Context, behavior change, and habit learning

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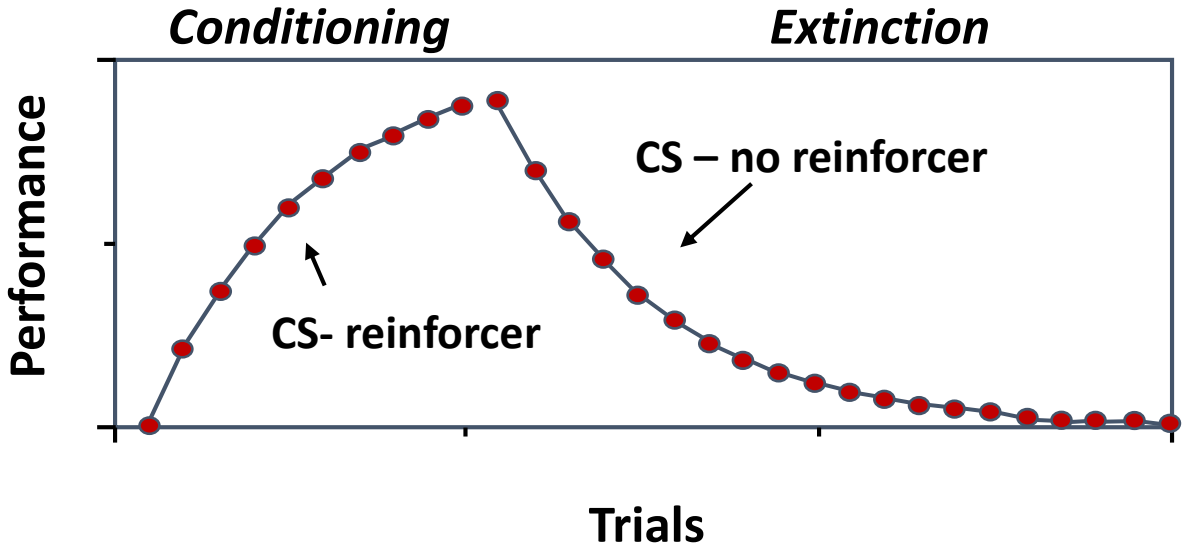
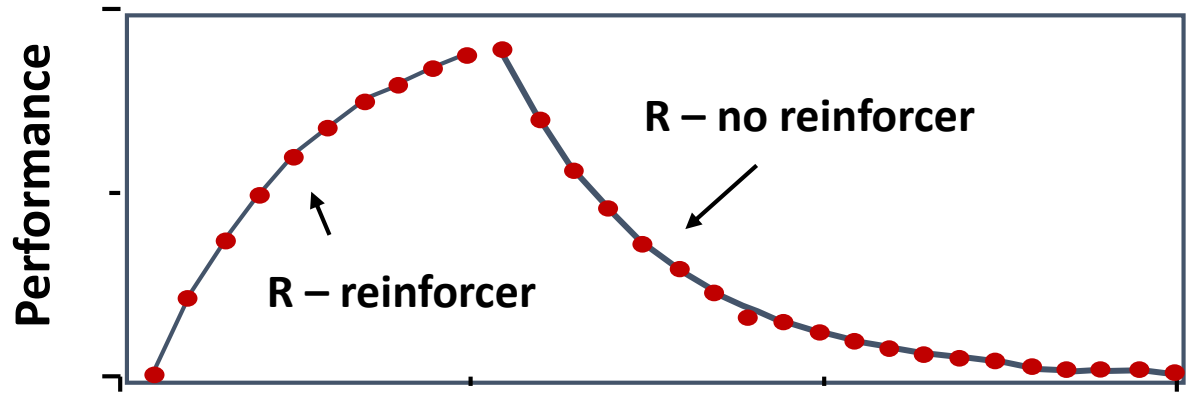
TODAY'S PLAN:
Context, behavior change, and habit learning

- Extinction is a basic form of behavior change
  - Context is crucial in both Pavlovian and operant extinction
  - Context is also crucial in other types of behavior change (punishment, omission, DRA)
  - There are many kinds of contexts
- Goal-directed actions and habits
  - Making habits
  - Breaking habits
- An integration
  - Action-to-habit conversion is another form of behavior change
  - Habit does not erase goal-direction, but like extinction, interferes with it in a context-specific way
  - Some implications for addiction

PAVLOVIAN AND OPERANT EXTINCTION

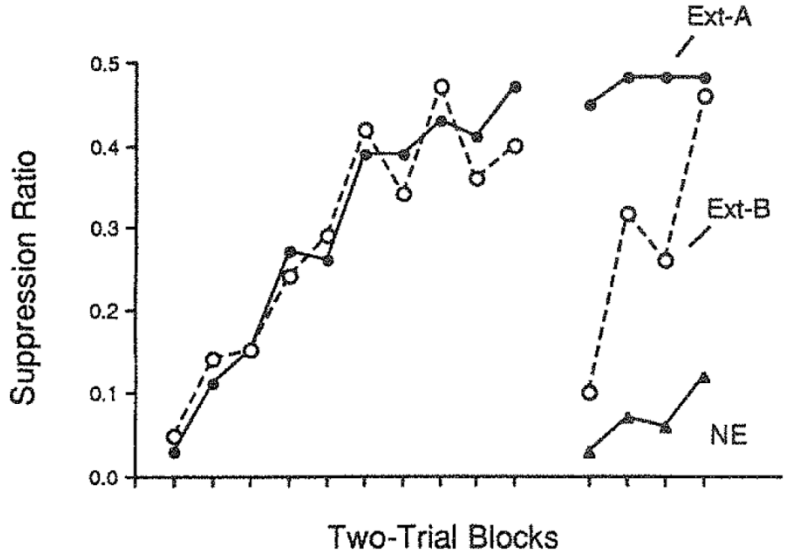


Pavlovian or respondent conditioning



Instrumental or operant conditioning

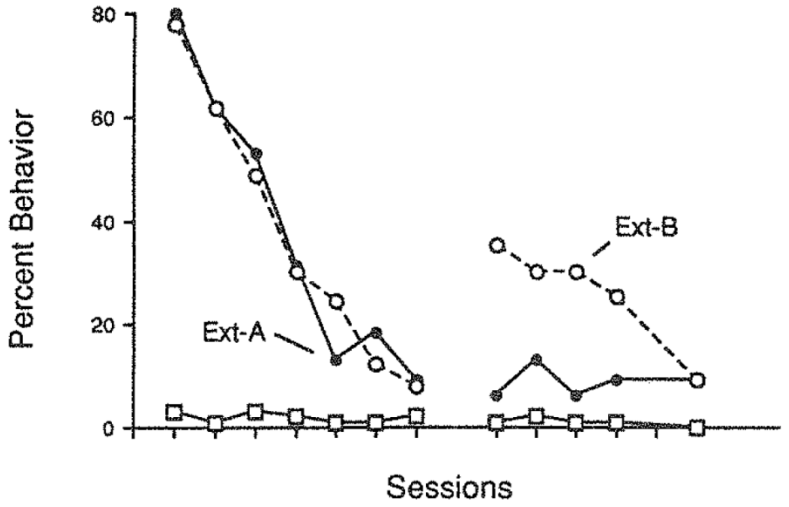
The renewal effect– Pavlovian learning



Fear conditioning

Conditioning (Tone-shock)	Extinction (Tone -)	Test (Tone?)
A	B	A
A	A	A

Bouton & King, *Journal of Experimental Psychology: Animal Behavior Processes*, 1983



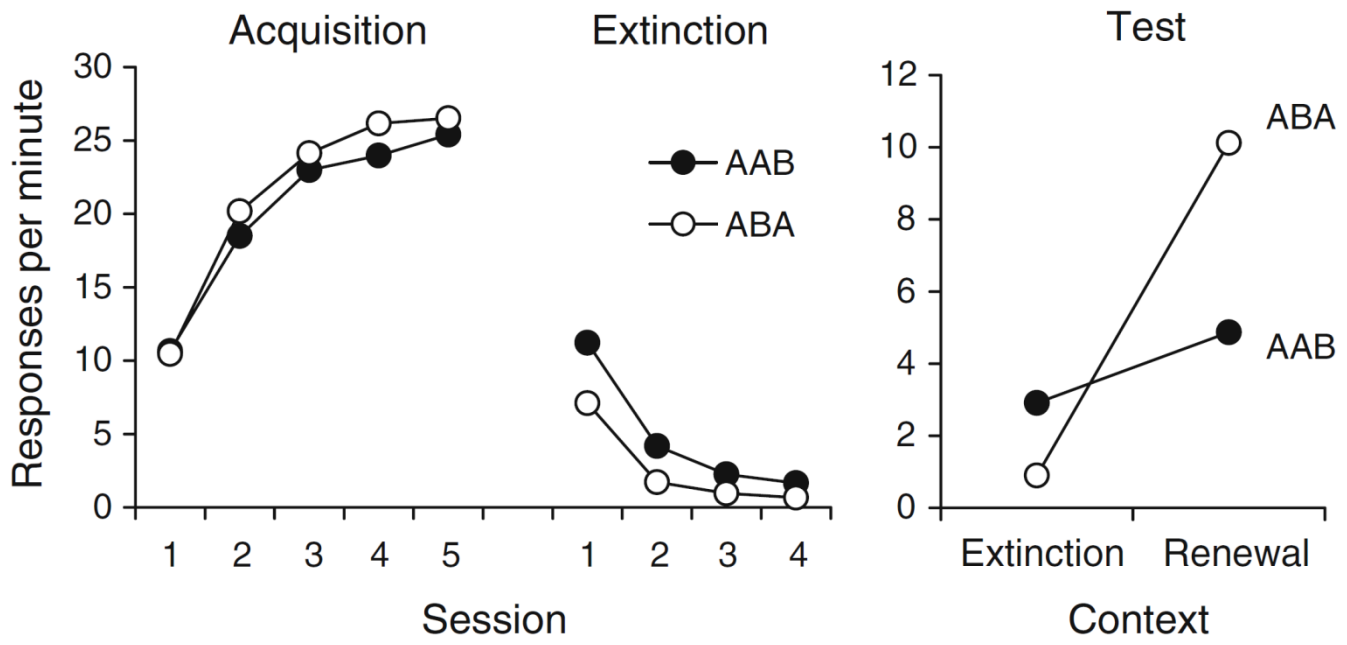
Appetitive conditioning

Conditioning (Tone-food)	Extinction (Tone -)	Test (Tone?)
A	B	A
A	A	A

Bouton & Peck, *Animal Learning & Behavior,* 1989

RENEWAL AFTER OPERANT EXTINCTION

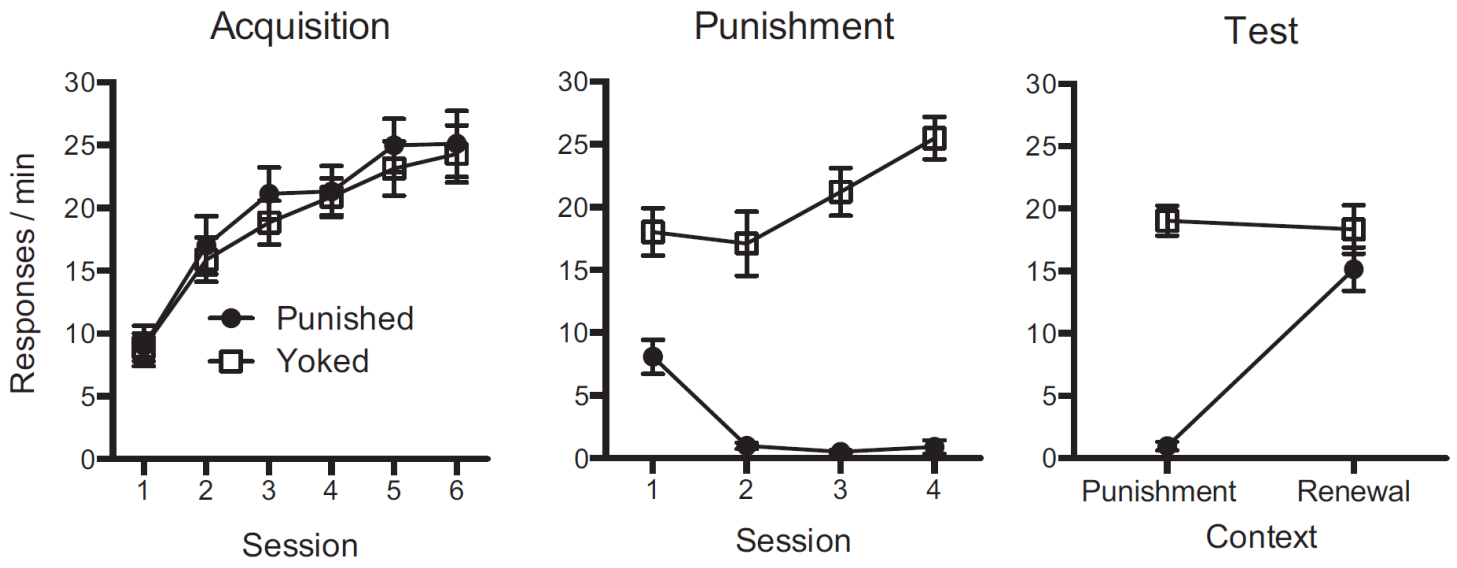
	Acquisition	Extinction	Test
ABA	A	B	A, B
AAB	A	A	A, B



Bouton, Todd, Vurbic, & Winterbauer, *Learning & Behavior, 2011*

RENEWAL AFTER PUNISHMENT

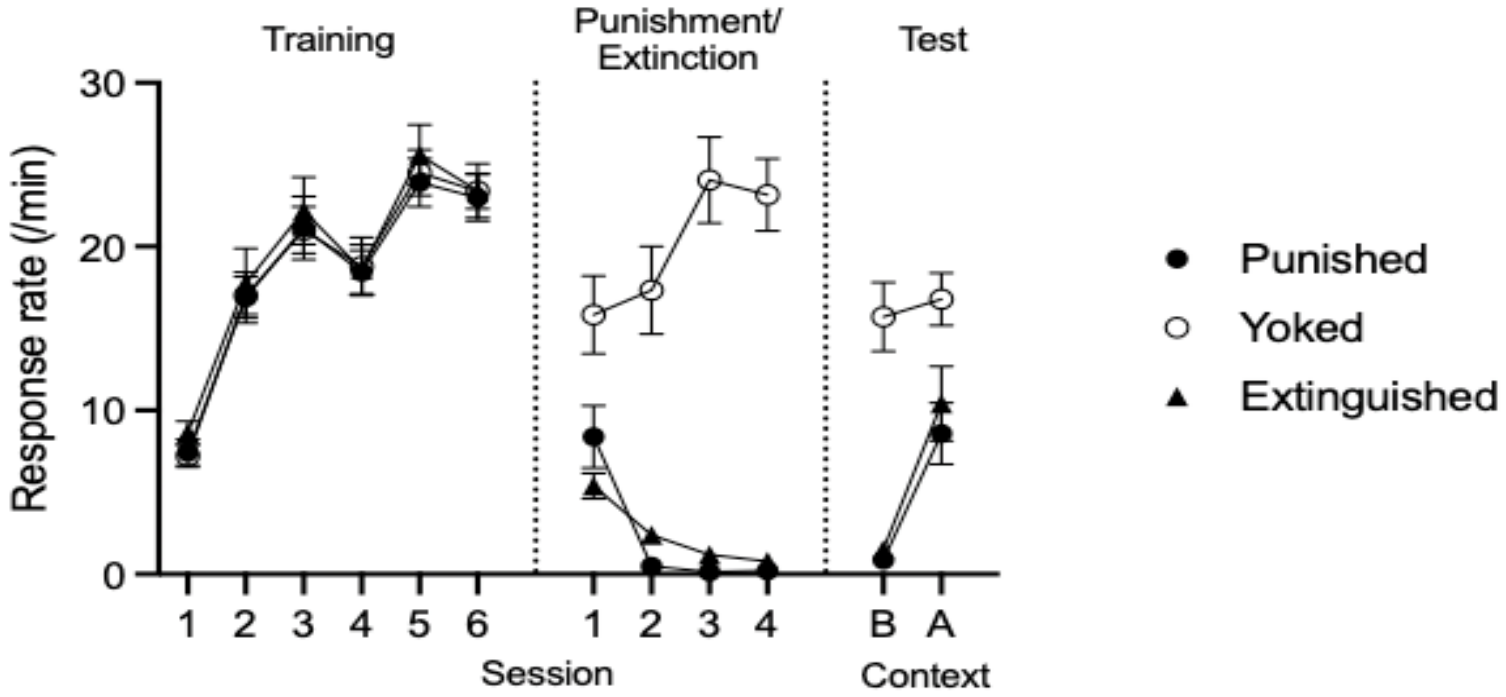
	Acquisition	Punish	Test
Punish	A: R-pellet	B: R-pellet/shock	A: R, B: R
Yoked	A: R-pellet	B: R-pellet/yoked shock	A: R, B: R



Bouton & Schepers, *Journal of Experimental Psychology: Animal Learning and Cognition, 2015*

RENEWAL AFTER PUNISHMENT

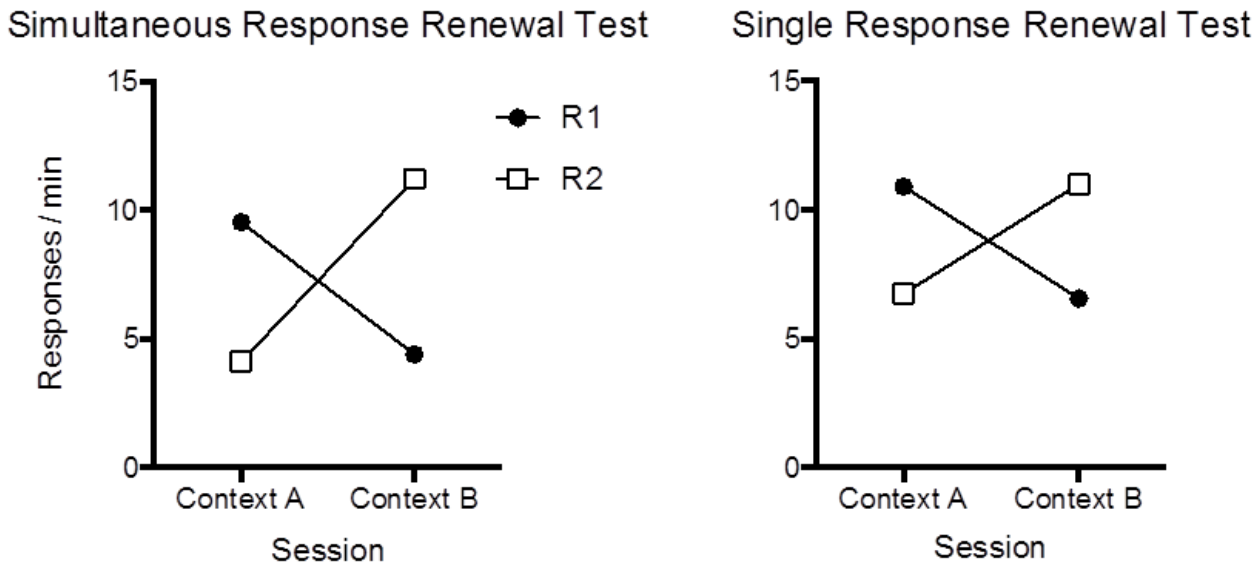
	Acquisition	Punish	Test
Punish	A: R-pellet	B: R-pellet/shock	A: R, B: R
Yoked	A: R-pellet	B: R-pellet/yoked shock	A: R, B: R
Ext	A: R-pellet	B: R-	A: R, B:R



Broomer & Bouton, in progress

RENEWAL AFTER PUNISHMENT WITH CONTEXTUAL HISTORY CONTROLLED

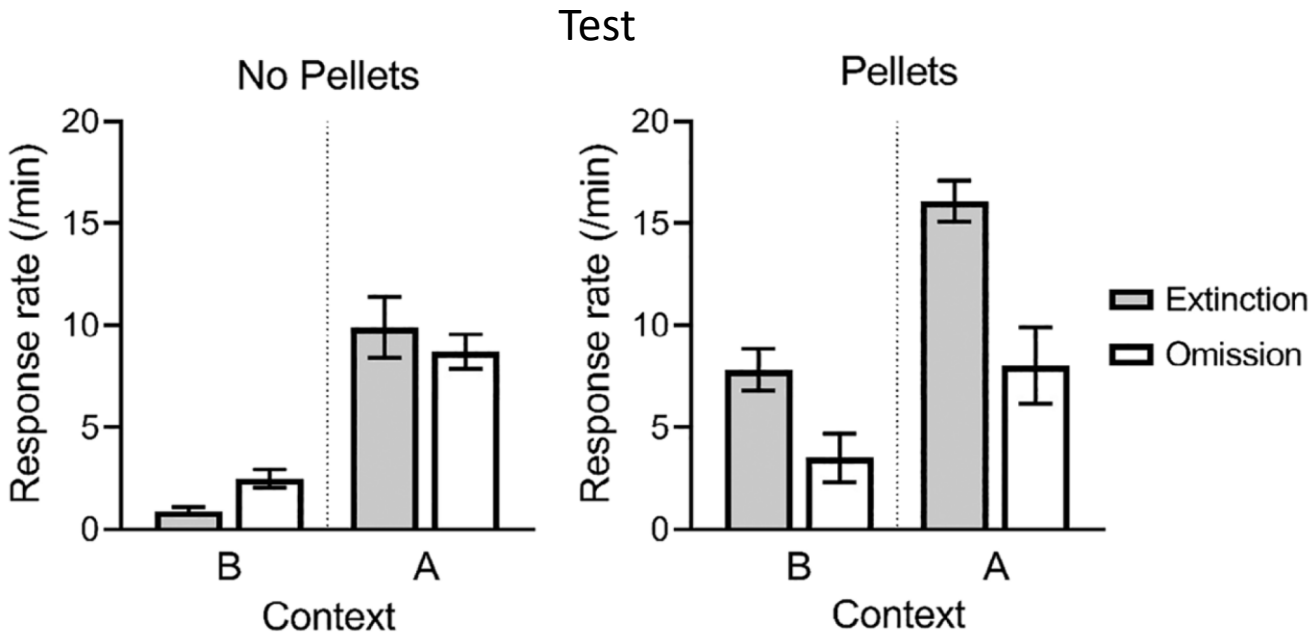
Acquisition		Punish	Test
A: R1-pellet	→	A: R2-pellet/shock	A: R1, R2
B: R2-pellet	→	B: R1-pellet/shock	B: R1, R2



Bouton & Schepers, *Journal of Experimental Psychology: Animal Learning and Cognition,* 2015

RENEWAL AFTER REINFORCING ABSTINENCE (DRO)

Acquisition	Response elimination	Test
A: R-pellet	B: R- (Ext.)	A: R, B: R
A: R-pellet	B: R-, pel. (Omission)	A: R, B: R
A: R-pellet	B: R- (Ext.)	A: R, B: R (pellets)
A: R-pellet	B: R-, pel. (Omission)	A: R, B: R (pellets)



Rey, Thrailkill, Goldberg, and Bouton, *Journal of the Experimental Analysis of Behavior,* 2020

Renewal after behavior change

- Context plays a clear role in extinction
  - ABA, AAB, and ABC renewal effects all obtain
- Context plays a similar role after several types of behavior change
  - Extinction, punishment, omission training, differential reinforcement of alternative behavior
- Behavior change does not erase the original learning
  - It depends at least partly on the subject *learning not to make a specific response* in a specific context

- Renewal is a reason why treatment effects are rarely permanent.
  - And why problem behaviors seem so persistent.
  - *Relapse is easy to obtain*

There are many kinds of lapse/relapse effects

- Pavlovian extinction
  - Renewal
  - Reinstatement
  - Spontaneous recovery
  - Rapid reacquisition
- Operant extinction
  - Renewal
  - Reinstatement
  - Spontaneous recovery
  - Rapid reacquisition
  - Resurgence

All of these are context change effects.
Extinction learning is highly specific to its context

There are many kinds of contexts

- Exteroceptive contexts
  - Apparatus, room, place, location, etc.
- Interoceptive contexts
  - Drug state
  - Hormonal state
  - Mood state
  - Social cues
  - Expectation of events
  - Time
  - Recent behaviors
  - Recent reinforcers
  - Stress state
  - Deprivation state

Bouton, *Psychopharmacology,* 2019
Bouton, Maren, & McNally, *Physiological Reviews,* 2021

Instrumental/operant behaviors come in two varieties

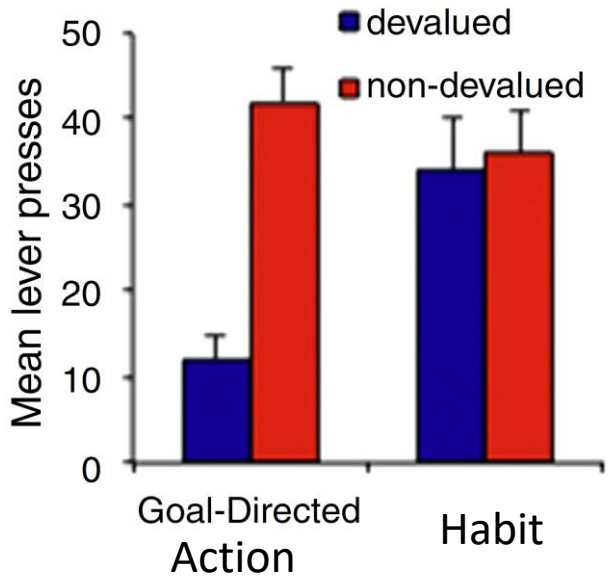
Goal-Directed Actions

- Goal-directed, deliberate
- Depend on knowledge of the relationship between behavior and the outcome or goal (R-O)
- Depend on knowledge of the goal's value
- Sensitive to reinforcer devaluation

Habits

- Automatic, mechanical, "mindless"
- S-R
- Evident after *extensive* practice
- *Insensitive* to reinforcer devaluation

Acquisition	Reinforcer Devaluation	Extinction Test
R-pellet	pellet→LiCl pellet / LiCl	R?



From, e.g., A. Dickinson, 1985, 1989, 1994, 2012; Balleine, 2019; Balleine & O'Doherty, 2010

What creates a habit?

Law of Effect (Thorndike, 1911)

→ S-R “habit” association is stamped in with every reinforcement

Rate Correlation View (Dickinson, 1985, 1987; Perez & Dickinson, 2020)

→ Habits form when the correlation between behavior rate and reward rate becomes low

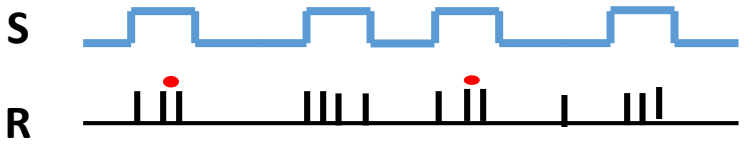
Our view

→ Habits develop when the reinforcer becomes predictable

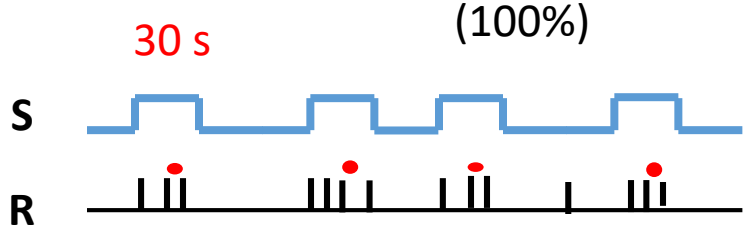
This allows us to pay less attention to behavior

Extends the Pearce-Hall (1980) model of attention in Pavlovian learning

Partial Reinforcement
(50%)



Continuous Reinforcement
(100%)

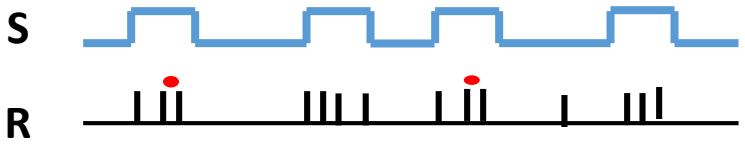


Pearce-Hall attention rule
Uncertain reinforcers (50%) maintain attention
Predictable reinforcers (100%) do not

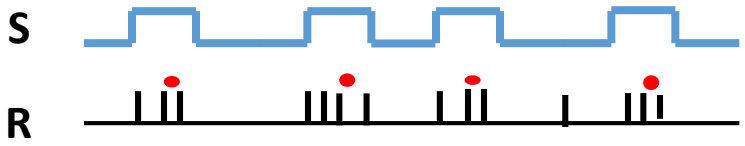
Acquisition	Reinforcer Devaluation	Extinction Test
S-R-pellet	pellet→LiCl pellet / LiCl	S-R?

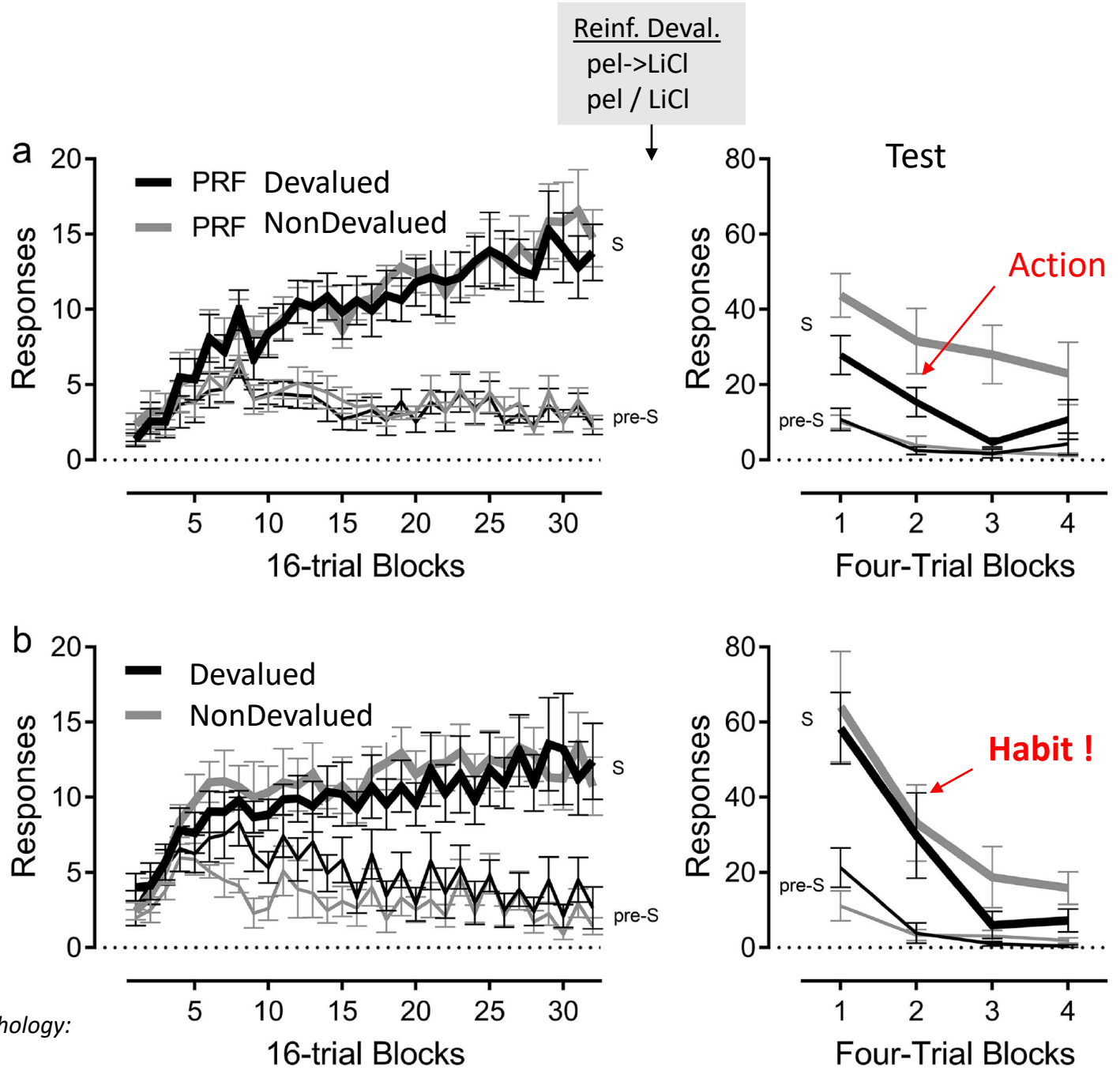
Thrailkill, Trask, Vidal, Alcalá, & Bouton, *Journal of Experimental Psychology: Animal Learning and Cognition,* 2018

Partial Reinforcement
(50%)



Continuous Reinforcement
(100%)

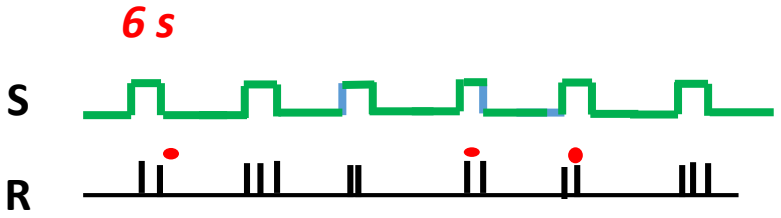




Thrailkill, Trask, Vidal, Alcalá, & Bouton, *Journal of Experimental Psychology: Animal Learning and Cognition,* 2018

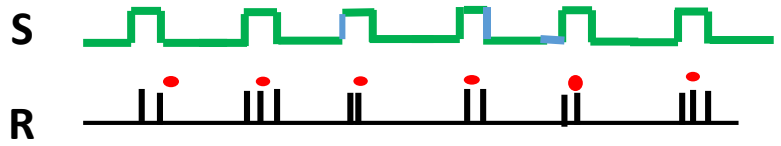
Test

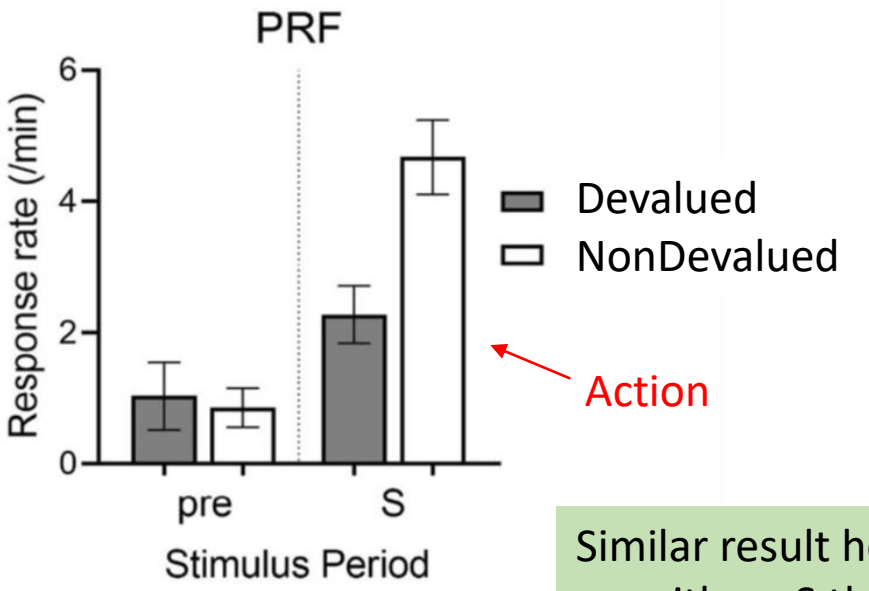
Partial Reinforcement
(50%)



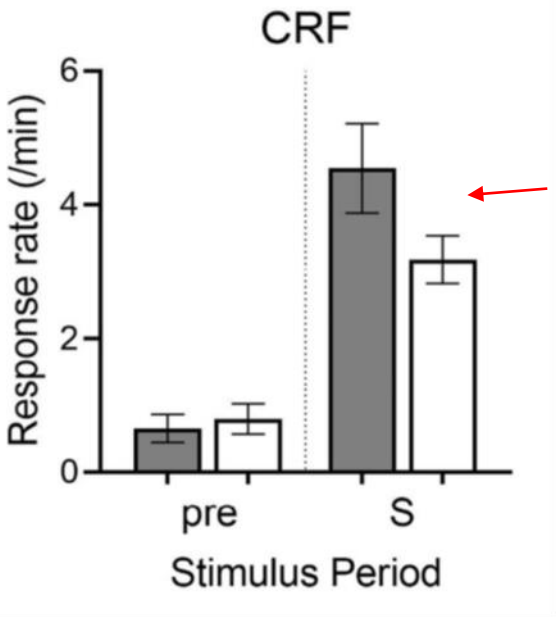
RI 3-s

Continuous Reinforcement
(100%)





Action



Habit

Similar result here
-- with an S that was 1/5 as long
-- and a reinforcement rate 10 times as rich

Thrailkill, Michaud, & Bouton, *Journal of Experimental Psychology: Animal Learning and Cognition*, 2021

Making habits

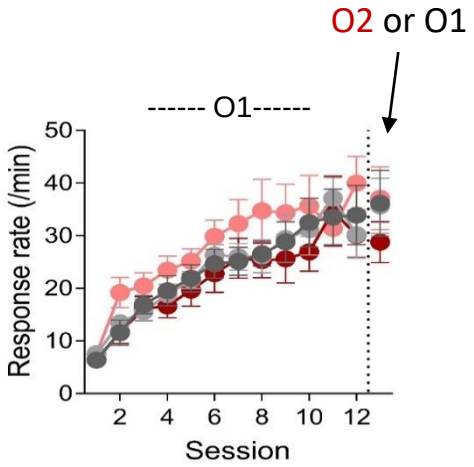
- Habit learning occurs when the reinforcer becomes predictable
- It is prevented when the reinforcer stays unpredictable– as in our 50% PRF schedule.
- Consistent with theories of attention and learning (the Pearce-Hall model)
  - Though nobody pointed it out before.
- Habit learning happens when we can “tune out” a behavior
  - Goal-directed actions are ones that are “tuned in”

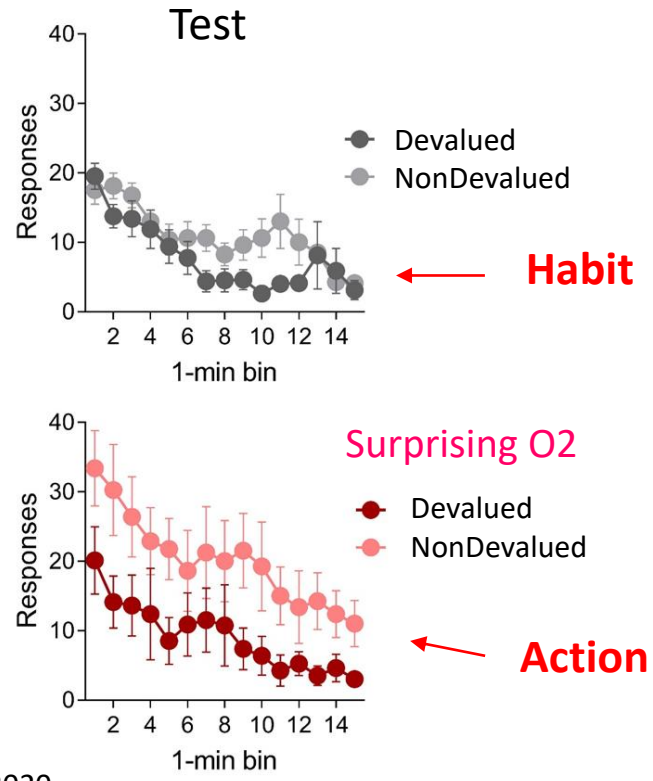
- This is a more flexible view of actions and habits than the prevailing view
  - Habit is not necessarily a fixed endpoint
  - Maybe we can turn a habit back into an action
  - If we make the reinforcer surprising again.

Implications for ***breaking*** a habit

Make the reinforcer surprising at the end of habit training

Acquisition (simple RI-30)	Reinforcer Devaluation	Test
13 sessions R-01	O1 Paired or Unpaired LiCl	R?
12 sessions R-O1; then 1 session R-O2	O1 Paired or Unpaired LiCl	R?





A surprising outcome at the end of habit training returned the habit to action

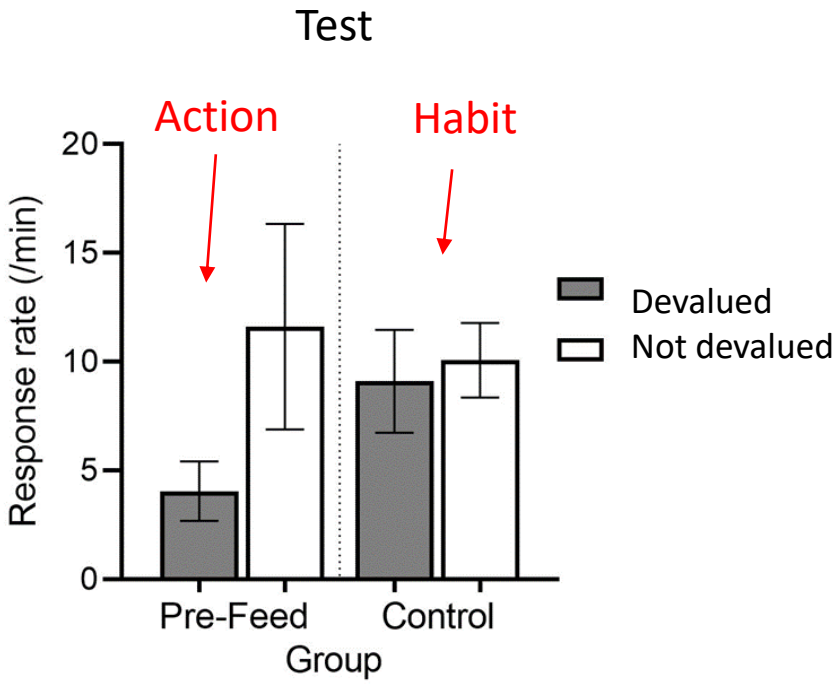
Bouton, Broomer, Rey, & Thrailkill, *Neurobiology of Learning and Memory*, 2020

Breaking Habits 2

Habits return to action status after other manipulations too

→Surprising reinforcers presented just before the test

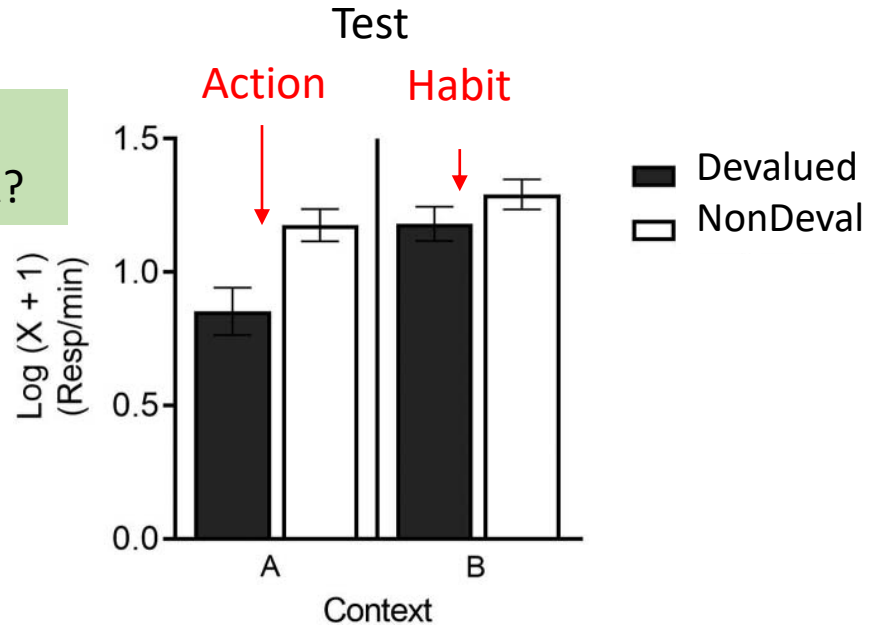
Acquisition	Reinforcer Devaluation	Test
		----- R?
20 R-01	O1 Paired or Unpaired LiCl	
		Pre-Feed O2: R?



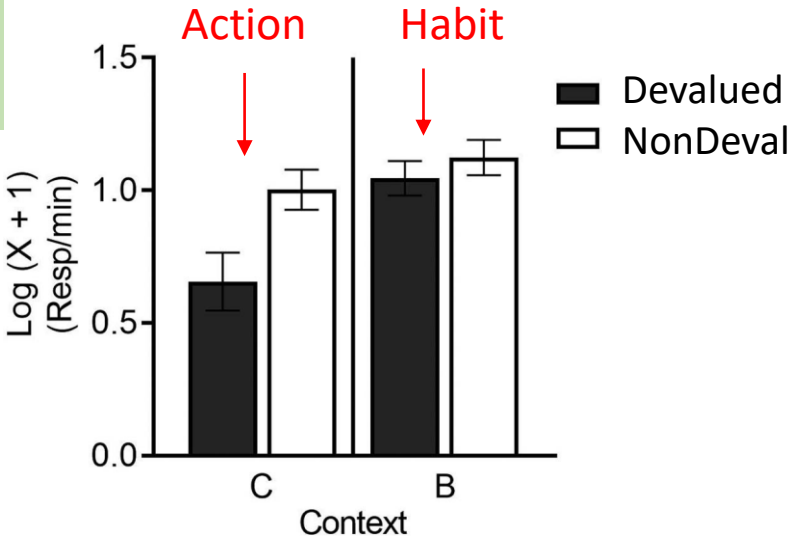
Bouton, Broomer, Rey, & Thrailkill, *Neurobiology of Learning and Memory,* 2020

Breaking Habits 3– change the context

Action (Context A)	Habit (Context B)	Reinforcer Devaluation	Test
3 R-0	12 R-O	O Paired or Unpaired LiCl	A: R? B: R?



Action (Context A)	Habit (Context B)	Reinforcer Devaluation	Test
3 R-0	12 R-O	O Paired or Unpaired LiCl	**C**: R? B: R?



*Action **renews** with context change after Habit learning*

Habit is more context-specific than Action

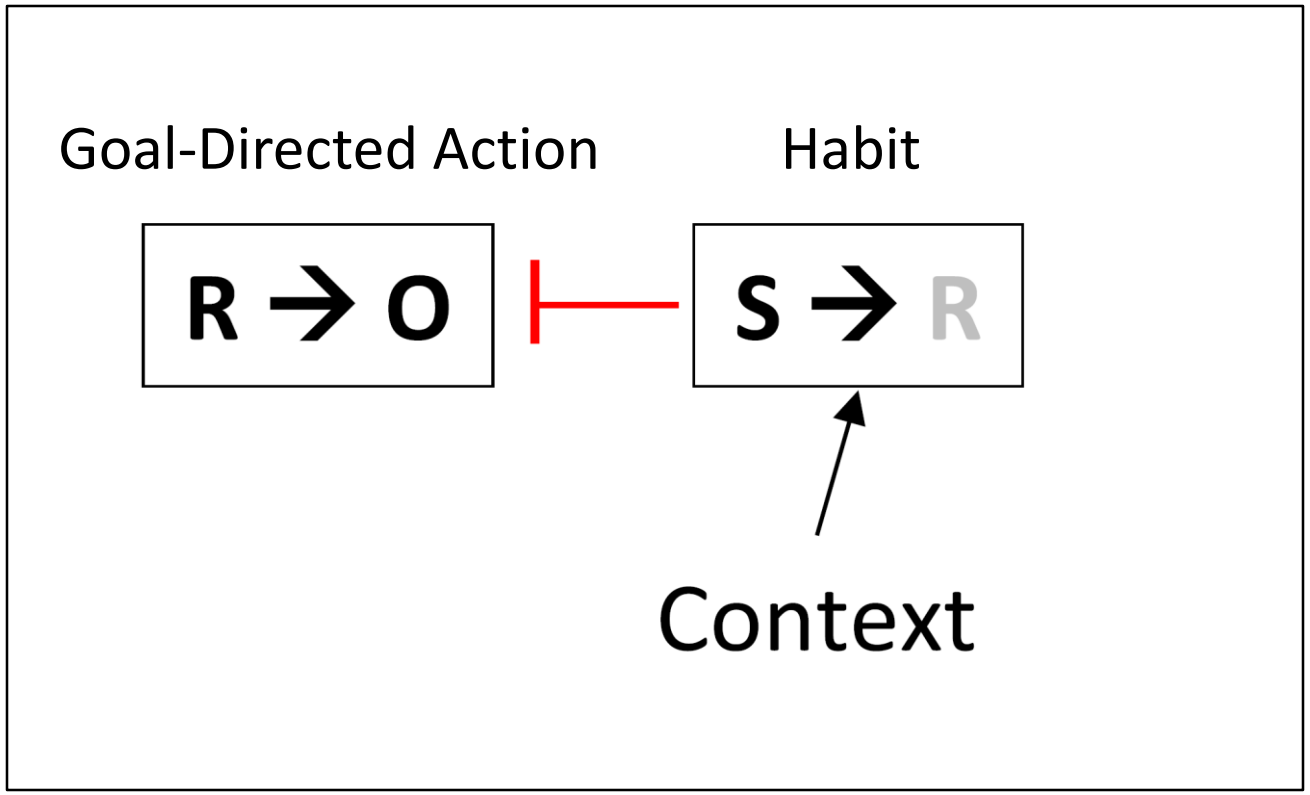
Steinfeld and Bouton, *Behavioral Neuroscience*, 2021

We have come full circle

Action→habit conversion is like extinction:
Habit does not erase action; it interferes with it in a context-specific way

A general principle of associative learning

R-O → extinction
R-O → punishment
R-O → omission
R-O → habit



Bouton, *Learning & Behavior,* 2021

Summary

- Behavior change is not erasure
  - Lots of research on extinction, punishment, and other forms of retroactive interference
  - It is extremely sensitive to the **context**
- The action→habit conversion is similar
  - Habit doesn't erase goal direction
  - It interferes with it in a context-specific way
- Habit learning itself occurs when conditions allow us to "tune out" our behavior

The Team

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Fair and counterbalanced.

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