheel chair. This caused continuous discomfort.

Though we do not know at this time how recovery takes place, the human system itself knows the pathway.

On the positive side, however, Lorie had no abnormal reflexes and did not have any reflex spasms in her legs. She did not have normal bowel and bladder control but she did have retention. Best of all, as a result of a series of acupuncture treatments begun prior to seeing me, she was experiencing a return of sensation in her legs and feet. And, of course, her desire to move again was strong and healthy.

This desire to get well, to no longer be an invalid, is to my estimation the most critical factor in the small but significant recovery Lorie has achieved so far. In the first months and years after the automobile accident that caused the injury and paralysis, Lorie, in her hospital bed and later in her wheel chair, was both depressed and angry. Twice in angry fits she threw herself out of her wheel chair breaking her hip on one occasion and her

knees on another. At the same time, by her own testimony, she was also locked into the role of a paralytic. She needed to be helpless. At the present she identifies this need as transcending the accident and in fact she attributes the accident, although she was not the driver of the car, to the need pattern that she feels dominated her life at that time.

She learned new sensations quickly and was amazed to realize how confused her body it was the beginning

Change came slowly at first for Lorie. As she learned to live with her paralysis and to take care of herself, she chose to marry and to have a child. But she did these things still as an invalid. At no time did she consider the possibility of getting well and restoring her functioning. The crucial change came with a consultation with a healer- religious teacher who told her she would walk again. The quality of this experience was apparently that of a religious conversion. Lorie had clearly turned around within herself. The part of herself that needed the invalid role was still there, but it did not dominate. In her subsequent therapy this part would appear often and with each initial change Lorie would become sick sometimes for a week at a time. But in her determination to go on she never allowed her momentary sickness to stop her progress, always recognizing that it was transitory, part of an old pattern that she was slowly dropping away as she often explained to me. I would describe this change as a clear choice for health, and as a mobilization of her system towards recovery. For though we do not know at this time how recovery takes place, and do not know how to do it through a mechanism, the human system itself knows the pathway.

Lorie for her part now sought a therapeutic path for herself. From nutrition to chiropractic treatment to acupuncture she tried everything she had ever heard about. Knowing that medical people had always discouraged her from considering recovery and that they seemed to have no knowledge of such recovery possibilities, she began by choosing alternative and naturopathic oriented therapies. Of all these therapies acupuncture showed the most promise initially. I would like to describe this work briefly because I think the effect was very significant in starting the recovery process and also because Lorie could clearly distinguish the effects of acupuncture from other things she had tried with equal enthusiasm, this indicating that the change is probably not due to a placebo reaction.

J. Michael Moore, the acupuncture therapist in Santa Fe, New Mexico, who was carrying out this work with Lorie modestly describes the beginnings of his acupuncture treatments as “working in the dark.” But using a model derived basically from traditional oriental acupuncture, he was able to find a pathway for change. From his initial observations he found that below the spinal injury there was no energy flow or Chi to Lorie’s pelvis and legs. For many sessions he placed needles and stimulated energy channels or meridians going from Lorie’s back down her legs without noticing any effect. But at some point a change did start to take place. Lorie describes this change as beginning to feel a “flow” into her legs. Later the flow became a tingling or sometimes a burning. When I first saw Lorie she did report being able to feel her ankles, although as it turns out this sensation was confused in her body image. Michael Moore now reported what he called an “energy flow” going on below the injury.

Lorie's injury at the tenth thoracic vertebra occurred in an auto accident ten years earlier.

As I began to work with Lorie she continued her work with Michael Moore. Now he began to use electrical stimulation of the acupuncture points as well as stimulation with moxa to see if he could, by moving down the meridians, stimulate muscle activity below the injury. He worked back and forth sometimes stimulating energy channels and sometimes slowing them down as he observed fatigue set in. Lorie for her part began to feel the muscles working as the stimulation succeeded in producing a contraction in the long unused muscles. Michael Moore discovered that recovery as reported in the oriental literature in acupuncture was a long process, but was quite possible over a period of years. He expressed to me considerable satisfaction over persisting through the period in which nothing seemingly happened, though he was expecting a sudden and dramatic change. By the time I began work with Lorie I was accustomed to working with initially miniscule changes that most people would ignore as being insignificant.

At the end of February she suddenly was able to contract part of the quadriceps muscle.

From my own scientifically biased perspective, I am not sure whether it is necessary to understand the effects of the acupuncture work in terms of Chi or life energy, but it was at least a powerful metaphor in Lorie's case and it did indeed lead to a change in neuronal activity below her injury. The most important point here is that the plasticity process can be activated in a number of ways and that acupuncture seems to be a good pathway towards this activation. I would like to mention that with another client I have worked with, James R., a quadriplegic, reflexology treatments have similarly had a stimulating effect on plasticity processes. Reflexology, like acupuncture, works with an energy channel model where reflex points on the hands and feet are stimulated with pressure.

My own work with Lorie began in October of 1979 with her initial visit to my office as previously described. Beginning with the new sensations Lorie could detect as a consequence of the acupuncture work and following the suggestion of Feldenkrais that one cannot move when one cannot tell right from left or up from down, my first steps in teaching her were to help her sort out her new sensations in terms of a body image. With her eyes closed I went up and down her lower back or stomach and legs, tapping first so she could tell me whether I was on the right or left side and then so she could identify ankle, knee, thigh, etc. She learned new sensations quickly and was amazed to realize how confused her body image was at the beginning.

During the third lesson I had Lorie, while lying on her back, imagine holding her knee standing while I carefully arranged her foot and knee so it would stand through balance. At first I could not get the knee to balance. The leg was so floppy it would fall too easily to one side or the other. I moved the knee right and left and asked Lorie to tell me to which side I moved it. When she could do this correctly, I then asked Lorie to resist the movement I made and try to feel if this made any change. If there was, it was too small for me to detect. But when I had Lorie go back to "holding" her leg in the standing position, this time I could balance her leg. She held it there for a long time and suddenly exclaimed "I can feel myself doing it." Her excitement was overwhelming and her body began to shake. We stopped at that point, but Lorie had achieved a breakthrough in

recreating a connection with her leg, something that had seemed impossible up to that moment. This was one of the sessions in which Lorie reacted afterwards by becoming ill. But it turned a spark of hope into a flame.

As of this moment, July 1980, Lorie is gaining strength slowly through the movements she can do.

Some of the work I had to do with Lorie concerned teaching her to organize her sitting so that her ribs on the right side did not fall against her right pelvis. This was part of her scoliosis problem, and it had caused her discomfort for many years. Initially her spine felt as if it were one solid piece at the injury site, and this resulted in a corresponding rigidity in her left lower ribs. Without recovering movement in this area it did not seem possible to change her sitting position. But over a period of weeks, by helping Lorie to slowly move what could move in her back and working towards the most rigid area, some movement became possible even at the most solid point at the apex of the scoliosis curve on the left. Now she could experience the feeling of her spine lengthening when I gently directed this movement with my hands. She found as a consequence that she could sit in a more comfortable way.

Both learning and healing are consequences of autopoiesis and plasticity.

In the meanwhile Lorie was working on her movements in a swimming pool, and we continued the imaging and sensing processes. Six months after we began working together Lorie could move her knee right and left slightly while sitting and she was beginning to feel the quadriceps muscle. At the end of February she suddenly was able to contract part of the quadriceps muscle, feel the contraction while sitting and move her kneecap a small amount from the position to which it had dropped as a result of the atrophy in this muscle. The next month she learned to rotate her heel right and left while lying on her stomach. This learning process was aided by her realizing that she had to contract her buttocks to make the movement. I am sometimes amazed at how small a movement may initially be in a recovery and how much faith I have had in assuming that the tiny change I saw was real. One way to check on myself was to have Lorie do a movement while I gave her feedback on whether she had moved to the left or right, If my feedback matched her intention, I knew and she knew that the movement was really there.

But Lorie also went through an internal process that accompanied each gain. The first step was to feel a tingling in a new area of her leg. Then while trying to work with the new movement, part of her leg would “freeze-up” and have a burning sensation. During the “freeze-up” she would feel an impossibility of moving even in her imagination. With rest, however, the tingling would return along with a freeing of her imagination process. At the point at which she got in touch with the feel of the movement and the muscles involved, the tingling would disappear or decrease. At each breakthrough Lorie would have a direct return of body image. Her statements would include, “I can feel it work,” or “I can feel where it is.”

As of this moment, July 1980, Lorie is gaining strength slowly through movements she can do. The atrophied muscles of her thigh are getting thicker. There is a long way to go before any of her movements are fully functional. But the pathway is well established.

IV

Structural or, if you will, somatic plasticity in living systems is a consequence of what biologist Francisco Varela calls autopoiesis. Autopoiesis, literally self-forming or self-creating, designates that state of organization that we recognize as a living entity. An autopoietic system is organized as a unity in space with a network of processes of material transformation and destruction that results in a continuous regeneration of the network. Autopoiesis, then, implies a maintenance of those internal and circular relationships that define self. As long as these relationships are not broken, i.e., remain invariant, a living self goes on. But the maintenance of the defining relationships also involves what we usually call adaptation. It is the material of life that is forever changing. Within the limits of not breaking the internal relationships it is somatic change that allows a living system to continue to live in differing circumstances.

Mislearning occurs, in the Feldenkrais view, when the goal of an action becomes more important than how an action is done.

Both learning and healing are consequences of autopoiesis and plasticity. A body system as well as the organism as a whole will be organized as an autopoietic entity. When a system is perturbed as a result of interaction with an external or internal contact some change results though the system continues to maintain the processes and process relationships. Each system then has a “memory,” but the structures so formed are a consequence of the system itself and its organizational closure. With regard to the nervous system this process is equivalent to learning.

Learning is not simply a matter of perturbation. For human beings, who have an extraordinary capacity to learn, learning can be done well or poorly. In addition the nature of the perturbation is important. A violent perturbation that is perceived as a danger will most likely result in the system finding a more safe and primitive state. For the kind of learning that leads to greater organization, safety and support are critical factors.

Imaging often works where conscious will power is useless.

Mislearning, as Feldenkrais has pointed out, in his *Body and Mature Behavior* is also common in the human condition. Mislearning occurs, in the Feldenkrais view, when the goal of an action becomes more important than how an action is done. Any means are used without regard to an efficient and easy organization of the action. In situations such as experienced by Suki and Lorie in this report understanding this is essential to the possibility of any change. Goal-seeking will inevitably lead to just those compensations which will prevent the discovery of the correct function, small as it is. One of the major characteristics of the Feldenkrais approach in movement and Functional Integration is

that the goal of a particular lesson is never made explicit and therefore never becomes a conscious interference. Similarly the use of imaging processes avoids the engaging of action before the action can be properly organized. The image forming process itself is an activity of organization. The formation of such cognitive structures is again, in Varela's view, a consequence of autopoiesis.

As a cognitive structure, an image parallels all other such organized entities. It is not surprising therefore that an image can engage other cognitive processes within the system, nor is it surprising that the nervous system will form images with any sensory modality. Bach-y-Rita, for example, found in his work with sensory substitution, that blind people, given tactile data produced by two small video cameras in the form of electrical stimulation of a matrix placed on their skin, will "see" objects in space. Imaging as part of the healing process is now well established from considerable experience with autogenics, biofeedback and other similar approaches. Imaging often works where conscious will power is useless. Elmer and Alyce Green found in the pioneering work on biofeedback that imaging could work as a kind of "programming" the self to do a task that normally was not under conscious control. Carl and Stephanie Simon- ton have observed how imaging processes can activate the immune system in helping cancer patients with their healing process. The immune system is a cognitively organized system as Varela has shown, and imaging in this case apparently activates a coupling from nervous system to immune system.

It is possible to activate a recovery process in some paraplegics, where the cord is not severed, and where the person is willing to enter into the process.

The recovery from severe trauma to the spinal cord is a slow process, taking years perhaps to reach a limit. The plasticity processes of the peripheral nervous system are much slower to activate than the central nervous system and such processes are much slower in man than in organisms lower on the evolutionary scale. The point of the observations of this paper is that it is possible to activate a recovery process in some paraplegics, where the cord is not severed, and where the person is willing to enter into the process. The process involves activating the inherent structural plasticity of the system, stimulating weak connections that still exist and inducing still alive nerve cells to "sprout" and make new connections. Phenomenologically the process involves learning, imaging, and a positive organizing of the self around a healthy outcome. What seems most central to Lorie and Suki's progress is their energized will to improve coupled with a learning process that increases awareness of sensory experience. This "will" in my view, is not a hope grasped from despondency, but a continuing engaging of the self in a process without a desperate desire for the goal.

Lorie and Suki are the real heroes of this report. To accomplish what they have they had to disregard most of what they had been told about their condition and rely on their own abilities as guided by myself and the other people they worked with. Both they and we who helped them had to find something new to use as a vehicle for learning and sensing. In his book, *The Case of Nora*, Feldenkrais sums up this process nicely. He says,

"If you are told that somebody cannot do something, logically there is nothing you can do about it. Every diagnosis in words inhibits the brain from thinking for

itself. If words say “incurable” the situation will not be changed by saying “curable.” But if you use your sensory ability to look, learn, listen, and touch you may find new data which will make you see what you can do to help.” (p.89)

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