CHAPTER 3

Conceptual and Methodological Issues Pertaining to Short-term Organismic Adaptation

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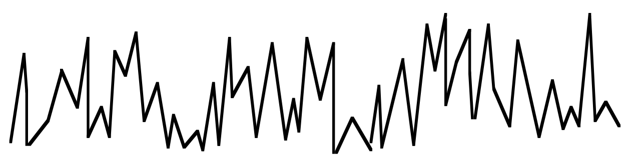
Chapter 3

Conceptual and Methodological Issues Pertaining to Short-term Organismic Adaptation

I. Conceptual Issues

A. Organisms Exhibit Changing Behavior

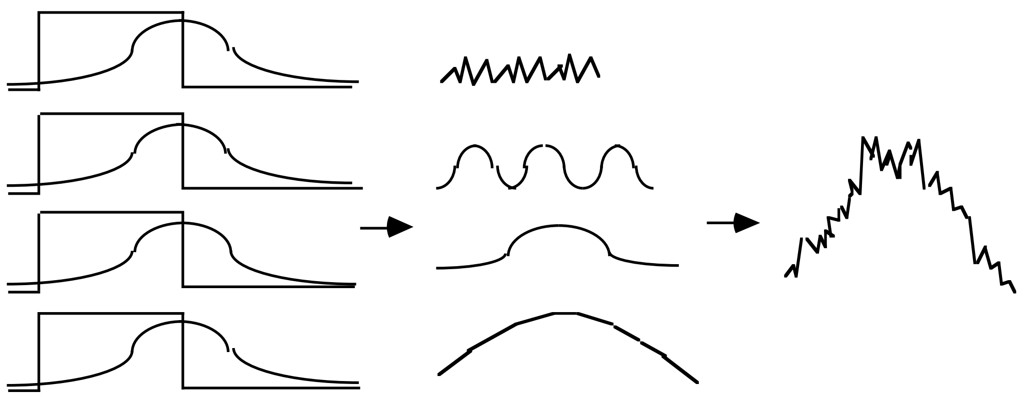
If an organism is observed, it can be seen to do many different things at many different rates. A bee may flit from one flower to another in an apparently random path. A person may watch TV, then study, then play basketball, then talk to friends. Each of these behaviors could be executed slowly or quickly. The following figure could be used to represent this changing behavior.



1. Conceptualizing Behavior Change in Terms of Time Scale

Organismic adaptation can be seen as the equilibration of a system to an environmental change. If the background noise increases, we talk louder. If a behavior provides relative reproductive success, it evolves. If we must learn to play the guitar, we eventually learn to play. If the environment changes again, behavior re-equilibriates. These equilibrations can be classified in terms of the amount of time it takes to asymptote and return to baseline. These time scale classifications were extensively discussed in the paradigmatic context chapter.

The ongoing behavior of an individual simultaneously contains equilibriations at all time scales, much like a symphony is the combination of the various frequencies and amplitudes of the instruments in an orchestra. Fourier analysis is an apt metaphor for seeing that complex behavior is made up of processes at a number of time scales.



B. The Subset of the Behavior Stream which is of Interest

If an organism is systematically observed, relationships between what occurs in nature and what that organism does become apparent. The fact is experience has important effects on the behavior. Our task is to understand how and why these effects happen and to develop a paradigm within which we can integrate them. We are interested in understanding how exposure to the environment changes the behavior of an organism in terms of such things as class, topography, or probability.

1. Understood Truth

We require that our data be "understood" and "true" and not simply a matter of opinion. We require that our subject matter be objective and reliable. Data must be empirical, have multiple converging support, be limited to those things which have an operational/functional definition, and be consensually valid. This rule limits us to the natural (or "real") world, which is as it should be. Further, we must understand the correlative processes involved. The ability to predict, control, synthesize, and explain behavior is essential. These issues were discussed at some length in the epistemological foundations chapter.

C. Elements

The relationships of interest are between observable events in the environment and the acceptable elements are responses, stimuli and time. It would be useful at this point to explicitly enumerate some of the many stimuli and many behaviors which could be manipulated or measured in the pursuit of an understanding of the nature of behavioral adaptation. Note, however, that our actual goal is to identify functional relationships between the environment and behavior rather than to detail isolated stimuli and responses.

The study of behavior entails the manipulation and observation of a variety of events. There are many dimensions across which those elements could change.

For example, a light could change its color or its intensity, and an animal may jump or get a job.

1. Responses/Behavior

Responses include all those objectively measurable activities of an individual life form. These include behaviors as molecular as a single muscle twitch and as molar as a journey or career.

a. Example Response Dimensions

Organisms are always behaving and doing many things simultaneously unless they are dead. Organisms never simply "respond or not respond." Additionally, few behaviors are mutually exclusive. The following list is to provide a sense of the breadth of behavior from which the researcher could choose the most apt for a given research question.

i. Modality (anatomical unit)

(1) Arm
(2) Leg

ii. Vector

(1) Toward a target
(2) Away from a stimulus

iii. Intensity

If various response intensity measures are thought to all represent a common "strength" of some underlying process then they should be correlated. This issue is covered in more detail below.

(1) Latency

Note that the distribution of latencies tends to be skewed and one infinite latency will shift the mean.

(2) Rate

Rate is a measure of probability and can therefore be used to index how the likelihood of a behavior changes over time as a function of the scheduling of reinforcement for that response

(3) Probability

The probability that at least *n* responses will occur in a trial. Most typically, it is the probability of at least one response in a trial.

(4) Quantity

(a) number of pecks
(b) trials to criterion
(i) acquisition
(ii) extinction
(c) number of errors

(5) Force / Amplitude

(6) Resistance to Change

iv. Ratio of Behaviors

(1) choice of alternative A versus B
(2) measure before versus after
(3) IRT distribution

v. Topography

Anatomical or physical form of the response

(1) lever press with hand, palm down
(2) lever press with hand, palm up
(3) lever press with elbow
(4) lever press by sitting on the lever

vi. Molecularity or Assembly Level

(1) muscle twitch
(2) step
(3) trip
(4) journey

vii. Behavior System

Generally speaking the behavior of a system is a function of that behavior system's significant events.

(1) food getting

(2) reproductive

viii. Behavioral Class

Members of a class should show similar functional relationships and members of different classes should show different functional relationships

(1) adjunctive / interim
(2) terminal
(3) facultative

ix. Flexibility

(1) fixed
(2) arbitrary

x. Paradigmatic Significance

(1) Define Sensor Operation as Response

(i.e., Operant). Flows from operant paradigm. Any response with same effect on the environment. One of the substantial ramifications of this conceptualization with respect to the basic experimental apparatus with a key or lever is that **all** of the behavior of interest is detected and recorded, **by definition**. If it fails to operate the recording device then does not meet the criterion for being considered a response. Alternately stated, operant analysis monitors the change in rate of the behavior which immediately preceded (activated) the reinforcer. Behaviors which do not operate the sensors are not in the same class of behavior and are thus irrelevant. Most typically, researchers are not interested in behaviors that look like the reinforced operant or less intense than the reinforced operant, they are interested only in how the reinforced operant is affected by that reinforcement.

(2) Behaviors which look like UCR

(i.e., Respondent). Flows from Pavlovian paradigm. The choice of exactly which of many behaviors is not arbitrary. The dependent variable has a strong relationship with the unconditioned response. The CS becomes in effect the US and the CR is actually some form of the UR. Any unrelated behavior is simply that: unrelated.

Note in reflex conditioning, the behavior could escape detection by the apparatus because the animal is in control of the nature of the conditioned behavior. A very minute eyeblink is still an eyeblink.

(3) Homologue of Behavior in Other Species

Flows from the evolutionary paradigm. The dependent variable is selected because it has some function in common with some homologous behavior in another species.

(4) Any Behavior which Shows Order

Flows from a Baconian paradigm. The dependent variable is selected simply because it varies in a systematic way with changes in the independent variable.

b. Relationships Between Response Indices

When we measure more than one behavior and they both change following a change in the procedure, what do the different measures tell us? When is each measure most appropriate? How do we conceptualize the different dependent variables? Are we measuring a single inner "response strength" or are we measuring functional relationships involving behavior with no commitment as to their correlation? If we believe that we are measuring response strength (all measures tell us the same thing), how well correlated must the behavioral instantiations of that response strength be and how do we conceptualize a less than perfect relationship?

Additionally, in what way do the changing IRTs between responses relate to maze learning? Often both measures are said to index learning and be a function of response strength, but one measure is the organization of behavior in time, while the other is vectors of behavior as a function of a series of choices.

How are we to approach this diversity of measures in a coherent manner? Most likely the proper focus should be on the factors which cause short-term adaptation, i.e., how maze running changes and how IRT distributions change as a result of particular exposures. This changes the question to one of the probability of a behavior (e.g., peck or turn) as a function of environmental factors such as reinforcement history and stimulus or response events.

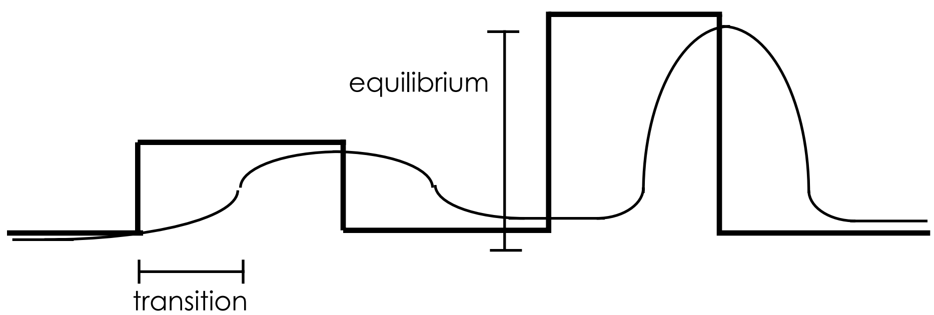
Interestingly enough, both a single underlying response strength view and an independent behavior view both suggest that measuring any behavior could be justified.

- If the various measures are all the same, then we can study any.
- If they are different, then we should study them all so that we can understand why they are related as they are.

We should not restrain the use of a variety of response units and response indices, but by the same token we must try to conceptualize them in some coherent framework.

c. Aspect of Adaptation which Provides the Dependent Variable

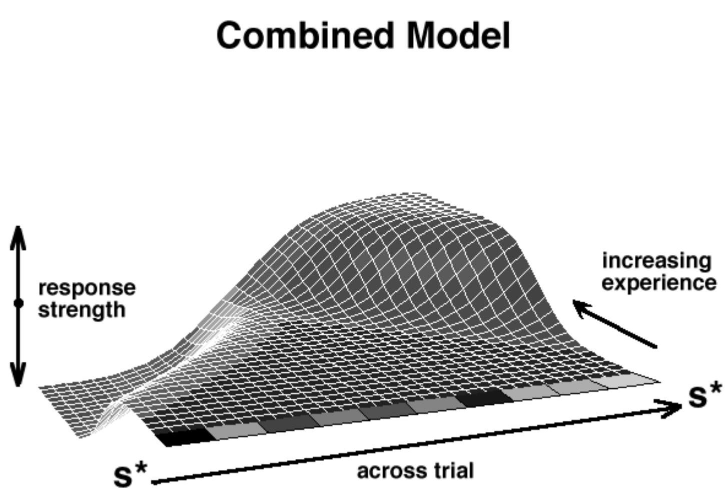
As can be seen in the two figures below, transition measures and equilibrium measures are orthogonal; there is no a priori reason to believe that the time it takes to learn something is necessarily related to its final asymptotic level or the pattern of behavior across the portions of the repetitive task.



If our task is to understand the factors which control behavior, we must determine:

- What factors affect each?
- Within what unit and time domain do each change?
- How do we wish to define learning?
- What are appropriate dependent variables?
- What are appropriate independent variables?

Equilibrium or maintenance measures tell us the probability of the behavior at asymptote at each point in a repetitively presented task (the *x*-axis in the figure below), and what factors move the behavior asymptote by how much within portions of that task. Presumably, the information tells us the factors from which that behavior equilibrium is built.



Transition measures, on the other hand, tell us the probability of behavior at each point throughout the course of the acquisition of behavior to a task (the *z* or front to back axis in the above figure), what factors change that acquisition, and by how much. They tell us the factors from which behavior change is build and tell us about the capacity of the organism, e.g., how hard the task is or how pre-adapted the organism is.

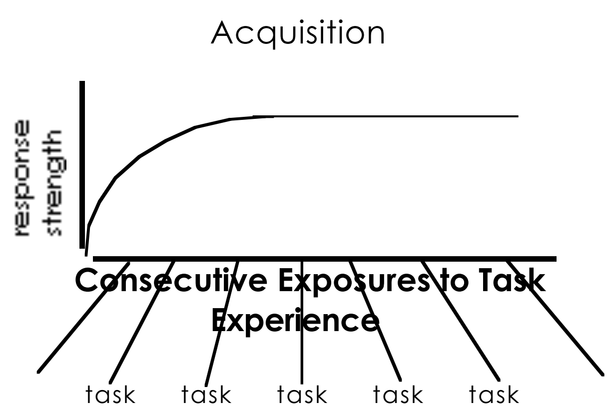
In either the transition or equilibrium case, the task is to understand what causes the behavior to be what it is, not to simply describe it. The important factor to consider is that rarely is a simple acquisition or equilibrium score of interest. Rather, it is how acquisition or equilibrium changes as a function of some independent variable that is of interest. The functional context must be established.

i. Transition (acquisition or extinction)

This measure is a transient dynamic. This measure tells us the mapping of environmental contingency to speed of behavior change; that is, how the confluence of a variety of factors cause differences in the speed of establishing a behavioral equilibrium. Acquisition speed or the learning curve is a prototypical transition measure. It is the degree of preadaptation for that functional relationship, behavior change, or "association."

Reductionistically, these changes in the speed of transition could be caused by the phylogenetic and ontogenetic changes in connectability discussed by Teitlebaum.

Note that the Rescorla-Wagner model specifies only the acquisition time course; it does not specify a behavior or its vector.



(For a second read through.) Note that behavior change (i.e., transition) at any time scale requires a contingency and that a contingency requires the "big four":

1. different antecedent behavior or stimuli (e.g., Stimulus A Stimulus B)
2. different subsequent events or outcomes (e.g., Outcome 1 Outcome 2)

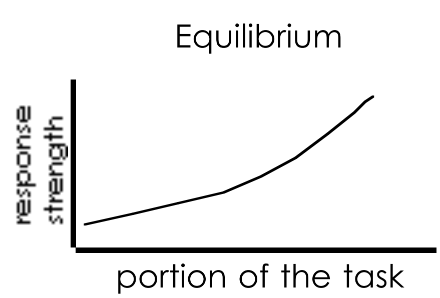
3. contingency (i.e., differential probability of 1 + 2 with A and B)
4. exposure to all four (i.e., A1, B2, A1, B2)

Tidbits
This is z-axis (front to back) on bipolar model.
This is by necessity z-axis. If it were x-axis, then it would be an equilibrium measure.
Resistance to change.
Degree of preadaptation.
Capacity of organism or behavior
Time is an essential element.
It is a process.
It takes time.
Growth of difference.
Speed test.
AC characteristics of op amp.
This is reminiscent of IQ where IQ is (amount of previous learning) * (breadth of previous learning).

ii. Equilibrium ("steady state")

This measure is a synchronous dynamic. This aspect of behavioral adaptation tells us the mapping of environmental contingency to amount and vector of behavior change at asymptote, such as the rate maintained by a VI 60-sec schedule or the shape of the average FI "scallop." It is how differences in the confluence of a variety of factors cause differences in the measures of behavioral equilibrium. It is the degree and vector of impact caused by that combination of environmental factors. It is often labeled the "optimal" behavior to a given contingency but that is true only in the sense that the obtained behavior is the asymptotic performance.

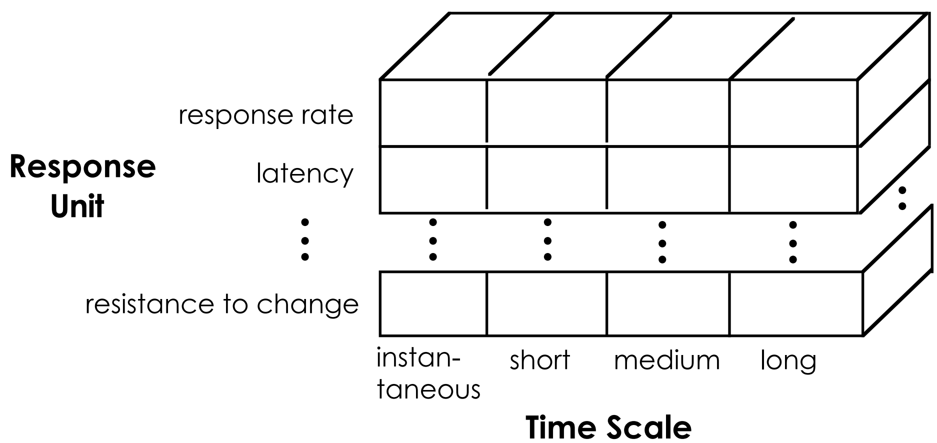
Maintenance measures tell us the probability of a behavior, what factors move behavior in what direction and by how much, and tell us the factors which result in specific end states, which could be labeled the "final cause" of the behavior transitions.



Tidbits
This is x-axis (left to right) on bipolar model.
Independent of time in the "time course of learning" sense.
It is a level or phenomenon.
Steady-state point of equilibrium.
Power test.
Static.
DC characteristics of op amp.
What difference in environment causes what difference in behavior?

d. Spatial Representation of Response Unit * Time Scale

Most response measures could be used to measure the dependent variable at any time scale. For example, if the temporal frame of reference changes appropriately, the notion of latency could be applied to a reaction to a stimulus, the learning of a response, the establishment of a personality, or the evolution of an instinct.



2. Stimuli/Environment

Stimuli include any objectively measurable events in the environment. These include stimuli as molecular as a light flash and as molar as all the events of a lifetime.

a. Example Stimulus Dimensions

The following is a simple enumeration of some potential stimulus dimensions or ways stimuli can differ. Each dimension is followed by examples. The intent is to provide some sense of the breadth of stimuli available. Each is especially apt for some research question.

i. **Modality (sense organ)**
   (1) vision
   (2) olfactory
   (3) auditory

ii. **Intensity**
   (1) one candle
   (2) sun at noon

iii. **Spatial Location**
   (1) left right
   (2) up down

iv. **Quality**
   (1) red
   (2) green

v. **Quantity**
   (1) amount
      number of stimuli, size of dot
   (2) scaling
      absolute
      number of JNDs

vi. **Degree of Likelihood to Enter into Relationship (salience)**
   (1) obvious, important, attended to
   (2) subtle. obscure, ignored

vii. **Vector of Controlled Behavior**
   (1) appetitive stimulus
   (2) aversive stimulus

viii. **Behavior System**
   (1) food getting
   (2) reproductive

ix. Flexibility
(1) constrained
(2) arbitrary

b. Time

Because time cannot be turned on and off and because no sense receptor for it has been identified its ultimate status appears impossible to establish. For convenience and because it seems to function as a stimulus time is categorized as a stimulus.

3. Stimuli and Responses With Respect to Dimensions of Research Activity

The "dimensions of research activity" theme which integrates the subsequent chapters of the present manuscript explicitly deal with both stimulus and response dimensions. The following information logically fits here but will be most useful after having read subsequent chapters. It is placed here for your second read through.

Dimensions of Research Activity	**Response**	**Stimulus**
Degree of ontogenetic contingency history (Degree of element flexibility)	Potential for arbitrariness arbitrary response … like UR	Potential for arbitrariness neutral … functionally significant … biologically significant :as cue :as consequence
Degree of stimulus independence	extended journey … muscle twitch	continuous context versus differentiable punctate "separatableness"
Degree of complexity in concurrent determination	Proportion of responses to each alternative	Simultaneity of controlling stimuli

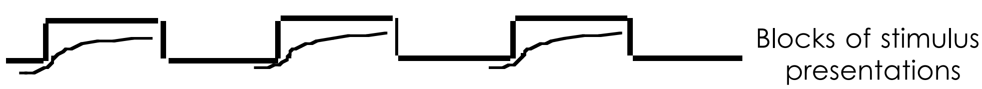
D. Short-Term Organismic Adaptation

In the present case, we are not interested in all possible behavior changes which occur as the result of all possible environmental changes. We are interested only in those changes which take place across the minutes to days time scale. We can exclude instantaneous (perceptual), medium-term (developmental), and long-term (instinctual) effects by holding them constant.

Observation shows that there are two kinds of behavior change which occur within the minutes to days times scale. Those that exhibit similar hysteresis at both onset and offset and those that have an onset hysteresis but no offset hysteresis. The term short-term adaptation is reserved for those changes which exhibit both onset and offset hysteresis.

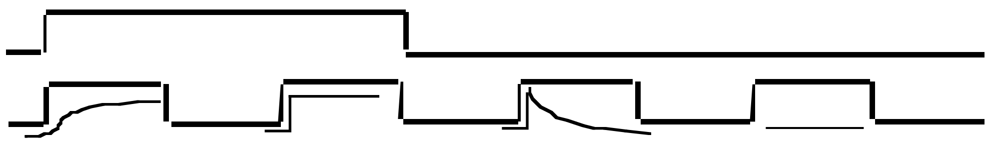
1. Adaptation Via Single Stimulus Exposures (non-associative) "Pseudo" Short-Term Organismic Adaptation

Many behavior changes occur "simply" as the result of single stimulus exposure. Habituation and fatigue are examples. These differ from "learned" or short-term associative adaptation in that habituation and fatigue disappear with nothing more than the simple passage of time, rather than requiring exposure to some contrary contingency. Additionally, they show the same hysteresis every time the series of exposures is presented. In a computer metaphor, this adaptation is like RAM.



2. Adaptation Via Contingencies Between Events (associative) Short-Term Organismic Adaptation

The behavior changes in this category are the result of exposure to specific relationships between events. That exposure results in short-term associative organismic adaptation. This class of adaptation does not spontaneously reverse with the passage of time. This adaptation requires the exposure to contrary contingencies to reverse. This second type of adaptation is labeled short-term organismic adaptation or "associative learning." It is the focus of the present manuscript. Short-term adaptation has hysteresis in both the acquisition and loss of the functional relationship. In a computer metaphor, this adaptation is like a CDRW.



3. The Evolutionary Origin of the Capacity for Short-term Adaptation

Recall at this point the discussion on plausible origins for short-term adaptation which was presented in Chapter 2 Section (1).

There is covariance in nature. Any organism that differentially behaves on future occurrences based on that covariance (information) will have greater relative reproductive success.

4. Locus of Short-term Organismic Adaptation

The referent for short-term organismic adaptation is a change in the functional relationship between the environment and behavior as the result of exposure to contingencies in the environment which exhibit a specific time scale. The locus of that change is irrelevant, but some conceptualizations are more productive than others.

a. Body Versus Mind

We cannot suggest that biological changes involve a change in some constituent or process in the body while psychological processes do not involve biological changes. Psychological changes which do not involve the body would imply that those changes exist outside the natural world at the locus labeled "the mind" – an unnatural entity. While our explanations need not consider the biological mediators, that does not imply that they are not involved, and it does not imply that "learning" can be defined **as opposed to** a change in the "body."

b. Behavior Versus Body

It is equally fallacious to suggest that the proper explanation for behavior is by appeal to the body simply because behavior changes involve the body rather than the mind. If reductionism is the most acceptable explanatory path, then one cannot stop at biology, but rather must proceed all the way to physics. Clearly all behavior changes ultimately involve changes in the strong and weak force and the electromagnetic force. It should be obvious that it would be of little practical help to discuss the cause of behavior change in terms of either biology or quantum forces.

There is an additional step beyond the traditional mind/body problem that psychologists must take. We are psychologists not biologists and therefore we study behavior with respect to its controlling variables **as opposed to** studying the organism(or the body). As previously presented, the appropriate explanation for behavior is by appeal to the environment.

Our task is made more difficult by our language tradition which typically describes things with the subject of the sentence being the animal rather than the behavior which is our actual interest. For example, we typically, but wrongly, say we like or dislike a person. We rarely say we like or dislike the behavior of that person. People often wrongly talk about rewarding or punishing the person rather than rewarding or punishing the behavior.

i. Useful Heuristics

(1) Avoid Reference to the Animal

Because we are interested in behavior rather than the animal, a useful heuristic rule is to avoid reference to the animal whenever possible. We are interested in movement, not the thing that moves. Focusing on the organism (as well as the organism within the organism) can lead us down blind alleys. If you avoid references to the animal, you must then focus on behavior. For example, the construction “when a peck occurred it was followed by food presentation” forces attention to what is actually happening. The construction “when the bird pecked, food was presented” can lead one to think that the bird was reinforced and can lead one into the tautology that the bird was the source of control over its own behavior.

Note the subtle shift from the natural world to problems of our own manufacture in the following series of “descriptions” of the same event.

- A key peck occurred when the light came on..
- The pigeon pecked the key when the light came on.
- The pigeon learned to peck the key when the light was on.
- The pigeon learned to peck the key in order to get the food when the light was on.
- The pigeon learned the rule “key pecks produce food when the light is on.”
- In order to get the food, the pigeon learned to use the rule "key peck produces food when the light is on" whenever the light came on.
- In order to get the food, the pigeon came to understand the “meta-rule “causation.”
- and on and on...

If the environment or the behavior is the subject of the sentence, that is where you and your readers put their attention and that correctly places the source of the action connoted by transitive verbs. In this regard, it is interesting to note that when other people do something bad, we tend to attribute it to the person or an internal cause. When we ourselves do something bad, we tend to give the environmental influences as causes. This shows that people may be ignorant about the determinants of behavior when it comes to others, but they are pretty insightful when it comes to understanding the determinants of their own behavior.

(2) Avoid the Active Voice with Respect to the Animal

A second useful "heuristic grammar" is to not use the pigeon in the active voice. When you must refer to the animal. If the "pigeon" is passive, then it is much easier to maintain our focus on the actual controlling variables, rather than to tautologically imply that the pigeon is the explanation for its own behavior. For example, "following 30 days of FR training, responding began within 2 seconds of the trial onset." In this case, the independent and dependent variables are obvious. On the other hand, "when the pigeon had learned the task for 30 days, he knew to respond right away." In this case, we are led to look inside the pigeon's head for the explanation for the behavior.

A second problem with the animal in the active voice is that you can be led into believing things that are simply not true. For example, it is a fact, when you say "the pigeon was exposed to the red light." You really don't know any more than that. To say that "the pigeon saw the red light" or "the pigeon understood what to do when the red light came on" is not necessarily true and you have no business saying it.

Putting causes into the pigeon that you simply make up leads to an infinite range of meaningless pseudoexplanations. For example, if the pigeon did not peck the key when the light came on, is that because the pigeon:

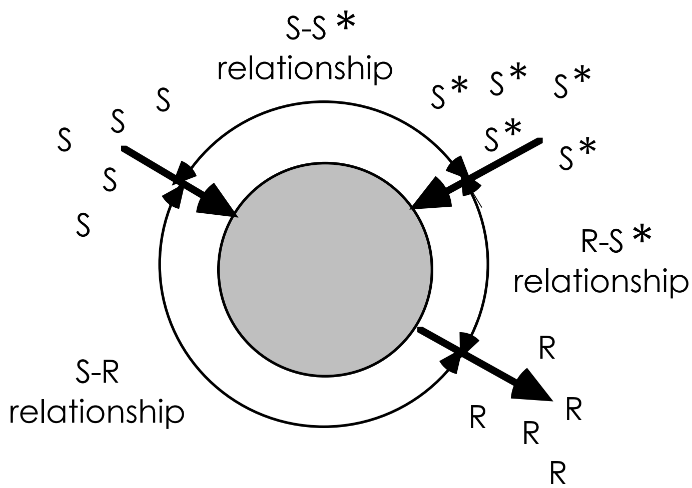
- did not notice the light
- failed to encode the information
- failed to retrieve the information
- failed to use the information
- failed to want to decode the information
- failed to understand which strategy to use
- actively wanted to encode the information incorrectly
- was being passive/aggressive
- had a need to fail
- etc.

(3) Focus on Functional Relationships

Research is the separate manipulation of environmental factors until the cause is isolated. The only data of interest are functional relationships, therefore we must emphasize the functional relationship between stimuli and behavior as the object of our research and the subject of our sentences. Our focus is on a relationship (between inputs and outputs) rather than just stimuli in isolation or just behaviors in isolation.

The interest is in revealing the specific factors that produce the effect thus reducing the animal's "will" or "mind" (or whatever an inner animal independent of the environment could be called) to an irrelevancy. It's **not** that the animal does not exist, nor that it has no brain, nor even that it is not "thinking" or even that it is not "conscious." The point is: the environment is the only useful and therefore meaningful explanation for why the behavior occurs or does not occur.

If an animal comes to salivate to the precursors of food, we want to understand that process in terms of its real world determinants. A summary of our task is illustrated in the following figure; we want to specify the relationships between stimuli, reinforcers, and behavior. What kinds of experiences produce the salivation, how much produces how much, what makes it change, what makes it stop, etc?



It is informative to stop for a moment to recall that your task is to understand behavior and to make empirical, falsifiable, meaningful predictions about behavior not to generate eloquent sounding words. Ask yourself which is better: a stupid subject or a stupid experimenter (recall that "stupid animals prove .....").

c. Coda: Correlative Versus Reductionistic Explanations for Learning

The point of this section has been to counteract the debilitating effect of our language tradition on psychology. Our "common sense" often describes behavior with an implied sentient homunculus inside the organism as the cause of the behavior, e.g., "the pigeon saw the stimulus and knew to respond." The implication is, that it somehow helps to know that some inner telephone operator is guiding the organism.

Pavlov's great contribution was to realize that simple empirical analysis was the key to understanding how or why animals learned to be adaptive. Rather than waxing eloquently about how smart the dog was by salivating in an adaptive way, Pavlov determined the environmental prerequisites of that behavior and thereby actually understood why the dog salivated. He wanted to know the cause of the learning. By pairing a bell with meat powder, he was able to get a perfectly normal dog to salivate when he rang a bell (a manifestly stupid thing for the dog to do, if you don't consider the learning history of the dog).

Pavlov could have claimed that a "contingency realization center" caused salivation rather than to do the experiments to actually find out why the dog salivated. He would have then proved the dog smart and himself stupid. By some twisted logic, Pavlov could have asserted that the dog had a contingency realization center and he could have then done the experimental analysis to show that the history of pairing bells and meat powder were necessary for the contingency realization center in the dog to understand what was going on. But, that would be a useless "middle man." If A causes B and B causes C, then A causes C. When B has no known properties beyond its relationship with A and C, then it adds nothing to our understanding of causation.

If you were allergic to something in your new apartment, you would do precisely the same things. It would be foolish to be happy with knowing nothing more than the fact that your foreign-agent-rejection processing center was rejecting something that you were experiencing. You knew that when you started to sneeze. Besides, if you are going to accept a nonempirical reductionistic causation, then you have to accept that it may be a hyperactive sneeze center, or a hypoactive sneeze inhibition center, or even a need to hate your mother which was sublimating into a symbolic expulsion of mother's milk. What a reasonable person would do is to start systematically manipulating what was in their apartment until they stopped sneezing when they were in their apartment. They would go on to return the item to see if they began sneezing again. After that, they could with confidence use that knowledge to avoid problems in the future.

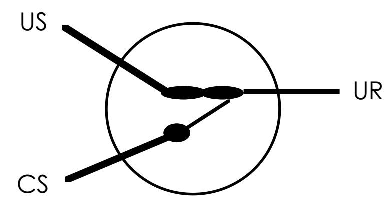
i. Traditional Reductionistic Representations of Learning (increments in "knowledge" or "connections")

From a reductionistic perspective, learning is seen as the acquisition of "knowledge about the world" or the "strengthening of connections." Research involves all those questions that come to mind when learning is considered a thing that is inside the head, for instance. How hard is it to get "it" in there? How long does "it" stay? How is "it" encoded? How is "it" decoded? How is "it" used? How long does it take to use "it"? Do you have to want to use "it"?, etc.

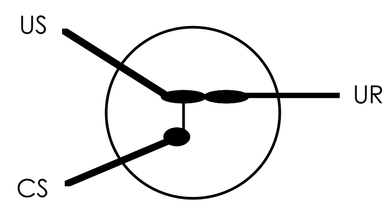
In the case of "knowledge gain," the philosophical conundrum of exactly **who** or **what** (e.g., telephone operator) was using this knowledge and how **IT** gained the wisdom to use the knowledge acquired by the body is ignored or overlooked. How does the inner telephone operator learn to tell the body to salivate when it hears a bell? In the case of "strengthened bonds," the relevance and reality of the mechanism is unnecessarily accepted. As an actual process which intervenes between the input and output, they are only a guess. As variables which may or may not be real, neither are necessary.

(1) Reflex or Pavlovian Conditioning

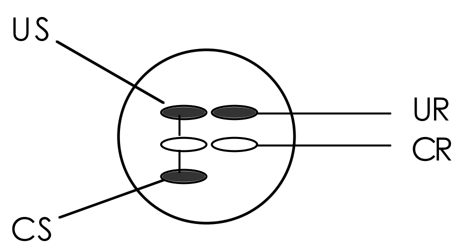
(i) S-R Connection



(ii) S-S Connection

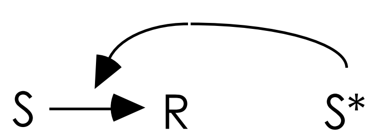


(iii) US Representation



(2) Operant or Thorndikian Conditioning

Thorndike argued that behavior change which shows short-term hysteresis is the result of strengthening a connection between a stimulus and a response.

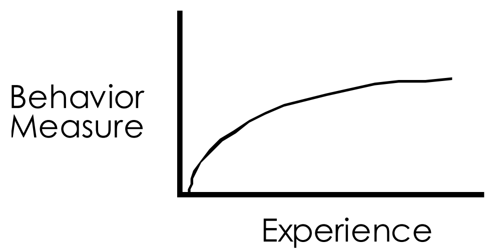


ii. Correlative Representations of Learning (input/output relationships which show short-term hysteresis)

A more appropriate perspective for conceptualizing what is traditionally labeled learning is to avoid constructs which lead to infinite regresses in explanation. In this case the task becomes the documentation of how behavior is altered by changes in the environment. In particular, functional relationships which can be brought into existence and can be "driven from" existence over a short time span (seconds to days) as the result of exposure to contingencies between events in the environment (e.g., if when the red light is on pecking is followed by food, and when it is not red, pecking is not followed by food; then pecking will come to occur to the red light over the course of several hours).

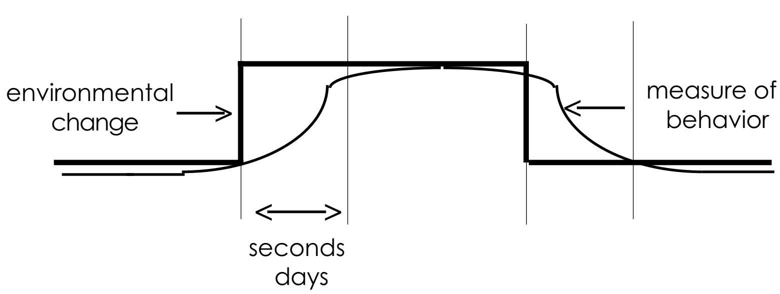
(1) The "Learning" Curve or Behavior Change

The following figure emphasizes a traditional aspect of learning. It is the acquisition of some behavior. It need not be taken as only the shadow of some internal process; it can be taken as is.



(2) Behavioral Adaptation to Environmental Change

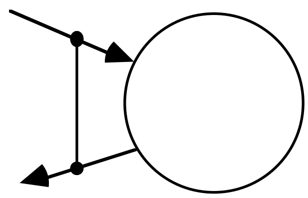
The figure below emphasizes that we are interested in behavioral adaptation (i.e., an equilibrium) to an environmental contingency which is acquired and reversed over a short time span.



Both states should be seen as equilibriations to the contingencies in the environment.

(3) Functional Relationships

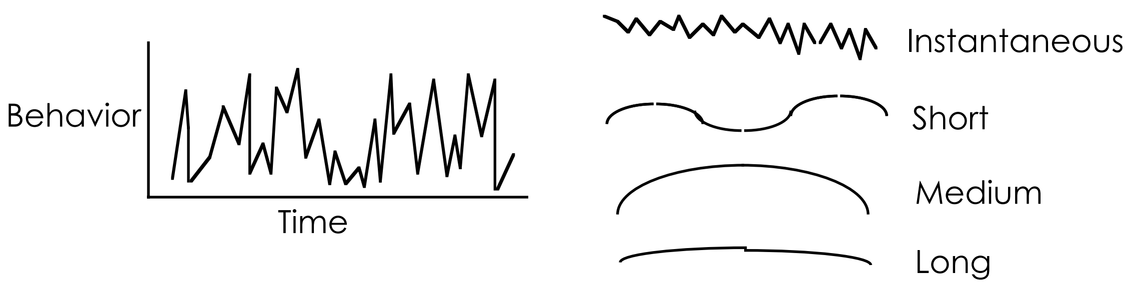
The figure below emphasizes that our explanation must be at the same level of analysis as our data rather than reductionistic or the percentage of a population of individuals reacting.



Behavior is to be understood and explained as functional relationships between inputs and outputs, or environmental conditions and organismic behavior.

(4) Fourier Metaphor

The figure below emphasizes that the most appropriate way to unravel the behavior of an individual is to see it as a complex combination of contingencies and resulting behavioral adaptation which occurs across many time scales.



Most often factors affecting time scales other than the one of interest are held constant in order to avoid confounded interpretations.

(5) Quasi Reductionistic Representations of Short-term Correlative Behavioral Adaptation

(i) Reflex or Pavlovian Conditioning

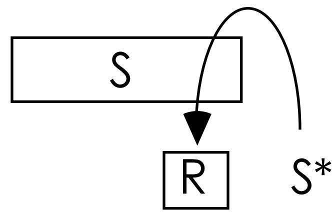
$$\text{UCS} \;\text{——}\; \text{UCR}_{\text{US}}$$

$$\text{CS}\;\; \text{UCS} \;\text{——}\; \text{UCR}_{\text{US}}$$

$$\text{CS} \;\text{————}\; \text{UCR}_{\text{CR}}$$

(ii) Operant or Thorndikian Conditioning

Ferster and Skinner argued that short-term behavior change was the result of strengthening a behavior class in a context.



Ferster and Skinner stated the process in this way in order to diminish the role of a "connection" between the S and R and to also provide for behavior that seemed to have no "eliciting" or "evoking" stimulus. A more correlative version simply states that the probability of a behavior given a stimulus was increased and does not rely on the concept of strengthening a response.

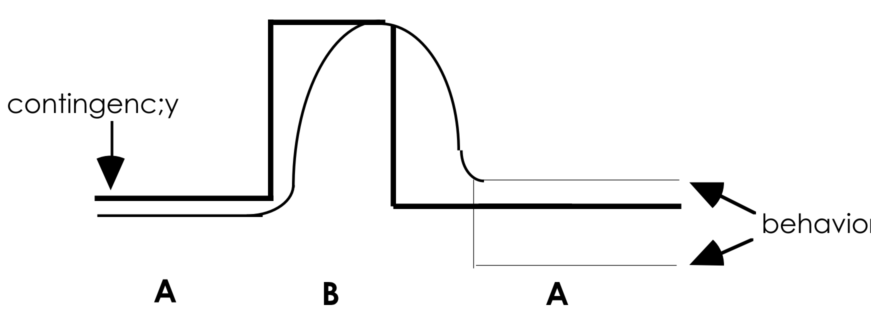
5. Conceptual Follow-Up: Time Scale Interaction

a. Behavior Irreversibility, Carryover, and Plasticity

While these are provocative from the perspective of learning researchers, these effects are the meat and potatoes of developmental research.
The descriptive class (i.e., time scale) of this particular behavioral adaptation is by definition medium-term because it does not adapt or show reversibility across a short time. However, these medium-term effects are subject to experimental treatments just as are short-term adaptation. Behavioral research on medium-term adaptation would study the factors which affect the acquisition, maintenance, and loss of these "irreversible" behavior changes, just as research on any other time scale of organismic adaptation. If research is on medium-term behavior change, then it is necessary to carryout whatever procedures are needed for demonstrating causal relations

i. Irreversibility of Equilibrium Rate

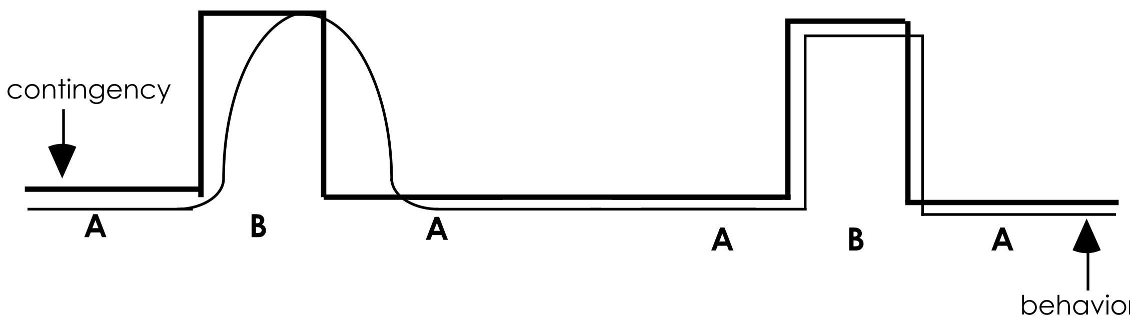
Following some treatments, it is difficult or impossible to regain baseline.



Following peck training (or learning to ride a bicycle), it is occasionally difficult to get the operant rate to drop to the initial base rate. Other procedures may result in the recovered baseline rate being below the original baseline.

ii. Irreversibility of Adaptation Speed

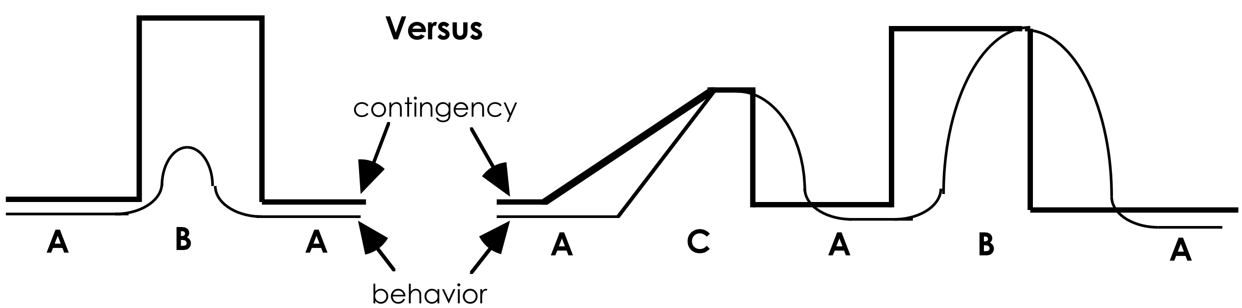
Learning a task for the second time often proceeds much more quickly than the first time.



Exposure to what would seem to be the same conditions produce different results.

iii. Behavior Plasticity

Often it is difficult to establish some new behavior in one step, but following some intermediate training that behavior is easy to establish.



For example, an FR 500 is virtually impossible to establish as an initial requirement. However, following a gradual acquisition of FR 100 training, the FR 500 task is relatively easy.

b. Time Scale Interaction

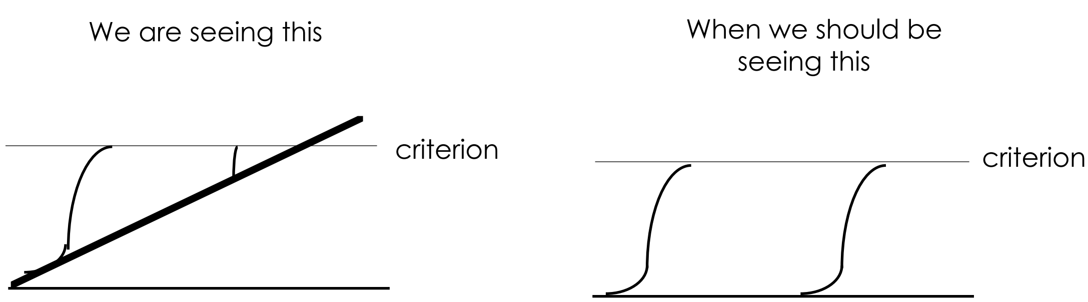
Variations in reversibility, carry-over, and plasticity may best be seen as interactions between short- and medium-term adaptation. The simple fact is that when learning procedures are implemented, variations can occur in other time scales. If other time scales are affected, then they function as confounds.

The extraction of a short-term effect from other time scale adaptations can be illustrated by using a correlation metaphor. We want something like the residuals of partial correlation. Medium, instantaneous, and long-term effects are vectors that must be partitioned out. We want only the deviation from the remaining vector(short-term) none of the components of the vector itself.

Those adaptations that occur at other levels and are not being measured function as confounds, while those ancillary changes at other levels that are being measured could function as components of an explanation. But, obviously this very general perspective may not be necessary in every case, in that “learning” refers to changes only across a short-time scale and most often everything is held constant.

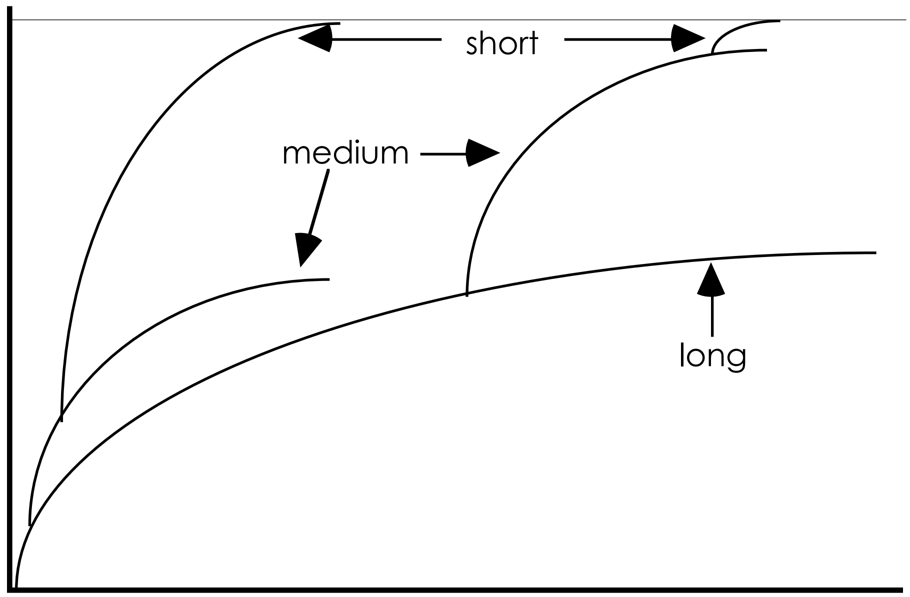
There are several ways to depict a time scale interaction such as those that occur when the time course of the results of short-term procedures are changed due to changes in the amount of medium-term adaptation.

The illustration below demonstrates that it may take more or less time to reach a criterion if the level of medium-term adaptation is changing. In this case, we are confounding a constant short-term effect with a change in a medium-term effect.



The pretraining effect (heavy line) shown on the left is, by definition, a medium-term effect and is the result of extended experience. It is a relatively nonreversible effect within the life of the individual and is therefore developmental rather than learning. Medium-term effects are the impact of extended experience on-the-course-of-behavior-change, as-a-function-of experience.

The interaction of long-term (evolution), medium-term (developmental), and short-term (learning) could be depicted as,



6. Grouping

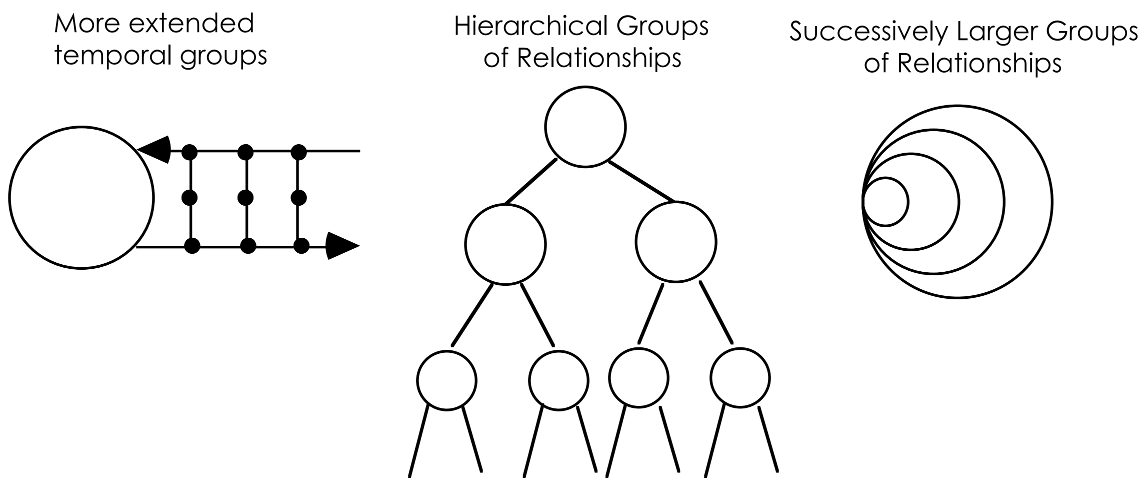
a. Grouping Based on Degree of Molecularity or "Assembly Level"

In the same way that all of nature can be partitioned into levels of molarity in the unit domain (e.g., cells versus organisms discussed in Chapter 2), so too can short-term associative behavioral adaptation be partitioned into grouping levels of finer or coarser detail (e.g., a muscle twitch versus a career). "Degree of molecularity" rather than "level of molarity" is used as the label for the degree of detail in the behavioral grouping of interest when referring to short-term organismic adaptation in order to reduce confusion in the present manuscript. But you should be prepared for the terms "molarity" or "molecular" to have a wide variety of meanings in the general literature.

Any behavioral unit includes many finer units and is itself a component of a more complex and larger group. This relativity applies to both response units (e.g., a muscle twitch to a journey) stimulus units (e.g., light flash, to all the words in a book) and for contingencies (e.g., a punctate stimulus with food, to experimental session with feeding opportunities). The chosen unit or level of focus on is therefore somewhat arbitrary.

The degree of molecularity of the behavior measured may be nothing more than grouping size but could entail additional processes. In that case we would need new laws for the emergent functional relationship which relate the more complex behavior to the more complex environment.

The following figure illustrates three different kinds of "degrees of molecularity." The first behavior example is made up of longer temporal units, the second is made up of higher and lower elements in a hierarchical structure, while the third simply contains more elements.



The use of finer degrees of molecularity in the study of behavior could be argued on evolutionary grounds. The logic being, if evolution advances by establishing hierarchical assemblies to produce more and more molar behaviors, then it is likely that evolution proceeds in small steps and relatively small units would therefore have wide generality.

Different levels of molecularity lead to different threats to meaningful explanation. Holistic groupings encourage mentalism through such constructs as "information" (The obvious problem in this case is, what uses the information? Is there really a telephone operator in the head?) and atomistic groupings encourage physiologizing through such constructs as S-R or S-S "connections" (The obvious problem in this case is what is the locus of the connection and what is its nature?). These threats to meaningful correlative explanation underscore the purpose of avoiding referents to organism doing things and elements connecting input to output.

But what level of molecularity or grouping is correct? Below a totally holistic grouping, the stopping point can be arbitrary. The research focus should be at a unit which:

1. is describable by laws
2. is atomistic enough to be easily manipulated in isolation
3. is simple enough to be understood without a "tag team" explanation (those which just dump the problem in someone else's lap)
4. can be easily assembled into holistic behaviors
5. provides for maximum paradigmatic knowledge gain

The degree of molecularity or unit of behavior had a very important impact in early theorizing about behavior. The difference between Hull and Tolman could be seen as the difference between studying footsteps and studying journeys. Tolman focused on goal attainment as a unit. In Tolman's case research assessed what precipitated or terminated that goal attainment; alternatively, in Hull's case, research focused on what altered the steps taken to attain that goal.

Issues such as how the animal thought out the solution, or read a map or how drives were multiplied by habits became impediments because they were both heuristic tools created by the theorists which quickly became reductionistic mentalisms or physiologizing which distracted attention from the systematization of the empirical functional relationships.

The obvious goal of the analysis of behavior is to understand both the small units of behavior as well as the larger structure. If laws obtained from one apply to the other good, either can be studied. If the laws are different, then both large and small groupings of behavior must be researched.

7. Continuous Versus Discrete Models of Organismic Adaptation

a. Continuous Models

e.g., linear operator; e.g., Bush / Mostellar
x
x

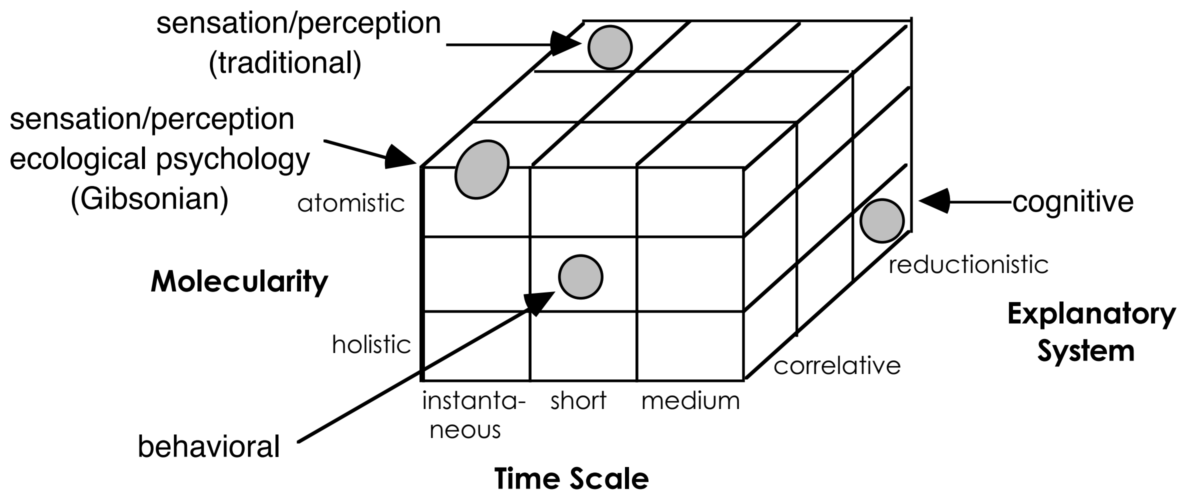
b. Discrete Models

e.g., Markov Process; e.g., Theios / Brelsford
x
x

E. Side Note: Molecularity, Time Scale, and Explanatory System

The following figure helps develop an understanding of short-term organismic adaptation by relating that functional class to its neighbors. As can be seen, the conceptual space has molecularity, time scale, and explanatory system as its axes. The study of sensation examines instantaneous behavior change (left slice of cube) typically of an atomistic behavior such as skin sensitivity (top surface of cube) and relates the effect to either an internal reductionistic perceptual center (back edge of cube) or to the types of exposure given to the organism (front edge of cube).

A cognitive researcher typically looks at medium-term (right slice of cube) holistic behaviors (lower surface of cube) and uses a nonempirical reductionistic explanatory framework (back edge). Behavioral research tends to study short-term adaptation (middle slice) and relationships such as key pecking in a matching task (middle surface), and uses a correlative explanatory framework (front edge).



The figure illustrates the three axes which differentiate typically behavioral and cognitive research. The unfortunate thing is that the defense of an interest in the important questions pertaining to medium-term molar behaviors has come to encompass a defense of a reductionistic explanatory scheme. In fact, it has often finessed otherwise reasonable researchers into arguing for what is in effect, mentalistic causation.

II. Methodological Issues

A. Choice of Subject, Apparatus, and Procedure

Obviously, if we are studying behavior, we must have a life form to do the behaving and an apparatus and procedure with which to manipulate stimuli and measure the resulting behavior. Several dimensions must be considered when selecting a subject, apparatus and procedure.

1. Conceptual Issue, The Impact of the Chosen Basis for Generality

Knowledge can be generalized on the basis of simple naive notions of similarity, or on the basis of understanding what's going on. This has led to two research strategies: 1. research emphasizing similarity to maximize generality and, 2. research emphasizing the understanding of the mechanisms of action and the control of confounding factors to maximize generality.

"Similarity" research is often done in the “real world” with "real" people or at least primates while "understanding" research is often done in the laboratory with very synthetic situations and very nonhuman subjects. "Real world" subjects or settings are maximally similar to the target in an effort to establish generality. Unfortunately they typically introduce many confounds which seriously undercut their actual generality as well as limiting the information they produce. The raison d'etre of synthetic subjects or settings is to maximize our ability to understand the true causal factors and thereby maximize generality to the target. Unfortunately synthetic subjects and settings could fail to generalize due to misunderstood or unaccounted for differences between the model and target.

If the task is simply to develop knowledge applicable to a narrow range of situations such as for a simple technical knowledge, then naive notions of similarity will often adequately serve as a basis for predicting generality. This is the rationale underlying vocational training programs. It is important to note however that if the student is expected to predict in a variety of situations, errors of prediction will occur, and those errors could have important consequences. That is of course, what separates professionals from technicians. A psychological technician is no less different than a psychologist, than a medical technician is different than a physician.

2. Optimizing the Methodology

Conditioning and learning research based on the use of pigeons pecking to colored stimuli for access to food pellet reinforcers, in sealed experimental chambers with transilluminated keys, and food magazines under schedules of reinforcement is not an accident. Every detail of this methodology is the result of decades of optimization. The choice of pigeons and "Skinner boxes" were a minimizing solution driven by a desire for the most apt and convenient methodology. That is, the interest is in a subject, apparatus and procedure which best reveals the laws of nature while at the same time is easy to use and is inexpensive.

Pigeons are pests in nature (they are in no way endangered). They mature rapidly (are ready to use at an early age), and live for about 20 years (can be used for a long time). They are behaviorally stable for most of that time (any behavior change is organismic adaptation rather than cellular adaptation). They are small, inexpensive to maintain, easy to handle and very rarely exchange diseases with humans. They have very good color vision. This enables the use of colored stimuli which are easy and inexpensive to produce. Light is easy to control in the environment with a simple light tight chamber. On the other hand, for example, auditory signals are easy to produce but extremely difficult to eliminate from the background. Key pecking is used as the response because pigeons can engage in it for hours with little or no fatigue and it is a behavior which can be made to "record itself." If the behavior is defined as "that which operates the key," then each occurrence of the behavior is easily and reliably monitored with a computer programmed to react to each key operation. If the animal fails to operate the key, then by definition, it did not emit the behavior of interest but rather some other behavior. The key is transilluminated (or back lit) because it assures that the pigeon is at least pointing its eyes at the stimulus if not actually "attending" to it. Food pellets are used as the reinforcer because they are easy and inexpensive to present and remove, they are a “natural” reinforcer, the food is inexpensive and easy to store, and it is straightforward to maintain a constant hunger motivation level without extraordinary procedures.

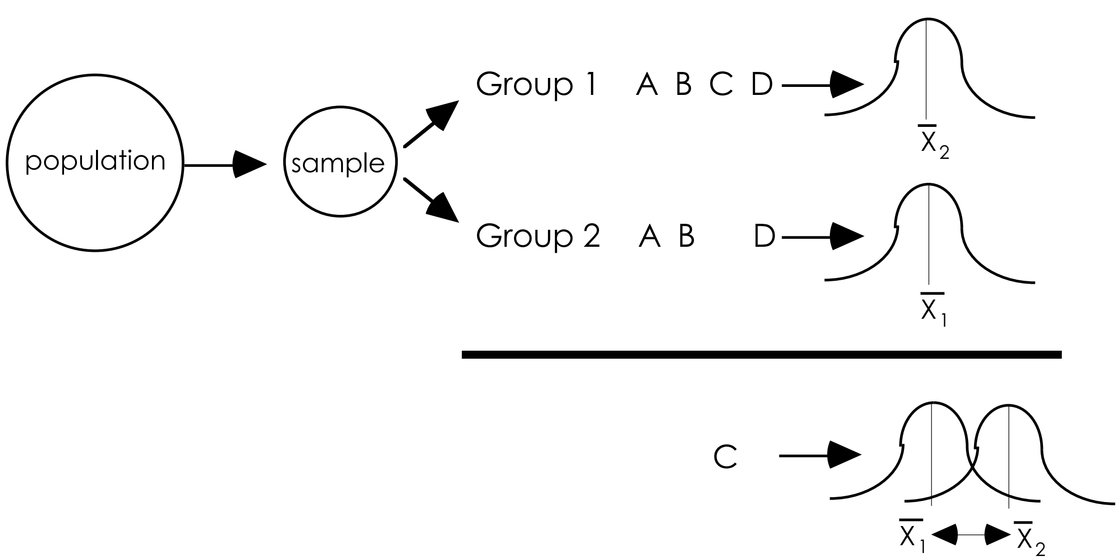
Schedules of reinforcement are procedures which carefully control the context of behavior at the moment of reinforcement (e.g., an FR 50 assures that a peck is always reinforced in the context of 49 previous pecks). The types of contingencies standardized in schedules are typically considered the "atoms" from which all behavioral contingencies are built.

B. Experimental Design

We will depend on the experimental method of assuming that differences cause differences. The logic is much the same as using an analytical balance and tareing the container in order to measure the weight of only the water in the container. It is also the same as subtracting one equation from another in order to find the difference.

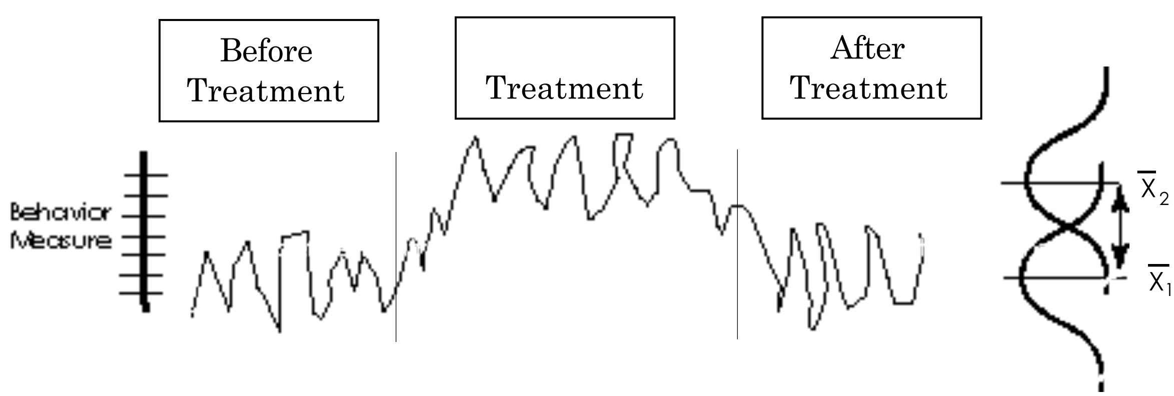
1. Group Design

In group designs, different groups of subjects serve in the treatment and control conditions. Clearly, the two groups must be as similar as possible and must be treated as much the same as possible, with the exception of the independent variable. In this way, everything but the independent variable cancels out as a potential cause for the difference in the dependent measures (plus any minute differences between the two groups that crept in). Below A B D subtracted from A B C D leaves C as the only difference. Any difference in the average behavior between the two groups can be attributed to “C” as its “cause.”



2. Single Subject Design

In single subject designs, the same individual serves as both the treatment "group" and the control "group." How the individual behaves under the treatment is compared to how that same individual behaved both before and after the treatment. Any difference in what the individual was exposed to (independent variable plus any other things that crept in) is thought to cause the difference in behavior. Single subject designs are used because they provide a powerful technology to detect very small treatment effects and provide the greatest generality to other situations. For example, if the body snatchers replaced your close friend with a nearly perfect clone, you would probably detect something wrong because you would be able to detect a very small change in that particular person from before to after the visit of the body snatchers. Group designs are not as powerful because any difference between the average of the two groups may be a treatment effect or may be simply random differences in those two groups. If you had a party first with one group then with a completely different group of people that may have been body snatched, could you tell if the second group had had the very slight differences that you easily detected in your body snatched friend.



The "before" and "after" baseline conditions and their resulting behaviors are used to cancel out the effects of the unwanted confounds as potential causes of the resulting behaviors during the treatment condition. Only the difference in the conditions are the likely causes for the difference in the behavior.

The second important value of single subject designs is that they have very good generality because if every single animal exhibits the same functional relationship, then it is very likely that a target animal will also exhibit that same relationship.