Stimulus Control and its Role in Errorless Learning

August 9, 2018
National Autism Conference
David Roth

Pennsylvania Training and Technical Assistance Network

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.

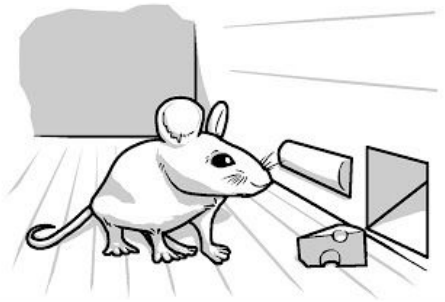
PDE's Commitment to Least Restrictive Environment (LRE)

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.

Men act upon the world, and change it, and are changed in turn by the consequences of their actions.

-B.F. Skinner

What Does Animal Research Have to Do with Human Behavior?

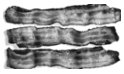


The Operant

Antecedent	Behavior	Consequence
• Environmental event • Immediately before response • Momentarily changes probability response to occur	• Activity of individual • Observable • Measurable	• Environmental event • immediately after response • Changes probability of response to occur in future

Reinforcement

- A consequence of response
- Increases future probability of response (class)
- Can be positive (+) or (-)



Unlearned and Learned Reinforcement

Unconditioned reinforcement: effective without prior learning

Conditioned reinforcement: effective only after a history of being paired with other reinforcement

Skinner on the Importance of Reinforcement

Reinforcement in Action

The "Facts in the Bag"

Antecedent	Behavior	Consequence
Motivating Operation (MO)	Response	Specific Reinforcement
Discriminative Stimulus (S^D)	Response	Generalized Conditioned Reinforcement
Stimulus Delta (S^Δ)	Response	(Extinction)
Neutral Stimulus (S^+, S^0, or S^-)	n/a	n/a
Discriminative Stimulus for Punishment (S^{DP})	Response	Punishment

Non-Verbal Behavior

Behavior in which the reinforcement is *not* mediated by other individuals

Verbal Behavior

Behavior in which the reinforcement *is* mediated by other individuals (i.e. listeners) who had been trained to do so

See Palmer (2008) for more in-depth discussion on Skinner's definition

The Beauty of Skinner's Definition

- **Functional vs. Formal**
- **Includes all forms of "communication"**
  - Talking
  - Signing
  - Writing
  - Gesturing
  - Morse Code
  - Smoke Signals

The Verbal Operants

Antecedent	Behavior	Consequence
Motivating Operation	MAND	Specific Reinforcement Mediated by a Listener
Non-Verbal Discriminative Stimulus	TACT	Generalized Conditioned Reinforcement Mediated by a Listener
Verbal Discriminative Stimulus	ECHOIC SIGNED IMITATION INTRAVERBAL	Generalized Conditioned Reinforcement Mediated by a Listener

Motivational Control

Antecedent	Behavior	Consequence
Motivating Operation (MO)	Response	Specific Reinforcement

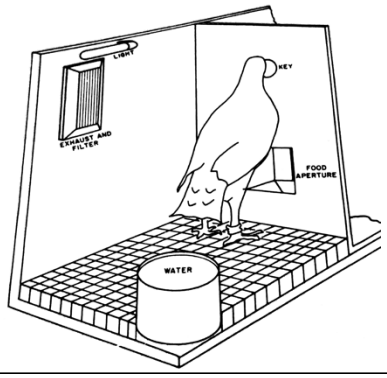
Motivational Control

Motivating Operation	Behavior	Specific Reinforcer
• Changes the value of something • Changes probability of behavior b/c of past history	• Response	• Item/Event made valuable by MO

"No matter how much one has read about a behavioral process, it is always a surprise to see it at first hand."

–B.F. Skinner

Experimental Analysis of Behavior

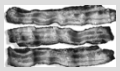


Meet Ebby

Artwork by: Simon Carlucci (Age 16)

Motivational Control for Turning

Definitions Revisited

Motivating Operation (MO):	Behavior	Specific Reinforcement:
• Food deprivation • Establishes the value of bacon as a reinforcer • Evokes/ strengthens *turning around* because of history of accessing bacon (when available)	*Turning Around*	• Bacon • Specifically reinforcing because of food deprivation 

Motivational Control for Pecking

Definitions Revisited

Motivating Operation (MO):	Behavior	Specific Reinforcement:
• Yerba Mate deprivation • Establishes the value of Yerba Mate as a reinforcer • Evokes/strengthens *pecking* because of history of accessing Yerba Mate (when available)	*Pecking*	• Yerba Mate • Specifically reinforcing because of Yerba Mate deprivation 

Motivational Control and Verbal Behavior

Antecedent	Behavior	Consequence
Motivating Operation	MAND	Specific Reinforcement Mediated by a Listener

The Mand

- SPECIFIES to a listener the reinforcement that is currently valuable to the speaker
- **Types of consequences that are specified by manders:**
  - Items present
  - Actions
  - Assistance
  - Removal of unpleasant stimuli
  - Missing items
  - The attention of another
  - Items with specific properties
  - Items in specific locations
  - Information

Stimulus Control

What is a stimulus?

An item or event in one's environment that directly affects his or her senses.

What is Stimulus *Control*?

Antecedent	Behavior	Consequence
Discriminative Stimulus (S^D)	Response	Generalized Conditioned Reinforcement
Stimulus Delta (S^Δ)	Response	Extinction
Neutral Stimulus (S^+, S^0, or S^-)	n/a	n/a
Discriminative Stimulus for Punishment (S^{Dp})	Response	Punishment

Stimulus Control

Thought Experiment

Antecedent	Behavior	Consequence
Discriminative Stimulus (S^D) 	"What's the kanux, man!"	Generalized Conditioned Reinforcement
Stimulus Delta (S^Δ) 	"What's the kanux, man!"	Extinction
Neutral Stimulus (S^+, S^0, or S^-) 	n/a	n/a
Discriminative Stimulus for Punishment (S^{Dp}) 	"What's the kanux, man!"	Punishment

"The Will Smith Effect"

Antecedent	Behavior	Consequence
Discriminative Stimulus (S^D) 	"What's the kanux, man!"	Generalized Conditioned Reinforcement

Discriminative Stimulus (S^D) Control

Antecedent	Behavior	Consequence
Discriminative Stimulus (S^D)	Response	Generalized Conditioned Reinforcement

Discriminative Stimulus Control

Antecedent	Behavior	Consequence
Discriminative Stimulus (S^D): • Item/Event • Historically preceded availability of reinforcement • Momentarily evokes/strengthens particular behavior due to historical successes	Response	**Generalized Conditioned Reinforcement (GCR):** • Item/event • Increases future probability of behavior • Effective because of its previous pairings with many other reinforcers • Relatively independent of current states of MO

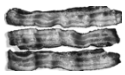
Discriminative Stimulus (S^D) Control for Turning

Discriminative Stimulus Control

Discriminative Stimulus (S^D):	Behavior	Generalized Conditioned Reinforcement
• Historically preceded availability of "clicking" sound (GCR) • Momentarily evokes/strengthens *turning around* due to historical successes following response	*Turning Around*	• " Clicking" sound • Increases future probability of behavior because of past pairings with bacon, girlfriends, yerba mate tea, etc. • Relatively independent of food/ Yerba Mate/social/etc. deprivation

Conditioned Reinforcement

The Reflex

(US)  → 

(UR): Salivating

\+

(NS) "CLICK"
(presented prior)

Conditioned Reflex (Reinforcement)

(CS) "CLICK" →

(CR): Salivating

Generalized Conditioned Reinforcement

(US)

+

(NS) "CLICK"

→

(UR): Salivating

Generalized Conditioned Reinforcement

Antecedent	Behavior	Consequence
Discriminative Stimulus (S^D) 	*Turning Around*	**Generalized Conditioned Reinforcement:** **"CLICK"**

Conditioned Reinforcers as Conditioned Stimuli or Discriminative Stimuli?

Generalized Conditioned Reinforcement and Stimulus Control

As a result of the generalized reinforcement conditioning history, the response is more heavily influenced by the antecedent stimulus than it is by any current states of motivation.

Generalized Conditioned Reinforcement and Stimulus Control

The more reinforcers that are paired with a conditioned reinforcer, the stronger the antecedent stimulus control will be in evoking the behavior. For example, look at, but don't read, the following slide…

Generalized Conditioned Reinforcement








1

Stimulus Delta (S^{Δ}) Control

Antecedent	Behavior	Consequence
Stimulus Delta (S^{Δ})	Response	Extinction

Eventual result is a weakening of that response in the presence of the S^{Δ}

"The Cillian Murphy Effect"

Antecedent	Behavior	Consequence
Stimulus Delta (S^{Δ}) 	"What's the kanux, man!"	Extinction

Stimulus Delta Control

Antecedent	Behavior	Consequence
Stimulus Delta (S^{Δ}): • Item/Event • Historically preceded UNavailability of reinforcement • Momentarily weakens particular behavior due to historical lack of success	(eventually weakened) Response	**Extinction:** • Absence of Reinforcement • Decreases future probability of behavior

Stimulus Delta (S^{Δ})

Control for Turning

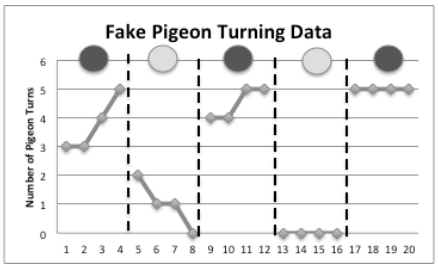
The Importance of Extinction

- Increases strength of momentary behavior
- Sharpens stimulus control
- Evokes variability of previously successful behavior

Definitions Revisited

Stimulus Delta (S^{Δ}):	Behavior	Extinction
 • Historically preceded the unavailability of reinforcement following *turning* behavior	(eventually weakened tendency) *Turning Around*	• Absence of clicks, bacon, yerba mate, and lady-pigeons following *turning* • led to an overall weakening of the future behavior.

Stimulus Control



Stimulus and Response Generalization

- **Stimulus Generalization:** After an individual has learned a response to a stimulus, the same response is made to a new (but physically similar) stimulus without any additional training.
- **Response Generalization:** After an individual has learned a response to a stimulus, a new (but physically similar) response form is made to the same stimulus.

Discriminative Stimulus (S^D)

Control for Pecking

Stimulus Delta (S^Δ)

Control for Pecking

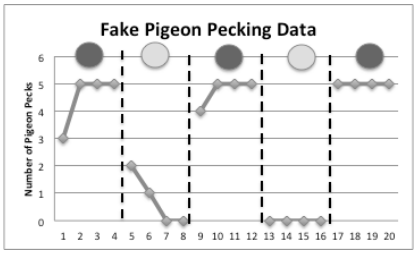
Definitions Revisited

Antecedent	Behavior	Consequence
Discriminative Stimulus (S^D): The green disk has been historically correlated with the availability of generalized conditioned reinforcement and evokes or strengthens *pecking* behavior 	*Pecking*	**Generalized Conditioned Reinforcement:** The sound of the click increases the future probability of *pecking* in the presence of the green disk as a result of its previous pairings with bacon, girlfriends, yerba mate tea, etc.

Definitions Revisited

Antecedent	Behavior	Consequence
Stimulus Delta (S^{Δ}): The blank disk has been historically correlated with the UNavailability of reinforcement following *pecking* and weakens the behavior as a result of extinction 	*Pecking*	**Extinction:** The absence of bacon, yerba mate, and lady-pigeons following *pecking* has led to an overall weakening of the *pecking* behavior

Stimulus Control



Bringing the Stimulus Control Pieces Together

Stimulus Control Outside the Skinner Box

- **Behavior: Approaching your boss at work**

Stimulus Control In the Classroom

- **Behavior: Approaching the instructor**

Stimulus Control and Verbal Behavior

Antecedent	Behavior	Consequence
Non-Verbal Discriminative Stimulus	TACT	Generalized Conditioned Reinforcement Mediated by a Listener
Verbal Discriminative Stimulus	ECHOIC SIGNED IMITATION INTRAVERBAL	Generalized Conditioned Reinforcement Mediated by a Listener

Non-Verbal vs. Verbal Stimulus Control

Response vs. Response Produced Stimulus

- **Response**: Any action performed by an individual
- **Response Produced Stimulus**: The sensory product (i.e. sound or sight) of that action

Verbal Response vs. Verbal Stimulus

- **Verbal Response**: Any action of an organism that is the result of and maintained by reinforcement mediated by a listener
  - Vocally manding "water" to a host
  - Manding by sign "candy"
  - Knocking on a door to be let in
- **Verbal Stimulus**: The sensory product of a verbal response
  - The sound of the vocal mand "water"
  - The sight of the signed mand "candy"
  - The sound of someone knocking on the door

Verbal Stimulus vs. Non-Verbal Stimulus

- **Verbal Stimulus**: The sensory product of a verbal response
  - The sound of the vocal mand "water"
  - The sight of the signed mand "candy"
  - The sound of someone knocking on the door
- **Non-Verbal Stimulus**: The sensory product of a non-verbal response and other properties of the non-verbal environment
  - The sight of a glass of water
  - The taste of a candy bar
  - The sight of a door
  - The sound of someone's footsteps

Verbal Stimulus *Control*

- **Verbal Stimulus Control**: When a verbal stimulus evokes or strengthens a response

Antecedent	Behavior	Consequence
Hearing someone ask for where the door is	Pointing to the door	GCR
Feeling the braille pattern for the word CAR	Saying "car"	GCR
Hearing someone knock on the door	Opening the door	GCR

Non-Verbal Stimulus *Control*

Non-Verbal Stimulus Control: When a non-verbal stimulus controls a response.

Antecedent	Behavior	Consequence
Seeing a door knob	Turning and opening the door	GCR
Seeing a wrapped birthday gift	Unwrapping the gift	GCR
Hearing a truck drive by	Saying "truck"	GCR
Seeing a red light turn green	Stepping on gas pedal	GCR

Non-Verbal Stimulus Control and the Tact

Antecedent	Verbal Behavior	Consequence
Non-Verbal Discriminative Stimulus	TACT	Generalized Conditioned Reinforcement Mediated by a Listener

Non-Verbal Stimulus Control and the Tact

- SPECIFIES for a listener the discriminative stimulus that controls the response (as opposed to the mand that specifies the reinforcer)

Stimuli that are Tacted

- Items
- Others' Actions
- Our Own Actions
- Properties of Items (parts, features)
- Stimuli in different sense modes
- Private Events

Verbal Stimulus Control and the Echoic

Antecedent	Verbal Behavior	Consequence
Auditory Verbal Discriminative Stimulus	ECHOIC (vocal response whose form matches antecedent)	Generalized Conditioned Reinforcement Mediated by a Listener

Echoic Skills

- Simple Sounds
- Words
- Phrases
- Novel Arrangements of Words
- Rehearsal of Complex Utterances
- Volume
- Tone/Pitch/Prosody

Verbal Stimulus Control and the Intraverbal

Antecedent	Verbal Behavior	Consequence
Verbal Discriminative Stimulus	INTRAVERBAL (verbal response whose form does NOT match antecedent)	Generalized Conditioned Reinforcement Mediated by a Listener

Intraverbal Skills

- Simple Fill-Ins
- Chains (Songs, Poems, Speeches)
- Complex Intraverbal Control:
  - Conversation
  - Recalling Past Events
  - Telling Stories

Stimulus Control or Motivational Control??

- Experiencing hunger pangs and telling your significant other "I'm really hungry" when in the kitchen and he/she is near the food.
- Telling your friend (who lives 3,000 miles away) on the phone "I'm really hungry" after hearing your stomach growl.
- Driving past a neighbor's house and telling your significant other, "That grass sure is tall."

"Gee, the grass sure is getting tall."
– Very Observant Wife

Pure Stimulus Control?

- Lying
- Exaggerating
- Misperceptions
- Pseudo-Sciences
- Ulterior Motives
- Recall
- **Multiple Control**

The Multiple Control of Verbal Behavior

"Skinner's discussion of multiple control is easily overlooked. **Readers sometimes fail to recognize that pure forms of the respective verbal operants are rare outside the laboratory or instructional contexts, and a common preoccupation of students is to try to classify utterances as one or another verbal operant on the assumption that the example must be exclusively one type.**" (Michael, Palmer, and Sundberg, 2011)

Conditional Discrimination Defined

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

(Michael, Palmer, and Sundberg 2011)

Conditional Discrimination for Turning

Conditional Discrimination

In a **conditional discrimination**, reinforcement for stepping on the gas is *conditional* upon a clear path in front of your car.

Verbal Conditional Discrimination

…. in a *verbal conditional discrimination (VCD)*, the effect of a discriminative stimulus depends (or is conditional upon) on other VERBAL stimuli.

Verbal Conditional Discrimination

"Simon says, clap your hands"

Simon Says that "Clap Your Hands" is an S^D

- **VCD**: The effect of the verbal stimulus "clap your hands" as an S^D depends upon the verbal stimulus: "Simon Says"

Conditional Discrimination Simplified*

Simple Discrimination:

If X-Then Y

(because reinforcement has followed in the past)

Conditional Discrimination:

If X, and If Y - then Z

(because reinforcement has followed in the past)

* Credit goes to Dr. Mark Sundberg for this description

Simon Says

- IF you hear someone say "Simon says" *and*
- IF you hear him say "clap your hands,"
- THEN clap your hands

Examples of Conditional Stimulus Control

- Putting on a folded undershirt rather than one in the dirty hamper
- When you are at the gas station but you drive past the pump with an orange cone in front of it, and pull up to the one without a cone
- Tacting an item loudly for someone at a crowded party, but quietly for someone in a library

Instructional Verbal Conditional Discriminations

- What is it?
- What color?
- What shape?

Other Multiple Control Topics

- Joint Stimulus Control
- Stimulus Equivalence
- Understanding Literature
- Listening to a Speaker (e.g. your behavior during this talk)
- Engaging in a Conversation
- Recalling Events from Your Past

Transfer of Stimulus Control

Transfer of Stimulus Control

As a result of reinforcing a previously established response to a discriminative stimulus(S^D) in the presence of a neutral stimulus (S^+), the S^+ eventually acquires S^D control over that response.

Transfer of Stimulus Control

→ TURN → TURN

→ PECK → PECK

Revisit the Definition

As a result of reinforcing *turning* in response to the red color (S^D), and in the presence of the neutral textual pattern **TURN** (S^+), the textual pattern (S^+) eventually acquires discriminative stimulus (S^D) control over that response.

Transfer of Stimulus Control and Teaching

Error-"less" Learning

The History of Errorless Learning

Terrace (1963):

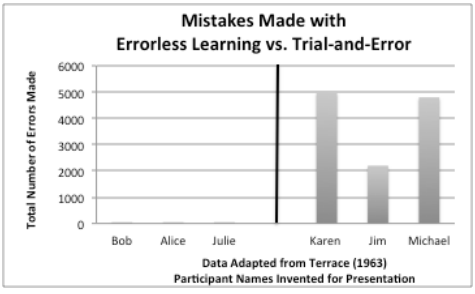
Discrimination learning with and without "errors"

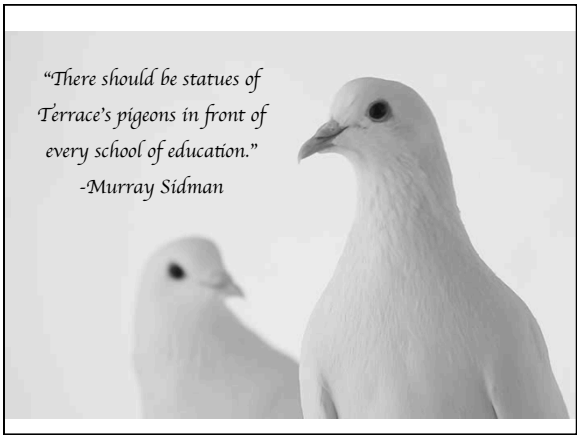
S^D S^Δ

Trial-and-Error Learning

S^D S^Δ

The History of Errorless Learning





Errorless vs. Trial-and-Error Learning

Marsh and Johnson (1968):
Discrimination reversal learning learning without "errors"

Errorless Group

S^D S^Δ

Trial-and-Error Group

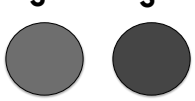
S^D S^Δ

"Out with the Old and In with the New"

After discriminations were acquired, the researchers reversed the stimuli to measure rate of unlearning the "old" and learning the "new" discriminations

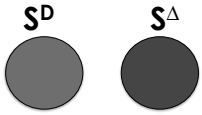
Errorless Group

S^D S^Δ



Trial-and-Error Group

S^D S^Δ



Results

- **Errorless Learning Group:** Persisted in responding to the "old" S^D despite extinction being scheduled for pecking
- **Trial-and-Error Learning Group:** Rapidly adapted to changing conditions and learned new discriminations

Errorless vs. Trial-and-Error

- **Errorless Learning**: Best for circumstances that are relatively unchanging (e.g. 2+2 always equals 4, crossing the street)
  - Reinforcement occurs more frequently
  - Learning is more enjoyable
  - Best for developing foundational skills
- **Trial-and-Error Learning:** Best for circumstances that are relatively unstable and require problem-solving for accurate responding (e.g. finding items at a grocery store, complex social skills)
  - Necessarily involves extinction schedules
  - Learning can be more frustrating
  - Best for skills requiring problem solving

Palmer's Definition of a Problem

1) A target response (or set of responses) is part of the organism's repertoire under one or more stimulus conditions.
2) Discriminative stimuli are present indicating that the response is scheduled for reinforcement.
3) The response is not under direct control of current discriminative stimuli.

How is a Problem Solved?

Palmer, D. C. (1991). A behavioral interpretation of memory. In L. J. Hayes & P. N. Chase (Eds.), *Dialogues on verbal behavior* (pp. 261-279). Reno, NV: Context Press.

Chapter 11

A Behavioral Interpretation of Memory

David C. Palmer
University of Massachusetts

Errorless Learning

vs.

Problem Solving

When Does Helping Help?

Watching myself with Lisa, I have been more impressed by this point. In my concern for helping a child I destroy the contingencies which would teach her to behave. I save her from annoyances and destroy the contingencies which would teach her to save herself. For example, I push branches aside which are getting against her face and deprive her of the chance to learn how to avoid branches. I pull on a sock and deprive her of the chance to learn to do it herself.

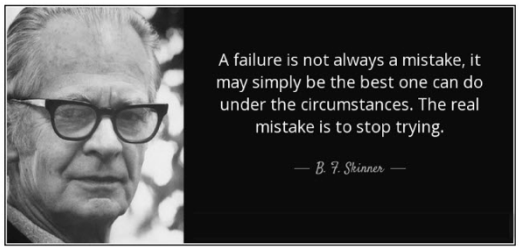
(From Skinner's Personal Notebooks, 1968)

Extinction: When "Errors" Help

- After problem behaviors have been successfully controlled by S-Deltas (e.g. blank disks)
- ...and when many different adaptive behaviors have been strengthened in the presence of a stimulus condition (i.e. divergent control)....

Extinction: When "Errors" Help

- Then, errorless teaching is no longer the preferred method of instruction
- Instead: Instructional environment is systematically set up to evoke extinction-induced problem-solving skills



Bottom Line

When teaching basic foundational skills to learners, errorless learning will result in:

- Faster rates of acquisition
- Higher likelihood of independent instructional settings and stimuli being paired with reinforcement
- Stronger repertoires of building blocks toward complex tasks that require problem-solving

Applied Research in Errorless Learning

Applied Research in Errorless Learning




Applied Research in Errorless Learning

Terms for Errorless Procedures

- **Neutral Stimulus (S^+ or S^0)**: Stimuli targeted for S^D or S^Δ
- **Prompt Stimulus:** Discriminative Stimuli used to pair with S^+ and eventually fade out

Types of Errorless Learning

Meuller, Palkovic, and Maynard (2007):

- Response Prevention
- Delayed Prompting
- Stimulus Shaping
- Stimulus Fading

Response Prevention

Definition: In a discrimination procedure, blocking access to selecting the targeted S^{Δ} (S^{0}) and ensuring an undisrupted path only to the targeted S^{D} (S^{+})

Delayed Prompting

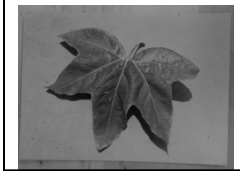
Definition: After presenting a targeted stimulus (S^{+}), the prompt stimulus (S^{D}) is presented at gradually increasing intervals allowing time for

Targeted Time Interval:	Example:
0 Seconds	Picture of a leaf + "What is it?" + "Leaf"
1 Second	Picture of a leaf + "What is it?" + 1 Second Pause + "Leaf"
2 Seconds	Picture of a leaf + "What is it?" + 2 Second Pause + "Leaf"
3 Seconds	Picture of a leaf + "What is it?" + 3 Second Pause + "Leaf"

Stimulus Shaping

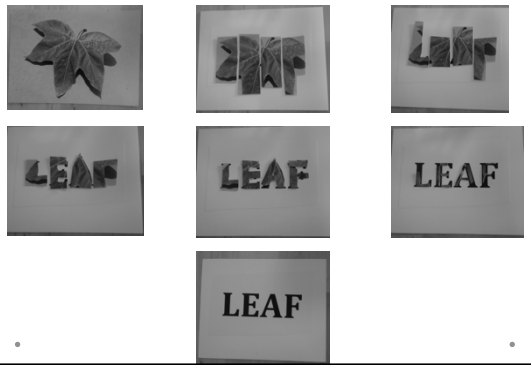
Definition: Systematically making changes to an established prompt stimulus S^{D} until it is transformed into a targeted S^{D} (S^{+}).

S^{D} **S^{+}**



→

Stimulus Shaping



Stimulus Fading

- **Definition:** After reinforcing a response to prompt stimulus (S^D) that is paired with the neutral stimulus (S^+), the prompt stimulus is systematically faded away.

"A constantly experimental attitude toward everything—that's all we need."

-B.F. Skinner

Thank You.

References

- Skinner, B. F. (1957). *Verbal behavior.* New York, NY: Appleton-Century-Crofts.
- Michael, J., Palmer, D. C., & Sundberg, M. L. (2011). The multiple control of verbal behavior. *The Analysis of Verbal Behavior, 27*, 3-22.
- Carbone, V.J., Morgenstern, B., Zecchin-Tirri G., & Kolberg, L. (2007). The role of the reflexive conditioned motivating operation (cmo-r) during discrete trial instruction of children with autism. *Journal of Early and Intensive Behavior Intervention*, 25(2), 110-124
- Roth, W.J. (2002). Teaching dolphins to select pictures in response to recorded dolphin whistles with few errors. *Dissertation Abstracts International: Section B: The Sciences & Engineering, 62* (10-B), No. 95008
- Toussaint, K.A. (2011). *Teaching tactual discrimination of Braille characters to beginning Braille readers.* Dissertation submitted to the Department of Psychology, Louisiana State University, Agricultural and Mechanical College
- Benbassat, D., & Abramson, C.I. (2002). Errorless discrimination learning in simulated landing flares. *Human Factors and Aerospace Safety*, 2, 319-338
- De Werd M.M., Boelen, D., Rikkert M.G., Kessels R.P. (2013). Errorless learning of everyday tasks in people with dementia. *Clinical Interventions in Aging*, 1177-1190
- Mueller, M.M., Palkovich, C.M., & Maynard, C.S. (2007). Errorless learning: Review and practical application for teaching children with pervasive developmental disorders. *Psychology in the Schools*, 44, 691-700

Contact Information

www.pattan.net

David Roth
C-droth@pattan.net

pennsylvania
DEPARTMENT OF EDUCATION
Bureau of Special Education
Pennsylvania Training and Technical Assistance Network

Commonwealth of Pennsylvania
Tom Wolf, Governor