

# *On Emotions and PCT: A brief overview*

William T. Powers

Emotions are confusing experiences, because they seem to be both cause and effect. To be angry is to feel a surge of energy and a powerful intention to act (whether it is allowed to take place or not), but it is also an experience that seems to arise passively or be “triggered” from some external source. An old question is whether an emotion arises before the action it seems to demand, or after the action and because of it. When there is danger, do we know there is danger because we feel afraid and flee, or do we flee because of the danger we perceive, and feel afraid as a consequence?

The PCT model of emotion is informed by control theory, in which closed causal loops are the rule rather than the exception. Sequential causality is not adequate as a description of how a control process works; rather, we must consider local causes and effects as existing in various parts of the system at the same time. We can see that emotion, as a physiological state of arousal or relaxation, is produced by the brain as it adjusts the neurochemical reference signals that are sent from the hypothalamus into all the major organ systems via the pituitary. This makes emotion a result of brain activity, for example the sort that is often called “emotional thinking.” On the other hand, disturbances that call control systems into action result in perceivable changes of physiological state, and those changes can be the first that one’s conscious awareness knows of the presence of a disturbance. In that case it seems that the emotion is a direct response to the disturbance, as if emotion represents the arousal of some independent primitive form of intelligence that is designed to take over to save us from threats we do not consciously perceive at first. According to PCT, both of these views of emotion are quasi-correct, but both require considerable clarification.

In closed-loop terms, we must recognize that an experienced emotion is in fact a collection of inputs, perceptions that we call “feelings,” and at the same time, an output-caused change in physiological state: heart rate, respiration rate, vasoconstriction,

metabolism, and motor preparedness—the “general adaptation syndrome” in the case of avoidance or attack behavior. Beyond those basic views we can see also that there are reasons for emotions that are based on what we seek and what we avoid: when we wish a high level of some experience, we give “good” names to the emotions that go with achieving them; when we wish to avoid some experience, we give “bad” names to the feelings even if, considered only as sensations, they are identical to the “good” ones. Exhilaration and terror are very similar if not exactly the same in terms of sensations, though one is involved with experiences that we, or some people, enjoy, while the other goes with experiences that are almost always disliked. Most of the large collection of emotion-words that we use describe error states or goals, with the number of actually different physical sensations involved being very much smaller, or different mainly in degree.

When we think of emotions as inputs, we tend cognitively to attribute them to external causes, as if the feelings were being stimulated directly by something outside us. Neurologists, in support of this view, have come to identify certain volumes in the brain such as the “limbic system” or end-brain as the producer of emotions. They do recognize that disturbances, external stimuli, must act to produce emotions through some mediating brain function rather than directly, but they have failed to see the limbic system as just one level in a hierarchy. Knowing essentially nothing about hierarchical closed-loop control, they do not realize that the limbic system, like any subsystem at that level, has to be told by higher systems whether to seek or avoid any given amount of a perception. The output of the limbic system may operate through the hypothalamus to produce the changes we detect as feelings, but it is not the limbic system that assigns a value to the perceptual signals it receives. That is done by higher systems via reference signals. The limbic system may be the proximal cause of changes in physiological state that we associated with emotions, but it is far from the final cause.

The final cause of an emotion is a reference signal in some high-level system which specifies a high or low intended amount of some perception. If the current state of the perception matches what the reference signal specifies, there is no emotion because there is no call for action to correct an error.

An emotion arises when there is a nonzero error signal in a high-level control system. This error signal is converted into changes in the reference signals of some set of lower-order systems, in a hierarchical cascade that, at some level in the vicinity of the midbrain, bifurcates. One branch of this cascade ends in the motor systems of the spinal cord, the systems that produce overt actions. The other branch passes through midbrain systems like the limbic system, through the hypothalamus and possibly the autonomic nervous system, through the pituitary gland and other glands, into the physiological control systems, the life-support systems of the body. That second branch adjusts the state of the physiological systems as appropriate to the kind and degree of action being produced by the first branch, the behavioral branch. This second branch is the one in which the changes we call feelings (other than the feelings of muscular activity) arise.

Under normal circumstances, behavior comes about for one of two reasons: either there is a disturbance which changes some perception and thus generates an error signal, or there is a change in the reference signal demanded by some higher control system, which change also generates an error signal. So whether the change is initiated by a change of reference signal or by a disturbance, the immediate result is an error signal, and it is the error signal that gives rise both to actions and to feelings.

When an error signal results in a change of action, the physiological changes that simultaneously take place support the change of action, either by providing the resources needed for an increase in activity, or by turning down the physiological/biochemical systems when less metabolic energy or other resources are required—when the organism relaxes and rests. Since the behavioral and physiological changes happen at the same time, they remain approximately in balance, so there is neither an excess or a deficiency in the state of preparedness.

If the requested action is prevented from happening, then the physiological state is no longer appropriate to the behavioral state. The system is flooded with energy that is not being used up because the motor systems have not come into action, or a reduced state

of preparedness becomes insufficient when the level of motor activity remains high instead of declining as demanded. Either combination of states is abnormal; both combinations are experienced as unpleasant.

When we perceive the unpleasantness together with the perceptions and goals behind them, we call the whole pattern an “emotion”—specifically, an unpleasant emotion.

(A pleasant emotion may simply be a sense that the physiological state is in harmony, or is coming into harmony, with the behavioral state; rates of change may be involved. At any rate, pleasant emotions are not ordinarily a problem, so we can ignore them here. People do not seek counseling to cure them of pleasant emotions.)

Consciousness and emotion are not directly related. Since an emotion arises when there is an error signal, and error signals can arise in control systems of which one is not currently aware, feelings can appear without any apparent cause or any apparent connection with the current objects of awareness. It is perfectly possible for an emotional reaction, a change in physiological state and even an automatic change in behavior, to occur before one is conscious of anything amiss. This fact is well known and has been used as a reason for assuming that emotional reactions are truly wired in and permanently unconscious. This has led to a picture of emotion as a holdover from primitive ancestors, or as an early-warning system built into the brain by evolution.

The PCT view of emotion is very different: emotion is simply part of the normal operation of the central nervous system and the physiological systems it uses to achieve its ends. The behavioral hierarchy has many levels with many systems at each level; awareness is in contact with only some subset of these systems, and those systems not involved with awareness simply go on working automatically according to the way they were last reorganized. A change in behavioral and physiological state can result from any error signal without regard to consciousness. Emotions, therefore, exist any time there is an error signal, which means any time we are acting, consciously or unconsciously, to reach a goal or correct an error at any level of organization.

When the degree of error is small, however, we do not use emotion-words: it seems that there is some minimum amount of error that must be exceeded to qualify a state of being as emotional. We use emotion-words when the degree of error

is significant, important to us. When the systems involved are conscious, we can understand what the error is about; otherwise we just feel the arousal without any explanatory cognitions, and say we are worried or anxious or apprehensive without being able to identify the cause.

Normally, unidentified arousals draw our attention to them and we become aware of the perceptions in the control systems that are the source of the problem. But when the error arises because of conflict, there are two control systems involved, each part of its own context, while the conflict is expressed as a control process that is satisfying neither of the higher-order systems trying to use it. Such conflicts are ordinarily resolved by normal processes of reorganization as soon as they arise. But a person may find the conflict so painful that the whole subject is thrust aside—the person avoids getting into situations where either side of the conflict arises. Then, of course, the control systems continue as they were when last reorganized, and the conflict remains. That situation will have to be avoided from then on.

So-called emotional behavior is simply ordinary behavior. However, strong feelings are involved because the errors are considered very important, so a small error produces a large output, and large outputs call for strenuous action and a high degree of physiological preparedness to support the action. The technical term for this state is “high loop gain.” In most circumstances the actions take place, the error is corrected before it can become large, and the physiological state returns to normal with no noticeable emotional state being seen. But if the actions are not allowed or if they fail to correct the error, the result is a continued state of preparation that does not return to normal, and the result is what we recognized as an emotional state.

Therefore emotional behavior and emotional thinking are simply ordinary behavior and thinking concerning subjects which are very important to the person, so that strong actions will be used as required to correct errors, and even small errors are not tolerated. There is nothing in this picture to suggest that emotional thinking or behavior are inferior to any other kind. That the behavior is ineffective is suggested by continuation of the emotions or lack of action, but to dismiss an argument because it is “emotional” is unjustifiable. In fact, it may be the unemotional argument that is defective, in that it concerns errors of no importance.

This conception of emotion suggests that we should understand it as simply a normal part of any behavior, on a continuum that varies from tiny changes in physiology involved in correcting small and unimportant errors, to large, protracted changes that entail extremes of action, feeling, and reorganization. The most intense negative emotions arise in connection with the largest errors and errors that we consider the most important to correct, and their greatest intensity and duration occur when something internal or external prevents us from acting to correct the error. Emotions do not come into us from outside, nor do they represent the action of some automatic or inherited system that exists separately from the rest of the control hierarchy. They are one aspect of the whole integrated hierarchy of control.

Bill Powers  
Lafayette, Colorado  
April 25, 2007