

CHAPTER 22

CONTROL THEORY APPLIED TO STRESS MANAGEMENT

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Control theory (Powers, 1973) provides a parsimonious account of the "psychosomatic" processes that mediate psychological stress, an account in which volition plays a central role (Pavloski, 1987; also see Pavloski's chapter in this volume). I have found, as a practicing clinical psychologist, that control theory conceptually unifies a variety of contemporary approaches to stress management, including psychotherapy, drug therapy, and biofeedback. In this chapter I relate these three methods to each other by examining each within the common theoretical context provided by Powers' control-system model.

Control Theory Concepts

According to psychological control theory, we control much of our own experience by offsetting environmental disturbances so as to keep some of our perceptual inputs approximately equal to a corresponding set of neural reference signals. The reference signals represent our *intended* perceptual inputs. We continually compare our actual perceptions (input signals) against our intended perceptions (reference signals), and any discrepancies, called error signals, serve to attenuate themselves more or less automatically by means of negative feedback loops which extend through our effectors into the environment. We are organized, as are all control systems, to keep error signals small. When the error signals are zero, effector output is nil. When the error signals are nonzero, effectors are activated. Error signals drive effector actions and the pattern of error signals determines the pattern of the effector actions. Error signals also change our internal body state so that it is prepared to take the overt actions, that is, so that our body is physiologically and biochemically ready for those actions.

Our controlled perceptions (i.e., voluntary actions) are the joint effects of our effector actions and independent environmental factors called "disturbances." Ideally, our effector actions combine with these

environmental "disturbances" to keep our controlled perceptions equal to our intended perceptions. To the degree that our controlled perceptions do in fact "track" our intended perceptions, our error signals are small, and we may be said to be in control of our lives, or to be behaving intentionally or voluntarily. Conversely, to the degree that our error signals are large, we may be said to be out of control and to be experiencing psychosomatic stress.

Each of us, according to Powers' model, is a complex, hierarchical control system, with error signals continually being evaluated at each level of the hierarchy. An error signal in any given control system at level N determines the reference signals for a set of control systems at level $(N-1)$. As each control system at the lower level achieves its goal, the control system at level N automatically achieves its goal.

Powers' model has eleven levels. The lowest level controls the intensity of simple sensory inputs. Higher levels deal with ever more meaningful, perceptual signals, including conceptions, and values. Reference signals at the highest level are called system's concepts, or system's reference signals. They, potentially, exert the greatest degree of control. A dramatic example of the influence of such high-level control systems upon the functioning of lower-level control systems appears to be found in cases of *multiple personality disorder*. Robertson, Goldstein, Mermel and Musgrave (1987) have suggested that a neural representation of a self-concept serves as a person's system-level reference signal. It follows that such a system's level concept should influence virtually all lower-level processes. They called this system-level reference signal the *self-image*. People with multiple personality disorder seem to have several self-images or self-systems which are active at different times. Research with cases of multiple personality disorder has shown that when people change their personality they also change their brain wave patterns and other seemingly unrelated "physical" traits, such as handedness, need for glasses, allergies, immune factors in their blood, muscle tension, and style of movements. The remarkable thing about such changes in personality is the coordinated rapidity with which these physical traits are changed. However, this is exactly what a hierarchical, control-system model predicts.

Stress Defined

Power's model defines feeling/emotion/mood as the relatively passive (i.e., relatively uncontrolled) perception of the internal bodily reactions which prepare a person for overt action, say for fight or flight. Since the

activity of both the internal organs (neuroendocrine system) and the skeletal musculature (neuromotor system) are driven by the same higher-order error signals, the two types of activity are normally coordinated and well matched. However, sometimes they are mismatched, and whenever they are, we have what is commonly referred to as stress. According to control theory, however, psychological stress is merely a reflection of an abnormally large error signal at some higher level in the hierarchy, an error signal which the neuromuscular system is failing to erase. That is, a mismatch necessarily reflects a chronic (i.e., persistently large) error signal. (A chronic mismatch reflects a *very* chronic error signal.) Consequently, stress may be quantified or operationally defined simply in terms of perceptual error signals, as Pavloski has done successfully (e.g., see his chapter).

A common cause of chronic error is internal conflict involving two or more incompatible intentions or goals; for example, intending simultaneously to please and offend another person, say a patrolman writing one a traffic ticket. Another common cause is attempting to control perceptions which require skills not yet developed or developed for different circumstances, for example driving a stick shift in traffic for the first time, or delivering a poorly rehearsed speech. A third cause of chronic error is an overwhelming disturbance which no amount of effector action or physical exertion can escape, offset, or overcome, such as flood, famine or "city hall."

Powers' control-system model is ultrastable in the sense that a persistent error signal (i.e., stress) serves to alter the organization of the system itself. That is, if chronic error signals persist indefinitely, a reorganization system (inborn control systems which help maintain physical stability necessary for health and body homeostasis) is activated. When this occurs, control systems which are in chronic error start to change in a trial and error way, until the intended perceptions come under control or are abandoned. This trial and error learning merely restores the polarity of the recalcitrant feedback loops, (restoring their negativity, i.e., restoring their error-reducing ability) and does not entail the acquisition of stimulus-response habits.

Managing stress

There are three traditional clinical means of managing stress: psychotherapy, drug therapy and biofeedback. I will relate these three

methods by examining each within the common context provided by Powers' control-systems model.

First it should be understood that tolerance for error (i.e., error sensitivity) may be expected to vary genetically across individuals. Indeed, Saunders (1985) has distinguished three classes of individuals who appear to differ in this regard; he calls them polyactive, proactive, and reactive. A polyactive person likes to engage in several tasks at the same time (Saunders used three tasks to measure stress-coping style: a version of the Stroop color naming test, the digit-symbol subtest of the Wechsler Adult Intelligence test, and a time interval estimation task). A proactive person likes to be working on only one task at a time. A reactive person does not like to work at a fixed task. A person who is proactive may view a polyactive person as seeking stress. A person who is polyactive may perceive the others as avoiding stress. Control theory suggests that sensitivity to error may distinguish between these three groups. The "reactive" person appears to be more sensitive or reactive to error, and is therefore more readily stressed. However, the polyactive person, although perhaps less sensitive or reactive to error, may be the first to be overwhelmed by stress simply because, in stretching himself thin, his control is readily undone, sometimes by the slightest additional disturbance. Also, the polyactive person appears more susceptible to the type of stress called "boredom," where the level of environmental stimulation is *less* than the person's set point or reference level. (Both understimulation and overstimulation are known to trigger the adrenal medullary and the adrenal cortical response.) Therefore, persons seeking clinical assistance for reasons of stress are as likely to be polyactive as reactive.

Biofeedback Therapy

Biofeedback therapy, from a control-theory viewpoint, focuses upon the symptoms rather than the causes of stress. The stress response is viewed as the presumed cause of bodily wear and tear, illness, and disease, and biofeedback is used to inhibit that response. The error signal driving the stress response is not itself addressed. In biofeedback therapy (Goldstein, 1978) people are provided with information about their body that has been detected by means of electronic sensors. When people are given this information about their body, they can develop a degree of voluntary control over their body's physiological activity. Various types of information about the body have been used in biofeedback: The more common types include EMG which provides skeletal muscle information, TEMP which gives a person skin temperature information, SCL which

conveys information about the electrical conductivity of the skin, and EEG which displays brain wave activity.

Since one hallmark of stress is excessive muscular tension, one clinical approach to the management of stress involves training individuals simply to relax. The person is trained to relax, and biofeedback, say EMG information, is provided in order to help the person discover which intentional actions at his command influence the variable (state of relaxation) he is wanting to control. At the same time, the person is trained to monitor various perceptual inputs which reflect the state of his relaxation. For instance a person learns to ask and answer the following kinds of questions: Am I having feelings/moods/emotions which suggest that I am not relaxed? Is the way I am breathing suggesting that I am not relaxed? Are the state of my skeletal muscles suggesting that I am not relaxed? Is the state of my skin temperature and skin moisture suggesting that I am not relaxed? Is my posture suggesting that I am not relaxed?

Once a person is able both to monitor and to selectively influence the value of a variable (in this case relaxation), that person is in a position to control that variable. Therefore, in general relaxation training, a person, in effect, develops a control system for controlling how tense or relaxed they are.

The physiological activity which a person is learning to consciously control is already under the control of control systems which are inborn. For example, our body breathes by itself. We can consciously control our breathing but do not have to instruct our body to breathe. In Powers' control theory, these inborn control systems are part of the reorganization system. The control of the reorganization system is superordinate to the rest of the control system hierarchy. Therefore, control theory leads us to expect that there are definite limits to the kinds of changes in our physiology which can be brought about by acquired control systems.

How well does the data in the biofeedback literature support the picture which control theory provides us?

Expectation 1. The self system of a person will play an important role in learning to be more relaxed. Only if the procedure is consistent with the persons self-image will it be feasible. Otherwise the "therapy" itself will be stressful.

I have found that some people find biofeedback therapy too boring or too frustrating; they are not able to concentrate during the session, or they do not practice the relaxation assignments between sessions. They seem unable to make it part of their life.

The literature on who is a good candidate for biofeedback therapy suggests that personality (self system) is a very important factor. Ford (1985) studied the relationship between the personality of 55 adult patients and their learning to relax by means of the QR audio tapes of Charles Stroebe, EMG biofeedback and TEMP biofeedback. The training sessions were on a weekly basis for eight weeks. The personality of the people were measured by the MMPI and a set of adjective descriptions. Ford found that "Patients who, upon admission, tend to like responsibility and who are executive and independent are those who generally benefit, at least in the short term. Unsuccessful patients were more often less forceful and more doubtful, obedient, and depressed" (p. 237).

Expectation 2. The better a person can perceive his/her body states, the faster he/she will learn during biofeedback therapy. After a person has acquired voluntary control over a physiological activity, he/she will have increased ability to sense that physiological activity.

This is a very critical control theory expectation. Once a person is disconnected from the electronic machinery, the person will have to rely on his/her own sensory information. One does not expect control of the physiological activity to be very good if the sensory information about the physiological activity is very poor. I have had patients spontaneously tell me that they were getting much better at sensing the signs of not being relaxed and the signs of being relaxed. Try this exercise with a friend. Ask your friend to hold both arms out in front of himself/herself while you support both arms with your hands. Then tell the person to relax both arms. Ask him/her if he/she is relaxed as much as possible. When he/she claims to be fully relaxed, quickly remove your hands and observe what happens. If he/she is really relaxed his/her arms will fall immediately and quickly. However, some people who believe they are relaxed continue to hold their arms outstretched, and only after a delay allow them to fall in a very controlled fashion. Obviously, such persons are not consciously aware of the muscle tension in their arms.

Stilson, Matus and Ball (1980) did a psychophysical study of people's perception of muscle tension before and after EMG training. They looked at two sites: forehead placement and forearm placement of the EMG sensors. Although each person was given only 11 trials, rather than learning to a criterion of mastery, sensitivity was greater after training for all the subjects. These results were true for the forehead EMG placement but not the forearm EMG placement. (While these authors favored a negative feedback model of control, and cited Powers,

they are apparently unaware that the intensity control systems are controlling effort which Powers describes as an input rather than an output variable.)

Appelbaum, Blanchard and Andrasik (1984) tested 44 people who came to them for treatment of headaches: 11 had migraine headaches, 15 had tension headaches and 18 had combined migraine and tension headaches. The treatment was eclectic and included EMG biofeedback for the tension headache group (10 sessions) plus TEMP biofeedback for the migraine group and mixed group (6 sessions); breathing and tense/relax exercises were also part of the treatment. The therapy-outcome measure was based on a headache diary which the patients were trained to keep. The ability of the patients to discriminate muscle tension at three different sites before and after treatment was determined using a psychophysical method in which they were to produce a particular magnitude of tension. The results were: (a) people with migraine headaches and mixed headaches were better at muscle discrimination before treatment, (b) treatment resulted in improved muscle discrimination ability, and (c) for people with migraine headaches only, those with better discrimination ability at the beginning of treatment had a better treatment outcome.

Expectation 3. There will be a limit to voluntary control over physiological activity because physiological activity is already being controlled by inborn control systems. These inborn control systems might consider the outputs of the acquired control systems as disturbances.

One way that these inborn control systems manifest themselves is in the so-called rebound effects after biofeedback therapy. DeGood and Williams (1982) present a case study in which a patient with chronic low back pain and leg pain for two and one-half years received EMG biofeedback with a forehead placement. The patient experienced nausea/headache symptoms after the first few sessions. The authors make a good case for the position that the within-session physiological changes were too great in the beginning and there was a parasympathetic rebound effect. When the treatment was modified to reduce the amount of change in physiological activity within a session, the rebound effects did not occur.

Drug Therapy

There is a class of drugs known as anti-anxiety agents which are commonly prescribed by physicians to help their patients cope with anxiety symptoms. An extreme case of this disorder is a diagnosis known as *panic*

disorder. I have had numerous patients with this diagnosis. Most of them came to me with a prescription for an anti-anxiety agent and sometimes an anti-depressant. People subject to panic attacks experience a very strong stress reaction which occurs at seemingly unpredictable times. In control theory terms, I think of a panic disorder as an example of reorganization. I have seen people who started out with anxiety attacks develop into a panic disorder diagnosis. There is usually some kind of chronic stress which is not recognized or addressed by these people adequately. I have found that they often have some strong angry feelings which they do not want to express for various reasons. Once people have a panic attack, they start to worry that they will have these attacks again. This thought takes over their life and they avoid circumstances similar to those in which the panic attack occurred. In some cases, the avoidance spreads to all circumstances except the person's home at which point they are housebound.

The psychiatric drugs used in panic disorder seem to be very effective in controlling the panic attack episodes. However, patients report that they don't really feel like themselves when they are taking these drugs. In control theory terms, these drugs do not seem to do away with the error signals but they reduce the body reactions to the error signals which results in a reduced perception of stress; they "deadend" the body's response to error signals. A person who only takes these drugs, and does not work on reducing the error signals through psychotherapy, winds up with a deadened reaction to all error signals. The experience of a panic attack is so awful that people often are willing to take psychiatric drugs for years, in spite of the side effects; they accept the psychiatric viewpoint that they have some kind of brain disorder and are quite relieved to find that a pill can control it. However, unless a person also receives psychotherapy, the control systems which are not controlling adequately never get reorganized.

For a general discussion of the relationship between psychiatric drugs, addictive behaviors and control theory, the reader is referred to Glasser (1981), a control theoretic psychiatrist.

Psychotherapy

From the point of view of control theory, psychotherapy consists of helping a person to identify those aspects of their life which are "out of control," and helping them to reorganize the "control systems" which are involved in these aspects of their life. That is, psychotherapy will involve reorganizing some subset of those control systems which are not working

properly so that a person will be perceiving their life as closer to the way they want it to be.

The first step in psychotherapy from a control theory perspective is to identify those aspects of a patient's life which are out of control. I have developed the Life Perception Survey (LPS) and Life Perception Profile (LPP) for this purpose (Goldstein, 1988). The LPS consists of 38 items, each of which refers to a different area or aspect of a person's life, such as, marriage, money, children, work, etc.. The items were selected so as to encompass the variety of presenting problems people typically describe to me during their first session. A person using the LPS is instructed to circle each item which represents an aspect of his or her life which is "not OK, and should be changed, improved or made better." Next, the person is instructed to pick the three most important problem areas and describe the kind of change desired. The LPP is given following the LPS. The person is asked to rank order the 38 items from "most like them to have problems in this area" to "least like them to have problems in this area." The LPS and LPP were designed to be administered at the beginning of therapy, but they can be readministered at different points during therapy to assess progress.

During a therapy session, I use techniques which have evolved out of control theory. One method is the *method of relative levels*, which can help a therapist explore a client's significant perceptions. Suppose a person says something, a word or phrase, which seems to be clinically significant. As a therapist I would say, "Tell me more about...(the significant word or phrase)...so that I can experience it as you do. Describe ...(the significant word or phrase)... in the present tense as if you were sensing it now." My purpose is not to empathize with the person, but rather to identify the relative level of the control hierarchy at which his or her perceptions are being described. Control theory contains the ideas that (a) the source a person's presenting problems are always at a level in the control hierarchy that is higher than the level of the presenting problems themselves, and (b) a person is not consciously aware of the level from which the person is speaking (see the chapter by Robertson in this volume). For instance, if a person is speaking about *program* level problems, he or she will be unaware of the *principle* level from which he or she is speaking, and from which the program-level problems are perhaps originating. The control-theory therapist tries to get the person to move up a level of control, in this instance, to the *systems concept* level so as to become aware of the principle level from which the problems may be originating (the origin may be even higher in the

hierarchy). By moving up a level of control, in this instance to the systems level, the person becomes consciously aware of the principle level and is, therefore, in a position both to understand and to begin to reorganize the program and lower levels of control.

A second method that has evolved out of control theory is *the test for the controlled variable* (Goldstein, in press). This test helps to discover a person's unconscious or unexpressed intentions (reference conditions) by identifying the particular perceptions the person is controlling or trying to control. If a patient is controlling a perception he or she will respond to a therapist's attempts to disturb it. The therapist attempts to "disturb" the patient by asking questions, or by reinterpreting what the patient has said or done. If the patient reacts to the therapist's offering in a compensatory manner, the perceptual variable in question is revealed to be a controlled variable. With a series of such "disturbances," each an educated guess as to what the patient is intending, the therapist can pinpoint the person's reference perceptions, or reference conditions (see Power's chapter on the quantitative measurement of volition).

For a slightly different application of control theory to clinical practice, see the chapter by Ford, who has also written on the topic of stress (Ford, 1989).

Conclusions

Control theory, which holds that chronic control system error is the psychogenic origin of stress, provides for a unified clinical approach to stress management: (a) Psychoactive drugs may be used to reduce a person's reactivity to control system error. (b) Biofeedback may be used to help a person develop conscious ancillary control over automatic/autonomic responses to stress which endanger the person's health. And, (c) psychotherapy can be used to identify and help reorganize control systems which are not working adequately and creating chronic control-system errors. Only psychotherapy addresses the question of the origin of the control system error. Therefore, psychoactive drugs and biofeedback training are methods which may be combined with psychotherapy, but they are not to be viewed as alternatives to psychotherapy.

References

- Appelbaum, K. A., Banchard, E. B., & Andrasik, F. (1984). Muscle discrimination ability at three muscle sites in three headache groups. *Biofeedback and Self-Regulation*, 09, 421-430.
- DeGood, D. E. & Williams, E. M. (1982). Parasympathetic rebound following EMG biofeedback training: a case study. *Biofeedback and Self-Regulation*, 04, 461-465.
- Ford, E. E. (1989). *Freedom from stress*. Scottsdale, Arizona: Brandt Publishing (Distributor: Meyer Stone, Oak Park, IL).
- Ford, M. R. (1985). Interpersonal stress and style as predictors of biofeedback/relaxation training outcome: preliminary findings. *Biofeedback and Self-Regulation*, 10, 223-239.
- Glasser, W. (1981) *Stations of the mind*. New York: Harper & Row.
- Goldstein, D. M. (1988). *Life perception profile q-sort*. Paper presented at the 4th Annual Meeting of the Control Systems Group, September 28-October 2, The Haimowoods Center, Kenosha, Wisconsin.
- Goldstein, D. M. (1978). *A theoretical interpretation of biofeedback therapy*. Paper presented at the Annual Meeting of the Biofeedback Society of Texas, October 13, Dallas, Texas.
- Goldstein, D. M. (in press). Control theory applied to clinical psychology. In R. J. Robertson & W. T. Powers *Introduction to Modern Psychology*.
- Pavloski, R.P. (1987). *Person-environment transactions and cardiovascular reactivity: implications for social systems*. Paper presented at the Special European Conference of the American Society for Cybernetics, March 16-19, St. Gallen, Switzerland.
- Powers, W. T. (1973). *Behavior: the control of perception*. Chicago: Aldine.
- Robertson, R. J., Goldstein, D. M., Mermel, M., & Musgrave, M. (1988). *Testing the self as a control system*. Paper presented at the 4th Annual Meeting of the Control Systems Group, September 28-October 2, The Haimowoods Center, Kenosha, Wisconsin.
- Saunders, D. R. (1985). *PAS Fourth Dimension Kit* (2nd ed). Lawrenceville, N.J.: MARS Measurement Associates.
- Stilson, D. W., Matus, I., & Ball, G. (1980). Relaxation and subjective estimates of muscle Tension: implications for a central efferent theory of muscle control. *Biofeedback and self-regulation*, 05, 19-36.