

## CHAPTER 1

# The Epistemological Foundations of Conditioning and Learning

### I. Relevance of Science's Epistemology to Conditioning and Learning

- A. The challenge
- B. Onus: what you accept as your obligation
  - 1. demand what is labeled “truth”
    - a. definition or meaning of “truth”
      - i. empirical
      - ii. reliable
      - iii. multiple converging evidence
      - iv. consensually validated
      - v. operationally / functionally defined
      - vi. coda
  - 2. have what is labeled “understanding”
    - a. definition or meaning of “understanding”
      - i. describe
      - ii. predict
      - iii. control
      - iv. synthesize
      - v. explain
      - vi. coda

### II. Goals of Science

- A. Research to understand (pure research)
- B. Research to solve a particular problem (applied research)
- C. Dispensing solutions (practitioner / technologist)

### III. The Meaning of Knowledge

- A. Conceptual precursor: variability and equilibrium
  - 1. variability
    - a. three types of variability
      - i. transient dynamics
      - ii. synchronous dynamics
      - iii. asynchronous dynamics

- 2. equilibrium
- B. Knowledge is covariance
  - 1. simple dichotomous change and a necessary and sufficient precursor
  - 2. continuous changes and continuous relationships
  - 3. multivariate change
  - 4. type of variance and its conceptualization
    - a. accountable variance or covariance
      - i. models of accountable variance
        - (a) cause effect models
          - (i) mechanistic or reductionistic models
          - (ii) functional models
        - (b) correlational models
    - b. residual variance, error, or ignorance
      - i. experimental solution
      - ii. assumption of “true score” and “random error”
      - iii. delegate problem
- C. Issues pertaining to knowledge
  - 1. purpose of research
    - a. for curiosity
    - b. construction of functional context
    - c. for theory testing
  - 2. breadth of research findings
    - a. production of single fact, isolated treatment effect
    - b. production of quantitative function
  - 3. generality or level of abstraction of research findings
    - a. face value or *per se*
    - b. specific only as a model of something else
  - 4. type of knowledge produced by the research
    - a. capacity of organism: structural
    - b. behavioral processes: functional
  - 5. phase of research helix
    - a. analysis
    - b. synthesis
- D. Source of our knowledge about conditioning and learning
  - 1. empirical versus rational source of knowledge
    - a. empirical evidence as source of knowledge
    - b. rational inference as source of knowledge
      - i. inferred measures / functions
      - ii. inferred reductionistic processes
- E. Direct versus vicarious source of knowledge
  - 1. direct experience as source of knowledge
    - a. methods for gathering empirical information
      - i. information obtained without manipulation (observation)

- ii. information obtained with manipulation (experimentation)
- 2. vicarious experience as source of knowledge

#### **IV. The Meaning of Explanation**

- A. Types of explanatory mechanisms
  - 1. explanation via confusion, emotion, empathy; or “rhetorical”
  - 2. explanation via specification of future causation; or “teleological”
  - 3. explanation via appeal to inner cause; or “reductionistic”
    - a. empirical
    - b. nonempirical
    - c. flaw of reductionism as psychological explanation
      - i. the fallacy of unobserved verbal activity as a cause of behavior
        - (1) it is not logical
          - (a) when internal is not tied to external
          - (b) when internal is tied to external
        - (2) it is not reliable
        - (3) it is inconsistent with evolution
        - (4) it is inconsistent with empirical findings
          - (a) introspection did not support it
          - (b) attending to verbal control hinders performance
          - (c) phobia can be desensitized without verbal
          - (d) split brain research contradicts it
          - (e) extinction is slow
          - (f) self-destructive behavior exists
- 4. explanation via specification of functional relationships; or “correlative”
  - a. conceptual follow-up
    - i. reductionistic versus correlative (behavioral) explanations
    - ii. mentalistic versus correlative (behavioral) explanations



## CHAPTER 1

# The Epistemological Foundations of Conditioning and Learning

### I. Relevance of Science's Epistemology to Conditioning and Learning

It is because of science's track record in producing desirable results that psychology is moving toward "science" as fast as it can. Science is only one of many ways of viewing the world. However it should be realized that science, which specifically rejects "trying to do good" has produced more good than any other system. It seems that being concerned with truth and understanding has the side effect of producing "good." Whereas being concerned with "good" very often has the side effect of producing half truths, misunderstanding, and horror (the Spanish Inquisition, the Salem witch trials, and Auschwitz).

Science does not produce statements that get to be labeled "the truth." Rather, the ground rule "only demonstrable real world truth" has come to be labeled "science." A key to understanding the activity labeled science; what it is, what it's not, why it's emphasized in courses such as this, and why you should follow its guidelines lies in the way it came about. It did not come into existence when some authority figure defined a creed called Science; and then began ordaining people as Scientists if they took the "oath." Science came about when people who demanded to know the truth and who demanded to understand what they were doing were seen as a group and came to be called scientists. The procedures that avoided erroneous conclusions and which lead to the truth came to be called the scientific method. These methods of science are best seen as conventions that have evolved through the pressure brought about by a primary emphasis on truth and understanding. Science is simply man's attempt to keep from being deceived by nature.

There is occasional resistance to the idea that psychology can be scientific. This resistance is based in a belief that behavior can never be understood, i.e., be measurable, analyzable, or controllable. This objection typically takes one of two forms: that behavior is capricious and without a cause, or alternatively, that behavior can be understood only by methods that are incomprehensible, unlearnable, or innate in a few very special people. (This latter view is typically argued most vociferously, of course, by people who think that they have that "special" skill.) The objections to scientific psychology are obviously not true when one considers the many professions that exist because of their ability to routinely change behavior on command, such as advertising, public relations, entertainment, education, and politics. However, even if the objections to the comprehensibility of behavior are partly true we should get on with understanding what we can

understand, and not be stultified by what at best is only a half truth or a rumor. We should assume that we can have an impact on behavior unless proven otherwise.

### **A. The Challenge**

If I were to ask you to list five good things about lynching someone, you would, after the shock of the apparent oxymoron wore off, put down that it's quick, inexpensive, requires no difficult or complex preparation, and that those who do it claim that it's appropriate, and that they enjoy it because they're helping society. If I were to ask you to list 5 bad things about civil law, you would point out that it is slow, expensive, requires a lot of preparation and work, and is stressful because it must be done right and isn't always fun.

The challenge faced by someone interested in psychology is analogous to that faced by a judge. We can do to our readers and patients what feels intuitively satisfying and what does not require taking difficult courses or we can become properly prepared at whatever the cost to do what is objectively the best thing possible. In criminal justice, no one argues that the easy path (lynching) is better than the hard path (civil law). We should be equally offended when someone in psychology wants to do things in some particular way simply because it is the easiest way to graduate and has the least homework.

### **B. Onus: What You Accept as Your Obligation**

The first step in building a logical foundation for your practice of psychology is to decide what is at the heart of your system of wants, beliefs or values. An onus is the most primitive or most basic demand a person feels obliged to meet, even if it is not fun and even if it is not easy. Generally these are obligations so basic as to require no justification. The questions are: is there any reason for you to do anything other than the easiest, fastest, simplest most natural thing that any 15-year old already does? Is there any reason to know anything more than you already do or to behave any differently? Presumably you would be willing to work hard to be ethical and to be prosperous. The question then becomes: what will make you ethical and prosperous? The answer is that you will need to understand what is actually causing things to be as they are if you hope to be either ethical or prosperous in your career.

#### **1. Demand What is Labeled "Truth"**

Your task is to set up a judicial system which will judge the truth or falsity of issues according to prescribed procedures known to work. It is necessary for you to accept that your "inner ability to understand people and recognize the truth" could be the problem rather than the solution. The actual solution is to determine what in the past has been shown to produce truth as opposed to procedures which only produced strong emotional commitment but little in the way of enduring truth. Some things can be taken as evidence, other things are only conjecture, and are

inadmissible. Your choice is essentially the same as that faced by society: rule by law; based on fact, and truth - or rule by lynch mob; based on popularity and what seems right at the time. Truth comes no easier to psychology than to society, and for the same reason: it's easier and more fun to do things by your heart than by your head. Let's face it, people are convinced that they are right while they're lynching someone. They also feel that a court hearing is an unnecessary delay and hardship which gets in the way. Lynchings require no homework and have no prerequisite and are therefore popular among people who care more about how they feel about something than the facts.

We must be more concerned about real facts than what we “feel” is the truth. We as psychologists have a great deal of power over people's lives. However, we cannot give ourselves the right to “lynch” our patients or readers just because they trust in us, they are unlikely to complain, and we earn a good living at it. Additionally, we must understand those facts.

#### **a. Definition or Meaning of “Truth”**

There must be rules to screen-out knowing-that-you're-right, opinion, bias and conjecture from the truth. Simply put, what does the word truth mean?

The following principles have been very useful in separating truth from fiction.

#### **i. Empirical**

Sense data is the final arbiter of reality. Things are real because we can experience them not because we can imagine them or because we like them. We cannot claim that a space man did “it,” and then when no space man is to be found, claim that it must therefore be an invisible space man. We cannot claim that an overactive ego caused the problem and then claim that it is an invisible overactive ego, detectable only by properly trained psychotherapists, of whom we are one and the questioner is not. If we wish to claim that something we cannot experience is real then the burden is on us to prove it to a skeptical audience; that is only fair. That we can prove it to ourselves, our friends, and our students is taken for granted.

#### **ii. Reliable**

Things are real or true if a second look confirms their existence. If we add a column of numbers twice, and get the same answer; then the answer is likely to be correct.

#### **iii. Multiple Converging Evidence**

The more evidence from the wider a variety of sources, the more believable. If the police find a fingerprint the same as yours at a murder scene, maybe it means you are guilty, maybe it doesn't. However, if the police also find your wallet there, and

the murder weapon in your house, and the tire tracks of your car at the murder scene, and the victim's jewelry at your house, and your teeth marks on the victim's throat, and a VCR tape of the murder with you in the starring role - well, then you're in trouble. (Unless you have a very good lawyer, of course. This is where the analogy breaks down; law and science play by very different rules.)

In science this has two aspects: 1) multiple measures of different types all indicating the same fact, and 2) an explanatory context which is very general with many cross validating findings in the theoretical net.

#### **iv. Consensually Validated**

If several observers who abide by the “rules” of science all agree concerning an event then it is probably true. It is reliable, it is objective. If only one person observes something and others do not observe the same thing then it is subjective. Just as you believe that the true sum of a column of numbers is the one that both you and others have obtained, so does science depend on consensual support. This criterion avoids the problem of considering a dream or a drug induced hallucination a fact. For this reason it may be the most important criterion. If a theory precludes consensually validatable statements then it is metaphysics not science. This criterion works especially well if the observers are widely separated with respect to theoretical orientation, time, etc. Oddly enough, complete agreement is not necessary. You only need to agree over the issues under discussion and to whatever extent is necessary for the discussion to proceed. If you want to know if your group can pay for the dinner you need not argue over whether you have \$105.75 or \$107.21 between you when the bill is only \$25.00. It is an entirely different question however if the bill is \$106.00.

#### **v. Operationally/Functionally Defined**

If we are to communicate to others, or if they are to communicate to us, we both must be able to correctly point to the same thing that is being talked about. The agreed to definitions cannot miss anything, nor can they add anything that isn't there.

The concept of a thing, or the set defining a thing, must be correct. This simple idea has two important ramifications. The first is with respect to what actually exists (ontological validity). The second refers to the degree to which our definition actually corresponds to what we are pointing to (the thing's referent). Ultimately, these two issues are the same thing, but it is pedagogically easier to discuss them separately. The subtle distinction between the terms is given by an example: when we talk of unicorns the issue is: do they exist. When we talk of pink elephants, the issue could be said to be only the lack of correspondence between our stated color and the color of the real elephant. But it could also be said that pink elephants do not exist.

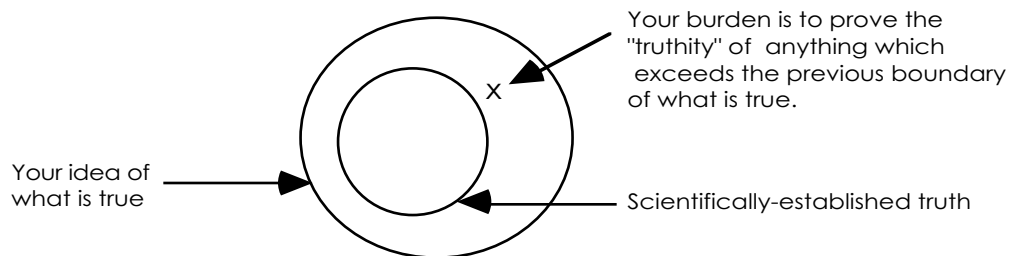
To be correctly defined, the definition must correctly capture the nature of the



thing, the definition must be testable, the errors between speakers or between the term and nature must be minimal, and the terms must be coherently integrated into some conceptual system or paradigm. The demand for integration is what provides generality to findings and provides the explanatory power of science.

#### vi. Coda

The following figure illustrates the essence of the present meaning of the word truth. There are things which have the characteristics specified in the previous sections (a through e). We call these things true in everyday language. We also call these things scientifically established facts. People who deal with things in the inner circle are called scientists. Science is nothing more than truth. Truth is nothing more than science. Science is NOT a subset of the truth. Rather than to start with the notion of truth and then provide science as a subset, we start with the notion of empirical, reliable evidence with multiple converging support which is operationally/functionally defined and has consensual validation and ask what is beyond. If someone wants to offer something else as a “truth,” it must be proven. Truth does not mean anything anybody wants it to mean. Anyone wanting to extend the meaning of truth to something beyond what science has already substantiated must explain to us what they are talking about. The irony is that by this criterion, we would simply expand the number of scientifically established elements not increase the difference between science and truth.



Neither can we say truth is some eventual ideal. In the first place we cannot know the future. Secondly, that position would suggest that we no longer have to worry about the accuracy of what we do today. The buck must stop now. The allure of reifying a future truth that is beyond what we know today is that it seems to give the speaker the “right” or “authority” to believe anything they want. By simply asserting “this may be right eventually,” that view comes to have a footing equal to any currently “proven” view. By similar logic, the person could reject anything regardless of the evidence supporting it by asserting that sometimes scientific paradigms change. Beyond what science has proven lies a vast sea of ignorance and pain that would remain that way forever if it were not for science identifying truth. The mechanism underlying the dynamic nature of science, with which science advances, is relatively complex and is detailed later.

## **2. Have What is Labeled "Understanding"**

We must understand how, when, and why things work the way they do. It is not sufficient to only be able to redescribe a demonstration we once saw. You must comprehend the controlling factors underlying the functional relationships involved. You will be unable to predict what will happen in other situations and you will be unable to control behavior in alternate situations if you do not understand what makes behavior work the way it does. By returning to the “see the dolphin” metaphor, the point could be illustrated. For example, suppose a person came to be able to find which of a number of objects was imbedded in each of a wide variety of pictures; then that person would be likely to also be able to find and see the new objects in a wide variety of completely novel pictures; whereas a person only memorizing that a particular picture contains a dolphin would be unable to identify which objects are in which new and different pictures. You must understand the set of various unifying principles which underlie various phenomena and how to find them if you are to be successful. The object is not to memorize that in this situation you do this procedure (the picture with squiggly lines has a dolphin in it) and not ever really understand what's going on.

### **a. Definition or Meaning of “Understanding”**

Understanding is like seeing the image in a random-dot stereogram. To understand is to be able to arrive at solutions for problems no one before has ever encountered and for which neither a “study guide” nor “answer sheet” is available. If you understand a phenomenon you can use that information in new situations.

The classical statement of someone who does not understand a phenomenon is “it works in theory, but not in the real world.” This means that that person can redescribe a classroom demonstration they once saw (“there is a dolphin in the picture”). But that didn’t help them any in their situation because the picture is different than the one they memorized in graduate school. The problem is that they don't understand why the phenomenon happened and what makes it happen or not happen in changed situations. (They never actually “saw” the dolphin in the picture; they knew only to say the words.) When presented with a picture they had never before seen, that happened to have a lion in it; they said “there is a dolphin in the picture” and they were obviously wrong!

Another impact that the requirement for understanding has on the scientific endeavor is that it focuses attention on what is the same about a variety of behaviors, rather than on what is different about those behaviors. This is much like a chemist focusing on the common elements of various substances rather than being stupefied by the superficial differences in those substances. The important task is to see through differences to the common underlying principles. With an understanding of the common principles governing nature, comes the ability to describe, predict, control, synthesize, and explain.

**i. Describe**

Given a language, a minimal understanding is exhibited by a description: which elements are contained in the set which are not.

**ii. Predict**

To predict is to specify what will happen in a new situation by virtue of understanding a rule that applies in a known situation; knowing how the unknown situation relates to the known situation; and how to correct the rule if differences exist between the situations. The importance of this aspect of science cannot be overestimated. It drives most of what science is. In order to predict in a new situation, nature must be correctly understood. Only by knowing the fundamental process will the person be able to correctly predict into a new situation. Knowing that the pigeon pecked the blue light more slowly doesn't help predict much. But, understanding that decreases in reinforcement rate typically reduce the rate of the supported behavior helps predict into a very large variety of situations for all life forms.

**iii. Control**

If you understand a functional relationship then you have the opportunity to modify its causes, which in turn allows you to modulate it or make it occur or cease. If you do not understand what makes a phenomenon work you will be unable to control it. It will occur or not occur irrespective of your efforts.

**iv. Synthesize**

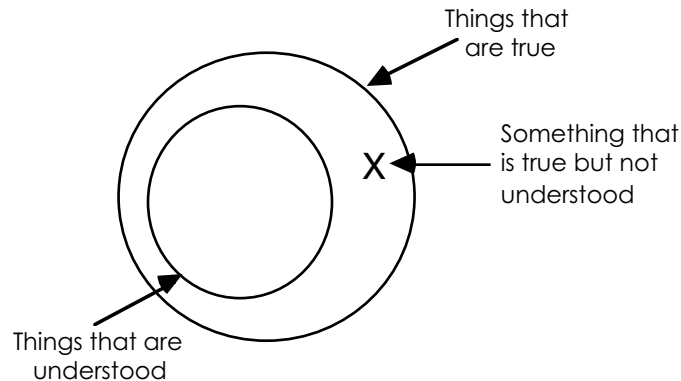
If you understand what makes a phenomenon work, not only will you be able to create or abolish it as you desire, you will also be able to produce completely new variations to suit your needs. You will be able to produce a behavior in an organism that previously did not occur.

**v. Explain**

To explain is to integrate the phenomena within a larger context or paradigm. This provides general rules in order to more easily describe, make predictions, control, and synthesize new phenomena and to communicate this ability to other people. A proper explanation must be based on the criterion specified under truth: it must explicitly and unambiguously specify its elements, it must be testable or capable of being validated, it must be nontautological and it must minimize errors. These factors are discussed in more detail in the section on explanation.

### vi. Coda: Understood Versus Truth

As the following figure illustrates, there can exist things that are true but that are not yet understood. Science could, in fact, be seen as that activity which strives to understand what is true.



## II. Goals of Science

The process of science typically has one of three goals.

### A. Research to Understand (pure research)

Pure research is concerned with developing valid, complete, and coherent descriptions and explanations. It is interested in organizing data into the most general and parsimonious laws or qualified statements of uniformity. The emphasis is on comprehension or understanding. It is motivated by curiosity and inquisitiveness about natural phenomena. It is interested in data for their own sake. Most often the details of the research are considered arbitrary; the fundamental process is the focus. Pigeons pecking for food is the arbitrary, irrelevant aspect; behavior under the control of reinforcers is the important point. Doing this type of research is like learning a language; once it is known, all things can be done. Benjamin Franklin was engaged in pure research when he tried to compare lightening with static electricity generated by feet rubbing on a rug. He did not do it to find a better way to illuminate Philadelphia at night nor how to transmit TV pictures. He just wanted to “know.” It is interesting to note that 200 years later, few Americans would survive a single year if electricity suddenly disappeared altogether. The practical impact of his indulgence of his curiosity is almost unimaginable. His discoveries are all the more impressive considering that his only reason was to add to the knowledge base. He did not do it for the money. He would not have had an answer to a critic who asked “just how will this help the human condition and if you don't know, then you should do something more practical.” Studying the nature of cell growth would be pure research. Trying to describe and understand the determinants of matching would be pure research.

**B. Research to Solve a Particular Problem (applied research)**

Applied research is concerned with the discovery of solutions to practical problems and places its emphasis upon those factual data which have more immediate utility or application. The emphasis is on control. Applied research is like learning phrases needed to accomplish a variety of specific things in a foreign language without really understanding the whole language. The search for a cure for cancer is an example of applied research; discovering a solution for manic depression is an example of applied research.

**C. Dispensing Solutions (practitioner / technologist)**

Practitioners are concerned with the direct application of principles and theories from one or more fields of science for the purpose of dispensing solutions to individual human problems rather than being concerned with the discovery and organization of knowledge. Strictly speaking, a practitioner is not a scientist, but that is not to say they are necessarily unscientific. Practitioning is like memorizing sounds of a song in a foreign language without necessarily knowing the language. It accomplishes an immediate specific end. While a practitioner may uncover a phenomenon of great importance to the understanding of nature, that is not their primary focus. A practitioner or technologist administers chemotherapy or psychotherapy. A physician or a psychotherapist is a practitioner.

**III. The Meaning of Knowledge**

In this section we will address "to what do scientists pursuing conditioning and learning ask their questions" and what is the nature of the response to those questions. We will see that we are interested in the relationships between observations, and that we can get the information that is the foundation for our ability to predict, control, synthesize, describe, and explain nature (i.e., "knowledge") directly through research or indirectly through vicarious experience such as reading a journal article. Obviously some scientists generate knowledge, while others use that knowledge, while others take that knowledge as the question to begin with.

**A. Conceptual Precursor: Variability and Equilibrium****1. Variability**

If the value of the dependent variable obtained from two different subjects differs, or if a single subject reacts one way on one occasion and a different way on a different occasion (even though the environment seems to be the same); what does that variability mean? What does it tell us about nature? How does science treat this variability?

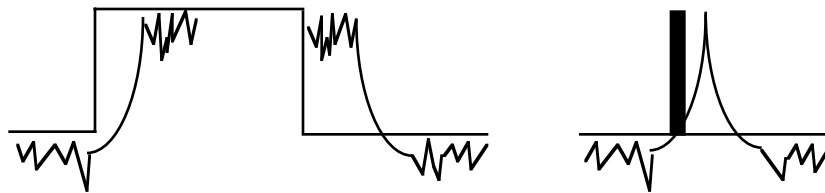
As a matter of practicality much variance is accepted as is. For example, simply documenting the probability distribution of behavior is often a substantial

contribution to the body of knowledge. However, the assumption of intrinsic randomness and deferral of explanation are seen as last resorts. The task of researchers is to minimize or account for the variance in the obtained data and thus prove themselves expert puzzle solvers.

### a. Three Types of Variability

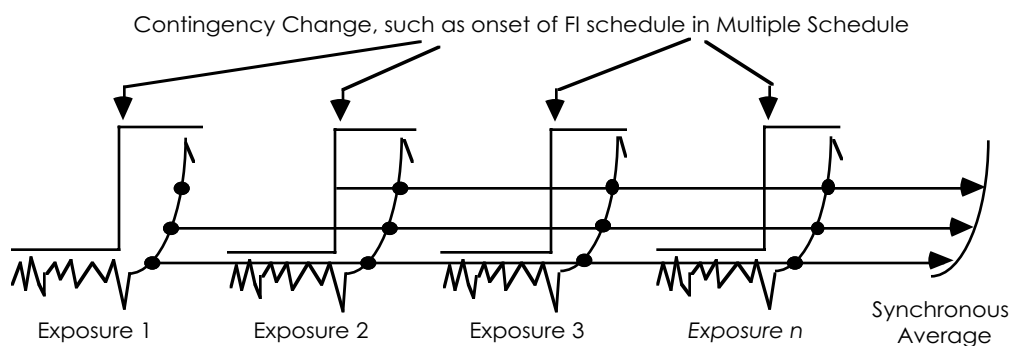
#### i. Transient Dynamics

The following figures illustrate transient change as behavior reacts to events. Examples are acquisition of behavior to a new task, the loss of behavior under extinction, and the change in behavior following some disturbance.



#### ii. Synchronous Dynamics

Synchronous dynamics are the real-time commonalities in the change in behavior associated with repetitive predictable changes in a schedule. In the case of an evoked potential to a light flash, a signal averager averages brain activity in synchronized consecutive bins following each flash.



The above figure illustrates synchronous dynamics in a fixed-interval (FI) schedule. In an FI, the mean behavior is called an FI “scallop.” Behavior can be averaged across repeated instances of each specific ordinal bin if the successive bins are synchronized to the event which controls behavior.

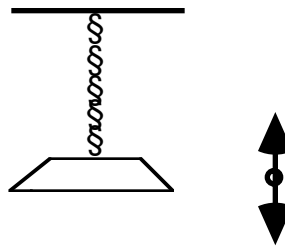
### iii. Asynchronous Dynamics

The final class of real-time behavioral variability is asynchronous dynamics. Asynchronous dynamics is the variability seen even with very extended exposure to the same treatment. It is the variability seen after the transient dynamics have passed and in the absence of any known disturbances.



## 2. Equilibrium

At equilibrium the tendency to increase or to decrease are in balance. A mechanical metaphor for equilibrium is a weight on the end of a spring:



The spring pulls up and the weight pulls down. They come into equilibrium. When the vertical position of the weight stabilizes at some point, the forces pulling in each direction are in balance. Adding or removing a weight in this weight and spring example is a metaphor for the change in equilibrium caused by the change in reinforcement contingency.

## B. Knowledge is Covariance

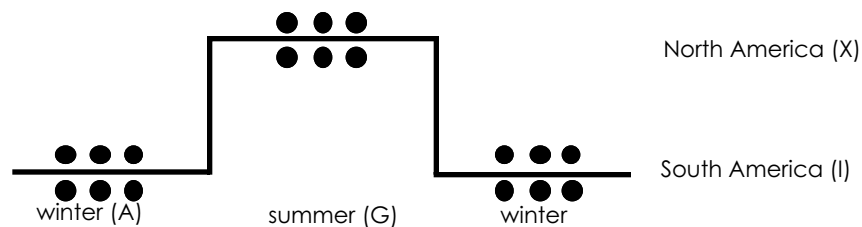
Things in nature change. The lights in a room may be on or off, a rat may be in the right or the left arm of a maze, a silent person may begin to speak. We flip the light switch, we place food in one goal box, we ask a person a question. Often, however, things are not so dichotomous: Dawn changes darkness to light in a continuous fashion. The number of soft drinks consumed per day varies, and people speak in a variety of rates, amplitudes, and languages and say a variety of things. There are both continuous changes and dichotomous changes in nature.

We also see relationships in nature; we flip the light switch and the lights go on,

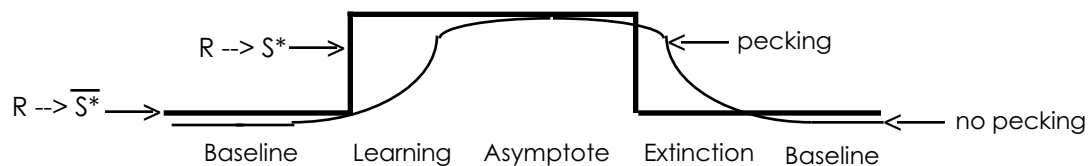
we place food in one goal box and the rat goes there, we ask a person a question and they answer. Additionally, we may not see simple discrete cause-effect relationships, but rather covariance. As consumption of cigarettes increases, incidence of cancer increases, but everyone smoking does not get cancer, and many people get cancer who have never smoked. Some relationships are very strong, like light switches and illumination level (often labeled "cause"); while others are weaker, like cigarette smoking and cancer (often labeled simply "covariance").

### 1. Simple Dichotomous Change and a Necessary and Sufficient Precursor

A very simple mechanical example of a dichotomous change caused by a necessary and sufficient precursor is a light switch position (up or down) and the amount of light in a room (bright or dark). The figure below illustrates a dichotomous change in the number of birds in North and South America between the dichotomous periods of winter and summer. Each dot could represent some millions of birds. (As with many examples in psychology, necessity and sufficiency as specifiers are problematic. Few things occur for one and only one reason; and few things cannot be altered by some other factor. But, for now leaving the example simple.) In winter, all birds are in the south (suspended weight is in lower position). In summer, all birds fly north (weight is removed and suspended weight rises). When winter returns, all birds fly south (weight is added again and suspended weight returns to the lower position).



The effect of reinforcement on behavior provides a psychological example. If you follow a particular behavior such as key pecking (the dependent variable) with food (a reinforcement contingency; the independent variable), the changes could be represented as follows:



The figure shows an initial zero frequency of response-dependent food presentation with an initial zero or near zero rate of key pecking. This relationship is stable and we can label it an initial baseline (a spring with no weight on it). The



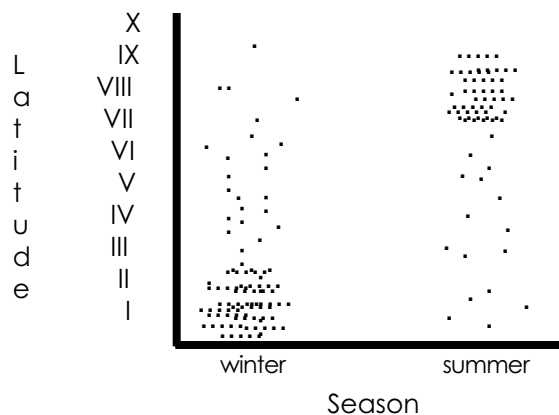
environment is then changed, food presentation now follows key pecking (the existence of a reinforcement contingency changes from zero to one) (a weight is removed from the spring). This is followed by a gradual increase in the rate of key pecking (the position of the suspended object rises). This is typically labeled the "learning curve." Eventually stability reoccurs. The response rate is then said to be at asymptote (i.e., it no longer changes). The two variables are again in equilibrium.

The reinforcement contingency for key pecking can subsequently be returned to its initial state (food no longer follows key pecks) (the extra weight could be added), and the response rate returns to its baseline level (the position of the suspended object falls). This rate loss is typically labeled the "extinction curve". Eventually equilibrium is reestablished.

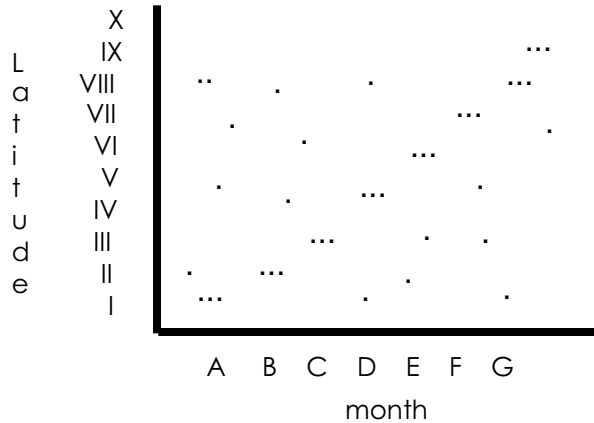
## 2. Continuous Changes and Continuous Relationships

Changes are often more complex than the simple dichotomous changes with dichotomous causal factors, just illustrated. The complex case can be easily illustrated by continuing the example of the migration of birds. Changes can be continuous like dawn rather than dichotomous like a room light. Changes can be statistical like the percentage of birds in each location. Not all need fly south. 100% can be in Canada and 0% in South America or the reverse or anything in between. In fact, the birds may stop in the US, Panama, or anywhere in between or some could even migrate backwards.

This next figure illustrates most, but not all, elements in the dependent variable (dots or birds) "switching" with a change in the dichotomous independent variable (season).

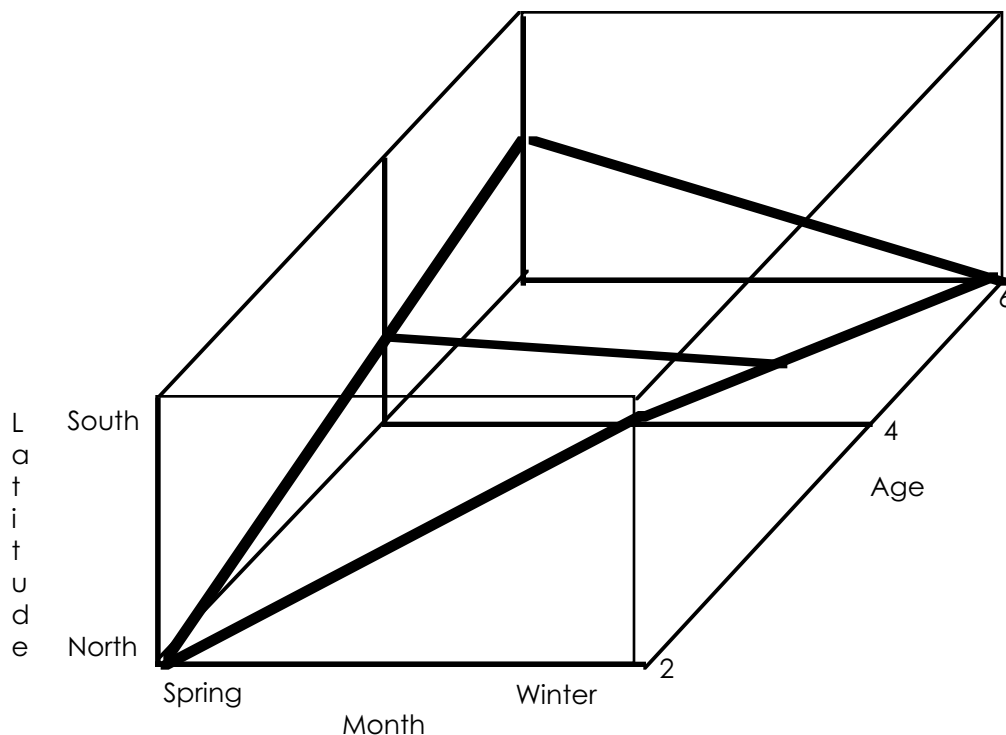


Further, it can be seen that change can be continuous in both its x and y amount. This is illustrated by plotting the data as a function of both all twelve months (A through G) and all ten latitudes (I through X) which gives us a more typical and more useful example.



### 3. Multivariate Change

Clearly a single dependent variable can change as the result of more than one independent variable. In fact, the dependent variable may not change unless several independent variables are manipulated in a particular way. Additionally, a single independent variable may cause several dependent variables to change. In this light, the previous examples can be seen as special cases of what changes we could expect in the natural world. The earlier examples have only one independent variable and one dependent variable; they are called univariate. The multivariate nature of the natural world is often overlooked because the analytical tools for multivariate analysis have only recently become available. In the past, all statistics were univariate.



In the above figure, it can be seen that 2-year old birds fly south for the winter, 4-year old birds stay around the equator all year, while 6-year old birds migrate north for the winter.

#### **4. Type of Variance and its Conceptualization**

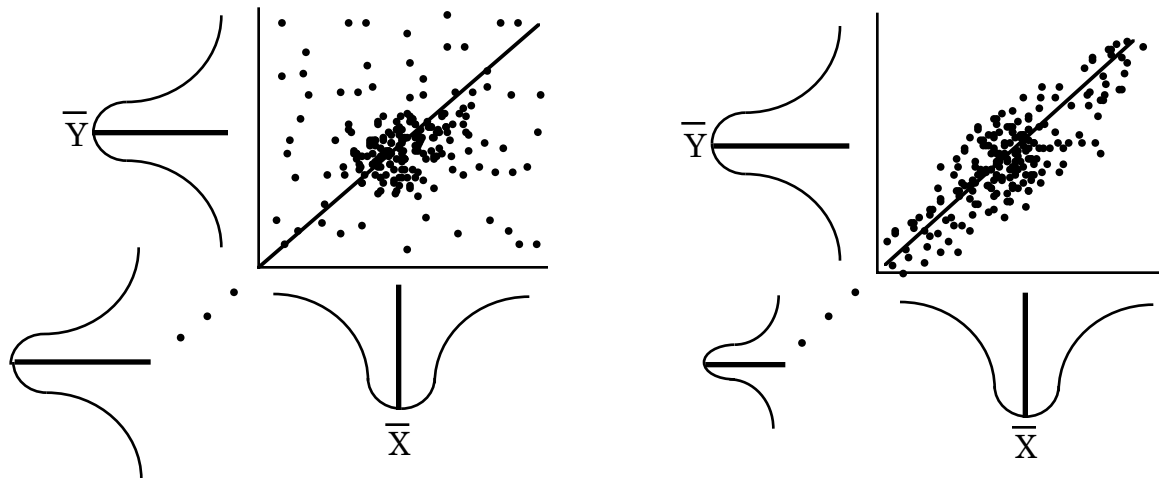
The previous section on covariance skipped around a relatively complex issue without drawing attention to it. The issue however must be dealt with. Rarely do we find two subjects with exactly the same score. Rarely does an individual behave in an absolutely identical fashion from one occasion to the next occasion of the same situation. We must have a responsible way to treat this variation. We must have an accurate and coherent way to understand why behavior varies.

If we were to accept that all things were randomly determined, we could easily "explain" any differences in our dependent variables, we could say "it just happened that way for no reason," but we would cease to productively function. If things have no cause, how are we to predict, control, synthesize, and explain? As a matter of principle, we must assume that things occur for a reason, and that we can understand that reason. We, therefore, must presume that any difference in our measure is the result of different deterministic causes. At a more practical level however, we will also have to accept that the deterministic source of the variation is sometimes beyond our resolving power.

##### **a. Accountable Variance or Covariance**

Suppose we go around a typical class and ask each person for their GPA and shoe size and we plot the left scatter plot below. We go up the  $y$ -axis their GPA, then across the  $x$ -axis their shoe size. We place a dot in that spot to represent that a person with that GPA and that shoe size occurred. We would notice that there are more people of average GPA than very high or very low. There are more dots in the middle  $y$  values, than at the extreme  $y$  values. This can be seen by imagining that each dot is a ball bearing and we tilt the page to the left. If the bearings roll straight to the left they would form stacks against the  $y$ -axis as is illustrated. There would be many in the middle, few to the top or bottom. Similarly, there are more values at middle  $x$  values. We can tip the figure and roll the dots into piles on the  $x$ -axis. Many would be in the middle and few to the left or right.

Next we repeat the whole plotting process by asking each person for their grade point average and hours studying and form the right figure below. Again there are more middle GPA people than low or high. There are also more middle studying people than little or lot.

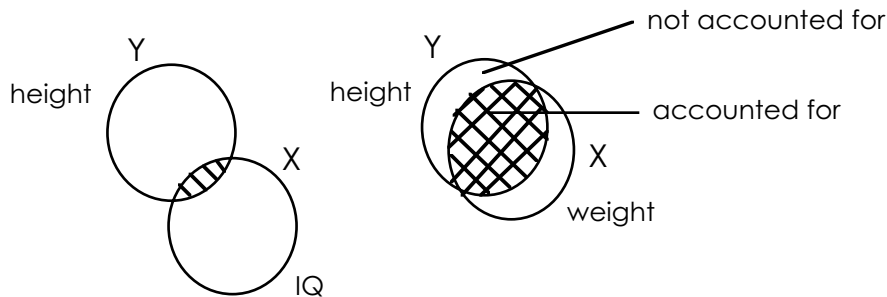


Note that the variability around the average Y (GPA) is the same in both figures (as it should be because it is the same measure), and the variability around the average X is the same in both figures. However, in the right figure we could find a way of looking at the figure (in this case up the line drawn at an angle through the origin) which dramatically reduces the error or variance around a central tendency. This is illustrated by the distribution drawn in the lower left corner of the right figure. If we had tilted the right figure at a 45 degree angle than the stacks of ball bearings would have been very close together and would have created the distribution in the lower left corner. This error is very much smaller than that on the  $x$ - or  $y$ -axis.

The figure on the left has the same spread around the  $x$ - and  $y$ -axes, as the right figure but it does not have any “line” around which the spread is minimized which is any better than the mean. A line from the origin is drawn for reference, but clearly the spread around it is no better than around the mean  $y$ . Prediction is relatively good in the right figure and poor in the left figure. If you start on the  $x$ -axis with a shoe size or hours studying that you know, then look to see what  $y$  values have occurred for your given  $x$  value, you can predict what GPA will occur. If we know a person's shoe size, we cannot accurately predict their GPA (left figure), whereas if we know their hours studying, we could predict their GPA (right frame). As can be seen on the left, prediction is not possible with a zero relationship. No information is available at all; whereas with the strong relationship on the right, accurate predictions can be made.

This can be illustrated yet another way. Each circle below represents the variability in a set of numbers. The area of the circle labeled Y represents the variability on the  $y$ -axis. The area of the circle labeled X represents the variability on the  $x$ -axis. The intersection of the two circles represents the covariance while the area in Y remaining in addition to the overlap represents the variability around the best fit line through the data points or the variability in Y not “explained” or

accounted for by the variability in X. The unexplained variance is the variability in the distribution at the lower left corner at the end of the diagonal line of the previous figure. The explained or "accounted for" variance is the difference between the distribution on the y-axis and that around the best distribution in the lower left corner.



As we will see in subsequent sections, prediction requires four elements: change on the "X" dimension; change on the "Y" dimension; reduced variability around the regression line as compared to around the mean; and sufficient spread in the elements or data points on each axis.

### i. Models of Accountable Variance

There are several types of models for accountable variance. They differ with respect to what is known, or what information is specified by the model, and the degree of control over the environment offered by that information.

#### (a) Cause Effect Models

The two types of cause-effect models are provided below. Note that it is necessary to experimentally manipulate the relevant variables to prove that a cause-effect relationship exists.

##### (i) Mechanistic or Reductionistic Models

Some things, like a billiard ball moving as the result of being hit by the cue ball can be seen in a cause-effect framework where each step in the process is well understood. A light switch and room illumination is another example. (Manipulation --> change; known reductionistic mechanism of action.) What molecular steps or processes led to the end are known, at least at one level down from the level of the dependent measure.

##### (ii) Functional Models

Things often stabilize in predictable ways without us understanding (or caring

about) the reductionistic processes involved. Planets stabilize at known speeds and positions, water runs down to the sea, the rate of responding changes in orderly ways when the reinforcement rate changes, and so on. It helps little to explain celestial mechanics by saying that an unspecifiable reductionistic force causes it or the rate changed because the animal knew something. Newton said "I have not been able to discover the (reductionistic) cause and I make no hypotheses." In this case explanation is the specification of necessary and sufficient conditions at the same level of measurement as the dependent variable. Note that a functional or correlative model can be causal, while a correlational model is not causal. (Manipulation  $\rightarrow$  changes; unknown reductionistic mechanism of action, but known order of effect and set of necessary and sufficient conditions).

### **(b) Correlational Models**

Some times we only know that things go together. One thing is not known to cause the other. Additionally, we may not even know which comes first. Social respectability and wealth covary. One can be predicted from the other but one does not force the other. Any of three relationships could underlie the prediction. It could be  $A \rightarrow B$ ;  $B \rightarrow A$ ; or  $C \rightarrow A$  and  $B$ . (No manipulation; predictor  $\rightarrow$  predicted with unknown order of effect.) (Subsequent experimental research could find the order of the effect.) Note that a correlational model should not be confused with a functional or correlative model or a correlative explanation which will be covered later.

### **b. Residual Variance, Error, or Ignorance**

When we have discovered why something happens, we have removed the accountable variance (the overlap in the Venn diagrams). The next question is obviously what to do with the variability which we do not understand.

#### **i. Experimental Solution**

The obvious and productive solution to the problem of residual variability in the data from the subjects is to do an experiment which answers "why." Why do these individuals score higher, how can I predict which of the scores will be higher? What will change an individual? By manipulating variables, you can find the answer.

#### **ii. Assumption of "True Score" and "Random Error"**

While not properly a solution, this approach allows the researcher to "pass" on the problem. A property of randomness is that deviations occur to either side of a true score to the same extent. The mean of random errors cancel. If we presume that our obtained scores are randomly distributed around a true score then the mean will be the true score. If we have unaccounted for variability in our data, we can presume

that it is random and of no interest by taking the average of our scores. This is covered in more detail in Chapter 5. However, we are: 1) presuming something which we do not know, 2) ignoring something which may be of importance, 3) giving up opportunities to explain variability, 4) assuming that each element in the group over which we are taking the mean is identical, and 5) that the relationship between the elements is linear. Undoubtedly some variability should be passed over. It is equally true however, that some variability is of great consequence.

### **iii. Delegate Problem**

What appears to be a simple solution to residual variability is the “tag team solution.” When faced with a problem which, for that individual, is insurmountable, they could do like the wrestler does: Rush over to the ropes (the boundary of their domain) and give the problem to someone else. This would be contending that there is a biological explanation for your psychological data or a developmental explanation for your obtained difference in learning. These deferrals are different from experimental solutions because the investigator who invokes them does not pursue the problem across the boundary, but rather lays a problem at someone else’s doorstep and then acts as if the problem is understood by using the invoked paradigm as an explanation rather than a description of ignorance. Passing an unsolved problem to some other domain is a mark of inadequacy, not a badge of honor.

## **C. Issues Pertaining to Knowledge**

### **1. Purpose of Research**

#### **a. For Curiosity**

It may be that it interests us and that is a good enough reason. If it interests us, then that means some implicit theory we believe did not prepare us for the event that piqued our interest. Presumably, whatever was of interest to us will be of interest to others once we get a “handle on it.”

#### **b. Construction of Functional Context**

This type of knowledge gathering systematically obtains facts as well as the necessary other information to develop a coherent frame of reference or context for meaningful explanation.

#### **c. For Theory Testing**

Often we carry out research to see if a theory is correct or not. We could deduce some experimental test such as: “according to my understanding of the processes involved, if we double the reinforcement rate then the rate of behavior should be halved.” Keep in mind that a single positive finding supports a theory but only

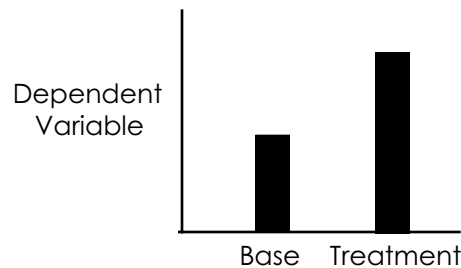
marginally, while a single negative finding whose interpretation is correct is very damaging to a theory. But also keep in mind that everything hinges on the author's understanding of the disconfirmation. For that reason, multiple converging evidence must be a requirement of theory testing.

## 2. Breadth of Research Findings

Research can produce a single fact or a large set of interrelated findings. This is not the degree of integration into the paradigm, but rather the degree of integration or completeness of the findings themselves.

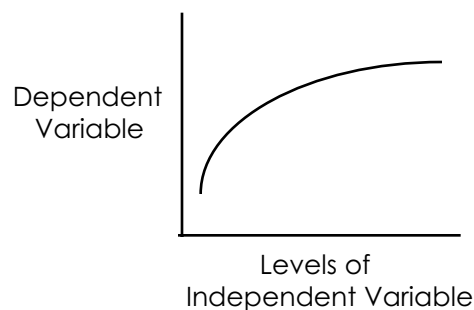
### a. Production of Single Fact, Isolated Treatment Effect

We may want to find out what happens if we do  $x$  to our subjects. This is a single fact. In this case, it is determined that level  $x$  of independent variable  $y$  will have  $z$  effect. Five grams of food results in 50 pecks. This is illustrated in the figure below.



### b. Production of Quantitative Function

The task in this case is to do enough research to understand how something works across its whole range. In this case, it is determined that the whole family of levels which independent variable  $y$  can take can be described by equation  $Z$ . This is illustrated in the figure below. Note the difference between the information it provides and the information provided by an isolated treatment (the above figure).





### **3. Generality or Level of Abstraction of Research Findings**

This refers to the degree to which an event is taken at face value or is seen as an instance of a more fundamental process. Do you see a pigeon pecking on a red key, or do you see an operant maintained by its consequences? The knowledge sought can be simple "at face value" information, such as "John jumped when I said boo." Or the knowledge sought can be a general rule, such as "sudden stimuli produce startle responses." Or your interest may be even broader, such as "some stimuli cause unconditioned responses." In order to generalize an event to a general class, you must have some paradigm within which to view the event. It is the paradigm that gives a finding its generality. Applied behavior analysis would not exist unless Skinner had realized that a pigeon pecking a key was the same as a person being a good parent or a person pursuing a career.

#### **a. Face Value or *Per Se***

In the absence of any abstraction, the actual behaving organism is what you are watching and you want to know, for example, if it will move to the right or to the left when you "poke" it. Precisely why that seems like an interesting thing or what it means is difficult or impossible to articulate. This type of question is very concrete. It tends to be interesting to an individual because of some implicit connection to some implicit paradigm for that individual.

#### **b. Specific Only as Model of Something Else**

At the other extreme of abstraction is considering some specific behavior as a representative of something else. In this case, a pigeon pecking a red key is taken to indicate that reinforcement rate affects response rate. A specific research question may be implemented with some specific subject and some specific procedure, but they are seen as arbitrary (other than the necessity that the model must accurately reflect the properties of interest in the target). Experimental paradigms, which are used to provide information on some other specific situation, or on all situations, are labeled "models."

### **4. Type of Knowledge Produced by the Research**

When studying behavior, two distinctly different kinds of questions emerge. One type asks things such as, "How fast can a pigeon peck," or "How many colors can pigeons discriminate?" A second type, one that's vastly more important to psychology, asks things such as, "Why does this type of experience produce that type of rate change," or "What type of experience produces that type of control by the stimuli?" Note that none of these questions necessarily requires a reductionistic explanation. Whether the explanation appeals to higher or lower levels of molarity or shorter or longer time scales is a different issue.

**a. Capacity of Organism: Structural**

This is the specification of how fast a pigeon can peck or the sensory capacity of a cat or the memory span of a person. This type of research is focused on determining the pattern in the behavior or the capacity of the organism. It characterizes behavior without specifying how behavior changes as a function of other events. This would be the determination of how much convergence was necessary before a person detected depth in the image or the pattern of walking used by various insects.

**b. Behavioral Processes: Functional**

This is the specification of the functional relationships relating behavior to its causal factors.

**5. Phase of Research Helix****a. Analysis**

This aspect of research proceeds by breaking a phenomenon down into simpler elements. Analysis is based on the assumption that the action of a whole is the result of the action of its parts and their interaction. By isolating the parts and coming to understand their simple processes, then complex wholes can best and most efficiently come to be understood. The belief is that the complexity and unpredictability of wholes is due to the action of the many small difficult to control processes making up the whole. Analysis is specifically designed to obtain information concerning the nature of the underlying behavioral process by breaking the phenomenon into its parts. This is the process of isolating active variables or ingredients, or the removal of irrelevant or confounding variables. Example: If given boxes and a hanging banana, a chimpanzee will move the boxes to form a ladder and will get the banana. We can easily show that that activity is not some mystical or transcendental insight by using analysis. By providing or withholding various component experiences, we get predictable variations in the final behavior. Experience with each precursor is necessary for the complete behavior to emerge.

An extremely important realization for a researcher to make is that the task is to show why the behavior occurred as the result of simple environmental experiences by proper analysis. To show that the behavior had to be the result of a "smart" animal -because you were unable to isolate the cause- is to have failed as a researcher: The question "why" has not been answered. Thus, "... and then a miracle happens," or "... and then the animal realized the right solution," or "... and then the animal used its cognitive map"-type of research is pointless. Rather than uncovering a cause for the behavior, the researcher needlessly demonstrated once again that sometimes animals do things that appear very "intelligent." We already know that. The point of research is to discover why. In perception research, we need not demonstrate that people know that some objects are far away. We already know that. We need to determine what aspect of the stimulus makes the person react as if the object were far away.

### **b. Synthesis**

Synthesis is the putting together or creation of something. The purpose of synthesis is to assemble known parts into a whole. The result is the production of a complex behavior or an integrated theory. It is an important stage in the empirical collection of knowledge because it provides feedback with respect to the validity of the presumed process.

The analysis phase is the first stage in the construction of an integrated framework of explanation. Synthesis is the next stage. The synthesized results demonstrate the validity of their presumed causal mechanism. If you are collecting information correctly and in such a way that you understand it, then you can generate correct theoretical models of the presumed underlying process and you can create or synthesize new forms of the behavior at will.

## **D. Source of Our Knowledge About Conditioning and Learning**

### **1. Empirical Versus Rational Source of Knowledge**

#### **a. Empirical Evidence as Source of Knowledge**

This is knowledge gained through experience. Experience can be said to result in access to knowledge of what is real. A pencil on the desk is real because we can touch, taste, and smell it; a unicorn is not real because we cannot experience one.

In point of fact, a reliance on personal experience to determine what is real is simplistic. What about errors or misunderstandings? How are we to deal with dreams, psychotic episodes, and drug-induced experiences. What about events which cannot be easily seen, heard, tasted, or felt. The solution has already been discussed earlier but to review, it is to demand reliable observations, integration within a theoretical network, and consensual validation, as well as some form of empirical support. However, for now, it serves pedagogical purposes to simplify all those factors into the statement “experience results in access to knowledge of what is real,” even though it is by its consistency with a wide variety of empirically supported observations that knowledge is validated.

#### **b. Rational Inference as Source of Knowledge**

If we observe some sequence of empirical measures such as; point 1 is measured to be 250, point 2 is 300, point 3 is 350, 5 is 450, and 6 is 500, then we can infer that the measure at point 4 is probably 400. There are many similar situations where we need information but we can only infer that knowledge because we have not yet measured them, or cannot measure them at all. Reasonable guesses can be made based on the evidence we have on hand, even though ultimately these inferences must appeal to empirical measures for their validity. While we cannot **know** that we are correct about our inferences, “valid” has no meaning other than that there is never a discrepancy between the inference and empirical measure, no matter what we or anybody else does to challenge it.

### i. Inferred Measures / Functions

The example of inferring what value “point 4” had was making an inference about what a measure would be in a series of measures. This is generally accomplished by considering the function that connects the data elements. For example, we can infer that a linear model will match the series of data elements.

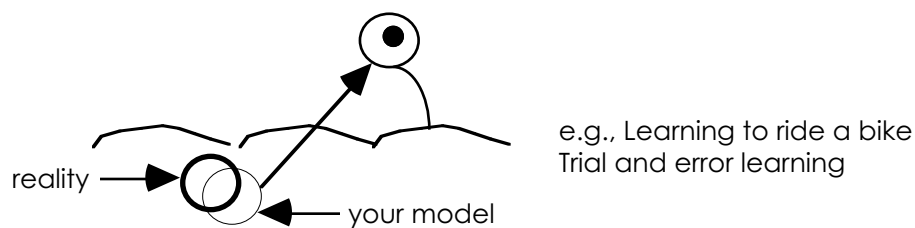
### ii. Inferred Reductionistic Processes

In this case, some underlying reductionistic process which would produce the measured data is inferred. This strategy is encouraged by our general cultural view that “causes” are to be found on the inside of organisms. It is critical, however, not to slip into accepting that an inferred function is actually a reductionistic process underlying the obtained data. We should be satisfied, for example, that a linear model predicts the obtained data, and feel no obligation to presume that there is an internal linear process, or a straight-line processing center in the brain or that a homunculus has an adding machine to figure out what to do next. The inferential illusion of positing a reductionistic causal process is similar to the illusion that seems to imply that *A* causes *B* when we find that *A* is correlated with our dependent variable *B*.

## E. Direct Versus Vicarious Source of Knowledge

### 1. Direct Experience as Source of Knowledge

The most fundamental source of information is what a person comes to know by direct personal experience.



Methodologies for gathering empirical knowledge can be categorized into several general classes. These classes could be seen as lying on a rough continuum which varies from a relatively passive observation to the active manipulation of abstract variables in a completely controlled environment.

### a. Methods for Gathering Empirical Information

If we wish to construct truthful systematic knowledge, then we will have to have procedures which will assure that we get exactly that.

**i. Information Obtained Without Manipulation (observation)**

Observational techniques take nature the way it comes. As a metaphor, if knowledge were food, observation is getting a meal by going to a restaurant, you get it the way it is served. Sometimes it's useful knowledge that you can use to better understand things, but sometimes it's mixed with confounds which make it impossible to consume.

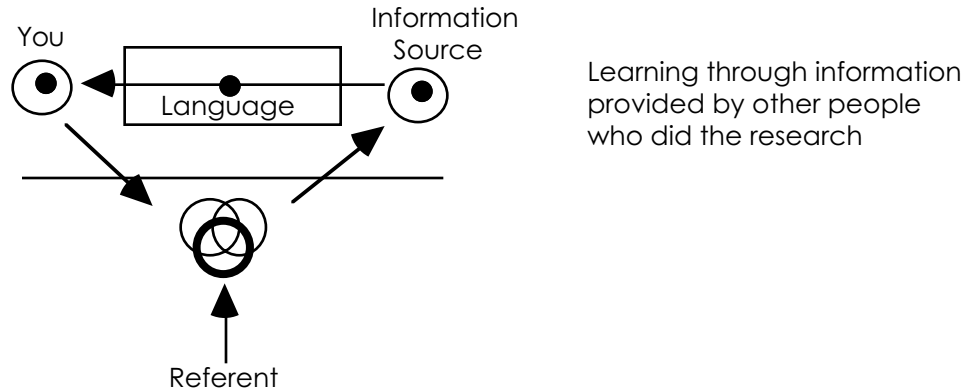
**ii. Information Obtained with Manipulation (experimentation)**

Experimental techniques do whatever is necessary to reveal what you need to know to better understand the world. Building on the previous metaphor, if knowledge were food, then experimentation is getting a meal by making it yourself. You have the power to optimize it in any way you want. You have complete freedom and are only limited by your own imagination and skill. However, if it doesn't reveal useful knowledge, then you have only yourself to blame. Experimental design gives you the ability to eliminate confounding and to establish causation. It is, therefore, the best way to gain knowledge.

**2. Vicarious Experience as Source of Knowledge**

Knowledge can be gained by receiving information from someone else who actually did the experiment rather than you doing the research yourself. Alternatively, you could get information third or fourth (or more) hand. Finally you could generate knowledge synthetically by using logic or mathematics such as trigonometry to determine the separation of a chasm. Because each person cannot directly experience for themselves all possible events, we rely on language, logic, and mathematics to provide us with information indirectly. A synonym would be symbolic experience. It acts like direct experience in its relevant aspects. It makes it possible to predict what would happen (i.e., respond correctly) in a new situation which has never been personally or directly experienced. Someone can tell you the path through a maze you never saw or a phone number you didn't know; you can validly determine the outcome of complicated statements; or you can calculate the distance between two points.

In these cases, behavior is changed as the result of exposure to language rather than as the result of direct exposure to the actual event. Education is the term for the communication of abstract, general principles vicariously to people rather than having them learn it themselves through direct experience with actual concrete problems.



Your task is to get your model to match reality by way of understanding the speaker's words. This is actually quite difficult for both the speaker and the listener.

The speaker must have a correct model of reality.

The speaker must articulate it correctly.

The listener must hear it correctly.

The listener must create a model from the words which matches reality.

## IV. The Meaning of Explanation

### A. Types of Explanatory Mechanisms

#### 1. Explanation via Confusion, Emotion, Empathy; or "Rhetorical"

Rhetorical explanations are not really explanations at all and are therefore unacceptable even though they can be made to appear correct by fiction writers or our own confusion. They are nonempirical verbal statements chosen to produce agreement not explanation. For example, "I hit Johnny because ...." (where reasons cause empathy for the view); "evolution is false because humans are debased by a view which suggests that they evolved" (an invalid emotional argument); "things fall because of gravity" (a tautology empty of any meaning). I saw a movie that made me believe it was true. These "explanations" are actually nothing more than verbal confusion.

This is not to say that all information or knowledge gained through rhetorical explanations is wrong. Some things are facts. It is a fact that you will burn your hand if you put it on a hot stove. It is a belief based in rhetoric however if you believe it simply because of the person telling you rather than because of its factual basis.

#### 2. Explanation via Specification of Future Causation; or "Teleological"

This type of explanation posits a cause in the future, but nothing can ever read the future, so it is clearly wrong. The future does not exist in the present. Things cannot reach out of the future to cause things to happen in the present. Only by the

twisting of a metaphor or in a simplistic shorthand can organisms work for a future goal. A pigeon cannot be placed on an FR 100 schedule and be expected to behave appropriately the first time. A teleological explanation is a shortcut description of what is actually the result of a history of exposure to the ontogenetic and phylogenetic contingencies. In this sense a teleological explanation is “backwards talk.” What appears to be a common trend in a history of functional relationships becomes a future state and subsequently becomes a future goal and eventually a future cause. Note that teleonomic (covered in Chapter 3, Section II. C. 4. b.) should not be confused with teleological. Teleonomic categorization does not imply causation.

### **3. Explanation via Appeal to Inner Cause; or “Reductionistic”**

These explanations are based on an internal, more fundamental or elemental process, or invoke additional more primitive elements to accomplish their explanatory power. These types of explanations have been very fruitful in medicine. However, they have had notoriously bad track records in psychology. Reductionistic explanations are sometimes also labeled “analytical” (“of what is the thing composed”) or “mechanistic” (by what reductionistic mechanism is the process accomplished).

The issue raised by behaviorists is not that there are no processes operating at a more reduced level, nor that only correlative explanations are ever acceptable for any conceivable purpose. The issue is not whether you have what you point to when you say “consciousness,” but whether it is productive to say that the reason you went to the store is that you “wanted to.”

Reductionistic explanations have three important faults. First, they divert attention from the independent and dependent variables of psychology. Second, an often over-looked fact is that reductionistic entities cannot be useful if they have not yet been anchored to environmental inputs and outputs (i.e., a well-developed correlative explanation comes first). Finally, correlative explanations are typically the most productive path to an applied solution.

#### **a. Empirical**

This is Physical Reductionism. The classic example is a physiological explanation for behavior. For example, “the behavior occurred because of activity in the brain.” It is important to keep in mind that a reference to the brain does not necessarily make something true. An empirical reductionistic explanation must show empirical evidence that that entity actually does cause the behavior. Few investigators would suggest that the brain has no role whatsoever in the behavior of the organism. An empirical reductionistic explanation must add substance and understanding to what everyone already accepts.

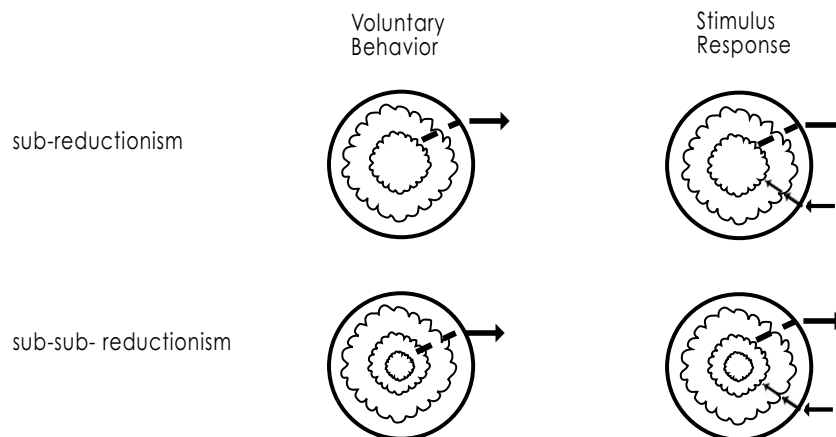
### b. Nonempirical

This is Nonphysical Reductionism or Conceptual Reductionism. This category includes any reductionistic entity without actual empirical support such as the mind (including nonempirical physiologizing). Ultimately this approach can be seen as tautological. (Cause and effect are both the same single observation).

### c. Flaw of Reductionism as Psychological Explanation

We would immediately understand the fundamental problem with the reductionistic stimulus-process-response approach if the example were perceptual. For example, if I show you a red card and you say red - I could argue that in your brain you actually see green and that you just learned to say red when you see green in your mind. We could argue the point forever. In actuality, no one really cares. Concern for what takes place in the mind is a metaphysical question not a scientific one. The relevant facts are presenting colored cards and documenting the answers. Similarly, if someone has a behavioral problem - how do we fix it? We change the environment, not reconnect the neurons in the brain.

An additional fundamental problem with a belief in the usefulness of reductionistic explanations is that they are arbitrary. If a mechanism operating at a lower more fundamental level is always better, then obviously a process more fundamental than the brain, the mind, or the mental processing center must be sought. We would be obligated to explain things chemically, but then we would be obligated to explain things with quantum physics. If one cannot accept a simple input/output (correlative) answer at some level, then one must go all the way to the bottom. If you cannot go all the way to the bottom, the stopping point is a matter of personal bias not epistemological validity.



Note in the above figure that the maximally reduced entity is typically postulated to work solely in terms of inputs and outputs, which is exactly what (as we will subsequently see) a correlative view of the entire organism has argued all along (note that the lowest level used in each figure are inputs and outputs with no reductionistic machinery). In this sense reductionistic explanations simply pass the problem to some other level. After all is said and done, all theories do nothing more



than account for the relationship between inputs and outputs; arguing that a behavior is caused by some reductionistic internal process is simply obfuscating what is at the bottom a correlative explanation anyway.

### **i. The Fallacy of Unobserved Verbal Activity as a Cause of Behavior**

(This issue is discussed more fully in Donahoe and Palmer (1994)). It could be believed that some cognitive verbal process is the root cause of our behavior. For example, we could claim that a person thinks something through, arrives at a decision, and then behaves.

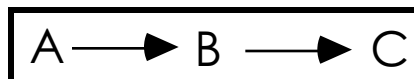
#### **(1) It is Not Logical**

##### **(a) When Internal is Not Tied to External**

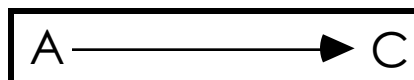
A precursor of any ability to use knowledge is that knowledge itself. Knowledge is "knowing" that A goes with B, such as "if more A, then more B." In the absence of an explicit A, there can be no prediction of B. In the absence of A, we have only one hand clapping. If the unobserved verbal activity which is thought to cause behavior is not tied in a one-to-one manner with events in the environment, then that unobserved verbal activity cannot be precisely known. If it is unknown, then we have nothing with which to predict the output behavior. A position which would assert that output behavior is controlled by unobserved verbal activity which is not under the control of the environment abandons the opportunity to develop accountable predictive models.

##### **(b) When Internal is Tied to External**

If the unobserved verbal activity which is thought to control the output behavior is under the control of environmental input, then the internal verbal activity becomes an irrelevancy in prediction. If:



Then, a more parsimonious and more productive model is:



**(2) It is Not Reliable**

Typically, when research has specifically examined peoples' verbal processes with respect to what they do, feel, or say, the findings have been consistent with that particular lab's theoretical assumptions but not consistent with other assumptions of other labs. Introspection failed one of the basic requirements of "truth."

**(3) It is Inconsistent with Evolution**

Brain structures mediating verbal behavior developed very much later than much of the brain. The ability to behave evolved well before the ability to talk. Additionally, it is unlikely that verbal behavior centers of the brain are in touch with older centers. There are too few neural tracks connecting those areas. As a result, it is reasonable to assume that verbal centers of the brain do not control significant portions of our behavior.

**(4) It is Inconsistent with Empirical Findings**

It takes little effort to show that the belief that unobserved verbal activity causes behavior is patently false or at best is useless as a predictive model.

**(a) Introspection Did Not Support It**

The introspectionist school of psychology tried for years to document the "verbal" or mental steps underlying decisions and failed. There were no logical, sequenced verbal steps. Decisions were nothing more than a behavior following a stimulus situation.

**(b) Attending to Verbal Control Hinders Performance**

Any number of behaviors are difficult to perform while trying to consciously control them. These vary from playing the piano to dancing to even having a conversation.

**(c) Phobia Can Be Desensitized Without Verbal**

It is relatively simple to remove a phobia without the therapist talking about it or the patient being able to articulate what happened.

**(d) Split Brain Research Contradicts It**

A child with a split brain had his left hemisphere exposed to a picture of a chicken claw and the right hemisphere exposed to a snowy scene. When given a set of pictures to match, his right hand (i.e., left hemisphere) chose a chicken while his left hand (i.e., right hemisphere) chose a snow shovel. When asked why the chicken, he

said “it goes with the chicken claw.” When asked why the shovel, he responded “to clean up the chicken coop.” This study revealed the erroneous and tautological foundations of mentalistic psychology. Thoughts can be shown to be different than the true cause of behavior and there cannot be presumed to cause any particular behavior. A thinking process (i.e., “oh yes, the shovel will be used to clean up after the chickens”) did not determine the behavior of pointing to the snow shovel. Rather, the mental process that the child asserted caused the behavior was created after the fact, even though the child truly believed that the thought caused the behavior.

### **(e) Extinction Is Slow**

Imagine a demonstration where a student is seated in the front of the room with a bell and a metal plate on the desk. Imagine further that an electrical apparatus is connected to the bell and plate. Suppose the student rests their hand onto the plate, the bell rings, and a shock is delivered through the plate. Suppose that procedure is repeated 50 times. Now the apparatus is removed to the hallway outside the classroom. The student explores the desk and confirms that nothing of the apparatus remains in the room. The student is asked to repeat "there is no shock possible" continuously. The student then sits at the desk with their hand on the Formica surface after which a bell rings. What do you guess will happen in spite of the student's verbal activity? In spite of verbal beliefs and statements, the behavior of a withdrawing hand will persist until it extinguishes.

### **(f) Self-Destructive Behavior Exists**

Ask anyone who smokes cigarettes if they think that it is healthy. In point of fact, the vast majority will respond with something like "smoking is unhealthy, it is hurting me, I wish I could stop." If verbal activity were controlling their behavior, they would stop smoking and would have stopped years ago.

## **4. Explanation via Specification of Functional Relationships; or “Correlative”**

The proper explanation of a behavior is the specification of the environmental variables which control that behavior by way of the specification and quantification of the contingencies which modulate it. This class of explanation documents how elements are interrelated by specifying the functional relations among them. Functional relationships are the specification of how a behavior changes with changes in the environment. For example, when the red light is on, the behavior occurs, or as the reinforcement rate increases, the response rate increases hyperbolically. Any meaningful psychological theorizing must ultimately be correlative in nature. If an explanation of behavior does not specify a relationship between empirical inputs and empirical outputs, then it is metaphysics rather than science. These explanations are sometimes also labeled comparative (“what are the

characteristic properties”), or functional (in what way does  $y$  change as a function of changes in  $x$  or what is the function that describes how  $y$  changes with changes in  $x$ ?).

These general statements can become more quantified and can come to precisely specify an outcome given an input. For example,

$$\log (B_1/B_2) = a \log(R_1/R_2) + \log c$$

specifies the way behavior occurs to two alternatives as a function of the available reinforcers. At this level of specificity, we have a correlative explanatory model.

Unfortunately, the simple specification of the functional relationship (i.e., mathematical or logical relationship) between independent and dependent variables often evolves into some physical or quasiphysical model. What is at first a functional description becomes a handy comparable process not presumed to be real and eventually an actual internal process presumed to intervene between input and output. (Cronbach and Meehl label the penultimate and latter, intervening and hypothetical variables, respectively; while Hull labeled them hypothetical and intervening variables, respectively. Hull’s usage would seem more consistent with typical English usage.)

The impact of a demand for correlative explanations for psychological phenomena cannot be overstated. A coherent explanation of a wide variety of behavior is possible by the specification of the functional relationships involved. Within this class of explanation, different areas of psychology can be seen within a coherent framework based on time scales of adaptation. This change has had a revolutionary and fundamental impact by focusing psychology on what is the same about behavior across a wide range of organisms - not only those that contain a “mind.” The knowledge obtained is applicable to all organisms not simply humans or not simply autistic children. We come to understand normal and abnormal humans and animals, from rural or urban areas, from one culture or another, younger or older, richer or poorer, doctors or lawyers, etc.

Note that correlative explanations and correlation have the same root but refer to different things. Correlation specifies a mathematical procedure which specifies how things covary and cannot be used to establish causation. Correlative explanations, on the other hand, specify that the elements of the explanation occur at the same level of analysis and can refer to causal relationships.

### **a. Conceptual Follow-up**

#### **i. Reductionistic Versus Correlative (behavioral) Explanations**

The difference between behavioral and reductionistic views is fundamental: pass the skin and you are a biologist or a philosopher, not a psychologist. Psychologists deal with environments and behaviors. For example, if a TV picture isn't exactly what you want, you usually turn one of the control knobs. You don't open up the back of the TV and start changing transistors and ripping out wires. TV sets have evolved just as biological organisms have. Adjustments which have to be made often and

locally are under the control of knobs responsive to the demands of the viewer. Channels can be changed, the volume can be raised or lowered, and so on. Ultimately, of course, all those things are mediated internally by circuitry, but this is not typically what we mean when we ask: "How do I change channels." From the practical perspective, what causes the channels to be changed is turning the knob, not changes in the inductance of a circuit. The same goes for life forms and their behavior. They, too, have evolved. The adjustments which need to be made often and locally are under the control of processes responsive to contingencies in the environment. Organisms learn as the result of nonrandom relationships in the environment. Ultimately, of course, all those things are mediated internally by the biology of the organism, but this is not typically what we mean when we ask: "How do I change that organism's behavior", or "what caused the behavior to be changed." The answer we want is what are the changes in the environment which will lead to the new equilibrium, not what changes in neuronal activity will lead to the new equilibrium. The conceptual difference is the difference between psychology and biology. The difference between the medical model (reductionistic) in psychology and the behavioral model (correlative) with psychological problems can be seen as the difference between seeing behavior as "blown transistors" and "knobs set wrong." Medical people fix transistors; psychologists turn knobs.

An example of the enormous difference in the power of a correlative approach over a reductionistic approach can be seen in the task of being responsible for helping someone develop muscles. Muscles are obviously of biological substance and are made up of cells. The revealing question is: what types of knowledge and what approach will be most productive in helping you accomplish your job, biology or psychology? It is your ability to provide reinforcers for lifting weights that matters, not your understanding of the cellular structure of muscles. When considering the issue of the difference between people with or without muscles, or how a person gains or loses muscles, muscles are best seen as the result of environmental experiences not cell growth. The same thing goes for personality, attitude, and any other aspect of psychology.

## **ii. Mentalistic Versus Correlative (Behavioral) Explanations**

The difference in a behavioral and a mentalistic explanatory strategy is the difference in the paradigm's willingness to be satisfied with what is ultimately a ridiculous answer. A frequently invoked reductionistic metaphor for how an organism comes to behave correctly is a telephone switchboard and an operator. For example, a stimulus is presented to the organism. It is said to travel to the processing center where the switchboard operator evaluates the stimulus, decides on an appropriate course of action and activates the appropriate effectors. This metaphor brings great comfort to many students of psychology. For example, in order to explain how an actual telephone operator at the phone company functions, we could say that the operator (outer) receives a stimulus (outer). This stimulus is sent to the operator (inner), who decides what to do and activates the proper response

(inner) which causes the operator (outer) to behave (outer) correctly.



Cartoon  
Infinte regress of mind

To argue that an operator knows what to do because an internal operator knows what to do is patently ridiculous as an explanation. Similarly, to argue that a rat learns a maze because a human telephone operator in the rat's head looks at a cognitive map, or to argue that a child behaves similarly on several tasks because a telephone operator in the child's head looks up a rule in a rulebook is silly. That type of reductionistic “explanation” is tautological. The power of a telephone operator explanation to account for baffling empirical findings is an illusion. It is like the cartoon mathematical derivation which jumps over a difficult step with the note “and then a miracle happens.” The question to ask is how does the telephone operator come to behave the way it does.

A critical point of focus in evaluating any theory, therefore, is the degree to which it invokes some unknown decision-making process within the organism to decide what to do (e.g., the inner operator telling the outer operator what to do; the child **uses** a rule to decide which alternative to select; the rat retrospectively **evaluates** the correlation, etc.). To the degree that the behavior of an inner rat decides the behavior of the outer rat, the explanation is empty, and is, in fact, silly.

The trap is that a cognitive explanation will always, on the surface, **appear** to make sense out of the behavior of the subject and therefore will always **appear** to be a better explanation than a behavioral explanation. This is because the inner operator is always magically given whatever knowledge is necessary to get the outer operator to do what it did. A behaviorist would argue that explaining how the outer animal behaves with the use of an internal processing center is simply explaining on “credit.” The real explanation is simply put off for another day and will eventually have to be paid in full with interest. Spending explanatory capital that you do not have requires that you then focus your effort on paying back your debt. Just what does it mean to say that, an inner rat is consulting a map, an inner child is using rules, or an inner switchboard operator is deciding what the outer switchboard operator should do.

In the same way mathematical models “fudge” over unknowns with free parameters (they can take on any value necessary to make the prediction work), so too can theoretical internal processes be used as free parameters. If a person uses a strategy to encode and decode information, then we have at least four free parameters or places where we can come up with whatever excuse is necessary to explain the obtained results. The person may or may not have had the correct

encode strategy, they may or may not have used the encode strategy, they may or may not have the correct decode strategy and they may or may not have used it. If we add "wanting" to use (i.e., the person had the knowledge, and had the strategy, they just didn't want to use it), and "inhibition" (i.e., the person had the knowledge, and they had the strategy, and they wanted to use the information; it was just that they had an overactive strategy (or knowledge or wanting) inhibition center)) we would have more than enough free parameters to "explain" anything. Mathematical models declare their number of free parameters and lose credibility as they increase in number. Theories should be equally obliged to declare their degrees of freedom and be willing to be evaluated in that light.

The entire issue is brought into sharp focus with the principle "smart animals prove the experimenter stupid, stupid animals prove the experimenter smart." What this principle means is that we as professionals must know what causes behavior, not simply come up with impressive names for it. For example, we could presume that the herring gull was smart because it knows that it must retrieve its eggs when they get bumped from the nest in order to keep them from dying and in order to preserve the species. We could give the bird any number of complex realizations, processing centers, or divine inspirations. We could try to impress our colleagues by showing how smart the birds were.

However, relatively straightforward research which varied the color, speckle pattern and size of artificial eggs showed that eggs were retrieved in the order green > yellow > brown > blue; more speckles > less speckles; and large > medium > small. This showed that stimulus conditions governed egg retrieval and that some unnatural stimuli worked better than natural stimuli (which were, in fact, brown, moderately speckled and a medium size). Similarly, a snail could be said to be smart because it knows to climb to the top of a tree in order to get to the most tender leaves. However, research has shown that the snail moves so that its shell pulls "back" (i.e., negative geotropism).

A herring gull can be made to retrieve very large pieces of green highly specked wood more than its own eggs and a snail can be guided toward the worst leaves by pulling on its shell. Both of these behaviors are inappropriate and in fact very destructive to the individual and species. They are stupid. Simply put, animals do things because of environmental cause not because of optimization. If you know the environmental causes: 1) you can make the animal do something stupid by controlling those causes, and 2) you can prove that you understand the psychological process controlling the behavior.

The Renaissance provides an exceptionally clear example of the importance of understanding empirical correlative causes of behavior and the vacuousness of even the most impressive sounding internal causation. Human beings react correctly to distance in the environment. They can throw an object to correctly land in a box placed 5 or 50 feet away. They can say "that thing is far away, this thing is close." Before the Renaissance, the "knowledge" of distance was an internal intelligent wondrous skill humans had. Humans reacted correctly to distance because they were smart. They had a depth realization center in their mind. A little research showed

that “perspective” or the convergence of parallel lines in the distance made humans say “that thing is far away, this thing is close” even though both things were equidistant. Humans were shown to be incorrect with respect to depth (i.e., humans were shown to be stupid). The discovery of the environmental determinants of distance or depth perception (apparent convergence of parallel lines) in Florence in the early 1400s proved Alberti brilliant and changed the world forever.

Those environmental details are what we mean when we ask for an explanation of how we see depth, and those details are what we want when we want to know how to paint a painting or make a two-dimensional movie appear to be three-dimensional. The mind of a homunculus is obviously useless tautology as a description of the process when we actually want to productively **use** the knowledge of what produces the experience “depth.”