Discovering Units of Analysis in our Concepts of Stimulus and Response

David Roth
Penn State National Autism Conference 2019
PaTTAN’s Mission

The mission of the Pennsylvania Training and Technical Assistance Network (PaTTAN) is to support the efforts and initiatives of the Bureau of Special Education, and to build the capacity of local educational agencies to serve students who receive special education services.
PDE’s Commitment to Least Restrictive Environment (LRE)

Our goal for each child is to ensure Individualized Education Program (IEP) teams begin with the general education setting with the use of Supplementary Aids and Services before considering a more restrictive environment.
Notebooks
B.F. Skinner

March 57

Learned Perception

For more than a year I used a toothbrush with a sharp bend at the neck. Then I changed to a straight handle. When I first used it, I felt the handle bend quickly to this shape. I had the impression the handle was rubber or soft plastic, or that it was a practical joker's toothbrush on the same principle as the table knife with a jointed handle.

I had learned to "feel" the position of my teeth with the appliance supplied by the orthodontist. This is the commentary case supplying the new stimulus. But I need not have resisted the inference that my teeth had moved. In the case of teeth it is always the Situation which accounts for different sets of feed-backs.

Edited, and
with an introduction by
Robert Epstein
Concealed Intraverbal
A Behavioral Unit

At the top of the basement stairs I turned to shut the door to the basement. Instead I shut the kitchen door, which is at a right angle to it. The kitchen door has a baseboard clasp, and as the door came free I saw that it was the wrong door.

"Closing a door" is a behavioral unit acquired with respect to hundreds of doors. "Closing the basement door" is a special case under special stimulus control. I emitted "closing a door" by responding to the first door that came to hand. (I was turning around and closing the basement door as an afterthought.)

This kind of analysis is needed, but I am afraid that we won't see much of it for a long time.

(Skinner’s personal note written January 13, 1975)
“This kind of analysis is needed, but I am afraid that we won't see much of it for a long time.”

-1975-
Context of Skinner’s Note

1975: 140 Papers and 10 Books

Lifetime: 200 Papers and 15 Books on the Science of Behavior
Outline of Presentation

• How Skinner discovered a science of operant behavior by being shaped by his own subjects.
  • How to identify units of stimulus (independent variable) and response (dependent variable) according to a Skinnerian account.
  • How do “post-Skinnerian” assumptions hold up to the Skinnerian position when attempting to explain complex behavior?
What is Science?

“It is a search for order, for uniformities, for lawful relations among the events in nature.”

(Skinner, 1953)
What is a Science of Behavior?

It is a search for precise order between environmental events (IV) and the actions of an individual (DV).
Examples of Behavioral Order
“Men act upon the world, and change it, and are changed in turn by the consequences of their actions.”
Behavioral Principles

- MO
  - UMO
  - CMO
- $S_D$
  - $S^\Delta$
  - $S^{DP}$
- Reinforcement
  - EXT
  - PUN
“What a strange discovery for a would-be tyrant, that the only effective technique of control is unselfish!“

Frazier (i.e. Skinner)
Skinner on Reinforcement
How Skinner’s Discovery for Order Began...
Pre-Skinnerian Accounts of Behavior
Pavlov

Thorndike

Watson
“Restricted Preparations”
“Freely” Moving Individual
B.F. Skinner
“I did not like the maze as a scientific instrument. The animal’s behavior is composed of too many different ‘reflexes’ and should be taken apart for analysis.”
“I had the clue from Pavlov: control your conditions and you will see order.”

- BF Skinner
Emerging-Skinnerian Account of Behavior
• Discovery of reproducible order between environment and behavior.
  • Discovery of “unformalized principles” for scientific practice.
  • Skinner’s behavior as most important subject.
Capturing Order
“…They should be taken apart for further analysis.”

Order between “click” (IV) and retreat (DV)
1.) “When you run into something interesting, drop everything else and study it.”

-B.F. Skinner
Order between tail-pull (IV) and postural reflex (DV)

Order between postural reflex and data
Order between click (IV), halt-bx (DV)

Order between halt-bx (IV) and data (DV)

Food to “elicit” running
2.) “Some ways of doing research are easier than others.”

-B.F. Skinner
Order between click (IV), halt-bx (DV), and data

“Behave as you ought!”
…Eventually I realized that the subjects were always right.”

- Skinner/Frazier (Walden Two)
Discovered order between eating food (IV) and pausing (DV)
Fixed Ratio Schedule: Post-Reinforcement Pause

Orderly Pauses

Time in Minutes
Order between food delivery (IV) and running (DV)

"Wait a minute!"
3.) “Some people are lucky.”
-B.F. Skinner
Rate of Behavior!
“The organism whose behavior is most extensively modified and most completely controlled in research of the sort I have described is the experimenter himself.”

B.F. Skinner
A Skinnerian Account of Behavior
The Generic Nature of the Concepts of Stimulus and Response
“I now recognize that the 1935 paper is one of the most important in our field, for it addresses a fundamental question: How should we determine appropriate units of analysis in a science of behavior?”

David Palmer
Brief Tangent...
Meet Ebby

Artwork by:
Simon Carlucci
(Age 16)
Meet Simon
Meet Raph

Artwork by: Simon Carlucci (Age 17)
Back to Skinner’s Discoveries…
“One fact that seems to be sufficiently well established is that there are defining properties.”
The First Instance of a Reinforced Response
Topography: middle of lever pressed with both paws

What happens after?
More instances of “same” response?

**Figure 16**

Extinction Curve Following the Reinforcement of One Response
The Operant

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<th>ANTECEDENT</th>
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**Figure 16 (10)**

**Extinction Curve Following the Reinforcement of One Response**
The Operant

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<tr>
<th>ANTECEDENT</th>
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<tbody>
<tr>
<td>Sight of Lever</td>
<td>Lever Press</td>
<td>History of Yerba Mate</td>
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What about the first instance?

More instances of “same” response?

*Figure 16 (10)*

Extinction Curve Following the Reinforcement of One Response
“In reassuring Fred [Keller] about my theory of learning, I said that ‘on two successive occasions the stimulus . . . varies considerably. One time the rat sees [the lever] with his left eye, another with his right eye, etc.’ Something of the same sort could be said about the response. Although a rat presses a lever in a fairly stereotyped fashion, all instances are not exactly alike. By ‘stimulus’ and ‘response’ we can mean only classes of events. That is what I meant by their ‘generic nature.’”
Classes of Stimulus and Response

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<td>Stimulus 3</td>
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Varied forms within each class.
How much can each member of the class vary?
Stimulus Class

“A group of stimuli that share specified common elements along formal (e.g., size, color) ... and/or functional (e.g., discriminative stimulus) dimensions.”

(Cooper, Heron, and Heward, 2007)
“Functional” Stimulus Class

(Sound of door opening)

“You open a ___”

Written word *DOOR*

Are these stimuli truly “equivalent?”
Response Class

“A group of responses of varying topography, all of which produce the same effect on the environment.”

(Cooper, Heron, and Heward, 2007)
“Functional” Response Class

- Turn door knob
- Kick open
- Say, “open the door”
- Push open with backside

Are these responses truly “equivalent?”
Skinner’s criteria for including variations within a class:

1. Induction
2. Quantitative Mutual Replaceability
Variations in Stimulus

“On two successive occasions the stimulus . . . varies considerably. One time the rat sees [the lever] with his left eye, another with his right eye, etc.”
Variations in Response

“Although a rat presses a lever in a fairly stereotyped fashion, all instances are not exactly alike.”
Induction

“The spread of the effect to other stimuli is called generalization or induction... The ‘identical elements’ of a response have their parallels in the values or properties of a stimulus which are separately effective.”

–B.F. Skinner (Science and Human Behavior)
The Role of Induction in a Reproducible Unit
“Perfect” Induction

Replicating circumstances exactly the same as first instance.

“The spread of the effect to other stimuli” and other responses as a result of their ‘identical elements.’
Induction of Varied Forms

"The spread of the effect to other stimuli" and other responses as a result of their 'identical elements.'
Induction of Varied Forms

“The spread of the effect to other stimuli” and other responses as a result of their ‘identical elements.’
Generic Stimulus Class

Instance Explained by Induction → Sight of Lever From Right Eye

Sight of Lever Head On → Lever Press

Instance Explained by Induction → Sight of Lever From Left Eye

Reinforced → Novel Instance
Generic Response Class

- Sight of Lever
  - Left-Paw Press: Explained by Induction
  - Right-Paw Press: Explained by Induction
- Two-Paw Press
- Reinforced
- Novel Instance
Generalization Gradients and Response Classes
Quantitative Mutual Replaceability (QMR)

- “The number of distinguishable acts on the part of the rat which will give the required movement of the lever is indefinite and very large…”

- “… Except for certain rare cases they constitute a class, which is sufficiently well-defined by the phrase ‘pressing the lever’” (discussed later)
Quantitative Mutual Replaceability (Skinner, 1935)

• “Not only are the responses of the class all equally [evocable] by the stimulation arising from the lever, they are quantitatively mutually replaceable.”

• “The uniformity of the change in rate ... forces the conclusion that ‘pressing the lever’ behaves experimentally as a unitary thing.”
Quantitative Mutual Replaceability

Whatever happens to one instance happens to the others *(because of their shared physical elements).*
How do we account for derived behaviors that lack overlapping elements with the existing ones?
Established unit explained by history of reinforcement.

New unit explained by ?
Shaping New Forms of Stimulus and Response
Stimulus Shaping

Definition: Systematically making changes to non-defining elements of existing stimulus class to eventually produce a new form.
Stimulus Shaping

“Within the class given by a defining property we may set up subclasses through the arbitrary restriction of other properties.”

(Skinner, 1935)
Stimulus Class Controlling Tact “Leaf”

Stimulus Class Controlling Textual “Leaf”
Stimulus Class
Controlling
Tact “Leaf”

Stimulus Class
Controlling
Textual “Leaf”
Response Shaping

**Definition:** Systematically reinforcing each variations in an existing response class that inches closer toward a new form.

Existing Response Class: Turning left

New Response Class: Turning in a full circle
Explanation of Newly Shaped Forms

Social Significance?
Established unit explained by history of reinforcement.

New unit without shaping?

“Generalized Operant”
“Generalized Operants”:

- Wholly unique stimulus or response forms (i.e. no similar elements) emerge from existing classes.

- **The mystery:** the law of induction cannot explain the new form.
“In most experimental situations, the functional/formal distinction may be safely ignored. Consider a rat pressing a bar for food. The contingency is related to whatever behavior deflects the bar a certain number of degrees, and a wide variety of topographies, such as sniffing, rolling, jumping, sitting, sneezing, and so on, might be part of the class.”

(Hayes, Barnes-Holmes, and Roche, 2001)
“Generalized” Response Class

Sight of Lever

- Paw Press
- Sniffing Lever?
- Rolling on Lever?
- Sneezing on Lever?
- Tail-Press Lever?
- Snout-Press Lever?

Reinforced

Novel Instance
Reinforced paw-press

Variations of Paw-Press

Metaphor courtesy of David C. Palmer
Derived Instance: “Sneezing on Lever” (notice no induction spread)

Metaphor courtesy of David C. Palmer
Skinner on Lever-Press Variability

“I had not been able to eliminate the possibly disturbing effect of the first movement of the lever, and it was also conceivable that some depressions were incidental to other behavior (for example, the lever might be struck by the rat’s heavy tail as it explored the ceiling of the box).”

(Skinner, The Shaping of a Behaviorist)
Derived Instance: "Tail-Press"

Metaphor courtesy of David C. Palmer
“Tail-Press”
(with induction spread).

Lower rate of Response

No overlapping elements

Metaphor courtesy of David C. Palmer
Derived Lever-Presses

Stimulus Induction????

Response Induction???

Where are the identical elements?
What about when the stimulus shares elements but the response does not?
First instance: Raph reaches for lever but incidentally hits with snout instead.
Subsequent instances: we see more instances of snout-presses

Although there are overlapping stimulus elements, no overlapping response elements.

Induction Spread: “Snout-Press”
Derived Lever-Presses

Where are the identical elements?

Response
Induction???
A Single Response Class?

Sight of Lever

- Paw Press
- Tail-Press Lever?
- Snout-Press Lever?

- Reinforced
- Novel Instance
Criteria: Induction and Quantitative Mutual Replaceability
“The responses are so divergent in form that we can assume different populations of neurons and muscle fibers…”
… There are no a priori grounds for predicting generalization from one form to another.”

-David Palmer (2004)
“… Except for certain rare cases they constitute a class”
“The concept of generalized operants is the name of our ignorance, not an explanation of it.”

-David C. Palmer-
Extending Skinner (1935) to an Analysis of Problem Behavior
A Story of Self-Injury
Pre-Defined

“Response Classes”

Analogy to “pain killers” as a class
Refined Generic Response Class
Pre-Defined

“Stimulus” Class
Testimonial
Testimonial (continued)
Hypothesized Stimulus Class
Initial “Generalized” Stimulus Class
Functionally-Equivalent (or Synonymous) Forms
Skinner on Synonyms

“There is no true synonymy in the sense of a choice between different forms. When all the features of the thing described have been taken into account... the form of response is determined.”

(Verbal Behavior)
“Instead of studying a thousand [individuals] for one hour each, the investigator is likely to study one [individual] for a thousand hours…”

-B.F. Skinner
A Discovery of Order
A Discovery of Order (continued)
A Discovery of Order (continued)
A Discovery of Order (continued)
A Discovery of Order (continued)
Refined Stimulus Class
Synonymous Forms?
“The concept of generalized operants is the name of our ignorance, not an explanation of it.”

-David C. Palmer-
Scientifically precise order between our variables leads to scientifically precise interventions.
“In a scientific analysis it is seldom possible to proceed directly to complex cases. We begin with the simple and build up to the complex, step by step.”

-Skinner (1953)
Verbal Behavior
"We begin with the simple..."

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“... and build up to the complex, step by step.”

**Part III: Multiple Variables**

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**Part IV: The Manipulation of Verbal Behavior**

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**Part V: The Production of Verbal Behavior**

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The Multiple Control of Verbal Behavior

Jack Michael, Western Michigan University  
David C. Palmer, Smith College  
Mark L. Sundberg, Sundberg and Associates
Some Topics Covered

- Divergent and Convergent Multiple Control
- Conditional Discrimination
- Joint Control
- The Emergence of Novel Behaviors
  - Bi-Directional Naming
  - Stimulus Equivalence
  - “Relational Framing”
Divergent Multiple Control

“A single variable usually affects more than one response”

(Skinner, 1957)
Divergent Multiple Control

*Synonymous Forms?

- Turn Door Knob
- Kick Open
- Say, “open the door”
- Push open with backside
Convergent Multiple Control

“The strength of a single response may be, and usually is, a function of more than one variable”

(Skinner, 1957)
Convergent Multiple Control

“When all the features of the thing described have been taken into account… the form of response is determined.”

- Turn Door Knob
- Kick Open
- Push open with backside
- Sound of Footsteps
- Say, “open the door”
- Doorknob won’t turn
Conditional Discrimination as Convergent Multiple Control

“In conditional discrimination, the effect of a discriminative stimulus depends (or is conditional upon) on other stimuli.”

(Michael, Palmer, and Sundberg 2011)
“In conditional discrimination, the effect of the sight of the lever depends (or is conditional upon) on the red disk.”
**Conditional Discrimination**

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<tr>
<td><img src="image1.png" alt="Red Circle" /></td>
<td>Lever Press</td>
<td>History of Reinforcement</td>
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Conditional Discrimination

In a conditional discrimination, reinforcement for stepping on the gas is conditional upon a clear path in front of your car.
What about complex behaviors that emerge as first instances (i.e. no history of reinforcement)?
Stimulus Equivalence

- Reinforced

- Novel Instance

Symmetry

Trained Relation

Transitivity
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Stimulus Equivalence

(A) "Dog"

Reinforced →

Novel Instance

Symmetry
(tact?)

Listener-Discrimination

Symmetry
(tact?)

Transitivity
(MTS)

(B)

(DOG(C))
“Induction” of Novel Instances?

“If [the response] has been conditioned to each of the stimuli separately, no explanation is required; but apparently this is not the case. ‘Induction’ appears to occur although common properties are lacking... Common mediating behavior supplies another possible explanation.”

(Skinner, 1953)
“If [the response] has been conditioned to each of the stimuli separately, no explanation is required…”

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<td>(B) Scans and selects</td>
<td>History of Reinforcement</td>
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<td>(A) “Dog”</td>
<td>(C) Scans and selects DOG</td>
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<td>(C) DOG</td>
<td>(A) Says, “dog” (textual)</td>
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“...but apparently this is not the case. ‘Induction’ appears to occur although common properties are lacking.”

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<td>(C) DOG</td>
<td>(B) Scans and Selects</td>
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How do we explain why “induction” sometimes doesn’t occur?
Teaching Naming to Vocal Children with Autism (degli Espinosa, 2011)

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Taught: “Dog” ->

Taught: “Dog” ->
“Common mediating behavior supplies another possible explanation…”
Mediating Behavior
Delayed Match to Sample
Mediating Behavior
Figure 2. Matching performance of Bird 5 as a function of delay. The different curves correspond to different periods during the experiment. Each point represents mean data from 5 to 10 sessions. (See text.) The inset indicates the bird’s delay behavior at the time when the data shown in the upper curve were collected.
Selection of a stimulus is jointly controlled by the mediation of two established verbal operants with overlapping response elements.
An Introduction to Joint Control

Barry Lowenkron
California State University, Los Angeles
The role of joint control in teaching listener responding to children with autism and other developmental disabilities

Kaitlin G. Causin, Kristin M. Albert, Vincent J. Carbone *, Emily J. Sweeney-Kerwin

Carbone Clinic, Valley Cottage, NY, United States

Vince Carbone - The Role of Joint Control in Teaching Complex Listener Responding (2015, Session #37)
Instructor: “Give me the car, the tree, and the bicycle”
Joint Control: A Discussion of Recent Research

David C. Palmer
Smith College

The discrimination of the onset of joint control is an important interpretive tool in explaining matching behavior and other complex phenomena, but the difficulty of getting experimental control of all relevant variables stands in the way of a definitive experiment. The studies in the present issue of The Analysis of Verbal Behavior illustrate how modest experiments can take their place in a web of interpretation to make a strong case that joint control is a necessary element of such phenomena.

Key words: joint control, verbal behavior.
When “induction” doesn’t occur?

“Dog”

Tact

Listener-Discrimination

Tact

DOG
### Taught:

- "Dog"

### Taught:

- "Dog"

#### Teaching Naming to Vocal Children with Autism (degli Espinosa, 2011)

<table>
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Teaching Mediating Behavior

Teaching Naming to Vocal Children with Autism (Degli Espinosa, 2011)
Derived Speaker Relations
Before and After Training Mediating Behaviors

Percentage Data Converted from
degli Espinosa (2011)
Relational Frame Theory as “Post-Skinnerian”?
is less than

is ___ than

?
is less than

is ___ than ___ ?
If... is more than and... is more than Does ?
Relational Frame Procedures (Theory?)

- "more than"
- "less than"
- "same as"?

Reinforced (e.g. "less than")
Novel Instance (e.g. "more than")
DATA IN SEARCH OF A PRINCIPLE: A REVIEW OF RELATIONAL FRAME THEORY: A POST-SKINNERIAN ACCOUNT OF HUMAN LANGUAGE AND COGNITION

DAVID C. PALMER

SMITH COLLEGE

RELATIONAL OPERANTS: PROCESSES AND IMPLICATIONS: A RESPONSE TO PALMER’S REVIEW OF RELATIONAL FRAME THEORY

STEVEN C. HAYES AND DERMOT BARNES-HOLMES

UNIVERSITY OF NEVADA AND NATIONAL UNIVERSITY OF IRELAND, MAYNOOTH

GENERIC RESPONSE CLASSES AND RELATIONAL FRAME THEORY: RESPONSE TO HAYES AND BARNES-HOLMES

DAVID C. PALMER
Skinner’s Analysis of Autoclitic Frames

“[one] has acquired a series of responses such as the boy's gun, the boy's shoe, and the boy's hat, we may suppose that the partial frame the boy's ______ is available for recombination with other responses. The first time the boy acquires a bicycle, the speaker can compose a new unit the boy's bicycle.”

-Skinner, (1957)
Autoclitic Frames Example
Physical Dimensions of Autoclitic Frames

Autoclitic frames mediate derived relational responses:

“A is less than B”

“B is more than A”

“B is the same as C”
Recommended Podcast Episode

Verbal Behavior and Relational Frame Theory: Session 80
with David Palmer and Josh Pritchard
“A mechanic could have a workshop full of tools, but if he only knows how to use the screwdriver, he will only be able to fix things held together by screws. Likewise a behavior analyst might be able to do useful work with a subset of behavioral skills, but the more completely one understands fundamental concepts like Skinner’s concept of the operant, the less likely one will encounter a problem that cannot be analyzed effectively.”

David Palmer
Resource Links

• Skinner’s A Case History in the Scientific Method:

• Skinner’s (1935) Generic Nature paper:
  o https://www.bfskinner.org/publications/pdf-articles/

• Free online subscription to Operants magazine (for Generic Nature discussion papers):
  o https://www.bfskinner.org/behavioral-science/operants/

• Michael, Palmer, and Sundberg’s Multiple Control paper:
  o https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3139558/

• Blough’s (1959) Delayed Matching paper:
  o https://www.researchgate.net/publication/9764737_Delayed_matching_in_the_pigeon
Resource Links

• Lowenkron’s Joint Control introduction:
  o https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2774602/

• Carbone’s Joint Control paper:

• Palmer’s Joint Control Paper
  o https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2774603/

• Degli Espinosa (2011) dissertation:
  o https://eprints.soton.ac.uk/197233/1/Thesis_FdE_Final.pdf

• Palmer’s (2004) review of RFT:

• Palmer’s paper on autoclitic frames:

• Behavioral Observations Podcast Episode:
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Commonwealth of Pennsylvania
Tom Wolf, Governor