

CHAPTER 2

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CHAPTER 2

Paradigmatic Context of Conditioning and Learning

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 comprehensible.

I. Relevance of a Paradigmatic Framework

A. Decision Based on Paradigmatic Framework (Science)

Decisions made as if they are done in a court of law.

1. systematic, public, accountable rationale for decision
2. systematic, public, accountable framework with which to organize results
3. feedback and, therefore, systematic advance

B. Decision by “Whim,” “Guess,” or “Intuition” (Eclectic)

Decisions made as if they are done by a lynch mob.


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

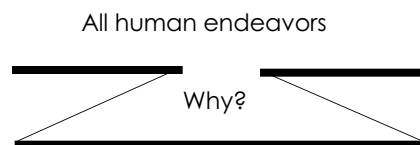
All possible human endeavors include such things as art, war, fishing or love.

All human endeavors



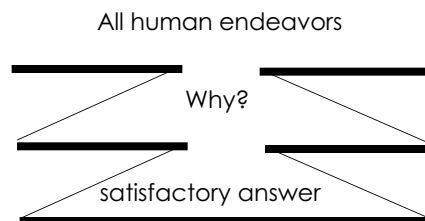
B. Set of Interest: Search for Answer to Question “Why?”

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.



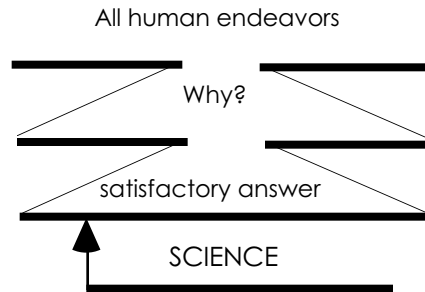
C. Subset of Interest: Only Satisfactory Answer

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 1, so that we can see that science is the name for the production of satisfactory answers.

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 honestly 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

1. The Goal of the Activity

The first dimension of the structure with which to understand psychology is the goal of that scientific activity. In the last chapter 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)

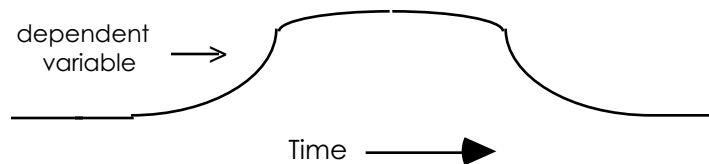
The second dimension of the structure is the molarity of the paradigmatic

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-equilibrates 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 class of adaptation 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 over the short term to various environmental influences by secreting a substance (functioning); 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



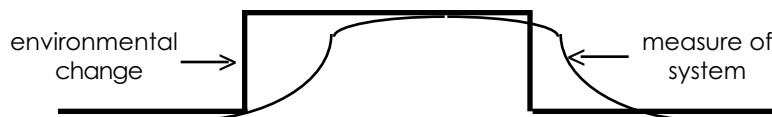
This class of adaptation involves the adaptation of the behavior of a whole life form, (not the adaptation of a cell or the adaptation of an anatomical structure) to changes in the environment. If a measure of behavior is altered as a function of changes in the environmental conditions then the behavior 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

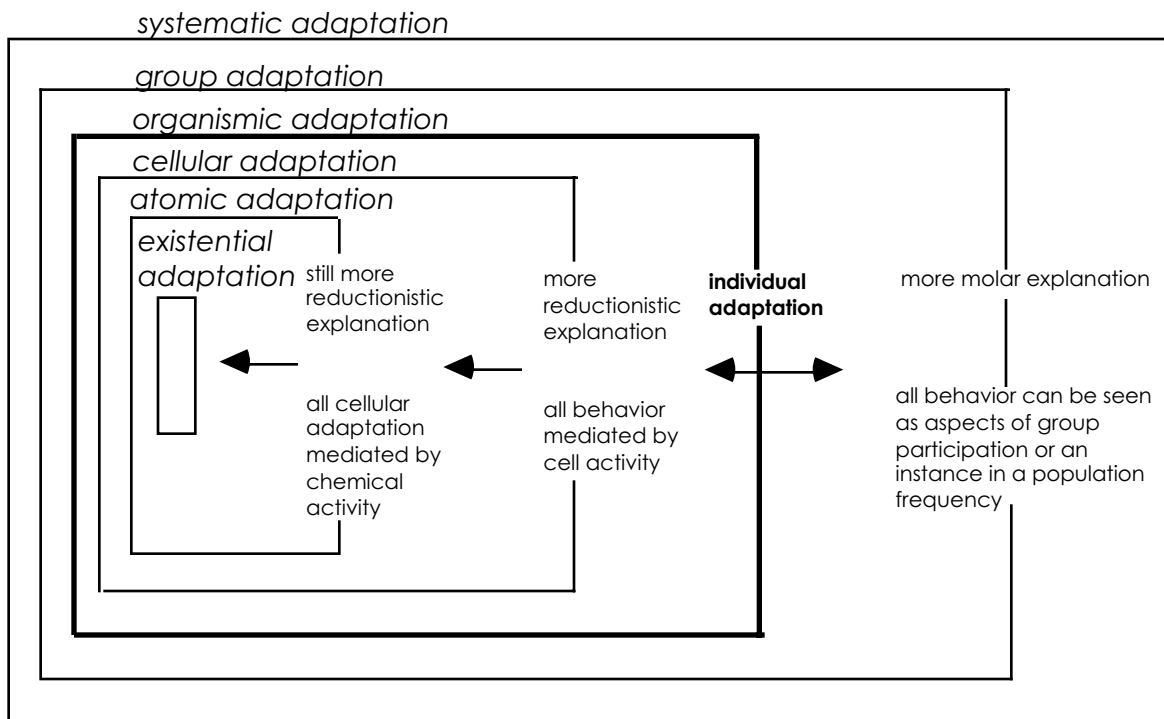
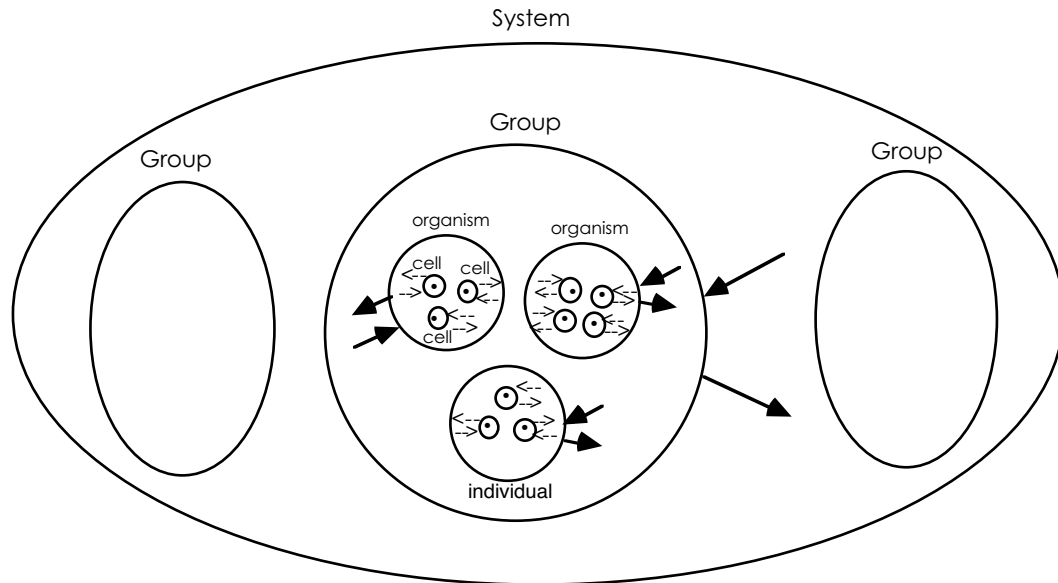
It is important to keep in mind that these conceptual categories or molarity do not exist in isolation. A specific member of a group is, in fact, a behaving individual which is made up of cells which are in turn made up of atoms which are themselves made up of forces. Additionally, that organism is a member of a subgroup of a population where some proportion of the members of the population behave the same way. The overall population is, in turn, 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. It changes with changes in the broadcast signal (stimulus-response relationships). It 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 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. But in both cases psychologists are most typically interested in only the input/output relationships of the individual. What does the pigeon, as a whole, do when the light is turned on? 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 that is only **one** meaning for “cause.” It is, in fact, more appropriate to see cause at the same level of analysis (how does what comes out change as a function of what contingencies or knobs we change). Recall the discussion on the difference between a reductionistic and a correlative explanation given earlier.

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 paradigm and the goals of that paradigm.

Paradigm Term	Existential Adaptation	Atomic Adaptation	Cellular Adaptation	Organismic Adaptation	Group Adaptation	Systematic Adaptation
Common term	Physics	Chemistry	Biology	Psychology	Sociology	Systematics
To Understand: Basic Research	why existential adaptation why existence	why atomic adaptation why substances	why cellular adaptation why life	why organismic adaptation why behavior	why group adaptation why participation	why system 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 country 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 does life exist – and not only do life forms behave but organisms behave in different ways as the result of experience with the environment. This is what organismic adaptation means.

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 a fundamental continuity underlying these approaches. The appropriate perspective points out that these areas of inquiry are inextricably interdependent and vary along a closed continuum. 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 hereafter 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, hereafter, will be 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, hereafter, will be 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, 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 an insufficiently comprehensive paradigm. 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

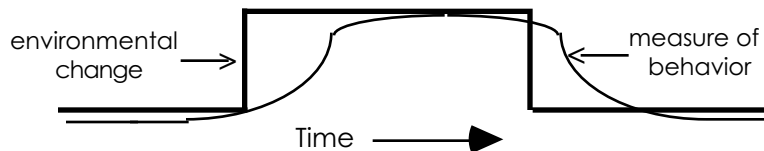
be held constant if their variation alters a functional relationship. If experience across other time scales is a source of confounding, then it is simply an interaction to be understood. It is not a failure of anything and should surprise no one.

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.

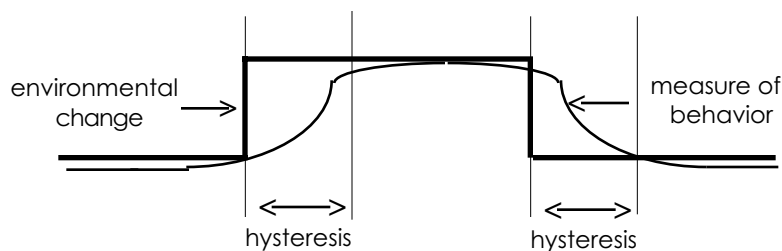
a. Temporal Duration of Change

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-equilibrates.

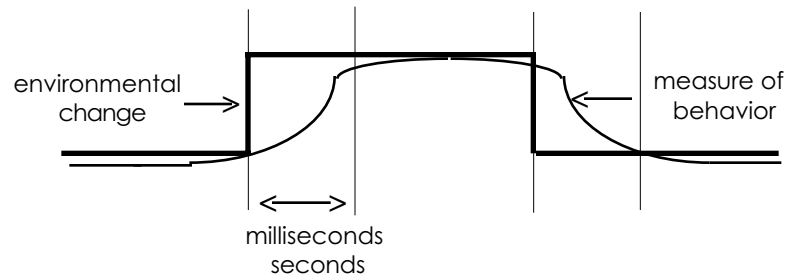
The following figure can illustrate the independent variable / dependent variable relationship in any area of psychology, only the time scale changes.



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 / peck red, don't peck green) 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
- (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.

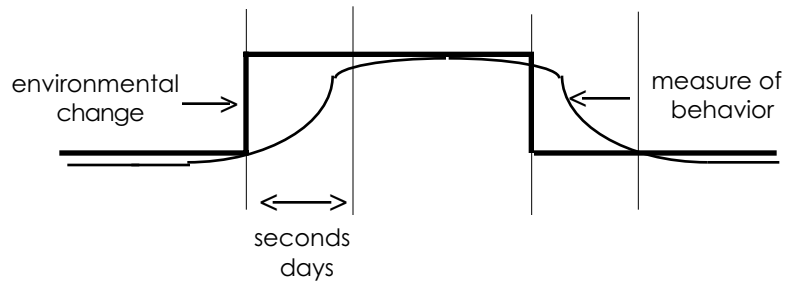
Descriptive unit of analysis:

"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
- (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:

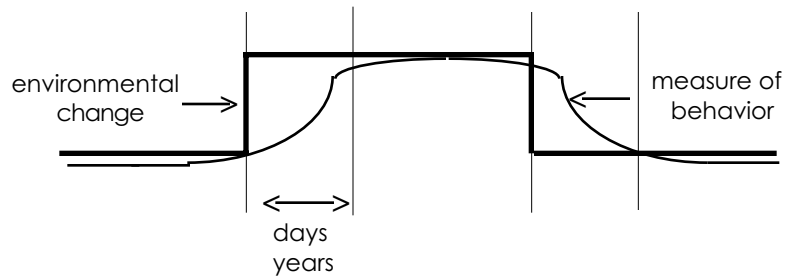
"Learning," which is a change in the behavioral repertoire associated with exposure to some nonrandom contingency. This behavior reverses with exposure to some contrary contingency. (Hysteresis of a few seconds to a few days.)

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.)

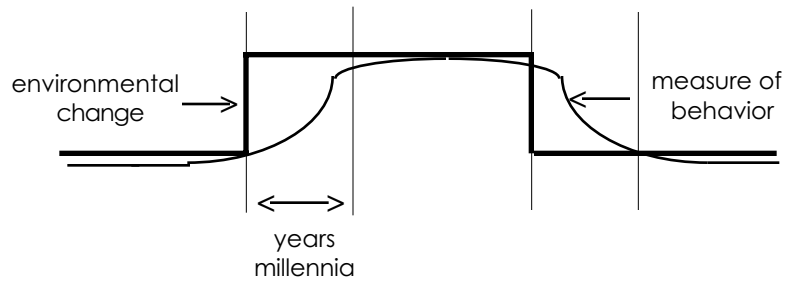
Explanatory framework:

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 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 reproductive impact. This organismic adaptation is very slow because most typically, many generations are necessary to install it into the gene pool. 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 the apparent intelligence of evolution finding the “ideal” solution 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, the water ends up downhill. Evolution is driven by similarly simple natural laws.

The spread of culture is a simple metaphor for how evolution leads to a new species or a new behavior displacing the old species or old behavior. If one culture landed on North America in the 1600s with guns and resistance to some very virulent diseases, it would have a reproductive advantage. What could you predict would happen in less than 500 years? The invading cultures 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 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 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. In sum, 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 made 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. It may be that neural network theory and PET scans will actually help us in some way to develop the set of functional relationships which describe learning. But it is also possible that neural network theory is wrong. or that the results of PET scans are irrelevant to learning, or that the results illustrate only for one individual one possible solution. Additionally, it is altogether possible that an emphasis on a structural solution for a behavioral task will impede progress by diverting attention away from the environmental factors which control behavior by drawing attention to structures.

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 things that can be the object of evolutionary change in behavior. First, various aspects of the functional relationship (for example, the time or target 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.

(c) Interaction of Time Scales of Adaptation and Evolution

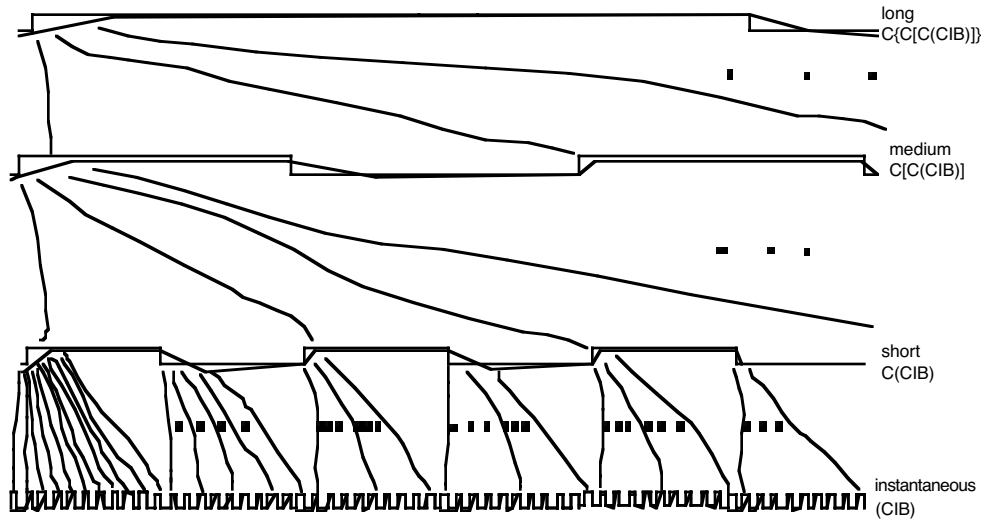
Because evolutionary selection must be through genetic selection (genotype), there must be a reliable way to select closer approximations to the genetic contributors to the desired behavior. Genotype is not immediately accessible. But in order for there to be evolution of behavior, there must be a way 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).

All time scales of adaptation contribute to the efficiency of evolution and the time scale across which an adaptation occurs to a particular class of problems can evolve. 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 related to genetic predisposition, then the frequency of that genetically provided complement of learning speed will be incremented, and organisms which learn faster will predominate in the population. As a result, even faster variations in learning “ability” can occur and then be selected. When what was previously a short-term functional relationship (because it had to be learned) can be 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 details 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 through the selection of incomplete expression of the behavior or the ability to quickly learn not to do the instinctive act.

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 learning 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.



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 function). 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 (right end of set on bottom row). The change in 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. Changes in the x -axis of learning become the y -axis change in developmental. Long-term adaptation or evolution is the difference in how behavior changes across the life of the individuals of two different species.

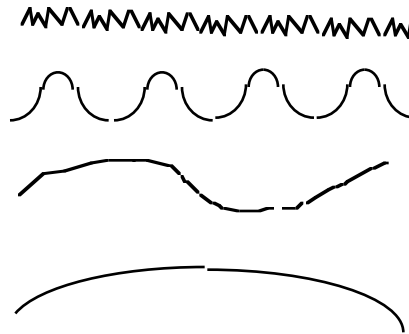
c. Fourier Analysis Metaphor for Time Scales of Adaptation

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.

the behavior stream



can be seen as having contributions from various component scales



An advantage of this metaphor is that it makes it clear that we cannot necessarily attribute a particular increment on the y-axis to a particular component frequency. 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 of the time scales of organismic adaptation is presented on the following pages. As can be seen, it compares the various subspecialties of Psychology. Each is a subparadigm. Given that where Psychology fits within science is understood, and given that where the subspecialty fits within Psychology is understood, then little appeal need ever be made to other levels of molarity (e.g., biology or sociology) 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.

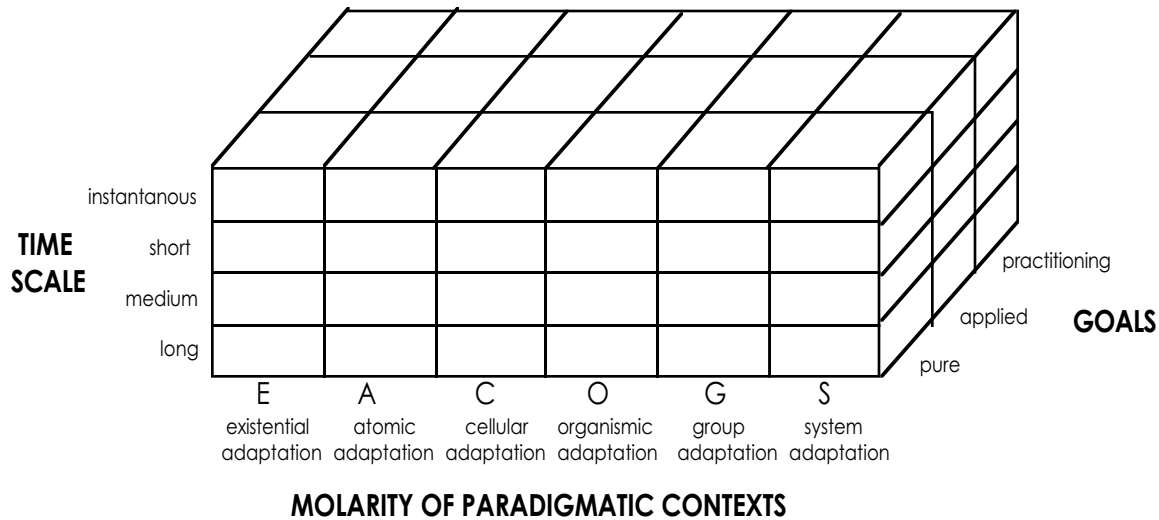
	Cellular Adaptation	Organismic Adaptation	Group Adaptation
Premise	pathway responsive- ness is controlled by activity	behavior is a function of the environment	a proportion of the members of a group will respond to an event
Descriptive unit of analysis I - IV are time scales	CONNECTION change in pathway 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 pro- portion 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 environ- mental history was sufficient to modify synaptic transmission (reductionistic would be chemical explanation)	why did behavior occur because the environ- mental history was sufficient to modify the behavior (reductionistic would be neural/hormonal explanation)	why did that proportion of the group do that? because the environ- mental history was sufficient to extract the behavior (reductionistic would be 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 pro- portion 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" memory organi- equiva- zation of llences 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 contingen- cies (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

A three-dimensional structure within which to view nature results if we combine the three previous dimensions. In this case, the “goals” dimension has been rotated 90 degrees to the z axis.



IV. Normal Science Within the Behavioral Equilibrium Paradigm

A. Explanation Within the Behavioral Equilibrium Paradigm

A paradigm specifies what are relevant questions and acceptable answers. Alternatively, an explanatory system defines a paradigm. Explanations can be classified in several ways. In general, explanation is the specification of the factors that are accepted to have produced the phenomenon. That specification is a set of conditions within a coherent interlocking framework of well-understood relationships and which is accepted by its practitioners as being sufficient or adequate.

Clearly any phenomena can be better understood when it's coherent interlocking framework includes all conceivable things. However, the specification of the correlative factors only at the same level of molarity and only within the same time scale is usually accepted as a sufficient explanation, even though it is not infinite. Specification of relationships across levels of molarity, (e.g., appeal to physiological explanations for learning) or across time scales (e.g., appeals to developmental or evolutionary factors for learning) are “bridging” explanations.

The present paradigmatic position is the unification of previously invoked types of empirical correlative explanations. The paradigm emphasizes that any functional relationship is the net result of mechanisms operating over all levels of molarity and time scales.

This has two important ramifications.

1. Explanatory Anchor

a. Within Time and Unit Domain

These are explanations that specify input/output functions within the same time and unit domain, e.g., reinforcement history for pecking.

b. Across Time Domains

These are explanations for a behavior which appeals to a different time scale for explanation. Unit domain may or may not be confounded, e.g., the reproductive advantage provided by some specific behavioral equilibrium such as a response rate of 2 responses per second to some specific reinforcement rate.

c. Across Unit Domains

These are explanations for a behavior which appeal to a different unit domain for explanation. Time domain may or may not be confounded, e.g., the chemical processes underlying a particular behavior.

2. The Multidetermination of Behavior and Confounding

An organism's adaptation can occur at any or all of a variety of unit and time domains and any change in behavior is best seen as the result of the sum of the changes across all of those processes. Alternatively stated this means that changes at any unit or time domain other than the one under consideration can confound the interpretation of the effect of interest.

Those factors not explicitly of interest must be considered and treated as sources of potential confounds. Successful predictions which consider only a single unit of molarity or time scale are actually special cases and are subject to failure if variables from other "contexts" are changed.

B. Plausible Reductionistic and Historical Determinants of Behavioral Equilibrium

An underlying reductionistic mechanism and a long-term historical origin could be advanced which would account for the commonality of process in the behavioral equilibrium paradigm even though it is not essential to the usefulness of the paradigm. It is offered only because there is, in fact, a reductionistic mechanism underlying the correlative relationships observed in behavior, and we can make a very good guess as to how and why those relationships came to be what they are. The reductionistic mechanism depends on two processes, "evolution" and "use controlled pathway responsiveness."

It is generally accepted that differential reproductive success can install a more extreme version of a trait into a gene pool and that that trait will continue to change or "evolve" as long as some different instance of it provides even greater success.

This is seen as the long-term historical origin of organismic adaptation.

It can also be postulated that the nervous system functions such that the activation of a pathway makes it more likely that any of these concurrently active and contiguous pathways will result in the same output given the same initiating situation again. For example, feedback from a post-synaptic membrane to a recently discharged or active pre-synaptic membrane could occur after the post-synaptic membrane was depolarized. This feedback could be such that it is more likely that that presynaptic activity generates that postsynaptic discharge on its next occurrence. This mechanism could be seen as the neurological origin of organismic adaptation (it is the essential feature in back propagation in neural network models).

Given these two mechanisms, evolution and use controlled responsiveness, a continuous time scale of behavior change and the entire behavior equilibrium paradigm follows. If a functional relationship could have occurred between an input and an output, and if that relationship provided relative reproductive success, then that relationship would be more likely to occur in subsequent generations. The functional relationship would continue to evolve as long as more extreme versions provided more reproductive success. If the pressure reversed, then so too would the properties of the functional relationship. Versions of the functional relationship between the input and the output could be more “extreme” in several ways; each being a different dimension along which evolution could proceed. For example: (1) the optimum wavelength to elicit a response could be shifted. If a tendency to approach green light were to provide reproductive success, then we would expect subsequent generations to come to exhibit more of that “instinct.” If approaching red light subsequently came to provide even greater reproductive success, then we would expect red approach to come to predominate. (2) The details of the controlled behavior could be changed, (e.g., rather than green approach, green avoidance could be selected), and (3) finally, the time scale over which the adaptation occurred could itself be changed. For example, if a fixed innate response to a stimulus were suboptimal (e.g., the appropriate response was not always the same), then the requirement that the appropriate response to the stimulus be learned would be reproductively successful. If, on the other hand, the correct response to the stimulus had previously required ontogenetic experience but subsequently the correct response did not change very much across the lives of many generations of individuals, then a stable common response (an instinctual response) would be reproductively successful.

Transitional forms between flexible and permanent relationships have been well described in the literature (Breland & Breland, and Waddington). In organismic adaptation, the transitional stages could be partitioned as: the ability to receive the stimulus and perform the response, learnable with difficulty or only under ideal conditions, learnable, easily learnable, occurring given some relatively typical developmental sequences, occurring given most developmental sequences, and finally occurring given virtually all developmental sequences which sustain life. The argument is that the source of the continuity underlying the behavioral equilibrium

paradigm is adaptation speed. Learning speed provides an index of the degree of genetic predisposition so that genetic selection can function on intermediate forms. It provides for genetic shaping.

In sum, the ramifications of the existence of “evolution” and “use controlled pathway responsiveness” are enormous. It suggests that there is an environmental mechanism which could result in the acquisition of the ability to adapt. It also indicates that there could be a mechanism which provides that functional relationships will be “caused” either anatomically through stages of faster or more permanent learning or become “caused” by specific ontogenetic experience, depending on which provided greater reproductive success. The time course of a organismic adaptation seeks its own optimum equilibrium somewhere between reversing instantaneously and reversing only after evolution. In these cases, the examples would be from immediately responding to a stimulus (an instinct) to having to evolve the capacity to respond to an event without experience (evolving an instinct).

C. Continuity Across Elements of the Behavioral Equilibrium Paradigm

All levels of molarity and time domain are in effect and, in fact, interact. See the discussion of interaction in Chapter 6.

1. Continuity Across Time Domain Factors

The full behavioral repertoire of an organism exhibits functional relationships at all time scales. Additionally, the time necessary to install and remove a specific organismic adaptation can be changed in either direction. But, in order to simplify the presentation of the following issues without explicitly stating all that complexity at every point, only a relationship from a single time scale and in a single direction of change will be presented at a time. The shorter time scales are labeled “shorter,” whereas the longer time scales are labeled “longer.” The initial time scale is labeled “precursor” and the end time scale is labeled “eventuality.” Factors at a smaller unit of molarity are labeled reductionistic machinery; factors at a larger unit of molarity are labeled population context.

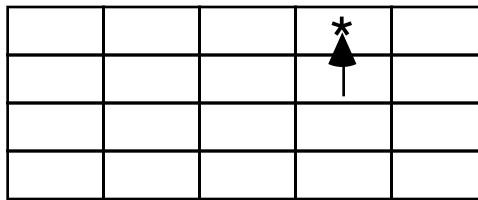
a. Instantaneous and Short

i. Instantaneous on Short

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			↓	

One precursor of short-term adaptation (or learning) is instantaneous adaptation or “sensation/perception.” An organism must detect environmental stimuli in order to learn. The eventuality of being exposed to some stimuli with some correlation is short-term adaptation or learning. Extraction of a contingency from nature is exactly the same as the extraction of a signal from nature. Our “realization” that an object is a straight line, or that something is closer is the same as our “realization” that the CS precedes the US. In that sense, laws of perception may give insight into laws of learning. Learning paradoxes may be like perceptual illusions.

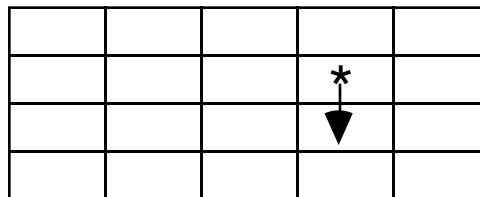
ii. Short on Instantaneous



One determinant of the detection of a stimulus is the experience the observer has with the consequences of decisions relating to those stimuli. If false alarms are cheap while misses are very costly then more false positives should be expected.

b. Short and Medium

i. Short on Medium



A precursor of medium-term adaptation or a “developmental” effect is short-term adaptation or learning. An eventuality of learning is developmental change. It is the higher-order commonalities in many functional relationships which produces medium-term adaptation. Exposure to a wide range of relationships with a common property establishes a “learned” effect which is not reversed by the exposure to one counter-instance. This is much like the fact that one anomalous point in a scatter plot does not undo the relationship established by a whole field of data points. Once a set is established, an individual experience is related to as an anomaly if it is inconsistent with the multiple converging evidence gained by the experience of that organism. Once the set is established, the system “falls past the cusp” and is not

easily reversed. This is the establishment of “equivalent sets,” or the extraction of a “rule.”

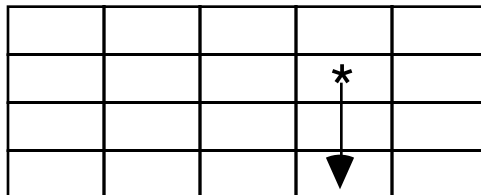
ii. Medium on Short



One determinant of learning is the amount of prior learning on similar tasks such as learning a tenth language is much easier than learning a second one. This is not really readiness such as "readiness to be toilet trained," in that that is usually conceptualized as a biological change relatively independent of specific experience. Using the metaphor established in the previous section, it is easier to learn an instantiation of a rule than to learn something *de novo* or to learn the rule.

c. Short and Long

i. Short on Long



The speed of learning may index genetic predisposition. If an organism learns a relationship more quickly (or that organism learns a disposition faster) than others of its species, then that organism may be “closer” to being phylogenetically predisposed to exhibit that relationship without any learning history at all. This allows genetic selection based on a phenotypic trait. It provides the intermediate steps which make shaping through evolution easier. Genetic extraction based on learning will result in an instinct much like genetic extraction based on reaction to heat shock will result in a new wing type.

x

x

ii. Long on Short

			*	
			▲	

Some species have a predisposition to learn some things such as poison avoidance in rats. Presumably, this is because genetic selection selected for that tendency or at least the building blocks of that learning.

x

x

d. Medium and Long**i. Medium on Long**

			*	
			▼	

In the same way that learning speed may reveal genetic predisposition, so may speed of acquiring a disposition. Animals that can acquire a disposition to behave in particular ways are probably more likely to be close to exhibiting the behavior as an instinct.

x

x

ii. Long on Medium

			*	
			▲	

Selection is very likely to produce animals that are predisposed to acquire particular dispositions such as imprinting. There would be every reason to believe that some of the "points in the scatter plot" could be installed in an organism by way

of genetic selection.

x

x

2. Continuity Across Unit Domain Factors

Each more molecular unit of analysis is the reductionistic machinery for a more molar unit and each more molar unit of analysis can be seen as the “population” context for a more molecular unit of analysis. An important aspect of these relationships is the independence of the sufficient causal explanation from the reductionistic machinery and molar context. This is analogous to the independence of the causal explanation of the molar properties of a gas (such as pressure) from its underlying individual molecules. The molar properties are absolutely caused by the molecular activities but the molecular causes need not be considered or even known if molar results to molar manipulations of the gas are all that is desired.

a. Molecular Machinery Underlying Short-term Adaptation

i. Cellular Adaptation on Organismic Adaptation

		*		
		*	→	
		*		
		*		

instantaneous

short

medium

long

(1) Connectability

Connectability is a notion which helps integrate various phenomena. It is presumed to be affected by activation or “use” and refers to the probability that an input will form a functional relationship with an output through a particular pathway. Two aspects of connectability are important.

(a) Parallel Connectability

“Connections” can be made at various levels in the nervous system. All are being “built-up” at the same time. The higher the brain structure the more the possible pathways and the more subject those pathways are to learned or ontogenetic influences. For example, in learning a maze, the “higher” level connections are

formed first. These are neuron intensive and labile. When more low level connections are finally made these are neuron efficient and less labile. These "lower" types of connections produce the seemingly anomalous behavior of a well-trained rat running over food to get to the goal box.

(b) Conditional Connectability

Many influences can modulate the probability of a pathway conducting or being formed. The most obvious are hormonal influences. For example, in the spring, some hormones are at much higher levels and probabilities of various functional relationships change accordingly.

(2) Hierarchical Organization

One impact of encephalization could be the emergence of control mechanisms which supervise many lower level control systems already in place. The evolution of some simple interaction between two control mechanisms into a higher level control mechanism itself is relatively easy to imagine.

The conceptual basis of hierarchical control is that successive levels of control do not uniquely arise and then independently organize all the minute aspects of behavior, but rather hierarchical control emerges from the interaction of control areas such that it extends, builds upon, or utilizes the available capacities of the organism. The result would be that several higher level control mechanisms may all exert control over a "motor unit" or receive information from a "stimulus analyzer." Doty has suggested "A recurring theme is that higher centers of the forebrain operate in large measure via their interaction with phylogenetically stable centers in the brain stem ..." Von Holst and von St. Paul demonstrated motor centers for various simple behaviors such as scratching and wing flapping and Hubel and Wiesel have demonstrated low-brain "stimulus analyzers" which responded only to very specific stimuli.

Altman effectively argued for a hierarchical view of behavior. It is based on the belief that organized life forms are reproductively more successful than life forms without organization; that some organizational schemes are reproductively more successful and will therefore predominate in specific environmental niches; that advanced organizational schemes are based on and emerge from preceding organizational schemes; and that variable and changing niches tend to produce increasingly complex control mechanisms that are capable of changing to meet specific changing requirements (i.e., sophisticated organizational schemes).

(3) Encephalization / Deencephalization

A functional relationship, or connection, can occur between an input (anything from a receptor output to particular activity in a sensory cortex) and some output (anything from the input to an effector to particular centers in the motor cortex) as a

result of either ontogenetic or phylogenetic contingencies. Encephalization is the implementation of a relationship in physiological substrates which are sensitive to ontogenetic contingencies, and therefore also refers to the resulting development of those substrates. Deencephalization is the loss of flexibility or the removal of extensive ontogenetic requirements for the implementation of a functional relationship. The path of deencephalization is through the selection of individuals which learn the relationships quicker and more permanently or with fewer and fewer environmental supports. The path of encephalization is through the selection of organisms which must “learn” the relationships, or learn it more slowly, less permanently, or with more dependence on specific environmental contingencies.

Additionally, within an individual, deencephalization is probably the mechanism underlying the “autopilot” characteristic of typing and other automatic activities such as driving, whereas the “voluntarization” of behavior has encephalization as its mechanism (Teitelbaum, Hebb). If a reflex occurs then it can come to be controlled by antecedent events, for example the shift from traction reflex to grasp reflex, to touch-controlled groping, to visually-controlled groping, and even to “voluntary” controlled groping. Birds gape and peck; at shaking nest, at sight of parent, at sight of worm, at sight of earth.

(4) Conceptual Follow-up: Modeling Reductionistic Mechanisms Underlying Short-Term Adaptation

Neural networks.

x

x

ii. Organismic Adaptation on Cellular Adaptation

		*		
		*	←	
		*		
		*		

The fact that an organism's history of interaction with the environment is responsible for the establishment of its neurological organization is often forgotten.

instantaneous — e.g., conditioned stimulus produces hormonal reaction

short

medium

long — learn faster --> change genes

b. The Molar Resultants of Short-term Adaptation
i. Organismic Adaptation on Group Adaptation

				*
			—▶	*
				*
				*

The distribution of factors which result in short-term adaptation, determine the distribution of a particular adaptation in the population. Widely distributed factors which strongly control behavior with little variance result in most members of a population exhibiting that adaptation. In fact, in the past, many dependent measures in the field of Psychology were the percentage of subjects reacting to a procedure. It is the rationale underlying group designs. The implication was the higher the percentage, the stronger the effect on the organism.

instantaneous
short
medium
long

ii. Group Adaptation on Organismic Adaptation

				*
			◀—	*
				*
				*

The actual effect of any treatment applied to the population is on the behavior of individuals. The effect on organisms of contingencies “targeted” to the population is easily seen in the case of fashion. Some specific individuals will wear the advertised clothes; other individuals will not. If the fashion fad were to wear bright chartreuse coveralls, then the individuals reacting to the extracting condition could easily be identified in the group.

instantaneous
short
medium
long