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.
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

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.”

“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
"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

A CASE HISTORY IN SCIENTIFIC METHOD

B. F. SKINNER
Harvard University

- 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
“Behave as you ought!”

Eventually I realized that the subjects were always right.”

~Skinner/Frazier (Walden Two)
3.) “Some people are lucky.”

-B.F. Skinner
“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
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

* Interview with David Palmer from Operants Magazine Quarterly Issue #3 (2018)
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 (38)
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

<table>
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<tr>
<th>ANTECEDENT</th>
<th>BEHAVIOR</th>
<th>CONSEQUENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stimulus 1</td>
<td>R1</td>
<td>Reinforcement History</td>
</tr>
<tr>
<td>Stimulus 2</td>
<td>R2</td>
<td></td>
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<td>Stimulus 3</td>
<td>R3</td>
<td></td>
</tr>
<tr>
<td>Stimulus 3</td>
<td>R4</td>
<td></td>
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</tbody>
</table>

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) "Door"

"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.’

Generic Stimulus Class

Instance Explained by Induction

Sight of Lever Head On

Sight of Lever From Left Eye

Sight of Lever From Right Eye

Lever Press

Instance Explained by Induction

Reinforced

Novel Instance
Generic Response Class

Sight of Lever

- Left-Paw Press
- Two-Paw Press
- Right-Paw Press

Instance Explained by Induction

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.

→ LEAF
“Within the class given by a defining property we may set up subclasses through the arbitrary restriction of other properties.”
(Skinner, 1935)
Response Shaping

Definition: Systematically reinforcing each variation 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
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)
"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.

Derived Instance: “Snout-Press”

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 (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.
Extensions of the 1935 Analysis to Complex Behavior

“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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<td>MAND</td>
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<tr>
<td>Non-Verbal Discriminative Stimulus</td>
<td>TACT</td>
<td>Generalized Conditioned Reinforcement Mediated by a Listener</td>
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<tr>
<td>Verbal Discriminative Stimulus</td>
<td>ECHOIC</td>
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"… and build up to the complex, step by step."

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Some Topics Covered

• Divergent and Convergent Multiple Control
• Conditional Discrimination
• Joint Control
• The Emergence of Novel Behaviors
  o Bi-Directional Naming
  o Stimulus Equivalence
  o “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
- Say, “open the door”
- Push open with backside
- Doorknob won’t turn
- Sound of Footsteps
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)
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

A
  Symmetry
  Trained Relation
  Symmetry

B

C
  Transitivity

Symmetry

Symmetry
“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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</tr>
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<td>(C) Scans and selects DOG</td>
<td>History of Reinforcement</td>
</tr>
<tr>
<td>(B)</td>
<td>(A) Says, “dog” (tact)</td>
<td>History of Reinforcement</td>
</tr>
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<td>(C) DOG</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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</tr>
<tr>
<td>(C) DOG</td>
<td>(B) Scans and Selects</td>
<td>?</td>
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How do we explain why “induction” sometimes doesn’t occur?
“Common mediating behavior supplies another possible explanation…”
Delayed Match to Sample

Mediating Behavior

Blough (1959)

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.
Instructor: “Give me the car, the tree, and the bicycle”

The Analysis of Verbal Behavior

Joint Control: A Discussion of Recent Research

David C. Palmer
Smith College

The analysis 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 complex experiments can take their place as 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

David Palmer – The Role of Joint Control in Behavior (2013, Session #9)

When “induction” doesn’t occur?

“Dog”

Tact

Listener-Discrimination

DOG
Teaching Naming to Vocal Children with Autism (Degli Espinosa, 2011)

<table>
<thead>
<tr>
<th>Participants</th>
<th>Tacting of selection stimuli</th>
<th>Selection of tact stimuli</th>
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<tr>
<td></td>
<td>S1</td>
<td>S2</td>
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<td>Sarah</td>
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<td>Charlie</td>
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<td>Tommy</td>
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<td>John</td>
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<tr>
<td>Dan</td>
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<td>0</td>
</tr>
<tr>
<td>Ched</td>
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</tr>
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</table>

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

Teaching Mediating Behavior

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?)

Skinner 1935 vs. RFT
Skinner’s Analysis of Autoclitic Frames

“If [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:
- Free online subscription to Operants magazine (for Generic Nature discussion papers):
  - https://www.bfskinner.org/behavioral-science/operants/
- Michael, Palmer, and Sundberg’s Multiple Control paper:
  - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3339558/
- Blough’s (1959) Delayed Matching paper:
  - https://www.researchgate.net/publication/9744737_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://epubs.soton.ac.uk/197353/1/thesis.pdf

• Palmer’s (2004) review of RFT:

• Palmer’s paper on autoclitic frames:
  o http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.461.8032&rep=rep1

• Behavioral Observations Podcast Episode:

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