CHAPTER 7

Paradigmatic Psychology

I. Relevance of a Paradigmatic Framework

A. Impact of decision based on paradigmatic framework (science)
B. Impact of decision by "whim," "guess," or "intuition" (eclectic)

II. The Context Within Which Science Exists

A. The universal set: All human endeavors
B. Set of interest: search for answer to question "why?"
C. Subset of interest: only satisfactory answer
   1. what produces satisfactory answer: science
      a. review: the product of science
         i. truth
         ii. understanding
      b. review: the problem addressed by science: changes in nature
         i. knowledge is understanding the variance in nature
      c. review: the process of science: generating satisfactory explanations
         i. characteristics of what science is and does (its definition)
D. Summary: of all human endeavors, science best answers "why"?

III. The Paradigmatic Context of Psychology Within Science

A. Dimensions of scientific paradigms
   1. the goal of the activity
      a. to understand nature
      b. to solve immediate problems
      c. to dispense solutions
   2. molarity of paradigmatic context or level of analysis (unit domain)
      a. levels of molarity
         i. existential adaptation
         ii. atomic adaptation
         iii. cellular adaptation
         iv. organismic adaptation
         v. group adaptation
         vi. systematic adaptation
      b. summary of levels of molarity
      c. spatial representations of levels of molarity
      d. comparative analysis of molarity * goals
   3. time scale of adaptation (time domain)

a. temporal duration of change
    i. “instantaneous” or “immediate” adaptation
    ii. “short-term” adaptation
    iii. “medium-term” adaptation
    iv. “long-term” adaptation
        (1) evolution
            (a) behavioral evolution versus structural evolution
            (b) what can evolve?
            (c) interaction of time scales of adaptation and evolution
b. conceptual follow-up
c. Fourier analysis metaphor for time scales of adaptation
d. comparative analysis of time scales * issues

B. Spatial representation of behavioral equilibrium paradigm
1. spherical representation of level of molarity * time scale
    a. level of molarity as a point on a radius
    b. time scale as a point on a surface
2. cubic representation of goals * levels * time scales

CHAPTER 7

Paradigmatic Psychology

This chapter develops a coherent paradigmatic world view within which scientific research in psychology can be seen, and within which the different areas of psychology can be understood. The approach will be to start at the most global level of human endeavors and focus down to the specific areas of scientific research in psychology. In this way scientific research in psychology will be seen within its context, and will therefore be more comprehendible.

I. Relevance of a Paradigmatic Framework

A. Impact of Decision Based on Paradigmatic Framework (Science)

Decisions made as if they are done in a court of law. The good thing is long-term progress. The bad thing is that you may be proven wrong.

1. systematic, public, accountable rationale for decision

2. systematic, public, accountable framework with which to organize results

3. feedback and, therefore, systematic advance

B. Impact of Decision by "Whim," "Guess," or "Intuition" (Eclectic)

Decisions made as if they are done by a lynch mob. The good thing is that you cannot be held accountable. The bad thing is that systems that use this approach haven't had much progress since the Dark Ages and there is little likelihood it will speed up in the future.

1. no systematic rationale for decision

2. no systematic framework with which to organize results

3. no feedback and, therefore, no systematic advance

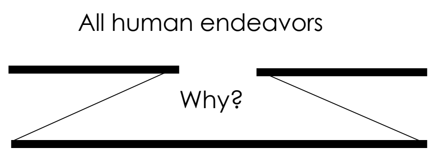
II. The Context Within Which Science Exists

A. The Universal Set: All Human Endeavors

All possible human endeavors include such things as art, war, fishing or love.

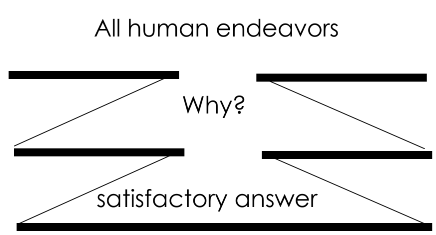
B. Set of Interest: Search for Answer to Question "Why?"

We choose one of those activities. We choose the human activities which can be labeled the search for an answer to the question "why?" Many things pique our interest. We want to know why butterflies change, why the sun rises, why we live, why we have war, or why we love. Some people want to indulge their curiosity and discover exactly why these things are the way they are or how they can be changed to better mankind.



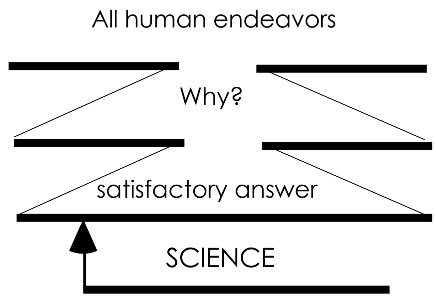
C. Subset of Interest: Only Satisfactory Answer

It's not appropriate to stop with answers which are lies, or which may or may not be the truth. We want the truth, the whole truth and nothing but the truth. If the answer is only a guess, we want to know that it's only a guess.



1. What Produces Satisfactory Answer: Science

In the last chapter we logically developed the case for why science is nothing less than the production of what are generally considered "satisfactory" or "acceptable" answers.



It would be helpful at this point to recall the extended definition of science presented in Chapter 2, so that we can see that science is the name for the production of satisfactory answers.

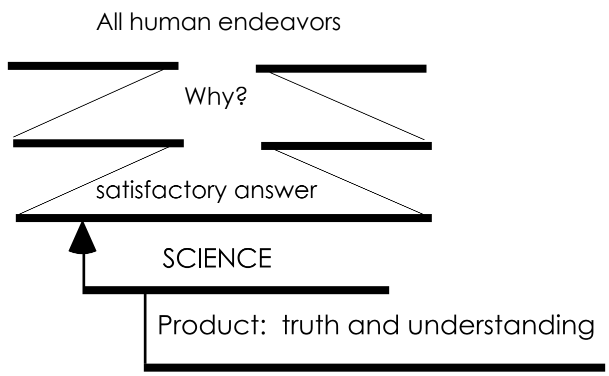
a. Review: The Product of Science

i. Truth

- empirical
- reliable
- multiple converging evidence
- consensual validation
- operational/functionally defined
  - explicit
  - ontologically valid
  - referential correspondence
  - testable
  - minimal error
  - systematic
  - comprehendible

ii. Understanding

- describe
- predict
- control
- synthesize
- explain
  - truthful
  - explicit
  - testable
  - minimal error
  - systematic or principled
  - comprehendible

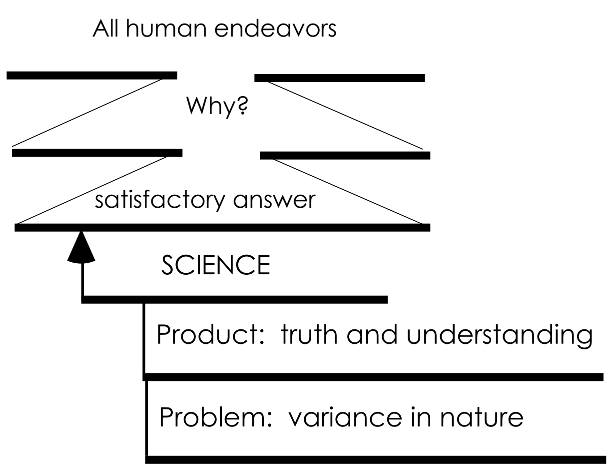


b. Review: The Problem Addressed by Science: Changes in Nature

Finally, to even further elaborate science, we can review the "problem" to which science addresses itself by considering the meaning of the term knowledge.

i. Knowledge is Understanding the Variance in Nature

knowledge via actual experience
knowledge via vicarious experience

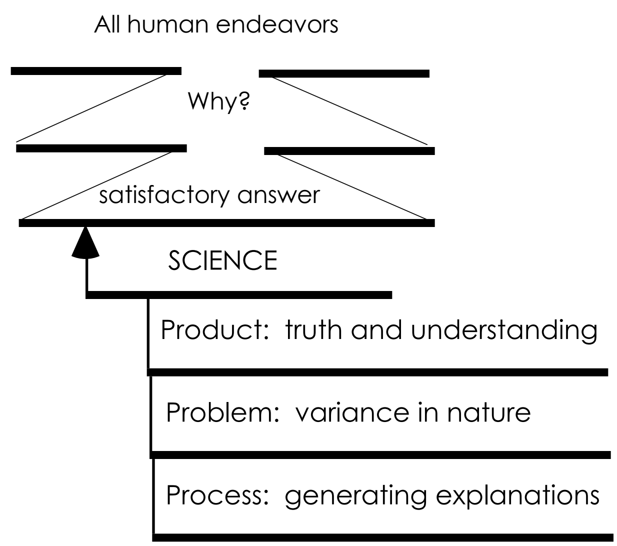


c. Review: The Process of Science: Generating Satisfactory Explanations

To further elaborate the point that science produces satisfactory answers, we also recall the process which produces that product by documenting science's definition.

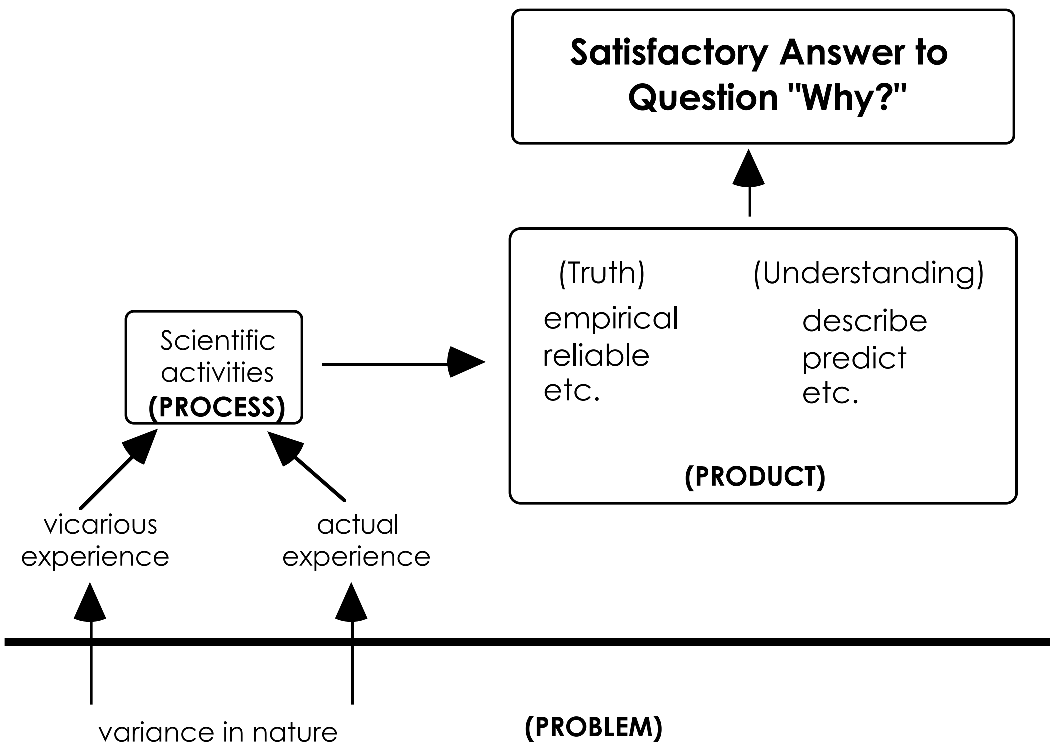
i. Characteristics of What Science Is and Does (its definition)

products
goals
lexical
activities
assumptions
proscriptions
misconceptions
motivational
paradigm



D. Summary: Of All Human Endeavors, Science Best Answers "Why"?

Science is the human endeavor which asks why things are the way they are, and which answers that question with a valid integrated answer. Science best answers "why" and therefore best answers how to fix what's wrong and how to make things ideal. People who have wanted to correctly understand nature have given us humanity and the freedom to enjoy it.



III. The Paradigmatic Context of Psychology Within Science

We ask “why” of change. The challenge is to generate a valid paradigmatic answer. We must see change within a coherent framework. The following section presents three dimensions within which activities trying to correctly understand change can be positioned. The terminology will be "equilibrium of adaptation" to emphasize that the change in a phenomenon can best be seen as the new equilibrium resulting from a change in the environment, and under new conditions the equilibrium can change

A. Dimensions of Scientific Paradigms

Traditionally each area of science and fields within each science has had its own premises, descriptive units of analysis, and explanatory framework. These have been reconceptualized to emphasize their continuity.

1. The Goal of the Activity

It is important to recall that different people within a field may have different goals. The first dimension of the structure with which to understand psychology is the goal of that scientific activity. In Chapter 2 we saw that the types of questions which are asked and the types of answers which are accepted vary as a function of the goals of the researcher. Generally basic research, or research to understand nature, will be used as the illustration, but it is not the only possible goal.

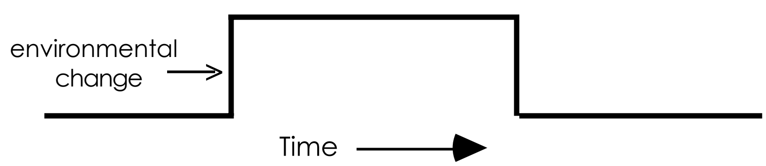
a. To Understand Nature

b. To Solve Immediate Problems

c. To Dispense Solutions

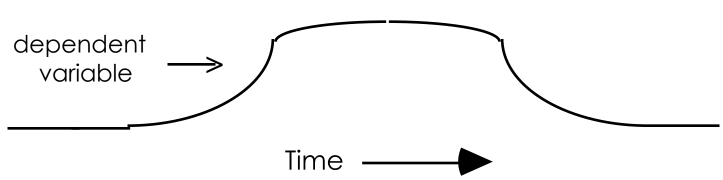
2. Molarity of Paradigmatic Context or Level of Analysis (unit domain)

The second dimension of the structure is the molarity of the paradigmatic context. Essentially the same figure can be used to characterize each of what has come to be known as the scientific disciplines. Only the molarity (and as we will subsequently see, the time scale) of the figure changes. If we represent some arbitrary change in the environment with a heavy line, then

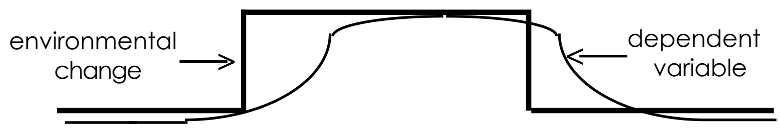


would show the environment changing from a baseline (one set of relationships, contingencies or rules) to an altered state or some different set of contingencies, then subsequently returning to the original baseline state.

We can also depict the change in some dependent variables as



If we scale the y axis so the vertical change in both measures is relatively the same, we can then add the change in the dependent variable to the change in the independent variable.

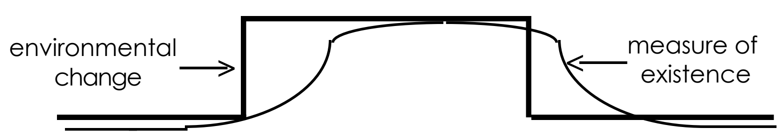


The dependent variable is to be seen as initially in some equilibrium with the environment. The environment then changes and the dependent variable re-equilibriates to the changed environmental state. As can be seen, this adaptation can be reversed. In fact to establish the existence of a causal relationship a reversal (or some control procedure) must be implemented.

a. Levels of Molarity

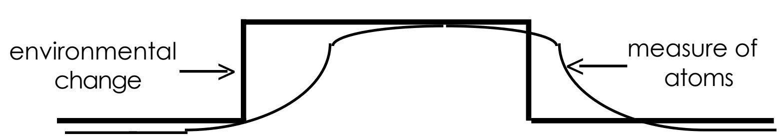
The various paradigmatic contexts of scientific investigation can be grouped in terms of the molarity of the subject matter. Each context is distinct because its measures are distinctly different. The measures simply do not exist at levels higher or lower in molarity. (The phenomena obviously always exist; it's that each of our measures don't isolate or react to every change at every level of molarity.)

i. Existential Adaptation



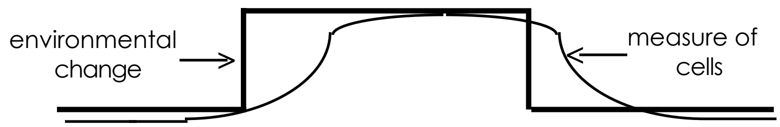
This involves the adaptation of existence itself (more precisely, the strong force, the weak force, electromagnetic force, and gravity). The basic forces in the universe adapt as a function of interacting. (The remaining basic forces are the "environment" for the one under consideration.)

ii. Atomic Adaptation



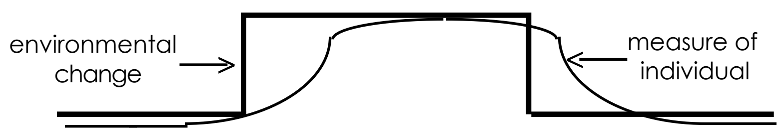
This class of adaptation involves the adaptation of atoms (more precisely, atomic structure or the positioning of electrons, protons, and neutrons). For example, when brought into conjunction under the right conditions the atoms of sodium and chlorine adapt thereby forming salt.

iii. Cellular Adaptation



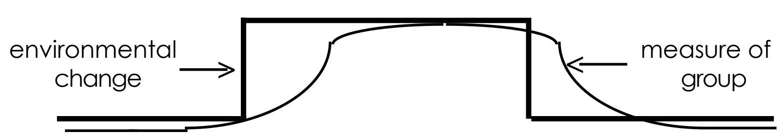
This class of adaptation involves the adaptation of cells to changes in the environment (more precisely, the activities labeled life). This adaptation can be seen across a variety of time scales. A cell may adapt immediately to various environmental influences by secreting a substance (functioning); a cell may adapt over the short term by exhibiting fatigue; a cell may adapt over its lifetime (maturation), or a cell (more accurately, a DNA pool) may also adapt over a very long time span by changing into a cell with other characteristics (evolving).

iv. Organismic Adaptation



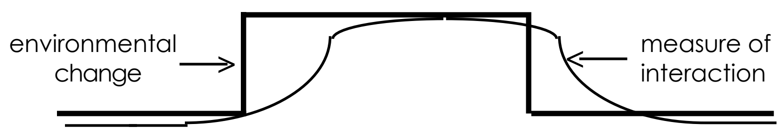
This class of adaptation involves the adaptation of the behavior of a whole life form, (not the adaptation of a cell or the adaptation of an anatomical structure) to changes in the environment. If a measure of behavior is altered as a function of changes in the environmental conditions then the behavior is said to have adapted. A human coming to fish in a particular spot is an obvious example. Elaboration of the various time scales of adaptation for this level of molarity will be covered in the next section.

v. Group Adaptation



This class of adaptation involves the adaptation of a group (more precisely the alteration in the proportion of a population responding to events in the environment (an exposure) as the result of some change in the contingencies established by that environment). This is a purely statistical property of a group and is not the behavior of a particular individual. The dependent measure could be, for example, that 12% of the population bought a product following an ad, but not that Harry or Mary bought the product. An example would be that a report of a plane hijacking would extract a behavior Z from xx% of the American population in 2000, while in 2002 following exposure to changed contingencies in the culture, the same event extracts Z behavior from yy% of the population. Finally, the same event in 2010 following further experiences by the culture extracts behavior Z from xx% of the population. Time scale groupings are applicable. Some cultural practices once established reverse only with a new culture, such as after a major social disruption. This is much like personality in an individual, once established it reverses only following relatively substantial disruption or only across progeny.

vi. Systematic Adaptation



This class of adaptation is the adaptation of a system of groups, each group containing homogeneous elements such as a group of humans and a group of trees, etc. The prototypical system is an ecosystem contained within a sealed glass sphere. A characteristic of a system is that it is virtually closed in that little or no input occurs to the whole system.

b. Summary of Levels of Molarity

It is important to keep in mind that these conceptual categories or levels of molarity do not exist in isolation. A specific member of a group is, in fact, a behaving individual which is made up of cells which are in turn made up of atoms which are themselves made up of forces. The group, in turn, is part of an "ecosystem." All levels exist and function simultaneously.

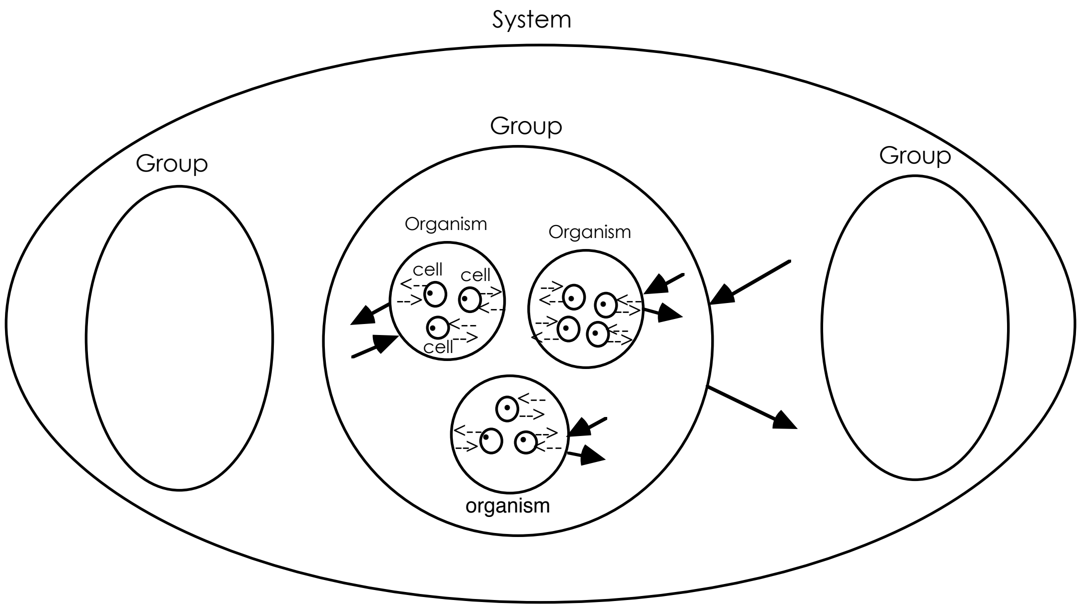
A television can be used as a second specific example. The television receives signals and presents a picture (just as a pigeon reacts to the environment). The TV changes with changes in the broadcast signal (stimulus-response relationships). The TV also changes as the result of changes made to its control knobs (reinforcement history). But none of these deny the fact that the television functions within a particular standard such as NTSC or PAL (culture), and is also made up of transistors and diodes (cells). And that the transistors are in turn are made up of semiconductors (chemicals), and that most basically the semiconductors are themselves made up of forces. (Note that at the two most basic levels a television and a human function for the same reasons; the fundamental forces are the same and the chemical processes are the same.) The fact is that the behavior of either a person or a TV is a combination of factors operating at both more molar and more molecular levels. Alterations at any level of molarity of the internal components or the molar context of either the television set or of the pigeon can have effects on the TV or pigeon.

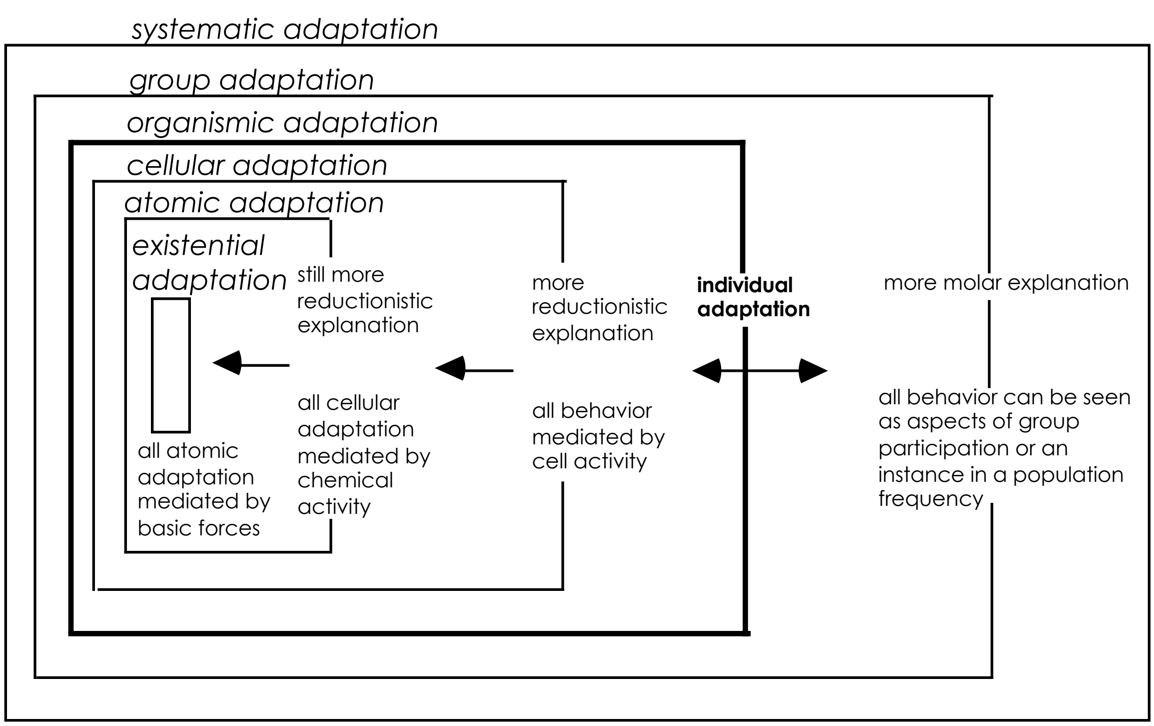
Psychologists are most typically interested in only the input/output relationships of an individual organism. What does the pigeon, as a whole, do when the light is turned on? (In the metaphor, what does the TV set, as a whole, do when the channel 6 broadcast signal contains a red and blue cross hatch)

Successively more molecular, or reductionistic explanations could be viewed as the "inner" causative forces for the emergent properties of more molar phenomena. But as was previously discussed, that is only one meaning for “cause.” It is, in fact, more productive to see cause at the same level of analysis (how does what comes out change as a function of what contingencies or knobs were changed). Recall the discussion on the difference between a reductionistic and a correlative explanation given in Chapter 6.

c. Spatial Representations of Levels of Molarity

The following figures illustrate the successively more molecular and more molar organization for nature. All exist simultaneously.





d. Comparative Analysis of Molarity * Goals

This figure presents the various scientific activities as a function of the level of molarity of that subparadigm and the goals of that subparadigm.

Paradigm Term **Common term**	**Existential Adaptation** Physics	**Atomic Adaptation** Chemistry	**Cellular Adaptation** Biology	**Organismic Adaptation** Psychology	**Group Adaptation** Sociology	**Systematic Adaptation** Systematics
To Under-stand: **Basic Research**	why existential adaptation why existence string theory	why atomic adaptation why substances	why cellular adaptation why life	why organismic adaptation why behavior	why group adaptation why participation	why systematic adaptation
To Solve: **Applied Research**	atomic weapons research fusion research	polymer research	agricultural research medical research	clinical research educational research	organizational research cultural research	ecological research
To Dispense Solutions: **Practitioning**	architect engineer bomber pilot	chemical sales-man, gas station attendant	exterminator county agricultural agent, physician farmer	clinical psychologist teacher salesperson	politician law maker advertiser	ecologist
Variation Process “Provenance"						
Selection Process “Consequence”	conservation	stability	life/ reproduction	reinforcement	culturation	balance

3. Time Scale of Adaptation (time domain)

The third dimension of the structure is the time scale of the effect of interest. If we use organismic adaptation as the example, we would consider how behavior adjusts to the environment. We would point out that not only do life forms behave, but organisms adapt in fundamentally different ways as the result of fundamentally different experiences with the environment. Organismic adaptation has many forms. Sensation, learning, developmental, and animal behavior are four seemingly distinct, nearly autonomous areas of inquiry involved in the analysis of behavior change. In point of fact, there is continuity underlying these approaches. The appropriate perspective points out that these areas of inquiry are individual aspects of a whole. This emphasis along with its implications provide a comfortable integration of available data, the production of fruitful research, and an understanding of behavior change.

The continuity underlying the seemingly disparate approaches to the analysis of behavior change are made more clear by viewing them in terms of the time scale of reversibility of their functional relationships. Time scale of adaptation varies from 1) behavior change which reverses almost instantaneously, such as the reporting of the presence and then the absence of a stimulus when a light comes on and then goes off (traditionally referred to as a "reflex" or a "sensation") or a behavioral output to a specific stimulus such as pecking while a key is green (traditionally referred to as the emission or elicitation of a learned response). This class of adaptation is referred to as instantaneous adaptation; to 2) behavior change which can be reversed only after some training, but that can be reversed many times within the life of the organism (traditionally referred to as "learning," as in coming to peck the green light but not the red light). It is the acquisition and loss of the relationship 'pecking to green and not to red" that is of interest and which defines this class of behavior. This class is referred to as short-term adaptation; to 3) relationships which are virtually permanent within an individual, once established, but that are reversible across progeny, such as personality or intelligence (traditionally referred to as "developmental changes.") Again, it is the time scale of the acquisition and loss of this relationship which is of interest and the defining characteristic of this class of behavior. This class, is referred to as medium-term adaptation. And finally to 4) long-term functional relationships which are reversible only across many generations (traditionally studied as species typical behavior by animal behaviorists). (Note that long term changes follow from variation and selection and do not in any way require the heritability of acquired characteristics). As before, it is the time scale of the acquisition and loss of this behavior which defines this behavior class.

If you give a person a piece of candy and they smile and salivate, what is the total “cause” of the smile and salivation? At first glance, it is certainly the stimulus of being given the candy; but, further thought adds the realization that the person learned over the course of a few experiences that those things that are wrapped in the bright blue wrapper are sour and taste good. Further, you would accept that it was necessary for the person to develop a preference for extremely sour candy over the years. Finally, it is obvious that animals developed the tendency to salivate to acids millions of years ago over the course of many many generations.

The interdependence of these processes is obvious when structured correctly, but it is often overlooked because we often mean only the efficient cause when we use the term cause. For example, the fact that a functional relationship can be confounded comes as no surprise to anyone. However, functional relationships are often not conceptualized with respect to all of the conditions under which they were obtained. The presumed "failures" with general process learning theory in the 1970s are a good example of overlooking the obvious. No behavior is the result of variables operating in only one time scale exclusive of all others.

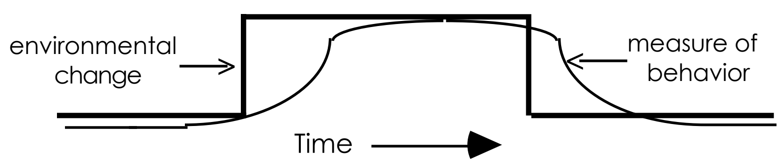
Behavior does not exist apart from perceptual, learning, developmental, and phylogenetic factors, and these must be held constant if their variation alters a functional relationship. If experience across other time scales is a source of confounding, then it is simply an interaction to be understood. It is not a failure of anything and should surprise no one.

This integrating perspective provides the most useful context to view obtained data and provides the questions which most effectively advance our ability to predict behavior. This continuum also provides the necessary frame of reference for explanations of functional relationships which invoke mechanisms from other time scales, such as the suggestion that ethological or developmental variables account for an important portion of the variability obtained in a learning task.

The various types of organismic adaptations studied by psychology can be categorized in terms of their time scale of adaptation. All organismic adaptation can be illustrated with the same diagram -- only the time scale changes.

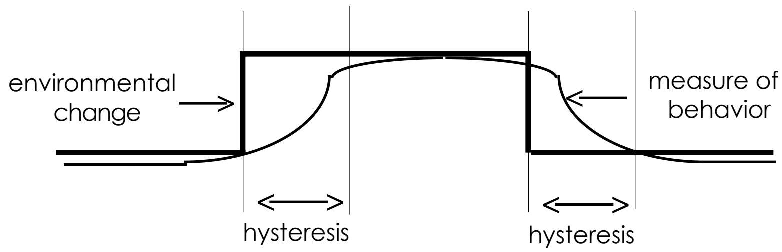
a. Temporal Duration of Change

Because our topic is organismic adaptation, the various time scale illustrations will all come from the organismic adaptation level of molarity, but in principle any level of molarity could be used. Returning to the basic depiction of organismic adaptation introduced in the previous section,



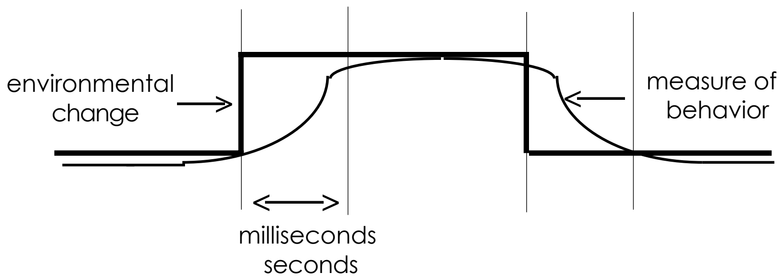
the initial state of behavior could be said to be in equilibrium with the initial state of the environment. When the environment changes, the behavior does not change at exactly the same time as the environment. There is a time lag between the environmental change and the behavioral shift. This lag is called hysteresis. Subsequently, the behavior comes into equilibrium with the environment. When the environment returns to its original state, the behavior re-equilibriates.

The following figure can illustrate the independent variable / dependent variable relationship in any area of psychology, only the time scale changes. Note that the independent and dependent variable axis have been scaled to roughly correspond in *y* extent.



It is important to note that the following four groupings refer to the time course of the change in a functional relationship, not the state of behavior before and after the independent variable changes. For example, in the illustrations in the following sections, it is not pecking (peck / no peck) that changes but rather pecking the green key (peck green, don't peck red) that changes.

i. "Instantaneous" or "Immediate" Adaptation



The measured behavior is a behavior difference to a stimulus difference. For example, the light is off and the person is quiet; the light goes on and they say "I see it." It goes off and they say "it went out."

It is a change in behavior (CIB).

(1) hysteresis in milliseconds - seconds range or single occurrence
(2) a stimulus change immediately controls a response
(3) previously known as a sensation, a learned reaction, a reflex, an instinctive response, etc.
(4) a typical functional relationship - recognition
(5) a typical research topic - signal detection

These adaptations occur immediately following the stimulus presentation, as soon as the organism "experiences" them. For example, presenting a green light (following key peck training) is followed by pecks to the key. It is a behavior change as soon as the stimulus changes. The appropriate response to the stimulus has been selected by the past consequences of that behavior (ontogenetic or phylogenetic). Often research is directed to the specific aspect of the stimulus that is controlling the behavior (e.g., convergence) or the capacity of the organism (e.g., threshold). In a computer metaphor, this adaptation is RAM.

Premise:

An external event can change the behavior of an organism. For example, a light can go on, and the subject can respond by blinking or saying, "I see it." Alternatively, a knee can jerk to a tap, or a pigeon can peck when a key illuminates, or a bird can fly to Patagonia when the light cycle changes.

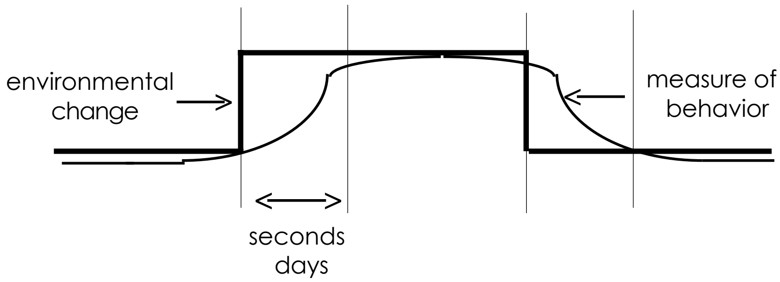
Descriptive unit of analysis:

"Reception," which is a change in the behavior of the organism associated with changes in the environment. This behavior reverses with the stimulus. (hysteresis of less than a few seconds).

Explanatory framework:

1) Why did the organism respond? Because the stimulus changed.
2) The empirical theory of signal detection.

ii. "Short-term" Adaptation



The measured behavior is a different instantaneous adaptation to a stimulus change as the result of exposure to a contingency change.

It is a change in the change in behavior (C(CIB)).

(1) hysteresis in seconds - days range – ca. 1 to 1000 trials
(2) different contingencies come to control different behaviors
(3) previously known as learning
(4) a typical functional relationship - discrimination
(5) a typical research topic - matching

These adaptations take time to occur. It is a change from a specific behavior difference to a stimulus change to some new behavior difference to the same stimulus difference. For example, a bell but not white noise could control salivation. Subsequently, white noise but not a bell could elicit it. This speed of adaptation (seconds to days) is optimal when the demands of the environment change many times within the life of the individual. In a computer metaphor, this adaptation is a "CDRW."

Premise:

A behavioral repertoire can be changed by exposure to environmental contingencies. For example, initially red key pecks but not green pecks could be followed with food; subsequently the reverse could be true. Behavior would adapt by changing from red pecks to green pecks.

Descriptive unit of analysis:

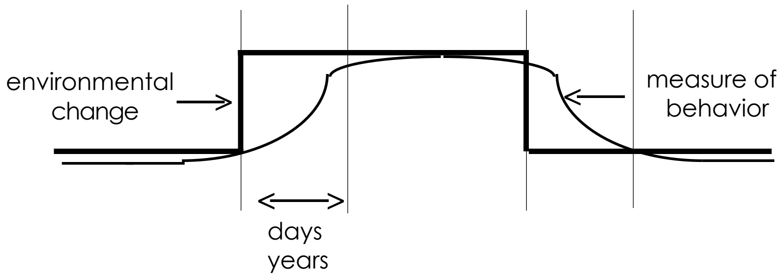
"Learning," which is a change in the behavioral repertoire associated with exposure to some nonrandom contingency. This behavior reverses with exposure to some contrary contingency. (Hysteresis of a few seconds to a few days.)

Explanatory framework:

Why did the organisms respond? Because of its reinforcement history. In this case, the "best" response to the stimulus can only be selected by the ontogenetic experience of the individual. The "correct" response cannot be known before the organism is born and the correct response is not necessarily the same across many ontogenetic experiences. The behavior is conditional on specific local information. There can be more or less carryover from developmental learning and from genetic inheritance.

Note that the reductionistic system which extracts invariant relationships from the environment (learning system) is essentially the same as the one which extracts invariant properties from the environment (perceptual system).

iii. “Medium-term” Adaptation



The measured behavior is a change in the equilibrium established by short-term adaptation as the result of correlations which extend across, or are shared by, multiple contingencies.

It is a change in the change in the change in behavior C[(C(CIB))].

(1) hysteresis in days - years range
(2) the ability of a stimulus to control a response is altered for the individual for virtually the rest of the organism's life
(3) previously known as developmental psychology
(4) a typical functional relationship - disposition
(5) a typical research topic - personality or memory

In a computer metaphor, this adaptation is a “CDR.”

Premise:

Environmental conditions can establish an enduring characteristic way of responding. This may occur because the environment changes from having one particular (or no) common relationship "underlying" many reinforcement contingencies to some other common relationship underlying many reinforcement contingencies. For example, a change from no exposure to conservation of volume to many exposures to conservation of volume results in the subject coming to respond that volume is conserved when water is poured from a tall, narrow container into a wide, shallow container.

Descriptive unit of analysis:

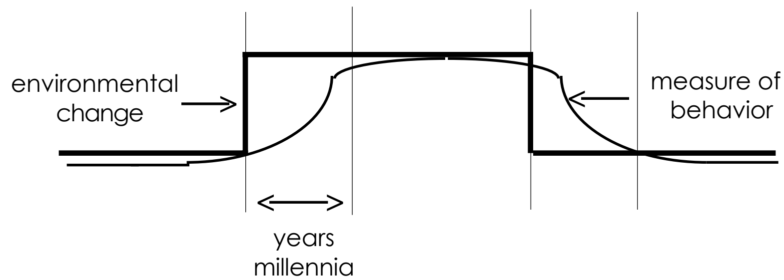
"Disposition," which is a virtually permanent change in the behavior of the individual organism. It may be attributable to the correlation of relationships (either actual or vicarious). This change is virtually life long but does not affect the genetic code. (Onset hysteresis of a few days to a few years.)

Explanatory framework:

Why did the organisms respond? Because it had been exposed to environmental conditions, i.e., correlation of relationships, which made it develop that way. In this case, the “best” response to a stimulus can be optimized because of experience with many contingencies across the ontogenetic and phylogenetic experience of the organism. This type of adaptation is conditional on the information common to a number of reinforcement contingencies and takes more than an exposure to a single contingency. As a result, it is slower to acquire or to reverse than simple learning. If learning is via correlation, then developmental adaptation is controlled by the correlation of correlations (typically indexed by the third axis in multiple correlation). Medium-term learning may be based on the accountable variance across many individual experiences. In fact, it would be expected that substantial *z* axis information could contravene the relatively minute local information in an isolated contingency.

It is important to realize that designs used to prove causation in short-term adaptation (recover baseline within same subject) may not be appropriate for medium-term adaptation. Proving causation for this time scale may require substantively different research designs. For example if we wish to study the acquisition of bicycle riding we may never be able to recover baseline within that same individual. We may never be able to make that subject naive again, but rather will only be able to recover baseline across progeny. The factors which control this time scale of adaptation are not well understood.

iv. "Long-term" Adaptation



The measured behavior is a change in the behavior difference to a stimulus difference as the result of differential reproductive success rather than ontogenetic experience.

It is a change in the change in the change in the change in behavior C{C[(C(CIB))]}.

(1) hysteresis in years - millennia range (actually generations)
(2) the ability of a stimulus difference to control a response difference is altered for the species or subspecies
(3) previously known as animal behavior or comparative psychology
(4) a typical functional relationship - instinct
(5) a typical research topic - migration

In a computer metaphor, this adaptation is "CD ROM."

Premise:

Genetic selection can establish a behavior difference to a stimulus difference. The subject (in this case, a gene pool) responds by coming to exhibit the new functional relationship. For example, the environment could shift the relative reproductive success of flying south for the winter to flying east for the winter.

Descriptive unit of analysis:

"Instinct," which is a change in the behavior to a particular stimulus change which is attributable to genetic selection. This class of organismic adaptation generally takes a very long time. (Hysteresis of years to millennia.) Common usage of "instinct" infers the time scale of adaptation. Obviously, experimental support is required if causal statements are to be offered.

Explanatory framework:

Why did the organisms respond? Because its ancestors that did, obtained differential reproductive success. In this case, the "best" response to a particular environmental condition is stable across generations and has a reproductive impact. This organismic adaptation is very slow because most typically, many generations are necessary to install its various components into the gene pool such that it will breed true. In principle however, it could be installed and removed very quickly with a mutation.

(1) Evolution

Darwin (1859) suggested that the diversity of life forms could be accounted for by genetic variation and differential reproductive success caused by natural contingencies. If a more extreme aspect of some trait reproduces more than alternative forms, then the better reproducing form will come to predominate even to the extent of eliminating the old species. Alternatively stated, given variation in functional relationships involving some behavior to the environment, if more and more extreme versions of the behavior provide greater and greater reproductive success, then the typical behavior of the species to that stimulus will shift in the successful direction. The eventual result will be that every individual will possess the “most successful adaptive strategy” to that environmental event.

Metaphors for evolution abound. Water flows downhill. It flows into your basement through a complicated sequence of paths. Alternatively, if you put ten consecutive bags, each with a hidden hole over a leaking bag of water, the water in the innermost bag will find its way to the floor. In fact, you could put 10,000 bags or 10 million bags, each with a hole in it over a leaking bag and the water would successfully find its way through the almost infinitely complex maze. This does not mean water has a mind or is being controlled by the space aliens. Water is following a very simple natural law. Molecules move downhill. Given a path, then the water ends up downhill. This is exactly the same natural law that drives evolution.

A simple metaphor for how evolution leads to a new species or behavior displacing the old species or old behavior is the spread of culture. If one culture landed on North America in the 1600s with guns and resistance to some very virulent diseases, what could you predict would happen in less than 500 years? The invading gene pool would experience relative reproductive success. That culture would own everything. The existing culture would be annihilated.

(a) Behavioral Evolution Versus Structural Evolution

Note that the focus of this discussion about evolution is on behavior not structures. As an extreme illustration, pigs (as a source of DNA) can be taught to fly (a behavior) and then the baseline can be recovered.

Of course, many changes will take place in the structure of “the” organism along the way but this is not unique to evolutionary changes. Presumably physical changes also take place when we learn to play the piano. If we play the piano now and didn't before, something had to change. If the change is not in nature, then what and where did the change take place? Obviously we need not actually discover the exact body change such as the specification of exactly which synapses are different and in exactly what way in order to teach someone how to play the piano or to determine what variables increase or decrease the time it takes to teach someone to play the piano. Most people don’t even think about the body change associated with piano playing. Technically, knowing the body change is unnecessary for the production of either flying or piano playing.

However, this does not deny the fact that in some cases it could be helpful to know what structures were changing and in what way they were changing. This is most obvious in the flying pig example. Knowing what structural precursors would make the pig's offspring lighter weight, develop feathers, and develop very long forelegs would help us to more quickly teach it to fly by helping us to more quickly acquire rudimentary precursors of the desired behavior. While structural changes must underlie behavior changes, they are not the point of the contingency and are in that sense are of no concern. There are many possible structural solutions for a behavioral requirement.

An important issue to note is that after recovering the non-flying pig baseline, we may not have a pig which will breed with the original pig species, unless we exert special control to shape the DNA toward that additional goal (needless to say recovering a true breeding pig baseline would be more difficult than simply generating a large land mammal good for bacon). When adjusting a life form with respect to one criterion, other characteristics are free to vary.

(b) What Can Evolve?

There are two different targets that can be the object of evolutionary change in behavior. First, various aspects of the functional relationship (for example, the time or destination of migration) can change as the result of the selection. The adaptive significance of the ability to adjust behavior in this way is obvious. Secondly, various organismic adaptations to environmental contingencies "seek their most appropriate time scale." For example, the reaction to light is an instantaneous eye blink, the reaction to key pecks to red being followed by food is learning to peck red. The different time scales of these two adaptations have as much adaptive significance as the target of migration. Very little flexibility is needed when "deciding" what to do to bright light in the eye; the only behavior change necessary is the response itself. It can be an instinctual response. On the other hand, substantial ontogenetic information is necessary to "decide" what to do when a red light comes on. Little can be "pre-learned" before the organism is born with respect to what to do when a red light comes on. What is learned is a change in the behavior change to the red light, and that functional relationship must be acquired across ontogenetic experience.

Evolution can be seen as: (a) a process whereby long-term functional relationships can be modified and, (b) a process whereby the time scale of adaptation for a functional relationship is established. Both changes occur because of their impact on reproductive success

(c) Interaction of Time Scales of Adaptation and Evolution

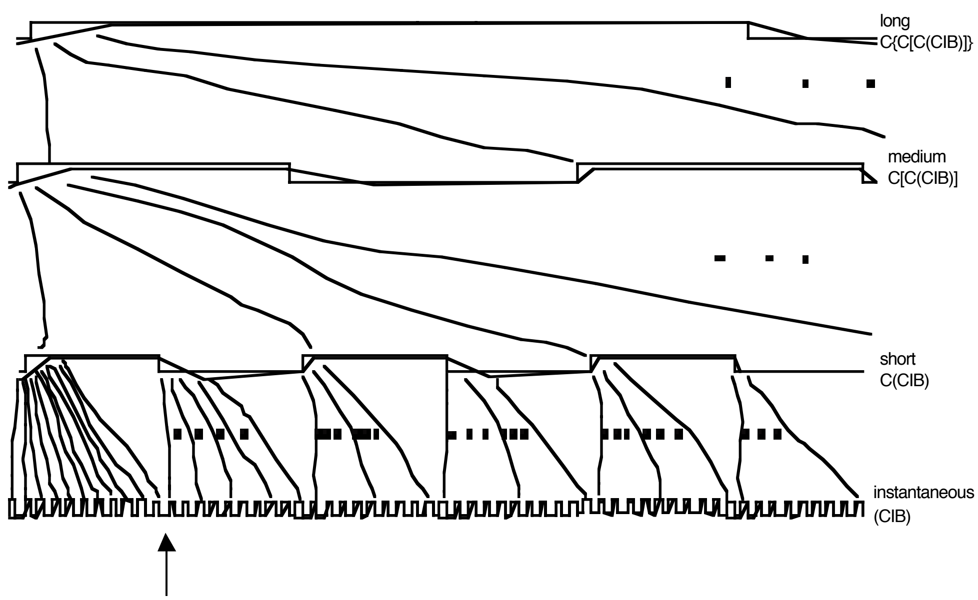
Because evolutionary selection must be through genetic selection (genotype), there must be a reliable way to select closer approximations to the genetic contributors to the desired behavior. Genotype is not immediately accessible. But in order for there to be evolution of behavior, there must be a way to select genotype based on something environmental contingencies can detect. Speed of learning, if it is indicative of the genotype, would provide the needed bridge. Learning speed may reflect underlying genetic predisposition much like sensitivity to heat shock revealed underlying genetic preadaptation (Waddington). See also Staddon (1983, page 11).

For example: from the genetically provided complement of functional relationships (long-term), behaving organisms could adapt by learning (short-term) to behave differently in some way. Speed of learning that adaptation could function to isolate the fast learners of the population. If that learned behavior provides reproductive success, and learning speed is in fact related to genetic predisposition, then the frequency of that genetically provided learning speed will be increased in the population, and organisms which learn faster will predominate in the population. As a result, even faster variations in learning "ability" could occur and could then be selected. When what was previously a short-term functional relationship (because it had to be learned) is installed in the gene pool as an instinct, then speed of learning can again be "used" to select even more (or less) extreme versions of that characteristic or even other aspects of the adaptation altogether. As a result, stable problems which require the same learned solutions can come to be instincts. On the other hand, problems which can no longer be solved with the same instinct will no longer have instinctual solutions but rather will require learned solutions. This can occur through the selection of the ability to quickly learn not to do the instinctive act, then incomplete expression of the behavior, and eventually the absence of the instinct altogether.

This ability to select based on intermediate forms of time scale of adaptation dramatically simplifies the development of the optimum time scale of adaptation for each problem posed by the environment and dramatically simplifies the task of establishing or removing an instinct. Enduring stable problems in the environment produce the correct adaptation process through intermediate forms in a process like shaping. In the same way you cannot easily establish an FR 100 in short-term adaptation by enforcing that criterion on a naive organism, but you can easily establish the behavior if you're able to reinforce successive approximations of the criteria. So does short-and medium-term adaptation provide for successive approximations or the selection of partial genetic solutions which are closer to the desired goal. In both ontogenetic and phylogenetic shaping, the mean of the distribution is incrementally shifted. This provides for the straightforward emergence and selection of more extreme instances in the future.

b. Conceptual Follow-up

The following figure illustrates the relationship between time scales of adaptation. As can be seen, the change in the x-axis changes at one level make up the y-axis changes at the next level. The x-axis for each successively higher function is compressed so that the effect can be seen across a very wide span of time scales. The angled vertical lines connecting the horizontal lines would be perpendicular to the x-axis without compression.



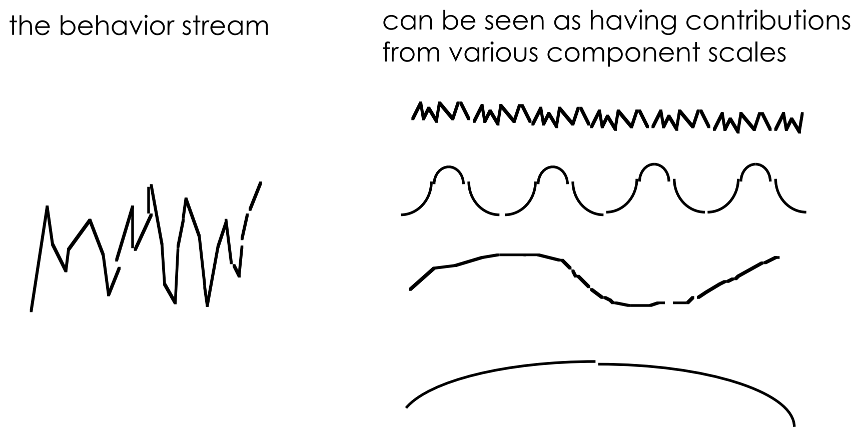
In the case of instantaneous behavior change, the comparison is between behavior when a stimulus is in effect, and when it is not in effect (the lowest pair of functions). In the case of short-term behavior adaptation, the comparison is between how behavior changes to a stimulus when the stimulus is first presented (left end of set on bottom row), and how behavior changes to that same stimulus following experience with that stimulus and a contingency (i.e., end of first training just before first extinction noted with arrow below bottom pair of functions). The change across the X dimension of an instantaneous effect becomes the Y dimension of short-term adaptation.

Medium-term behavior change is the change in learning as a function of experience with various contingencies. For example, learning speed could change across successive reversals. This is often labeled learning to learn. Changes in the x-axis of learning become the y-axis change in developmental. Long-term adaptation or evolution represented in the top pair of functions is the difference in how behavior changes across the life of the individuals of two different species.

c. Fourier Analysis Metaphor for Time Scales of Adaptation

The following depiction of the net effect of all the time scales acting on behavior together uses complex waves and Fourier analysis as its metaphor.

Fourier's theorem states that any wave form can be expressed as a sum of sinusoidal components. In the same way as a complex sound can be seen as a combination of various frequencies, the complex behavior of an organism can be seen as the result of contingencies operating at a variety of time scales.



An advantage of this metaphor is that it makes it clear that we cannot necessarily attribute a particular change to a particular component process. Rather, it is the net change of all the factors together which determine behavior. Some factors could be increasing and some could be decreasing at any point in the behavior stream.

d. Comparative Analysis of Time Scales * Issues

A detailed analysis and comparison of the time scales of organismic adaptation is presented on the following pages. As can be seen, the tables compare the various subspecialties of Psychology. Each column is a subparadigm. Given that where Psychology fits within science is understood, and given that where the subspecialty (e.g., learning) fits within Psychology is understood, then appeal to other levels of molarity need not be made of necessity (e.g., biology or sociology for psychology) or time scales (e.g., perception or developmental for learning).

The subspecialties one level of molarity above and one level below Psychology are provided in the figure directly below for perspective.

	Cellular Adaptation	**Organismic Adaptation**	**Group Adaptation**
Premise	pathway responsiveness is controlled by activity	behavior is a function of its contingency history	a proportion of the members of a group will respond to its contingency history
Descriptive unit of analysis I - IV are time scales	CONNECTION change in pathway responsiveness associated with I. the occurrence of an event II. the contingencies III. commonalities in correlations IV. genetic selection	BEHAVIORAL ADAPTATION a change in behavior as the result of events in the environment I. the occurrence of an event II. the contingencies III. commonalities in correlations IV. genetic selection	PARTICIPATION a change in the proportion of a group reacting as a result of I. the occurrence of an event II. the contingencies III. commonalities in correlations IV. genetic selection
Explanatory Perspective	why did the nervous system react that way because the environmental history was sufficient to modify synaptic transmission (reductionistic would be atomic adaptation i.e., chemical explanation)	why did behavior occur because the environmental history was sufficient to modify the behavior (reductionistic would be cellular adaptation i.e., neural/hormonal explanation)	why did that proportion of the group do that? because the environmental history was sufficient to extract the behavior (reductionistic would be organismic adaptation, i.e., behavioral explanation)
Of what is "why?" asked	why does the pathway change? Of what is the pathway a function of?	why does behavior adapt? Of what is behavior a function of?	why does some proportion participate? Of what is participation a function of?
Product	which factors change connections? how and by how much?	which factors change adaptation? how and by how much?	which factors change participation? how and by how much?

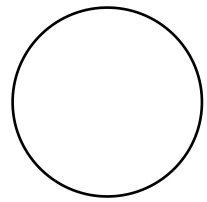
Organismic Adaptation

	instantaneous milli - sec	short sec - days	medium days - years	long years - eons
Premise	an external event can change behavior	the behavioral repertoire can be changed by environmental contingencies	enduring characteristic ways of responding can be established by exposure to commonalities in correlations "rules" equivalences memory organization of behavior	genetic selection can establish a characteristic behavior to an environmental event
Descriptive Unit of Analysis must be input output relationship	RECEPTION a change in behavior associated with changes in the environment (reverses with stimulus)	LEARNING a change in behavior repertoire associated with exposure to some nonrandom relationship in the environment (reverses with some contrary contingency)	DISPOSITION a change in the characteristic way of responding attributable to commonalities in correlations predisposition enduring contingencies (virtually life-long but does not affect offspring)	INSTINCT a change in behavior attributable to genetic selection (breeds in and breeds out)
Explanatory Perspective	why did organism respond? because the stimulus changed	why did organism respond? because of its reinforcement history	why did organism respond? because it was exposed to commonalities in correlations	why did organism respond? because its ancestors that did, obtained differential reproductive success
Of What is "Why" Asked	why does an organism react to a stimulus? of what is RECEPTION a function of?	why does an organism respond differently following some contingencies? of what is LEARNING a function of?	why does the organism consistently respond that way? why does exposure to commonalities in correlations result in characteristic ways of responding? of what is DISPOSITION a function of?	why does an organism respond in "species-typical" ways? why does genetic selection produce different behavior? of what is INSTINCT a function of?
Product	which factors change reception?; how, and by how much?	which factors change learning?; how, and by how much?	which factors change dispositions?; how, and by how much?	which factors change instincts?; how, and by how much?

B. Spatial Representation of Behavioral Equilibrium Paradigm

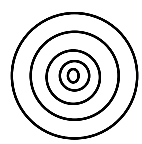
1. Spherical Representation of Level of Molarity * Time Scale

The two major dimensions of adaptation (level of molarity and time scale of adaptation) can be represented with the two "axes" of a sphere.



a. Level of Molarity as a Point on a Radius

Measures can be more or less molar. Distance from the center of a sphere could conveniently represent molarity of measurement.



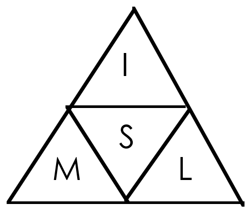
More physiological variables toward the center and more molar variables more distant from the center. Successive layers of the “onion” represent specific molarities of paradigmatic context. The sphere depicted in the initial figure is actually one concentric layer of a solid. The molarity dimension depicts that physiological variables underlie all behavior and that ultimately biological (or chemical or physical) mechanisms mediate all behavior change. A weakness of this metaphor is that only one individual lies within the group level and only one cell lies within the organism level, etc.

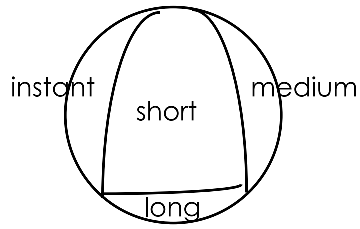
A reductionistic explanation, or an explanation which appeals to a lower paradigmatic context would be seen as appealing to an inner sphere for an explanation with this spherical model. With this model, correlative explanations would be seen as appealing to factors on the same surface at the same level as the original question. A point on the surface of the sphere could then represent the time scale of reversibility for a behavior at a particular level of molarity.

b. Time Scale as a Point on a Surface

The behavior change of interest can be across any of a number of time scales. Points on the surface of the sphere could be used to represent the time scale dimension. Any specific time scale of adaptation within some level of molarity could be represented as a point on the surface of the sphere, at some distance from the center (some particular layer of the onion).

For example, the surface of the sphere at the level of organismic adaptation could depict time scale of reversibility of behavioral phenomena.





The surface could be partitioned into four equal quadrants, like the four sides of a pyramid mapped onto a sphere (imagine a pyramid tin can exploded out). The left figure shows the covering of the pyramid flattened out.) The spherical representation provides all time scales as contiguous or interacting. For example a functional relationship such as discrimination would be depicted on the surface labeled "short" and could be drastically changed by changing any of the other three time scales, just as topologically changing Cartesian space changes a form on that space. A figure drawn on a rubber sheet changes as the sides of the sheet are distorted or changed by pulling. An advantage of a spherical surface metaphor is that it provides orthogonal axes all of which could be continuous rather than discrete and any of which could affect a relationship on any other.

It is important to reiterate that these categories do not exist in isolation. A behaving pigeon is alive, is chemicals, is matter, and has an evolutionary, a developmental, a reinforcement, and a perceptual historical context. These multiple coexisting determinants are analogous to the determinants of a point in space. A point does not exist in the x-axis alone. It is simultaneously in the x-, the y-, and the z-axis.

With this spherical spatial model several important ramifications of characterizing a particular functional relationship in terms of its time scale of reversibility are also represented. The continuum is closed rather than being linear. It is not appropriate to view instantaneous relationships at one end and long term relationships at the other extreme, related only through all intermediate stages. All are equally interdependent with one another. No one time scale exists in isolation from any of the others. The meaning of a functional relationship in any time scale is with respect to the context or boundaries established by the other class of variables. Clearly a demonstrated relationship at any one time scale can be changed by changing variables in any one of the other three time scales.

In point of fact, category boundaries are actually a matter of pedagogical convenience.: a scaffolding. There is no sharp demarcation between classes of functional relationships. There is no real reason to maintain a hard distinction between enduring perceptual variables and brief learning variables. On the contrary, there is every reason to examine manipulations typically reserved for one time scale by other research areas.

2. Cubic Representation of Goals * Levels * Time Scales

A three-dimensional structure within which to view nature results if we combine the three dimensions of science. In this case, the "goals" dimension has been rotated 90 degrees to the *z*-axis from the earlier figure depicting the goals of science.