Volition and Causation: Theoretical and Methodological Considerations

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Introduction

Little attention has been given to volition as a psychological construct, and hence little emphasis has been placed upon including volition within mechanistic models of behavior and learning. Western science still displays remnants of Cartesian dualism wherein it is conceived that beliefs and volitions have no place within mechanistic models. In this paper, I present a mechanistic model, Perceptual Control Theory (PCT), that gives volition a causal role in behavior. I show that acceptance of such a model has implications on how one defines behavior, making a distinction between behavioral outputs and behavioral outcomes, and how one conceptualizes its causes, wherein both the environment and volition influence behavior, but the environment determines behavioral outputs and volition determines behavioral outcomes. Volition is not simply an intervening variable, but rather a partial cause; "cause" is not singly equatable with terms such as "stimulus," "environment," or "input." The relationship between volition and learning is discussed, and it is argued that learning occurs by a blind variation and selection retention (BVSR) process. Implications of a PCT model for instructional practices focus primarily on scaffolding, providing a framework with which to eliminate ineffective random variations.

Implications of such a model for social science research methodology are also discussed. It is argued that much social science correlational data is uninformative and would improve from consideration of volitional states of individuals. A method for determining what individuals are controlling for is presented. A framework for understanding different types of research designs is suggested wherein there exist designs with the environment as the independent variable and designs with volitions as the independent variable. Finally, the cross-discipline variability of the importance of considering subject's volitional states is investigated.

Theoretical Considerations

Psychological Perspectives on Volition and Causality

The singular term "cause" is used to refer to any one of a number of distinct temporal relationships existing between events. In order to make these distinctions more apparent, philosophers have ascribed qualifiers to the term "cause" such that we have multiple causes, partial causes, proximal causes, remote causes, material causes, efficient causes, formal causes, final causes, negative causes, specific causes, and general causes.

It is not my intention to resolve the dilemmas associated with causality or comment on which of the above terminology is most "correct" or most useful. I wish instead to give a causal account of human behavior and learning, avoiding the categorization of these causal relationships. If asked to use such terminology, I could state that I wish to explain behavior in terms of efficient causes, in keeping with traditional science; that behavior has multiple causes which can be summated into the partial causes of "environment" and "referenced perceptions (volitions)"; and that volition is always a more proximate partial cause than the environment, whose remoteness depends upon the activity being described. But such semantic quibbles would only result in ambiguity. I will minimize the ambiguity by denoting causal relationships within an already developed mechanistic model of behavior and learning.

The use of the model discussed here may potentially convert psychology from a soft science to a hard science, alongside physics and chemistry. This conversion is related to the issue of predictability. For the physicist, greater predictability is achieved by taking into account the effects of as many (external) influences as possible. One can predict the position or velocity of a rocket at time t if one knows the forces of combustion, gravity, wind, friction, rocket mass, and so on. And through such ability to predict, there arises the ability to control. Technological advances would not be possible if it were otherwise, if observed causal relationships were not stable across instances.

Psychologists have looked for the same ability to predict (and control) by attempting to determine the effects of external environmental conditions (stimuli) on an organism's behavior. They have attempted to show that the mechanism behind much behavior is analogous to simple "reflexes," such as the knee-jerk reflex, wherein the external application of pressure from the hammer results in the kick of the leg. When Pavlov observed that his dogs would salivate after he entered the room, apart from the dogs' sensing of any food, he reasoned that a reflexive process could explain the salivation behavior. Such was the thinking behind a half-century of psychological research.

Psychology was not to become a hard science via a greater knowledge of external causes, however, for organisms have what HarrÇ and Madden (1975) call "causal powers," intrinsic conditions which influence behavioral outcomes. External conditions could not fully account for an organism's behavior since organisms, unlike rockets and billiard balls, do not behave the same in identical environmental conditions. In fact, results of simple conditioning experiments such as the air-puff/eye-blink experiment cannot be replicated if conditions internal to the subject vary (Brewer, 1974).

Missing from these causal explanations has been a recognition of volitional action, that while a force exerted on a ball is not met with resistance from the ball itself (although the ball may seem to "resist" the force as a result of gravity and friction acting upon it), a force exerted on an organism might be met with resistance from the organism itself. Eventually, however, cognitivists reintroduced intentional states, which include beliefs, volitions, etc., into explanations of behavior.

There are two primary perspectives under which psychologists who acknowledge the role of volitions on behavior can be categorized--Instrumentalist and Realist. Those holding the Instrumentalist perspective contend that volitions are "useful falsehoods" for explaining psychological phenomenon. They equate explaining an organism's behavior in terms of volitions with explaining evolution in terms of species trying to become more adaptive; such talk may be useful, but it is certainly not scientifically accurate. Realists, on the other hand, contend that volition is more than just useful, that it is indeed real. They agree, of course, that species do not try to become more adaptive, but they still contend that organisms do, in fact, exert volitional control over their behavior.

There exists a third option, however, located between these two. Dennet (1987) contends that depending on one's purposes, one may take either a design or intentional stance towards explaining an object's behavior. Taking a design stance would entail using volitional terms such as "wants" or "expects" or "desires." From this account it appears to Realists that he is an Instrumentalist. However, Dennet (1987) contends that while he is not a Realist (with a capital "R"), he is a realist (with a lowercase "r") for he states that intentions (including volitions) have the same ontological status as centers of gravity, the Earth's Equator, and lines drawn by computers when the CRT is off. For Dennet, the difference between being a Realist and a realist is that the former believes that intentional states correspond to some internal physical state which could theoretically be identified by an MRI device, while the latter believe that intentional states do not have such correspondence to physical states. The Realists also contend that mental processes are about symbol manipulation while the realists contend that symbol manipulation is unnecessary. Bechtel (1985) argues that Dennet's instrumentalism (realism for Dennet) is a special kind of realism (Realism for Dennet), but Dennet's distinction will be recognized here, nonetheless.

Hence, psychologists fall under three primary perspectives: Fictionalism, Realism, and realism. The term "Fictionalism" is defined as Instrumentalism was defined above; its use is preferable since Dennet's perspective is not associated with it. Fictionalists, who contend that volitions (and all other intentional states) are only "useful falsehoods," include Hebb (1972, 1974), Churchland (1979, 1981), and Stich (1983). Realists (with a capital "R"), who contend that volitions are real and correspond to particular physical states, include Searle (1983), Fodor (1985), Burge (1986), Richardson (1980), Maslow, Rychlak (1983, 1991), and Howard (Howard & Conway, 1986; Howard & Myers, 1989). Realists (with a lowercase "r") include Dennet (1978, 1987), Lewis (1990), Rummelhart and McClellend (1986) and other connectionists. They contend that while volitions are real, mental processing is not about symbol manipulation and no mapping can be found between volitions and internal neural states.

The theory to be utilized in this discussion (Powers, 1973, 1988, 1989; Hershberger, 1987, 1989) can be classified under the category of this latter perspective, realism. I choose to focus on this theory for the following five reasons. First, unlike the Fictionalists and the behaviorists, volition is considered to be real. Second, unlike Maslow and the humanistic psychologists, this volitional model is mechanistic. Third, unlike the Realists, mental processing is not thought to occur via symbol manipulation. Fourth, unlike Rychlak, volition is explicated in terms of teleonomic efficient causes, not teleologic final causes. Finally, unlike most of the above theorists' models (excluding Maslow's and Rychlak's), this model leads to the realizations that in reference to behavior, the terms "stimulus", "input", "independent variable", " and "cause" are not necessarily equatable; that volition is not simply an intervening variable between input and output or cause and effect; and that volition has equal, if not greater, influence on behavior than does the environment.

<u>Perceptual control theory.</u> Control Theory was developed in an attempt to design machines that would behave like humans. The basic principle of control theory is that of reducing error via closed feedback loops. Artificial control systems, machines designed with the above principle in mind, differed from other mechanistic devices in that they were capable of performing a given task under a variety of unpredictable conditions, in much the same way as humans are.

Recently, Powers (1973) has applied control theory, originally modeled after human behavior, to an understanding of the behavior of living control systems such as humans. In this model, referred to as Perceptual Control Theory (PCT) when applied to psychology, perceptions are compared to reference signals, also known as goals, standards, or internally specified perceptions. This comparison translates into an error signal. An output occurs as an attempt to reduce the error, and this output affects perceptions. What is perceived is not the outputs, nor the environmental disturbances, which are those aspects of the environment that alter those perceptions which the organism is presently controlling for, but rather the combined effects of the disturbance and output on outcomes. This process of the output affecting the perceptions is known as feedback; structures with a feedback architecture are known as closed-loop structures.

Figure 1. Elementary Control System (ECS). Source: Powers (1988, p. 272).

Closed-loop structures with negative feedback, feedback that results in the maintenance of a variable at some level, are known as elementary control systems (ECS) (Fig. 1). Elementary control systems are arranged in a hierarchical fashion such that the output of ECSs at one level combine to form reference signals for ECSs at the level below. Outputs at each level result in behavior, in the broadest sense of the term. Outputs at low levels may result in behavior as a behaviorist would define it, wherein there is a motor action which alters (perceptions of) the external environment, while outputs at higher levels may result in a "cognitive behavior," such as imagination, wherein the environment being manipulated is an internal one (Fig. 2). In any case, the process occurs continuously via a negative feedback loop whereby outputs occur in an attempt to make perceptions match reference signals. As the title of Powers (1973) seminal book states, behavior is the control of perceptions.

Figure 2. A Hierarchy of ECS's. Source: Powers (1988, p. 278)

This notion of perceptual control via continuous feedback is central to the model and is to be distinguished from mainstream perspectives on four accounts. First, perceptions, not actions are controlled. Most psychologists (e. g. Searle, 1983) believe that actions (motor behaviors) are controlled, but such a view cannot account for why the consequences of motor behavior remain stable while the motor behaviors themselves vary tremendously. Second, the feedback is immediate and real, not metaphorical as it is in the sentence, "She gave me feedback on my homework." Moreover, the feedback of interest is not solely proprioceptive feedback of muscle position, but also exteroceptive whereby the effects of actions upon the environment are perceived by the senses. Third, the control of perceptions via feedback occurs continuously within a closed-loop, not iteratively across open-loop structures. Only closed-loop models with continuous feedback can explain both how perceptions are controlled and why there is observed no "graininess" to behavior even when analyzed at frequencies higher than neural firing rates (Powers, 1991a). Fourth, the model implies that the environmental disturbance (or stimulus or input) is not synonymous with the cause of a behavior, as it often is in other models, but rather is only one of two primary causes of behavior. But before explicating what the causal relationships are, clearer definitions of behavior and cause are necessary.

Defining Terms

<u>Behavior.</u> Perhaps it seems that the term "behavior" is straightforward and thus needs no explanation, but brief consideration of its meaning quickly reveals its subjective nature and semantic ambiguity. There are issues of intention versus accident, level of description, and outcome versus action.

First, Marken (1982, 1983) argues that behavior is always a volitional (but not necessarily conscious) attempt to control a perception and hence an experimenter must know the subject's intentions (what they are trying to perceive) if he wants to know what they are doing. In one task he sets up five boxes on a computer monitor screen. The subject's use of the joystick influences each of the boxes in an identical manner, but each box has applied to it a different computer-generated, random disturbance. When the subject is asked to control the position of one of the boxes and ignore the others, the computer is able to determine which box is under the subject's (volitional) control. The behavior here is only the movement of the one box, not the movement of the four boxes, for, as Marken states, to behave is to control. Or as Wimsatt (1972) states, not any causal effect counts as a function, (e.g. the sounds made by the heart), but only those (e.g. the heart's pumping of blood) that serve a purpose to the system.

Searle (1983) provides two examples of unintentional effects that would not be considered behaviors. First, in Penfield's (1975) experiments in which motor cortex regions are stimulated electrically, the resulting motor responses are not truly behaviors since they were not intended by the subject. Searle's second example is that of Gavrilo Princip murdering Archduke Prince Ferdinand in Sarajevo. If volitions are not considered important attributes of action (behavior), then it could be said that moving a lot of air molecules, ruining Lord Grey's summer season, starting the First World War, etc., were behaviors of the Princip in addition to killing the Archduke. But if one accepts that such unintentional effects as moving the four boxes or ruining Lord Grey's summer season can be considered behaviors, then one must accept that an individual engages in an indefinite number of behaviors every minute. If one does, however, grant that these are indeed behaviors, which I contend they are not, then they are behaviors of no interest to a psychology that is interested in explaining behavior in terms of volitional variables since these effects do not represent an individual's attempt to control a perception.

Second, identifying a behavior is confounded by levels of description. A behavior can be understood in terms of a number of hierarchical levels. In Searle's example, for instance, Princip's behavior could be described as pulling the trigger, shooting the Archduke, killing the Archduke, or avenging Serbia. Vallacher and Wegner (1987) use a similar example concerning the behavior of drinking coffee: is a person applying a lifting force of two pounds with his right arm, taking a drink of coffee, or getting a caffeine fix? They discuss this issue in further detail, asking whether one defines behavior in terms of actions or volitions satisfied by the actions; is running in order to get in shape better classified with running in order to escape a killer or biking in order to get in shape? Does one define behavior in terms of actions or desired outcomes? One would most likely say that behavior is better defined in terms of volitions ("in order to get in shape"), but in psychology, "same behaviors" are measured on the basis of what is observable (running), not what is intended. Later I will address whether the "same behavior" at different levels of description has the same causes (i.e. Does getting a caffeine fix have the same cause as lifting a cup?).

Third, a distinction can be made between behaviors, actions, and desired outcomes (Powers, 1990). Powers shows that a behavior (opening a car door) is made up of actions (grasping and pulling) and an outcome (door angle at eighty degrees). In another example, the behavior "driving a car" is made up of outcomes (keeping car in center of road) and actions (movement of steering wheel by arms). It should be noted that "actions" refer to motor outputs exclusively and do not include any aspects of volition as Searle's definition of action does. If it was the case that outputs and not perceptions were controlled, then Searle's use of the term "action" would be appropriate, but since it is perceptions that are controlled, a distinction must be made between actions and volitions.

Psychologists often confuse or interchange these terms among themselves and even within their own individual articles. For example, throughout a recent article by Sappington (1990) summarizing various perspectives on volition, the "free-willists" use of the term "behavior" is more closely related to Powers's meaning for "outcome," while the "determinists" use of the term "behavior" resembles Powers's meaning for "action." Vallacher and Wegner (1987) seem to use "action" and "behavior" almost interchangeably, throughout their article, although at times it seems as if a distinction is intended. Even Powers himself interchanges these terms. In one article in which he even makes the distinction between behavior, action, and outcome, he states, "When we see consistent behavior in the presence of independent disturbances, we can deduce that the actions of the organism must be varying" (1989, p. 26), meaning "outcome" for "behavior." Later he states "the external cause varied in just the way needed...to make behavior change to preserve a particular outcome" (p. 27), meaning "action" for "behavior." More recently, Powers (1992) states "the environment determines behavior, while the autonomous organism determines consequences of behavior," meaning "action" for "behavior."

This interchanging of terms will go unnoticed by the reader due to the broadness of the term "behavior," but the distinction is a critical one; for while organisms are consistent in their outcomes (opening a door), they are varied in their actions, depending on the size of the door, the weight of the door, the angle of approach, the relative difference of air pressures on each side of the door, etc. As James (1890) noted a century ago, organisms produce consistent ends through variable means. Powers (1989) elaborates:

> There is no linguistic problem with calling all these activities as"opening doors," but in terms of the motor actions we carry out, not only are the actions very different over all these instances of the"same behavior," but they are quantitatively different each time we open the same door. (p. 24)

Even Skinner noted this when he observed that mice placed four steps from the bar were "conditioned" to press the bar (outcome, desired perception), not take four steps (action), for when placed five steps from the bar, they would "respond" to the "stimulus" by taking five steps and pressing the bar. The "observed behavior," or "response," or "operant" as Skinner called it, was not an action as one might think, but an outcome. For this reason, there is no "best terminology." Whether one chooses to say "behavior/consequences of behavior", "behavior/action", "action/behavior", "behavior/outcome", or "action/outcome," one will inevitably run into difficulties. For the remainder of this paper then, I will avoid the use of the term behavior and arbitrarily select Powers' (1990) terminology of "actions" and "outcomes."

Cause. Powers (1991b) makes a distinction between three terms--"influence", "determine", and "control"--such that

> A influences B if A is one of several variables on which the state of B depends...A determines B if, given A, B is completely predictable...A controls B if, for every disturbance applied to B, A changes its influence on B in such a way as to counteract the effect of the disturbance on B.

Note that control is a special case of determine, which is a special case of influence. Powers replaces the term "determine" with the term "cause" and states, "The reference signal is the internal cause, and what it causes is the outcome of the behavior. The sum of the disturbances is the external cause, and what it causes is the action" (Powers, 1989, p. 31). I choose, however, to replace "influence" with "cause," for while the concept of "determine" may reflect what is most often meant when using "cause," neglecting the influences makes for an inaccurate conception of the model. As will be evident in the following statements, this replacement of terms better preserves the causal role of volition throughout the entire perceptual control system.

Causal Explanations of Behavior

Within isolated control systems. Given the above definitions, I propose that actions are caused by both reference signals and environmental disturbances; actions are determined by the environmental disturbances. Such is the case for while both volition and the environmental conditions affect the action, the action will be equally opposing that of the disturbance, hence predictable from the environmental disturbance. Actions are not controlled.

Outcomes are caused by both volition and environment, just as actions are. They are determined, however, by volition. If outcomes were externally determined, then there ought to be as many different outcomes as there are stimuli. Nevertheless, we observe that in the context of varying stimuli, organisms are capable of producing consistent outcomes. Here again, one might want to say that outcomes are caused by volition to emphasize the relationship of interest, but for modeling purposes, it must be noted that both volition and the environment play a role. The role of the environment is masked when there is good control, however, since outcomes are controlled by actions. If control were poor, the influence of the environment would be evident.

Taking the example of a person driving a car and assuming that this person has a goal to stay in the center lane, one will observe that barring any outstanding disturbances, outcomes (staying in center lane) remain stable while actions (moving steering wheel) will vary. The stability of outcomes is determined by the stability of the goal state. If environmental disturbances (stimuli) such as wind are not effectively counterbalanced by actions, the causal role of environment becomes evident; so we can conclude that outcomes are caused by reference signals (goals) and environment. And since a direct relationship exists between the outcome and reference signal, such that given A (reference for center of road), B (outcome of being at center of road) is completely predictable, we can say that the outcome is determined exclusively by the reference signal.

The actions did vary in direct opposition to environmental disturbances. In order for something to vary in opposition, there must be a middle point around which disturbances and actions are symmetrical. This middle point is the referenced perception. Hence, actions are dependent on both environmental disturbances and reference signals. Therefore, we can say that actions are caused by both, but determined by the environmental disturbance since there exists an inverse relationship between the two.

An appropriate example would be the knee-jerk reflex, from which psychologists have drawn many analogies. Here is a case that clearly seems to be an example of environmental condition x causing behavior y. But such is not the case. An examination of it's sister psychological phenomenon, the "knee-jerk response," will make the issue clearer. It is clear that when an individual acts in a "knee-jerk" fashion following another's comment that he does so in order to bring attention to the statement and possibly correct it. The individual does not act reflexively, but rather purposefully in order to create the perception that others have the "right" beliefs. The cause of the "knee jerk" response is both the referenced perception (to perceive in the other person "correct" beliefs) and the environmental disturbance (the person's remarks). Similarly, when the knee is hit with the rubber hammer, stretch receptors perceive what is equivalent to the perception of a lengthened muscle. These perceptions are compared to reference signals that are controlling for a particular muscle length, resulting in the production of an error signal that attempts to restore the muscle to the specified length. For convenience of speech one might designate this attempt as the reflex action of the leg, but if one is interested in modeling this phenomena, one must consider the action as purposive, not reflexive. The action is determined by the "stimulus" but is caused by both the "stimulus" and the reference perception.

To summarize, both actions and outcomes are caused by both the reference signal and the environmental condition; actions and outcomes are singly determined by the environmental disturbance and the reference signal, respectively; outcomes are controlled by actions.

The literature on causation often speaks in terms of a cause (or stimulus condition) and an enabling condition, which is defined by HarrÇ and Madden as "a state of readiness....for the exercise of a certain power" (1975, p. 88). Although I choose to not use this terminology here in order to be more precise and avoid the ambiguity of these terms, the above ideas can be expressed in this terminology as follows: The cause of an action is the environmental disturbance with volition as the enabling condition, and the cause of an outcome is volition with the environment as the enabling condition.

<u>Within a hierarchy.</u> Proponents of volition might suggest that action is also determined by volition, for muscle activity changes as reference levels change. This point is well taken for the discussion so far has focused on causal relationships within isolated control systems with static

goal states. Nevertheless, it will become clear that when considered in the context of a perceptual control hierarchy, a changing reference signal does not necessitate a modification of the causal relationships stated above.

Powers theorizes that a dozen control system levels exist within the adult human, wherein the output signals of level n+1 becomes the reference signal for level n, and only the lowest level interacts directly with the external environment. Accepting the notion that an output of one level becomes the reference signal for the one below significantly complicates matters. First, the distinction between actions and outcomes becomes blurred, such that actions at one level become indistinguishable from outcomes at the level below. This is the case since outcomes are determined by reference signals that are composed of outputs of higher levels.

Second, one is forced to accept that a reference signal at level n is determined by the environment (when considered from the n+1 level). Thus, most reference signals change as a result of environmental events. As Powers states, "What seems free will at one level of analysis is a necessary adjustment to external disturbances at another level." (Powers, 1989, p. 34). This seems in direct opposition to all ideas presented thus far, but it is not as it seems for two reasons.

First, these reference signals change in order to satisfy stable reference signals at a higher level. During a compensatory tracking task, if one's reference signals for cursor position change, they do so in order to satisfy the stable reference signal of keeping the cursor in line with the moving cursor. The change of reference signal for cursor position is determined by the environment, but the outcome (staying with the moving cursor) is determined by the reference signal (n+1). It should be recognized that we could take control system level n in isolation, beginning with the reference signal and ignoring its environmentally determined nature, and could explain hand movement and cursor position as we did earlier. But the changing nature of the reference signal at this level appropriates consideration of higher levels.

Second, "environment" may take on a different meaning, depending on what levels of the hierarchy we are speaking of. As Bickhard (1992a) states, the environment for any control system is that which exists hierarchically below that control system. Hence, if we are concerned about causal relationships at higher levels, the environment is no longer the familiar external environment, but an internal environment consisting of complex arrays or integrations of perceptual and error signals. In most cases it can be stated that the reference signal is determined by the environment if it is understood that the "environment" is most often internal to the organism, the effect of the external environment becoming increasingly remote as one analyzes higher levels of the hierarchy.

At these higher levels, cognitive behaviors (such as imagination) have the same cause/determine/control relationships as low-level motor behaviors. Research by Campion and Lord (1982) demonstrates the determining effect of environmental conditions on goal selection at cognitive levels. In seven studies, the effects of students' achievement outcomes on their goal selection were observed. Results demonstrate that given certain higher-level volitions (desire for an "A"), certain outcomes will determine the selection of intermediate-level volitions (desire to study more). Issues of automaticity are relevant here, for all volitions below the volition of interest are determined by perceptions of environmental conditions.

The issue of levels of description discussed by Vallacher and Wegner (1987) is relevant here. If Powers's hierarchical levels and Vallacher and Wegner's levels of description are equatable, then one must ask whether there are separate causes for "lifting a cup" and "getting a caffeine fix." Vallacher and Wegner state, "Strictly speaking, of course, the proximate cause of behavior is always personal, inasmuch as behavior is initiated and guided by a mental representation of the behavior" (1987, p. 10). This statement and others associating higher-level identifications with internal causation and lower-level identifications with external causation are compatible with the ideas being expressed here. If these events are considered to be actions, then they are both environmentally determined, but the "environment" for "getting a caffeine fix" is an internal one, possibly consisting of signals representing a lack of physical energy or mental clarity. If these events are considered to be outcomes, they are determined by reference signals which in turn are determined by the "environment" (up to, but not including, the highest level) which is more internal for "getting a caffeine fix" than for "lifting a cup."

To summarize the above ideas, behavior must be considered in the context of a perceptual control hierarchy. There are "derivatives" of the environment, wherein "environment" might reside within the organism, and "derivatives" of reference signals, wherein some reference signals are output signals. How much of the hierarchical structure one chooses to focus on determines what is considered an output, outcome, environment, and reference signal, and hence what causal relationships will be derived.

Within nonliving control systems. No discussion of behavioral analysis would be complete without addressing causal relationships within nonliving control systems. Is the interaction between the environment and a thermostat or control-system-designed robot the same as the organism-environment interaction? Can one speak in terms of volition for such nonliving systems? Much has been said in the artificial intelligence literature in response to these questions; it is not my intention to summarize these perspectives but to comment on the issue in terms of causal relationships.

Concerning the first question, there is no difference between carbon-based control systems and silicon-based control systems in the quality of interaction that occurs. The fact that organisms are biological while thermostats and robots are not makes no difference in terms of modeling. In fact, the latter can inform us of the former, making clearer the "derivatives" of environment that were mentioned in the previous section. In other words, the "line" between organism and environment becomes fuzzier when considering non-living control systems.

The difference between the two systems is found in answering the second question. While both living and non-living control systems when viewed in isolation have reference signals/volitions/goals that cause actions and determine outcomes, only living control systems when viewing the entire hierarchy have reference signals that are not determined by the external environment. In other words, living control systems have reference states at higher levels that are "self"-determined, not externally determined. Something ultimately has to either set the perception to control for or program the mechanism how to learn how to select its own perceptions to control for.

There are, of course, issues of consciousness, emotion, development, what is meant by "self"-determined reference signals, and whether reference signals set by genes are "internal" or "external." These are interesting and important, but are tangential to issues of causality within psychology. The points to be derived here are as follows: (a) consideration of the interaction between a non-living control system and the environment informs us of the fuzziness of "environment" and (b) while we may speak of causal relationships toward outcomes and actions in the same manner for both living and non-living control systems if we look at isolated sections of the hierarchy, only for living control systems is it not possible to speak only in terms of external causation. In other words, one may avoid volitional explanations for non-living control systems since direct manipulation of reference signals is possible, but not for living control systems since direct manipulation of reference signals is not possible (Powers, 1978).

Causal Explanations of Learning

Previous discussion has focused on the effects of the environment and volitions on actions and outcomes within a perceptual-control-theory paradigm, wherein relationships are considered within functional control systems. Nothing has been said about causation in reference to learning, the development or structuring of these control systems. In the following section the causal relationships in the learning process--the effects of perceptions on volitions--will be explicated.

Learning is traditionally defined as a permanent change in behavior as a result of experience (as opposed to biological maturation). This definition, however, prevents psychologists from making progress in understanding learning theoretically and developing practical means of promoting learning. It does, however, afford a hint of its error by stating that learning is a permanent change. Since environmental conditions vary considerably, any permanent change in behavior must result from a permanent change in volitions. Thus, learning is more accurately defined as a permanent change in reference signals as a result of experience. It is a process of perceptions affecting reference signals, not behavior. Of course, changes in volitions will result in changes in behavior, and in most cases it is difficult to make a distinction between volitions and behaviors, as will be argued later. But it is critical that when one says that a student has learned, one understands that the student has learned what to perceive, not what to do. More will be said on this later, but first a causal explanation of learning is necessary.

The permanent change in reference signals known as learning is the result of a process known to perceptual control theorists as "reorganization," wherein new connections or connection strengths are tried out on a random basis. The process commences when there exists a significant amount of error within a system. What qualifies as "significant" is unknown. The random trials are made until a relative minimum amount of error is reached. Hence, reorganization is an evolutionary process wherein there is blind variation and selective retention (BVSR) of neural connection strengths. Thus, when it is stated that the investigation of the learning process constitutes an investigation on the effects of perceptions on reference signals, it is not meant in the same manner as "the effects of the environment or volitions on actions or outcomes" wherein causation is direct, for in the case of learning, the perceptions only determine which variations of reference signals will be selected.

In order to explain this change in terms such as cause, influence, determine, and control, it is perhaps best to understand reorganization as a control process also, located "perpendicular" to the original hierarchical control system. In doing so, the perceptual signals, or outcome, for the Reorganization Control System (RCS) is the error signal in the ECS. The "referenced perception" for the RCS is a signal representing the desired summation value of error states, known as intrinsic error, within the organism. The value of this signal is, in theory, set to zero and is most likely never attained, only approximated. The output signal, or action, of the RCS changes the reference signal values somewhere within the ECS. The environmental disturbance is the perceptual signal of the ECS.

It should be noted here that this model of the RCS structure is only theoretical and may not represent real neural events as the model of the ECS structure does; thus, there may be a variety of neurological changes that result in "learning," such as changes to the "gain" of the control loop via intensification or dulling of signals around the control loop. In these cases, the output of the

RCS changes the values of one of these signals, just as it changed the ECS reference signal. In this discussion, I focus only on learning as a result of a change in reference signals.

Using the same analysis applied to the ECS earlier, one finds that the change of ECS reference values (output signal of RCS) and the resultant intrinsic error (outcome of RCS) are caused by both the internal reference for intrinsic error and the ECS perceptual signal. If the RCS is effective, the RCS outcome will be near-zero intrinsic error. Hence, it is determined by the reference signal for zero intrinsic error, and the causal influence of the ECS outcomes are masked. The RCS action (change of reference values) is determined by the ECS perceptual signal. Note that the "environment" perceived by the RCS is an entirely internal one. Only error is perceived; nothing of the external environment is perceived.

Instructional implications. Implications of Perceptual Control Theory for how instruction theoretically proceeds are twofold. First, the student must find himself in a state of disequilibrium (error). This error state might not be sensed consciously if error is reduced rapidly, and it might not be consciously intended by the instructor, as in the case of teaching simple facts; but the error exists, nonetheless. The above paragraph explains why it is that a permanent change will occur in a student who finds himself in a state of disequilibrium. Since the final outcome must approximate zero intrinsic error, one can predict that a change will occur to reduce that error. The change that results may not be one preferred by the instructor, but a change occurs, nonetheless, and follows necessarily from a state of disequilibrium (intrinsic error). While the student may reduce error by making the preferred reorganization, he could also reduce error by learning a faulty procedure that only works in some cases or by learning to not care about the topic if attempts at reorganization lead to greater intrinsic error. In any case, unless one knows the student's internal environment, one cannot know what the student will learn. This inability to know the individual's environment relates to the number of degrees of freedom existing and the complexity of "trickle around" effects. One's certainty of what learning will occur decreases as one moves up levels in the hierarchy. A student experiencing error in "fingering" while practicing playing a stringed instrument will reduce error and will do so in a way which is highly predictable due to the lack of degrees of freedom afforded by the external environment and the minimal number of control systems affected. A student experiencing error in "finding self-worth" will reduce error but will do so in a manner significantly less predictable due to the abundant degrees of freedom and excessive number of control systems affected.

This relationship between error (disequilibrium) and learning is well known in psychology. Getting some sort of learning to occur is not difficult, but inducing someone to learn something specific is another story. Which volitions are chosen is determined by the environment, and this is where the second implication of Perceptual Control Theory (PCT) to instruction becomes relevant.

While learning begins with disequilibrium, the evolutionary (BVSR) nature of the learning process entails that learning occurs only by making mistakes (Perkinson, 1982) and that knowledge is not actually transmitted from teacher to student, but is rather constructed by the student. The illusion of direct transfer of knowledge from teacher to student occurs when there exists a small amount of viable random trial "search space" which allows the BVSR knowledge construction processes to proceed quite rapidly. The actual indirectness of knowledge acquisition and the number of "mistakes" that occur become more evident as the complexity of the knowing process becomes greater. What constitutes greater knowing complexity in terms of the PCT model is not known, but since this section concerns practical implications to instruction, it will suffice to say that there exists a hierarchy of knowing complexity like the cognitive taxonomy developed by Bloom. Engelhart, Furst, Hill, & Krathwohl (1956), such that processes involved in "knowledge level" or "comprehension level" knowing are less complex and have less "trial search space" or quicker selection than processes involved in "synthesis level" or "evaluation level" knowing. Thus, teaching is not truly about transmitting knowledge, but is instead about creating an environment (internal or external) conducive for constructing knowledge efficiently.

Hence according to PCT, the job of a teacher is to provide scaffolds with which to eliminate the ineffective blind variations (mistakes) such that the preferred reorganization will occur. With tasks low on the cognitive taxonomy, "direct" instruction will suffice, although the instruction only appears direct because the BVSR process proceeds so rapidly. But for tasks high on the taxonomy such as "determining the topic of a paragraph" (analysis), "summarizing a story" (synthesis), or "critiquing a poem" (evaluation), more teacher interaction in the form of scaffolding--"the reduction in the demands of a problem for the sake of the eventual solution of the full problem" (Bickhard, 1992b, p. 43)--is required to assist in eliminating random variations which do not approach the preferred reorganization. Although direct instruction and scaffolding may be quite different in practice, in theory the former is only a subset of the latter, wherein the time required to proceed through the BVSR process and arrive at the preferred reorganization approaches zero.

These implications are not new, but perhaps their place within a constructivist framework is. An error-initiated/BVSR perspective on learning processes implies that disequilibrium preceeds all learning, that mistakes must be made if learning is to occur, and that all teaching is a form of scaffolding of which direct instruction is a subset.

Methodological Considerations

There are numerous implications of a volitional science of psychology for research methodology. As stated above, there exist two classes of causes in psychological phenomenon: volitional and environmental. Psychology, thus far however, has interested itself primarily in the role of environmental influences on behavior. While this is necessary, it is incomplete. Psychological research must also focus its attention on the role of volition and its interaction with external disturbances if it is to be complete. This is not to say that all present research is invalid, for if a subject's volitional states are known and remain constant throughout the study, then effects can be attributed to environmental causes. But such is not the case in most psychological studies. In this section, an alternative model of psychological research methodology that considers both classes of causes is presented.

Correlational Data

I begin with a discussion of correlational data. Although correlations in themselves are not suitable for establishing causal relationships, one hopes, nonetheless, that they may give a hint of these relationships. If one begins a correlational analysis of motor behaviors, one may find the relationship between environmental conditions and actions or environmental conditions and outcomes. In a tracking task, for instance, it is noted that an environmental stimulus (the amount of random disturbance applied to cursor) correlates strongly (r approaches -1) with the subject's arm movement of the mouse and poorly with the outcome of cursor position (Powers, 1978). This is interesting for one is most likely interested in the outcome, but the correlation of outcome and environment approaches zero. A volitional science of motor behavior, on the other hand, demonstrates that outcomes (cursor position) are highly correlated (r approaches 1) with referenced perceptions.

Most correlational data in psychological research, however, do not concern motor behaviors, but rather cognitive behaviors. In these cases the ability to distinguish between outcomes and actions proves very difficult, if not impossible. For example, while it is easy to describe driving behavior as "maintaining the perception of the car at the center of the road" (outcome) and "moving hands on steering wheel" (action), determining whether "achievement scores" are actions or outcomes is quite difficult. Any distinction which could be made of useful relevance to research methodology can only be made in relation to motor behaviors, not cognitive behaviors. If distinctions at the cognitive (higher) levels could be made, which is doubtful since actions at one level (except the first) are experienced as outcomes at the level below, they would be philosophical in nature, of no benefit to research strategy and development.

Hence, most correlational data represent relationships between two environmental conditions (SES and frequency of child abuse), an environmental condition and a behavior (SES and aggression), or two behaviors (aggression and school performance), making no distinctions between actions and outcomes. Such data is useful for it informs psychologists of potentially relevant relationships. But like the correlations found with environmental conditions in tracking tasks, the correlations found in much psychological research are weak and uninformative in comparison with physics and chemistry research. And just as finding high correlations in the tracking tasks required making referenced perceptions one of the variables, finding high correlations in most psychological research requires the same.

Including volitions adds three more varieties of correlational designs, finding relationships between environmental conditions and volitions (SES and desire to go to school), volitions and behaviors (controlling for lack of distractions and achievement test scores), and volitions and volitions (desire to go to school and controlling for being popular). "Volition" may in some cases be identical to "intrinsic motivation" (Ames & Ames, 1985) or may be synonymous with "strategies" or "roles" as will be discussed later. Such designs will most likely not provide the high correlations found in the tracking task, for effects of other control systems play a larger role at higher levels. Nonetheless, they should theoretically turn up higher values of r than designs that do not include volition as one of the variables.

Superiority of results comes with a higher price tag, however. One must determine what the subject's volitions are. Runkel (1990a) proposes a method called the Test for the Controlled Variable. The following is the procedure for the Test:

1. Select a variable [e.g. position of car on road] that you think the person might be maintaining at some level. In other words, guess an input quantity...
2. Predict what would happen if the person is not maintaining the variable at a preferred level.
3. Apply various amounts and directions of disturbance directly to the variable.
4. Measure the actual effects of the disturbances.
5. If the effects are what you predicted under the assumption that the person is not acting to control the variable, stop here. The person is indeed not acting to control it; you guessed wrong about the variable.
6. If an actual effect is markedly smaller than the predicted effect, look for what the person might be doing to oppose the disturbance. Look for a cause of the variations in the input

quantity. That cause many be caused by the person's output. You may have found the feedback function.

7. Look for the way by which the person can sense the variable. If you can find no way by which the person could sense the variable, the input quantity, stop. People cannot control what they cannot sense.
8. If you find a means of sensing, block it so that the person cannot now sense the variable. If the disturbance continues to be opposed, you have not found the right sensor. If you cannot find a sensor, stop. Make another guess at an input quantity.
9. If all of the preceding steps are passed, you have found the input quantity, the variable that the person is controlling (Runkel, 1990b).

Such a procedure may be more time and energy consuming than a researcher interested in only correlations is willing to sacrifice, but knowledge of the black box does not come easy.

Experimental Designs

Traditional experimental designs investigate the causal relationship between environmental conditions and behaviors. However, if the dependent variable in psychological research could be either actions or outcomes, and the independent variable could be volition or environment, then four basic research paradigms exist. They are: environment-->action, environment-- >outcome, volition-->action, and volition-->outcome, wherein the first term designates the independent variable and the second the dependent variable. But as was stated earlier, distinguishing between actions and outcomes proves difficult. Hence, we are left with these four paradigms for research on motor behaviors, but only two (volition-->behavior, environment-->behavior) for most psychological experimental research.

The first paradigm (volition-->behavior) has received little attention from psychologists. In this research, whether between subjects or within subjects design, it is important that the researcher control for environmental conditions. It is of no value to observe the effects of various volitional states on behavior if each individual (between subjects) or each trial (within subjects) is exposed to different environmental conditions.

The second type of research (environment-->behavior) is most common, but in most cases fails to control for volitional states of individuals. An individual who performs a memory task with a volition to perform well is different than an individual who wants to get done as soon as possible or an individual who wants to foil the experiment. This is also the case when these conditions exist within the same individual over time. Dependent measures of research that do not control for volitional components report unknowingly the effects of (at least) two causes in terms of only one cause. Just as a chemist would not report the effects of adding two different substances to a solution in terms of adding only one substance, so it is errant of a psychologist to report the effects of the environment and volition in terms of only the environment.

The problem with controlling for variance in volitional components is, of course, simply determining what these unobservable volitions are. How can one know what the volitional states of the subject are? Here again, one must use the Test for the Controlled Variable for this is the only known method for determining a volitional state. While it is not being implied here that all research must proceed this way, any social scientist who wants to approach the degree of experimental rigor present in the hard sciences must utilize this method. And while the Test is an experimental design in itself, capable of finding interesting information (what individuals are controlling for), I suggest that it be used in conjunction with environment-->behavior and volition-->behavior methodologies. In particular, it would not be beyond the scope of a creative researcher to incorporate the Test within and throughout an environment--> behavior research design. It would, in fact, behoove a researcher to develop such a system, for if the subject's volitions change, hence the data with it, the researcher who can experimentally account for the change has greater predictive power than one who relegates the change to random variance.

Consideration of Volitions Across Disciplines

How volitional states should be taken into account and the degree to which they should be taken into account will vary across disciplines. Certainty of and ability to manipulate subjects' volitions varies across cognitive, social, and educational psychology research, wherein cognitive research will have less room for variance as a result of volitional factors than social or educational research.

Cognitive psychology. To begin with, certainty of the subject's volitions varies between domains. While the subjects in the cognitive psychology experiment may be doing the experiment for different reasons, a cognitive researcher can be relatively certain that if the instructions are "remember as many letters as possible" that the subject will adopt these volitions. Hence, volitional states (remember letters) are already known and well controlled for across subjects.

Subject's volitions can also be manipulated fairly easily. In one experiment in which subjects determine the truth or falsity of the relationship between a sentence (Plus is below star, star is not below plus) and its picture (+*), no particular relationship was found between mean verification reaction time and the hypothesized number of comparisons made. But if only data from subjects with high scores on a psychometric verbal test was used, then a linear function emerged between reaction time and hypothesized number of comparisons (MacLeod, Hunt, & Mathews, 1978). In a follow-up study, subjects were divided (on the basis of psychometric test results) into "verbal" and "spatial" groups. Each group was instructed to use the strategy of the other group. Mathews, Hunt, and MacLeod (1980) found that subjects who used the verbal strategy conformed to the linear function while those who used the spatial strategy did not. Strategies can be thought of as sets of volitions, programs of what to perceive. Hence, in this study, the volitions determined the outcomes. Had the researchers not considered the volitional differences in the first study, no significant results would have emerged; the environmental conditions produced no significant findings by themselves. This latter experiment is an excellent example of a volition-- >behavior design, wherein the volitions of the subjects are manipulated.

Social psychology. In social psychological research, however, the experimenter does not really know what the subject is doing, since the volitions of the subjects may vary considerably. For instance, in research investigating "aggressiveness," one subject may act aggressively to "get back at someone" while another to "demonstrate power over others." The behavior "aggressive" is given qualifying terms as new volitions influencing the behavior are noted. Certainly, it is good that such distinctions are recognized for more of the between subjects variance is accounted for, but the end result may be an infinite variety of qualifying terms. Additionally, if a "behavior" occurs for 30 different volitions and are given 30 different names, then the term for the original "behavior" loses its meaning. This subjectivity of behavior will vary across disciplines, being perhaps most pronounced in social psychology research.

Harrÿ and Secord (1973) address some of these difficulties in social psychological research and suggest role-playing as an experimental methodology. They state "if man is indeed a self-directed agent...it makes sense for the behavioural scientist to treat him as such" (p. 313), as actor not a subject. In such a methodology, "subjects" are given situations (environmental conditions) or character descriptions (volitions) and asked to act out or imagine what they would do. In the first case, the environmental condition is the independent variable and volitions are controlled for by having the subject/actor use his own volitions. In the second case, the volitions vary as the experimenter suggests different characters or roles to assume. Here the experimenter may also vary environmental conditions to note the interaction effects of volition and environmental conditions.

In addition, they suggest that the experimenter give the subject/actor a particular outcome to achieve and then observe how the subject/actor achieves that outcome. Such an experiment separates the traditional relationships of independent variable with cause and dependent variable with effect, for while the experimenter manipulates the outcome (independent variable) to note how it is achieved, "how it is achieved" precedes the outcome, thus making the outcome the effect, not the cause.

The logic of using role-playing as an experimental methodology may seem suspect, but Harrÿ and Secord argue that humans are always assuming various roles (volitions) and (in perceptual control theory terms) act in order to maintain the perception that they are approaching the particular role-volition that they are presently assuming. They contend that in traditional methodology, subjects assume the role of "subject in a scientific experiment." So while role-playing seems less controlled than traditional approaches, Harrÿ and Secord state, "If they are acting anyhow, then it would seem desirable to exercise maximum control over what they are enacting and what roles they assume" (1973, p. 315).

Educational psychology. In educational psychology research, one attempts to determine either the effects of various "environmental conditions" or instructional practices on student learning, or the effects of motivation (volition) on student learning. It would seem that the former might represent an environment-->learning design and the latter a volition-->learning design. But in research on learning, the concept of "environmental condition" requires two qualifications.

First, finding the best environment is an attempt not to find what condition causes learning, but to find under which conditions the student is best able to satisfy a volition. For example, desk arrangement may be an environmental condition, but it cannot be considered a partial cause of learning in the same way it would be a partial cause of behavior. If the environmental condition is such that all desks face away from the chalkboard, then it can be said that this condition is not effective for satisfying a volition (reducing intrinsic error). The environmental condition is an enabling condition, not a stimulus condition.

Second, "environment" often refers to an internal environment that can also be considered a set of volitions. This is the case with research by Palinscar and Brown (1984) on reciprocal teaching. In this research it is found that the method of reciprocal teaching, which entails teachers modeling how to read a text for understanding and gradually letting the student take over until the student has mastered the task, is an effective means of getting students to learn how to learn. Such a method can be described as the effect of a particular environmental condition on student learning wherein it is understood that one attempts to find the condition under which a volition (understand text) is best achieved. Or it could also be construed as research investigating which volitions are best to assume if one wants to achieve the volition of "understanding text." A simple analogy to the latter description would be that if one wants to perceive oneself in some distant place, perceiving oneself in a vehicle at some point will be conducive for attaining this former volition. I contend that this latter description/conception is preferable for it is easier to conceptualize goal hierarchies than internal enabling conditions.

Thus, research on learning is best conceptualized as finding which (sub)volitions yield the best learning. For instance, Corno (1986) finds that self-regulated learners use volitions conveyed in statements such as "Attend to only the relevant information" and "Don't let mistakes discourage you." These are called "goal-oriented control" mechanisms by Kuhl (1984, 1985), for they serve to reduce the effects of disturbances to the learning process. To use terminology used earlier, research in learning is concerned with determining which volitions intensify or dull ECS perceptual signals (RCS disturbances) accordingly.

Conclusion

In this thesis I have discussed the role of volition within causal explanations of behavior and learning. I have shown in presenting Perceptual Control Theory that volition is not only real but that it can be accounted for within a formal mechanistic model. There are numerous implications of this. First, behaviors in the sense of outcomes cannot be observer defined, but must rather be defined in terms of what the behaving individual intends. Second, a distinction must be made between outputs, or actions, and their consequential outcomes, for while the environment determines the former, volitions determine the latter. Third, "stimuli" and volitions are each partial causes; volitions are not simply intervening variables. Fourth, the role of a teacher is one of an initiator of an intrinsic error state within the student and a scaffolder of knowledge wherein the teacher assists in the elimination of the student's ineffective reorganizations. Fifth, research methodology can be classified into three categories: environment as independent variable, volitions as independent variable, and environment and volitions both as independent variables. Sixth, the degree of necessity and effort given to determining subjects' volitional states varies between disciplines.

Psychologists would benefit from adopting a model such as PCT that recognizes the causal power of organisms and considers volitions as more than just useful fictions but rather complex arrays of neural states whose causal pathways can be modeled and whose effects on variables can be quantified. If psychology is about explaining human activity, and if all human activity is goal-directed, then psychological theory and research ought not to only focus on the relationship between the organism's behavior and the environment but also the relationship between the organism's behavior and its web of volitions.

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