

Stimulus Control and its Role in Errorless Learning

David Roth
National Autism Conference 2017

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)

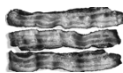
Our goal for each child is to ensure Individualized Education Program (IEP) teams begin with the general education setting with the use of Supplementary Aids and Services before considering a more restrictive environment.

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

B.F. Skinner

Reinforcement

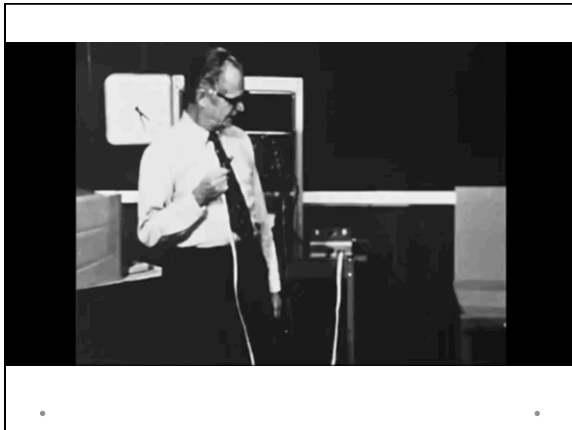
- A consequence of an individual's behavior/response
- Increases the probability of that response (class) occurring again in the future
- Can be positive (i.e. a consequence added to environment) or negative (i.e. a consequence removed)



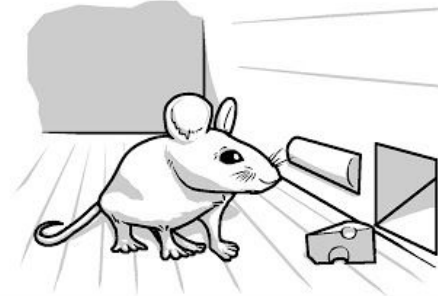
Unconditioned and Conditioned Reinforcement

Unconditioned reinforcement: effective without prior learning (e.g. food is an example of an unconditioned reinforcer)

Conditioned reinforcement: effective only after a history of being paired with UC (e.g. the sound of a click after being paired with food delivery is an example of an conditioned reinforcer)



What Does Animal Research Have to Do with Human Behavior?



The Operant

Antecedent	Behavior	Consequence
Something that happens <u>immediately before</u> a response that changes the likelihood of the response occurring	Anything an individual does that is <u>observable</u> and <u>measurable</u>	Some event that <u>immediately</u> follows the response and alters the <u>future probability</u> of that type of response

Note: the operant and the first instance

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

Antecedent	Behavior	Consequence
Motivating Operation (MO): An environmental event that alters the <u>value</u> of something else as a reinforcer and alters the probability of any behavior that, in the past, has produced that reinforcement	Response	Specific Reinforcement: The reinforcing item/event whose value has been specifically altered by the MO

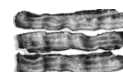
Meet Ebby

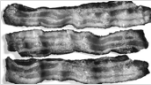



Motivational Control for Turning


Food
Deprivation

"Click"



Definitions Revisited		
Antecedent	Behavior	Consequence
Motivating Operation (MO): Food deprivation establishes the value of bacon as a reinforcer and evokes/strengthens the behavior of <i>turning around</i> , since that behavior has been specifically reinforced with bacon	<i>Turning Around</i>	Specific Reinforcement: Bacon, whose value has been specifically increased by food deprivation 

Motivational Control for Pecking		
Yerba Mate Deprivation		
"Click"		
		

Definitions Revisited		
Antecedent	Behavior	Consequence
Motivating Operation (MO): Yerba mate deprivation establishes the value of yerba mate as a reinforcer and increases the probability of <i>pecking</i> behavior, since it has been specifically reinforced with yerba mate	<i>Pecking</i>	Specific Reinforcement: Yerba mate, whose value has been specifically increased by the yerba mate deprivation 

Motivational Control and Verbal Behavior		
Antecedent	Behavior	Consequence
Motivating Operation	MAND	Specific Reinforcement Mediated by a Listener

The Mand		
<ul style="list-style-type: none"> SPECIFIES to a listener the reinforcement that is currently valuable to the speaker Types of consequences that are specified by manders: <ul style="list-style-type: none"> 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		
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What is a stimulus?



An item or event in
one's environment



that directly affects
his or her senses.

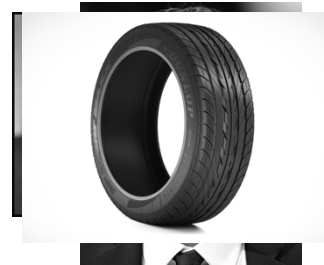






What is Stimulus Control?

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


Thought Experiment

"What's the kanux, man!"



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): An antecedent stimulus that has been historically correlated to the <u>availability of reinforcement</u> and evokes (or at least strengthens) any behavior that in the past has led to the reinforcing consequences	Response	Generalized Conditioned Reinforcement: A consequence that increases the future probability of the behavior it follows as a result of its previous pairings with many other forms of reinforcement and its effectiveness is relatively independent of current states of MO

Discriminative Stimulus (S^D) Control for Turning



"Click"

Etc.



Definitions Revisited

Antecedent	Behavior	Consequence
Discriminative Stimulus (S^D): The red disk has been historically correlated to the availability of generalized conditioned reinforcement and evokes or strengthens the behavior of <i>turning around</i>	<i>Turning Around</i>	Generalized Conditioned Reinforcement: The sound of the click increases the future probability of turning around in the presence of the red disk as a result of its previous pairings with bacon, girlfriends, yerba mate tea, etc. and is still effective regardless of the current MO.

Conditioned Reinforcement



Generalized Conditioned Reinforcement

- When a conditioned reinforcer (e.g. "click") is paired with only one type of unconditioned reinforcer (e.g. food pellet), its effectiveness depends on motivation for the unconditioned reinforcer
- If that conditioned reinforcer is paired with many types of other reinforcers, then its reinforcing effectiveness is relatively independent of certain types of motivations

In other words...

When the sound of the click was only paired with bacon, it's reinforcing value depended on Ebby's motivation for bacon, but when the click is paired with many different kinds of reinforcers (e.g. bacon, Yerba Mate, girlfriends, praise, money, etc.), it becomes a generalized conditioned reinforcer and its effectiveness does not depend on any momentary motivation for a particular reinforcer.

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...

Weren't you
asked not to read
this?

Generalized Conditioned Reinforcement




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

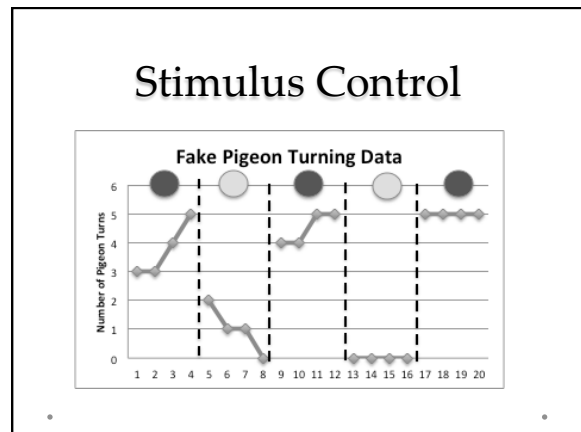
Stimulus Delta Control		
Antecedent	Behavior	Consequence
Stimulus Delta (S^{Δ}): An antecedent stimulus that has been historically correlated to the <u>UNavailability</u> of reinforcement and weakens any behavior that in the past has led to extinction	Response	Extinction: The absence of reinforcement following a previously reinforced behavior and leads to an overall weakening of the behavior

Stimulus Delta (S^{Δ}) Control for Turning




No
Bacon, Yerba
Mate, or Lady-
Pigeons


Definitions Revisited		
Antecedent	Behavior	Consequence
Stimulus Delta (S^{Δ}): The blank disk has been historically correlated to the unavailability of reinforcement following <i>turning</i> behavior and weakens the behavior as a result of extinction.	<i>Turning Around</i>	Extinction: The absence of bacon, yerba mate, and lady-pigeons following <i>turning</i> behavior has led to an overall weakening of the behavior.




Discriminative Stimulus (S^D) Control for Pecking




"Click"
Etc.




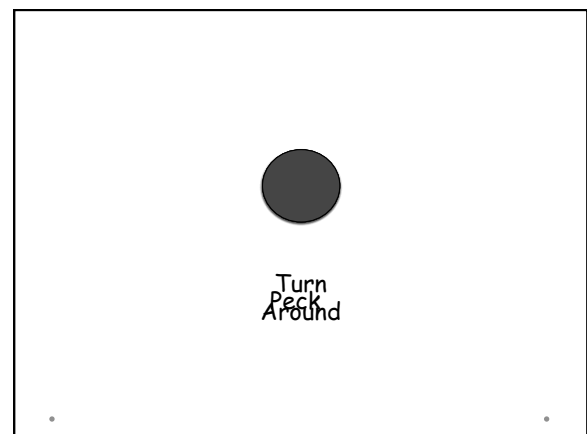
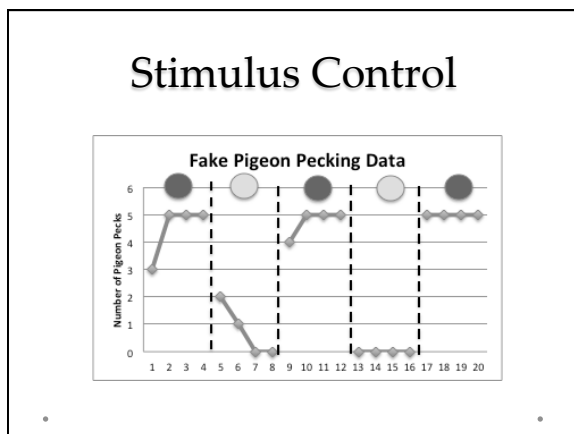
Stimulus Delta (S^{Δ}) Control for Pecking




No
Bacon, Yerba
Mate, or Lady-
Pigeons

Definitions Revisited		
Antecedent	Behavior	Consequence
Discriminative Stimulus (S^D): The green disk has been historically correlated to the availability of generalized reinforcement and evokes or strengthens <i>pecking</i> behavior 	<i>Pecking</i>	Generalized Conditioned Reinforcement: The sound of the click increases the future probability of <i>pecking</i> 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 to the <u>UN</u> availability of reinforcement following <i>pecking</i> and weakens the behavior as a result of extinction 	<i>Pecking</i>	Extinction: The absence of bacon, yerba mate, and lady-pigeons following <i>pecking</i> has led to an overall weakening of the <i>pecking</i> behavior




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 "water"	Getting the Water	GCR
Seeing someone hand "candy"	Getting "candy"	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 glass of water	Bringing the water to one's lips	GCR
Seeing your favorite wrapped candy bar	Unwrapping the wrapper	GCR
Hearing a truck drive by	Saying "truck"	GCR
Seeing a keyhole in your door knob	Inserting and turning the key	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

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

Conditional Discrimination:

If X, and If Y - then Z

* 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 your grandfather who is hard of hearing, 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

Multiple Control and Memory

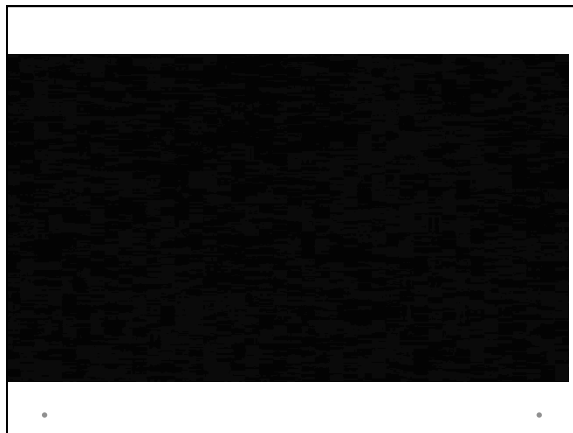
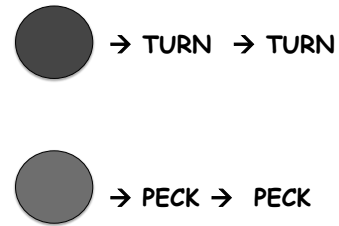
Check out Dr. David Palmer's session #49 this afternoon to see how these basic principles can explain the complex phenomena we call “memory”

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



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):

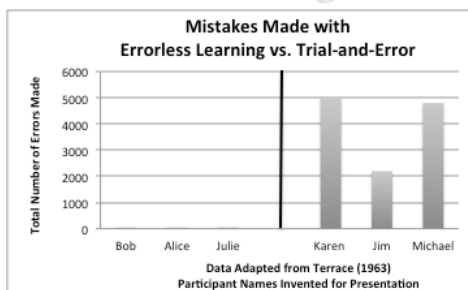
Discrimination learning with and without "errors"



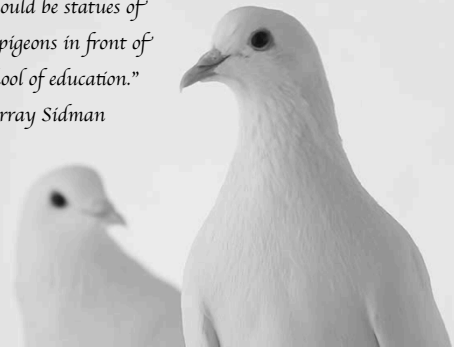
Trial-and-Error Learning



The History of Errorless Learning



"There should be statues of Terrace's pigeons in front of every school of education."
-Murray Sidman

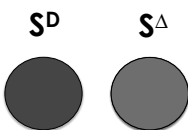


Errorless vs. Trial-and-Error Learning

Marsh and Johnson (1968):

Discrimination reversal learning without "errors"

Errorless Group



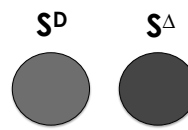
Trial-and-Error Group



"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



Trial-and-Error Group



Results

- **Errorless Learning Group:** Persisted in responding to the “old” S^D despite extinction
- **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

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



Roth (2002): Teaching dolphins to select pictures in response to recorded dolphin whistles with few errors

Also, much of the research conducted by Karen Pryor

Applied Research in Errorless Learning



Touissant (2011): Teaching tactual discrimination of Braille characters to beginning Braille readers

Applied Research in Errorless Learning



Benbassat and Abramson (2002): Errorless discrimination in simulated landing flares

Applied Research in Errorless Learning



De Werd, Boelen, Olde Rikkert, and Kessels (2013): Errorless learning of everyday tasks in people with dementia

Applied Research in Errorless Learning



Mueller, Palkovic, and Maynard (2007): Errorless learning: Review and practical application for teaching children with pervasive developmental disorders

Terms for Errorless Procedures

- **Neutral Stimulus (S^+ or S^0):** Stimuli targeted for S^D or S^A
- **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^A (S^0) and ensuring an undisrupted path only to the targeted S^D (S^+)



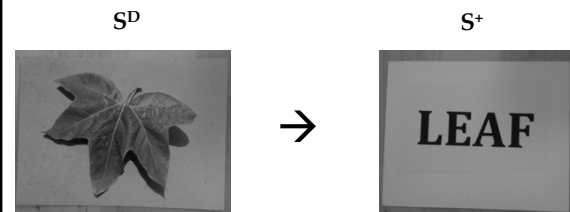
Delayed Prompting

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

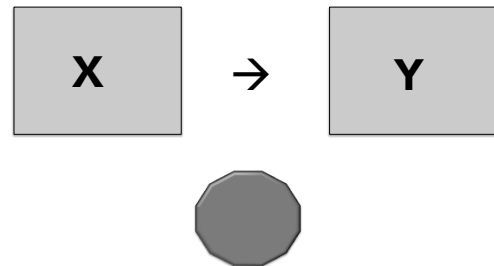
Definition: Systematically making changes to an established prompt stimulus S^D until it is transformed into a targeted S^D (S^+).



Stimulus Shaping



Stimulus Shaping: an App for That?



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.

Stimulus Fading and Intensive Teaching

• Errorless Procedure:

- PROMPT
- TRANSFER
- DISTRACTER
- CHECK



A great deal of the unrest among students today can be traced to a slow recognition that somehow or other they are not actually being taught. They are simply held responsible for learning.

-B.F. Skinner-

Thank You.

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Commonwealth of Pennsylvania
 Tom Wolf, Governor