Modeling acquisition

- In his 1930s series of papers, Hull showed how simple processes (reinforcement, extinction, response competition, and spontaneous recovery) are sufficient to generate seemingly complex behavior (e.g., discrimination learning).

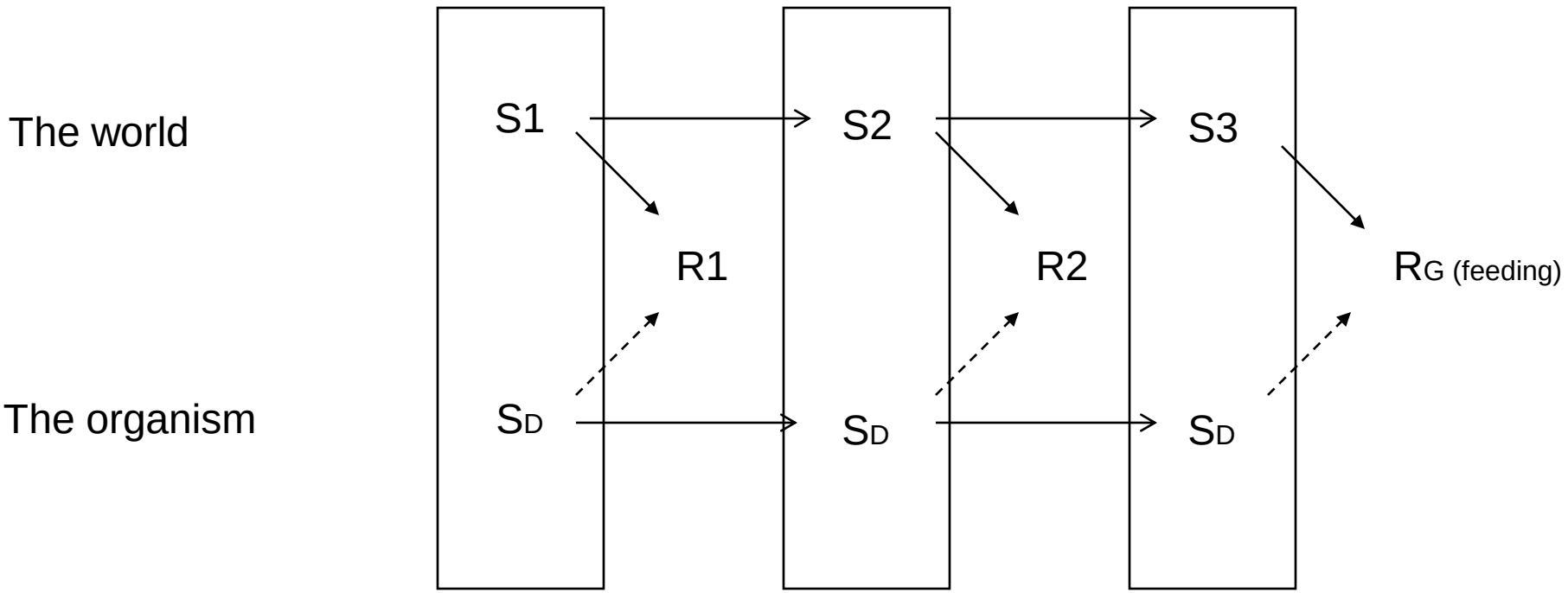
- Hull (1930) showed the rudiments of model simulation by assuming arbitrary values for the initial strength of various responses and for the processes assumed to operate in a situation.

- Hull also developed a terminology that allowed for an explanation of so-called cognitive phenomena in simple stimulus-response (S-R) terms.

- In the 1930s, “cognition” referred to a process of expectation or anticipation of the reinforcer.

Hull (1930). Simple trial-and-error learning: A study in psychological theory. Psychological Review, 37, 241-256.

Hull's associative mechanism for expectancies



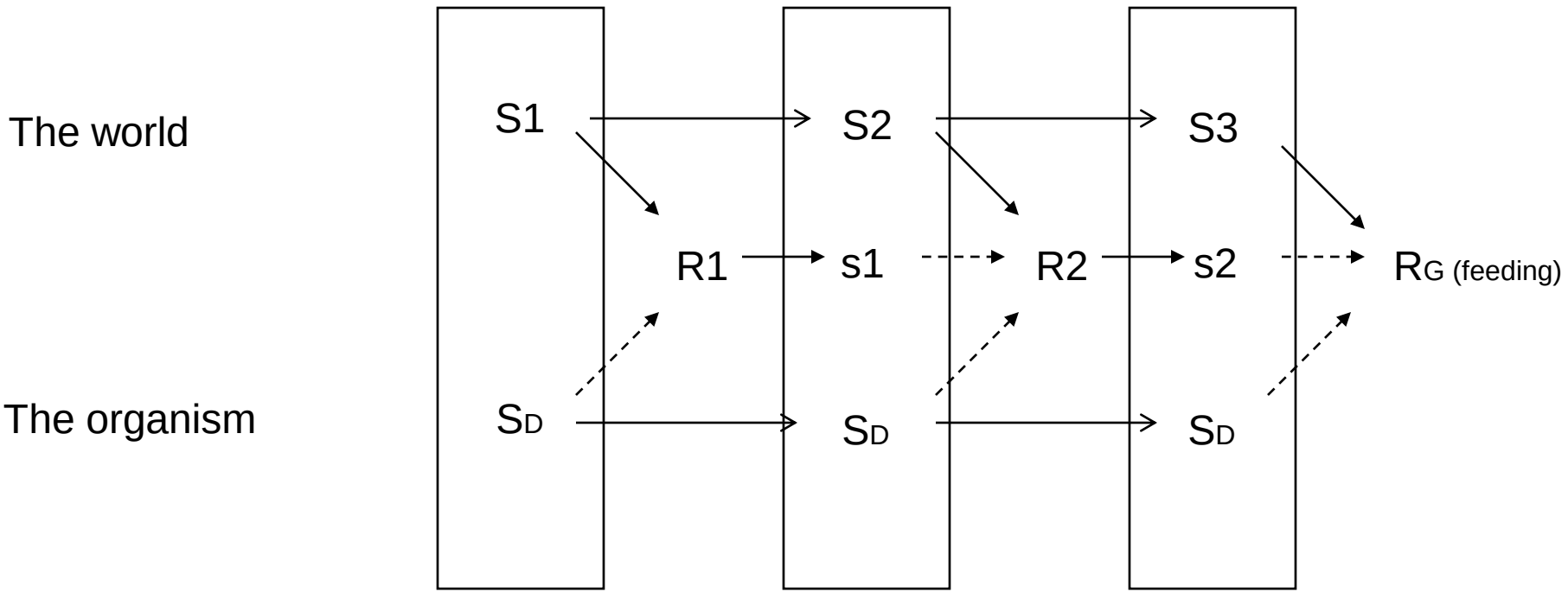
S1, S2, S3…: stimulus stream present in the animal's environment.

S_D: drive stimuli, continuously present while the internal state of hunger remains unchanged.

Principle of redintegration: stimuli present an any time when a response occurs independently acquire the capacity to evoke that response (S-R contiguity).

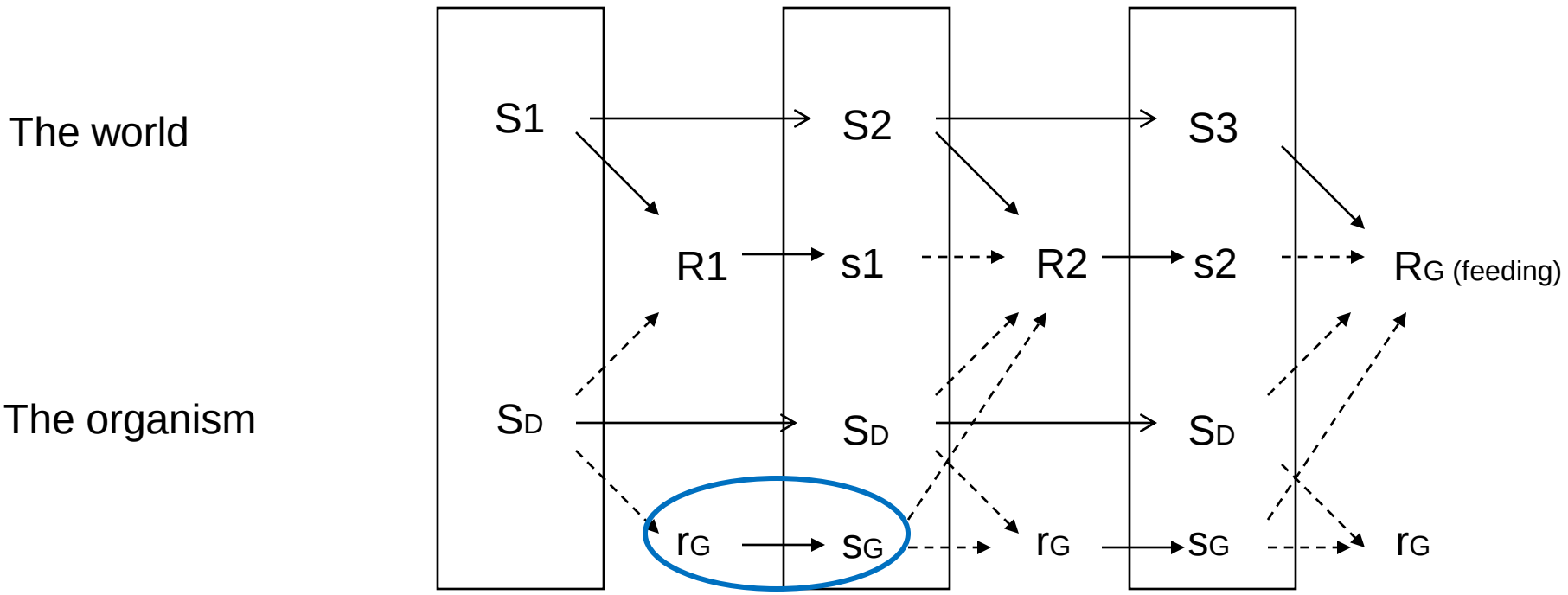
Hull (1931). Goal attraction and directing ideas as habit phenomena. Psychological Review, 38, 487-506.

Hull's associative mechanism for expectancies



s1, s2…: propioceptive stimulus feedback from each response.

Hull's associative mechanism for expectancies

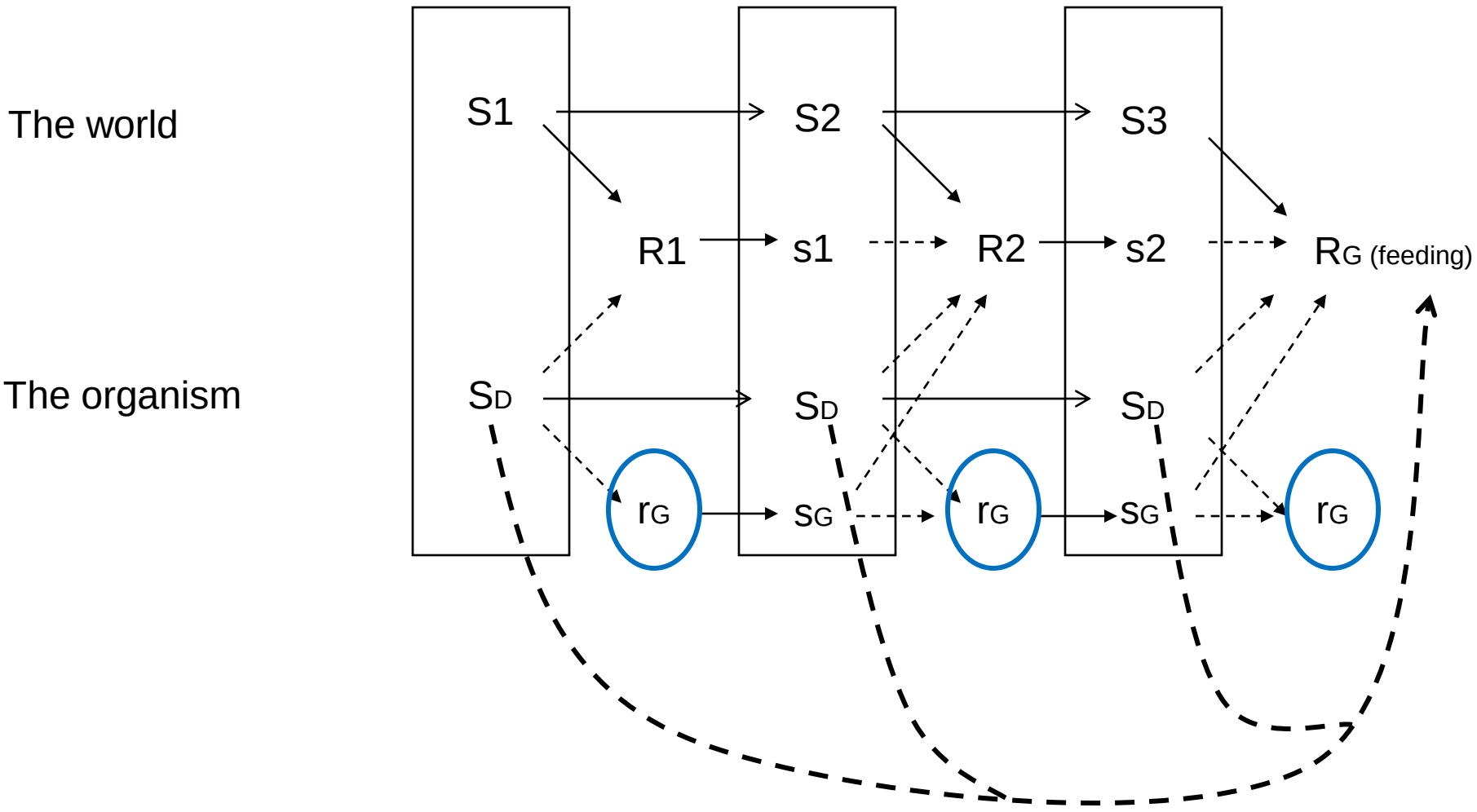


r_G: anticipatory fractional goal response.

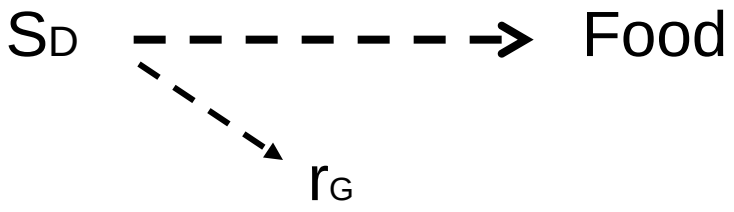
s_G: feedback from the anticipatory fractional goal response.

r_G → s_G: Hull interpreted this construct as a peripheral response and its feedback. This was disconfirmed experimentally. However, this could be considered as a central construct akin to an expectancy of the goal event.

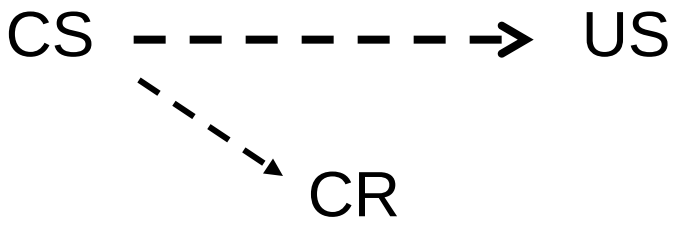
What is the source of r_G?



The source of r_G is Pavlovian conditioning



That is…

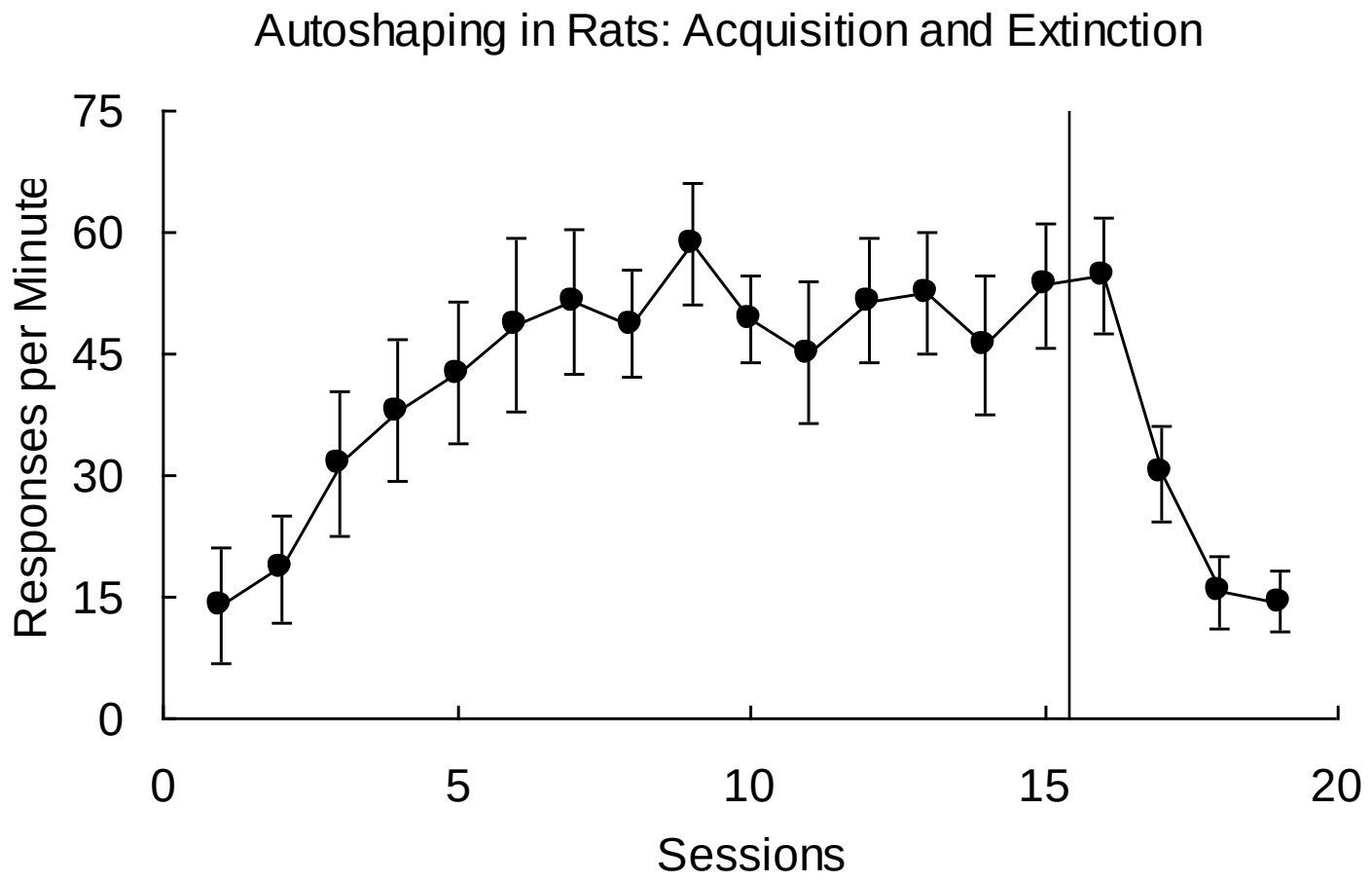


Hull wrote that r_G "is peculiar to the one sequence of which it is the terminal action," namely, R_G. Notice that the distinction between classical and instrumental conditioning was unclear in 1931, when this paper was published. In modern terms, however, r_G can be safely assumed to arise from the Pavlovian pairing between S_D and the goal event (i.e., a CS-US pairing).

An example of a more recent conditioning model: Rescorla-Wagner (1972)

1. RW proposed a model similar to the notions advanced by Hull in the 1930s.
2. Hull's "excitatory tendency" is analogous to RW's "associative strength."
3. Values are arbitrarily chosen.
4. Thus, RW can only make ordinal predictions.
5. RW is designed to account for conditioning in situations involving compound stimuli.
6. Let's start by understanding how the model explains simple acquisition.
7. CS-US pairings endow the CS with associative strength or value (V).
8. Associative strength changes, ΔV, as a function of the discrepancy between the maximum possible level of conditioning, λ, and the current strength of the CS: $\Delta V = \lambda - V$
9. The speed of this change is modulated by the intensity of both the CS, α, and the US, β, according to the following equation: $\Delta V = \alpha \beta (\lambda - V)$

How does RW explain acquisition and extinction?



Typical parameters:

Rate parameters: $1 > \alpha, \beta > 0$

Asymptote: $100 > \lambda > 0$

Associative strength: $V_{trial\ n} = V_{trial\ n-1} + \Delta V_{trial\ n}$

Boughner & Papini, 2006, Learning & Motivation, 37, 304-323.

Understanding RW conceptually

1. (λ – V) = an index of the degree of surprisingness of the US.

2. A large discrepancy, λ > V, implies a surprising US (not well predicted by the CS).

3. When λ = V the CS is a reliable predictor of the US, the discrepancy is equal to zero, and there is no further change in V.

4. The speed of change in V is a positive function of the salience of the CS, α, and of the salience of the US, β.

5. Thus, V changes faster with more salient CSs and with more salient USs.

6. Let's see a simulation.

Is learning S-S or S-R? A review of Holland (2008)

Cognitive theories: “emphasized the formation and modification of cognitive patterns representative of the relationships in the environment” (Spence, 1950).

S-R theories: “emphasize such constructs as habits and S-R bonds, which referred to hypothetical learning states or intervening variables” (Holland, 2008).

- Training assessment
  - Responses without stimuli
    - Subtitution of US by electrical stimulation of cortex
  - Stimuli without responses
    - Peripheral blockage of responses (e.g., curare)
    - Sensory preconditioning
    - Mediated learning

- Post-training assessment
  - Transfer tests
    - T-maze rotation
  - Postraining changes in reward
    - Incentive contrast
  - Reinforcer revaluation: inflation or devaluation
    - Goal devalued by shock in appetitive conditioning
    - Shocking rear vs. front paws
  - Modern devaluation experiment

Modern devaluation experiment

Group	Phase 1 (Acquisition)	Phase 2 (Devaluation)	Test	Outcome
Exp	Tone→Food	Food→Rotation	Tone?	Exp<Con
Con	Tone→Food	Rotation	Tone?	

Evidence that the devaluation experiment does not demonstrate that learning is just S-S.

(1) Devaluation effects are typically small (Fig 3). Large residuals suggest S-R learning.

(2) Variation as a function of devaluating agent (e.g., LiCl vs. rotation)

(3) Variation as a function of dependent variable

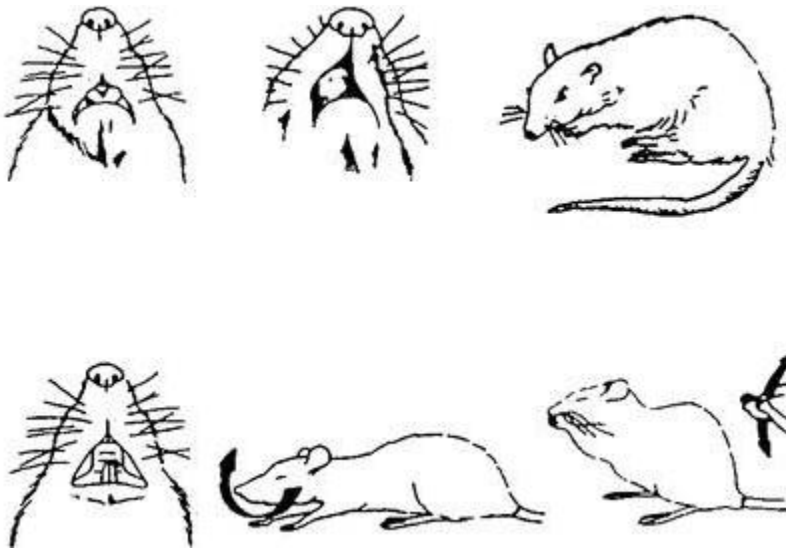
3a. Consummatory behavior more sensitive than appetitive behavior

3b. Response measure and devaluation interact

3c. Appetitive and consummatory responses may respond differently to devaluation

Appetitive and consummatory responses may respond differently to devaluation

Taste reactivity test (evaluative TR): hedonic reactions (some appetitive, some aversive) to a taste delivered in a solution and usually detected by positioning a camera underneath the box's floor.

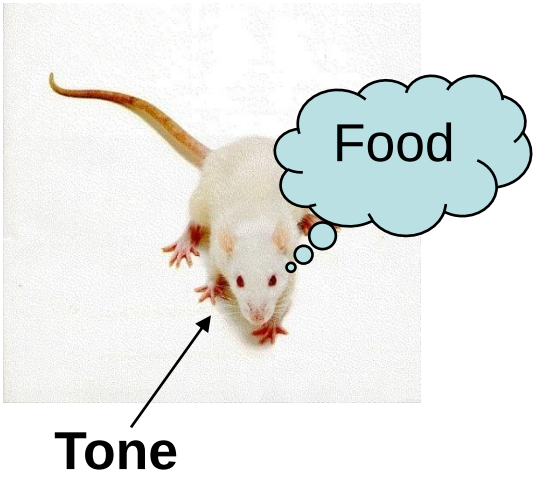


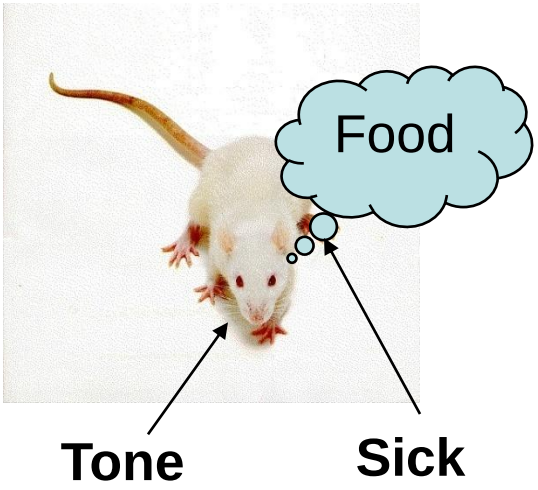
Affective reactions to taste.
Hedonic reactions [appetitive] are elicited by sucrose and other palatable tastes.
Hedonic reactions include rhythmic midline tongue protrusion, nonrhythmic lateral tongue protrusion, and paw lick.
Aversive reactions [bottom] are elicited by quinine and other nonpalatable tastes.
Aversive reactions include gape, head shake, face wash, and forelimb flail.

Appetitive and consummatory responses may respond differently to devaluation

Mediated learning: associating a CS-reactivated representation with a US.

Group	Phase 1	Phase 2	Test	Outcome
Exp	Tone→Food	Tone→LiCl	Food?	Exp<Con
Con	Tone→Food	Tone, LiCl	Food?	





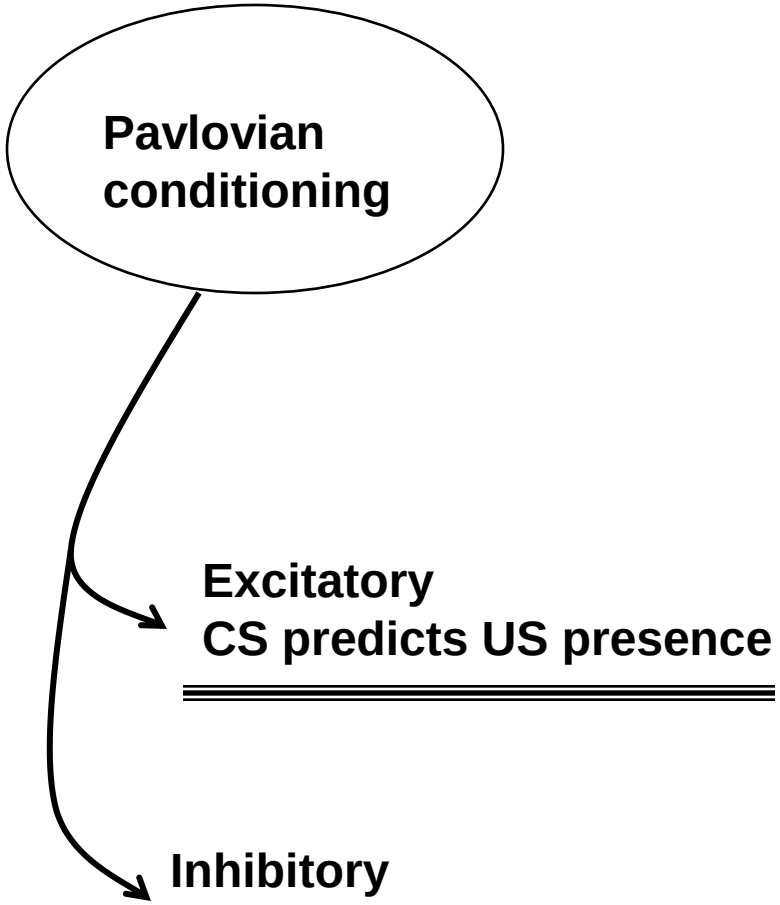
Appetitive and consummatory responses may respond differently to devaluation

Length of training modulates some of these effects:

	Minimal	Extended
Devaluation	Yes	Yes
Evaluative TR	Yes	No
Mediated learning	Yes	No

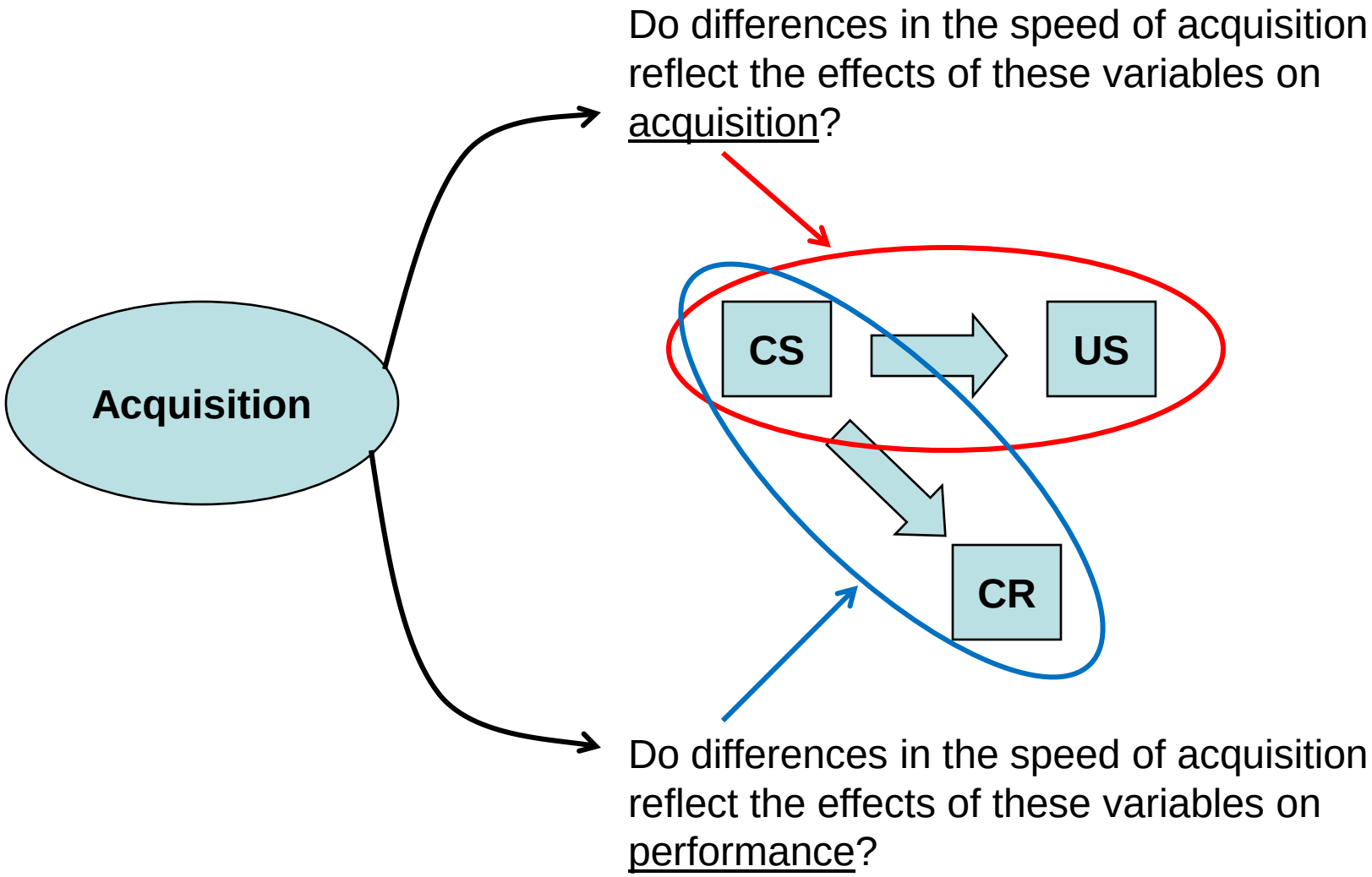
Holland (2008, p. 237): “Clearly, there is more to the story than S-S versus S-R associations. The representations activated by CSs after minimal and extended training can be distinguished by their ability to participate in new (mediated) learning and by their ability to control appropriate evaluative TR responses. Nevertheless, even after extended training, CSs can activate reinforcer representations that include rich sensory information, which can subserve reinforcer devaluation effects. This distinction resembles one suggested by Konorski (1967, e.g., pp. 170-181), who distinguished between … sensory “projective” units activated by the US itself… [and]… “gnostic” units, which coded information about the US but did not normally generate perceptual processing.”

Acquisition processes (emphasis on excitatory Pavlovian conditioning)

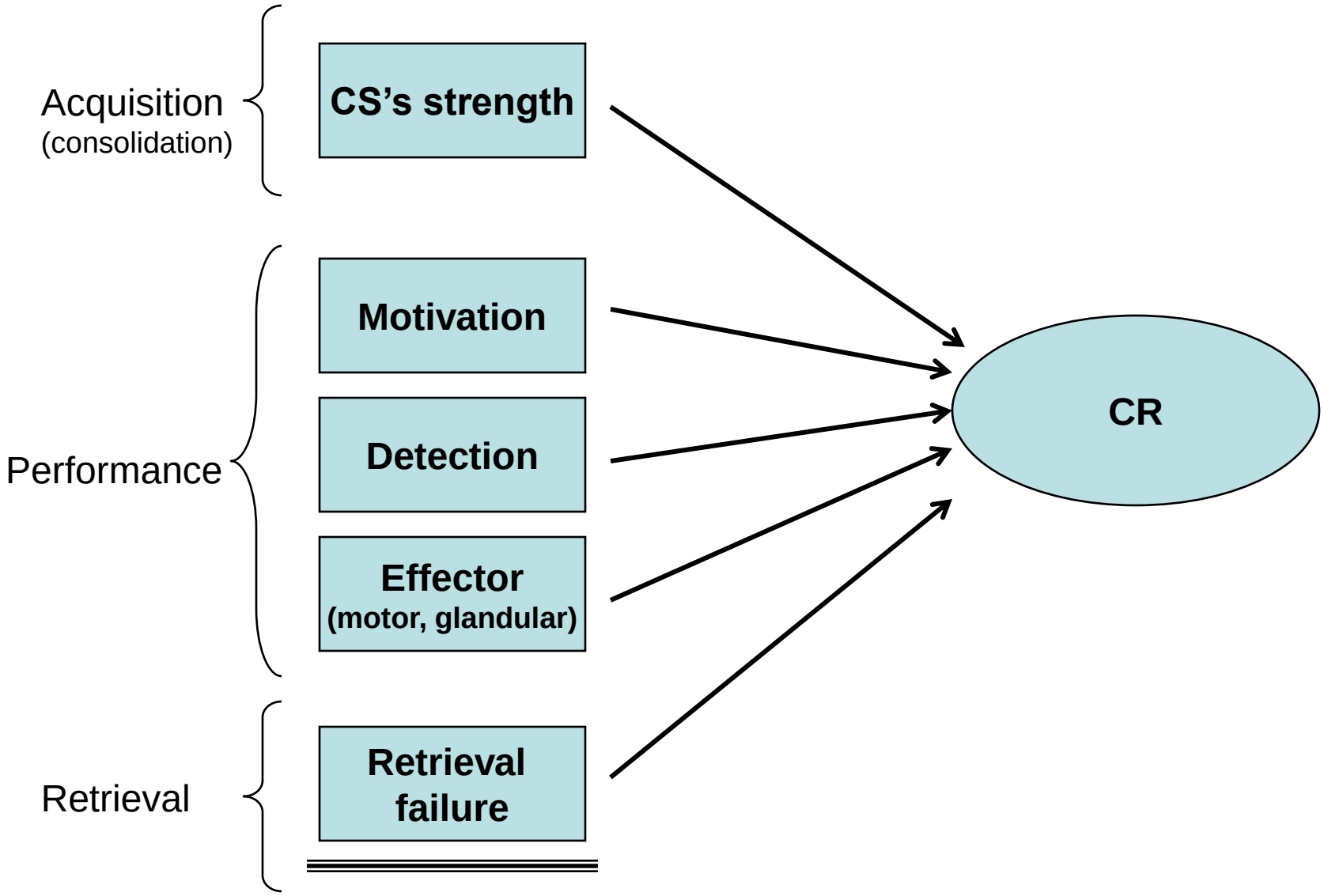


- Intensity or magnitude of the stimuli (CS, US)
  - Direct
- CS-US interval
  - Optimal
- Duration of the CS
  - Indirect
- Intertrial interval
  - Direct
- Expectancy ratio: ITI / CS duration
  - Direct
- Probability of CS-US pairing
  - Direct or indirect?
- Trials per session
  - Indirect

Learning vs. Performance



Determinants of performance



Acquisition and memory retrieval: Miller (1982)

- Increments in performance during acquisition are usually attributed to the learning of new information.

- But it is possible that learned information is not always fully accessible.

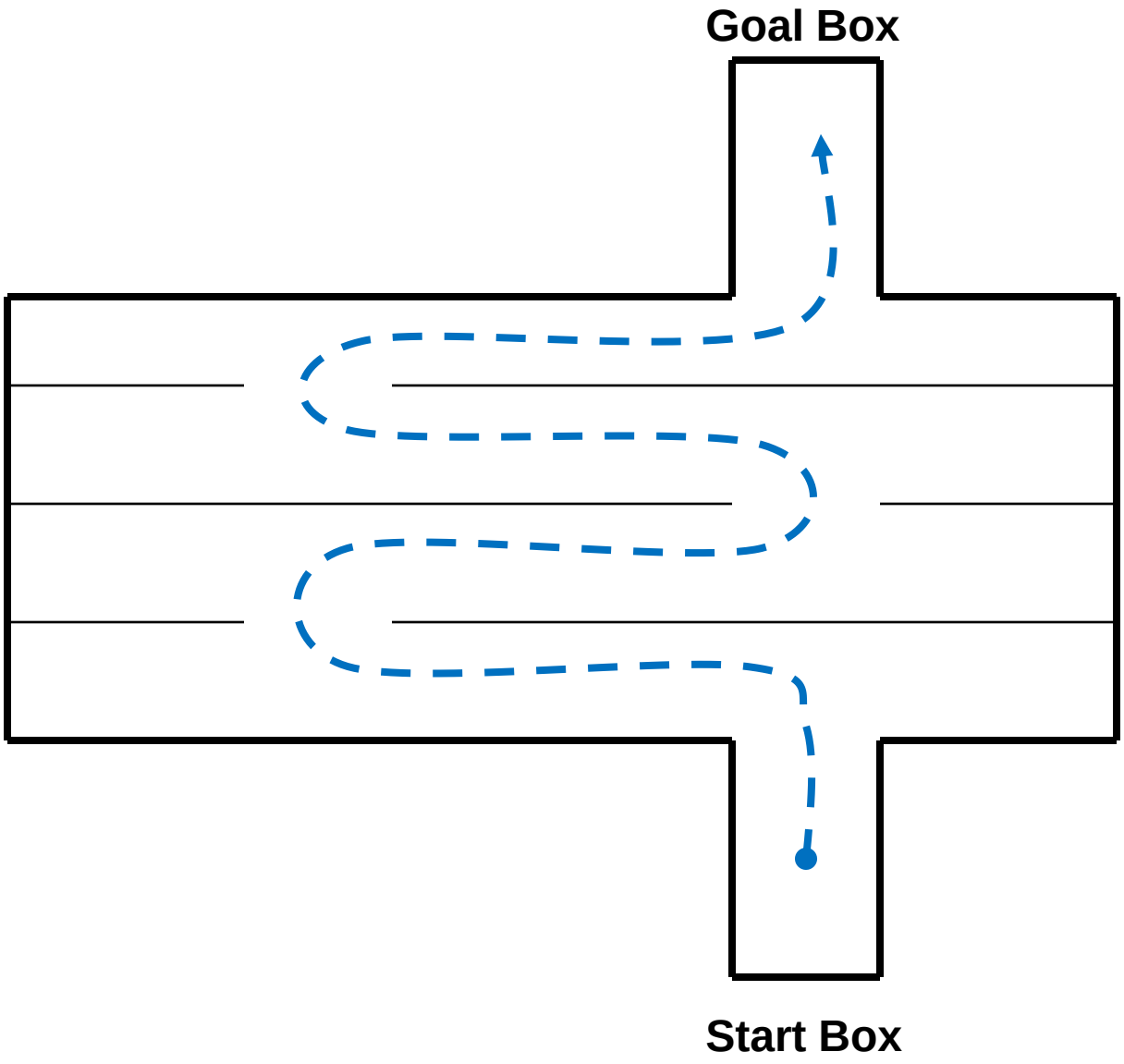
- Enhanced retrieval refers to increases in behavior during acquisition that cannot be attributed to further learning.

- This retrieval-enhancement hypothesis states that improved performance of a learned response can occur under conditions that prohibit relevant new learning or changes in nonassociative variables.

- The technique used in these experiments involves the presentation of selected stimuli from the training situation in a manner that prevents new learning, but may influence the retrieval of previously learned information.

Miller, 1982, Journal of Experimental Psychology: Animal Behavior Processes, 8, 86-109.

Miller (1982): General method



- 8 trials of training
- US=shock, escape learning
- US=sucrose, approach learning
- ITI was usually 5 min
- Reminder treatments:
  - US
  - Context
- Dependent variable: errors
- Control conditions:
  - No treatment (NT)
  - Handling (H)

Miller, 1982, Journal of Experimental Psychology: Animal Behavior Processes, 8, 86-109.

Experiment 1: Reinstatement of an aversive reinforcer

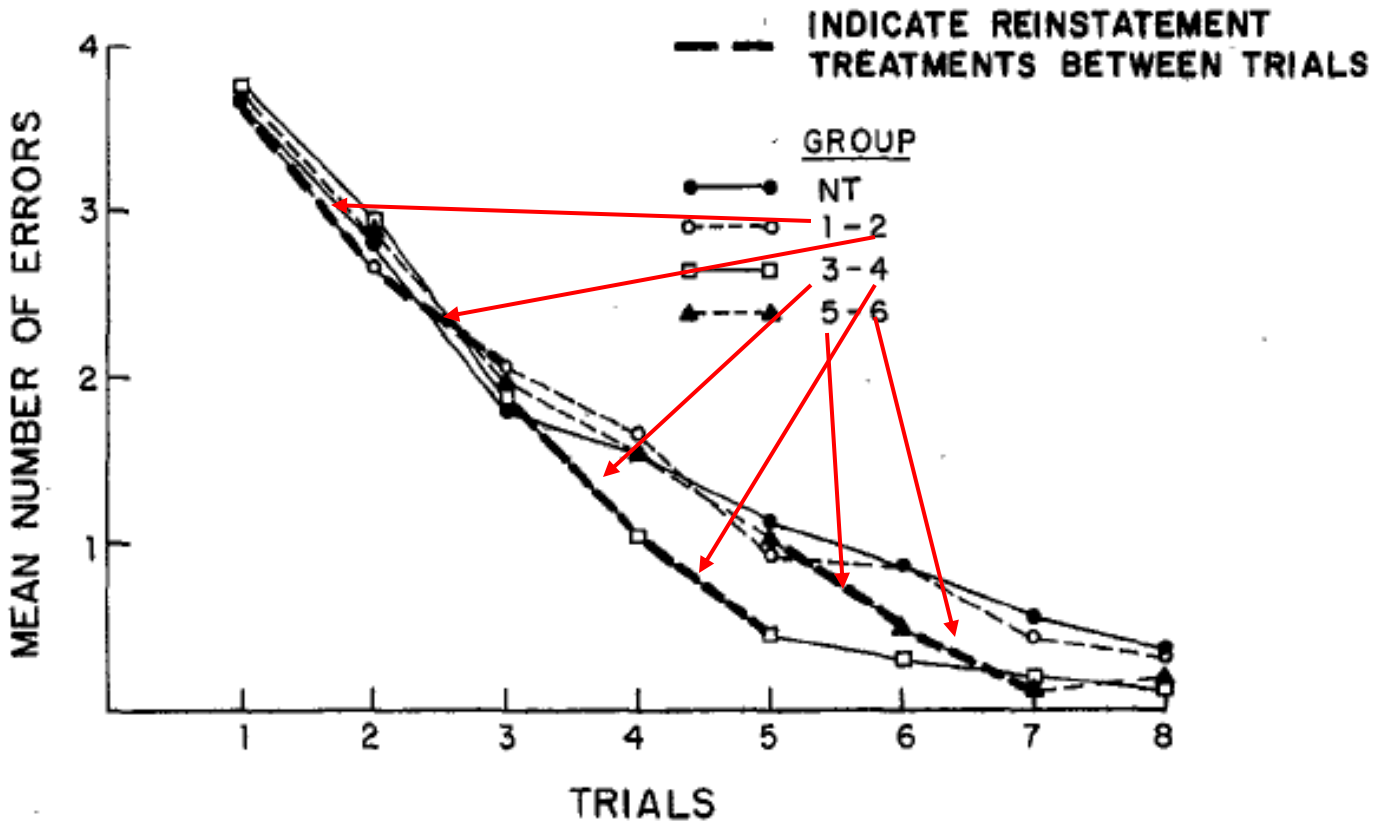


Figure 2. Choice performance over trials by treatment groups in Experiment 1. (Treatment consisted of two response-independent footshocks given outside the maze midway between footshock-escape training trials in the maze. NT = no treatment.)

Experiment 1: Results and discussion

Basic result

•Reinstatement treatment (RT) either in the middle or in late acquisition (but not in early acquisition) facilitated learning.

Discussion: Main interpretation and alternatives

•Early acquisition serve as true learning, whereas later trials serve as retrieval practice.

•RT enhanced learning because it is a surprising event. But RT effect is seen in the first trial after RT, whereas an increase in attention should lead to enhanced learning in subsequent trials after the first RT.

•RT increase stress. But RT effect is seen in several trials after, whereas an increase in stress should affect only the first trial after RT.

•RT increases habituation to shock, making it less likely to disrupt retrieval and thus increase learning. This is eliminated by the results of Exp 2 (US=sucrose, a less potent US) and Exp 4 (RT based on exposure to context, rather than to the US).

Experiment 2: Reinstatement of an appetitive reinforcer

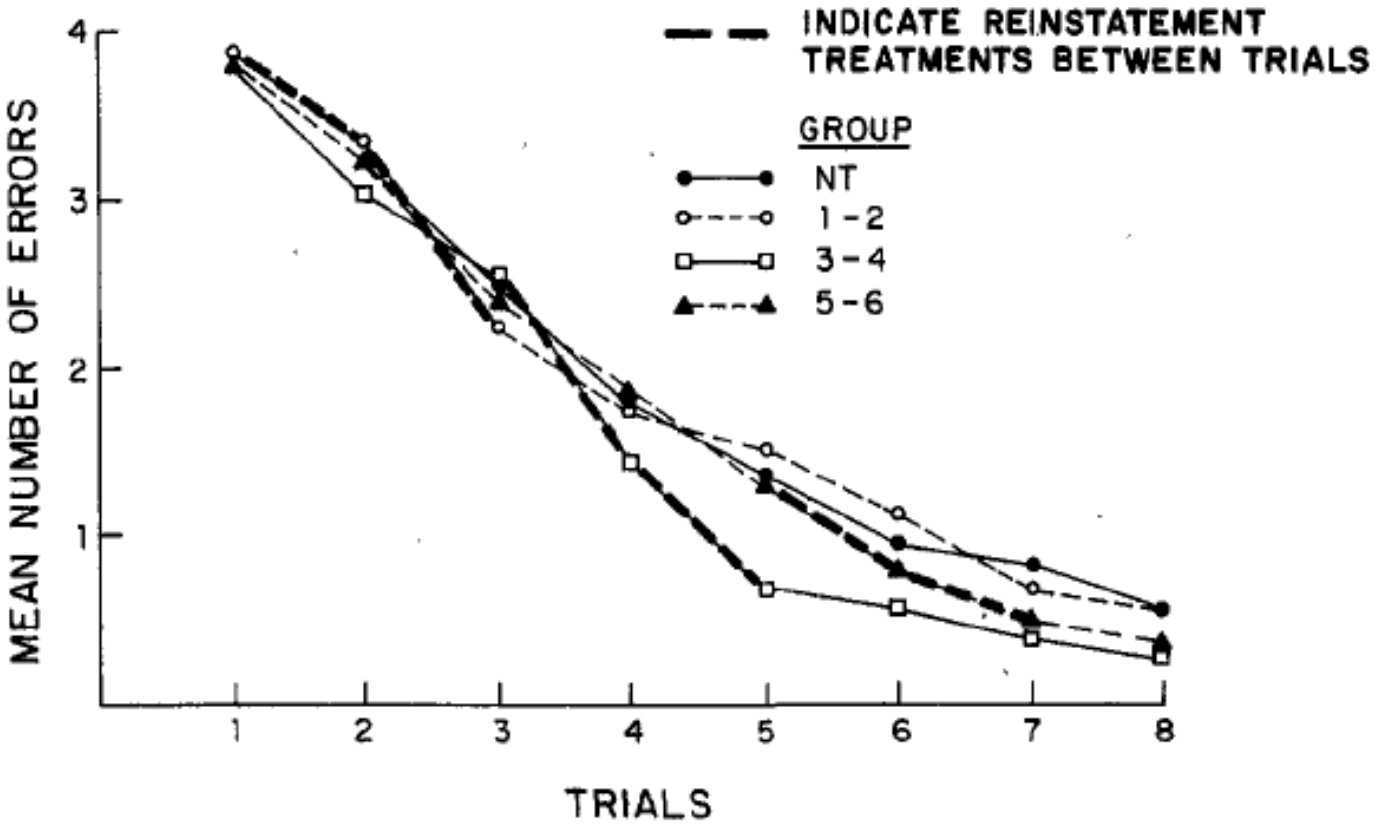


Figure 3. Choice performance over trials by treatment groups in Experiment 2. (Treatment consisted of two exposures to sucrose outside the maze midway between sucrose-approach training trials in the maze. NT = no treatment.)

Experiment 2: Results and discussion

Basic result

•RT in middle acquisition (but not in early or late acquisition) facilitated learning.

Discussion: Main interpretation and alternatives

•Early acquisition serve as true learning, whereas later trials serve as retrieval practice.

•When combined with the results of Experiment 1, this result provides some generality to the enhancing effects of RT on learning.

•The generally weaker effects of Experiment 2, when compared with Experiment 1, suggest that the stress and habituation alternatives considered previously are less likely to apply here.

Experiment 3: Specificity of the reinstatement treatment

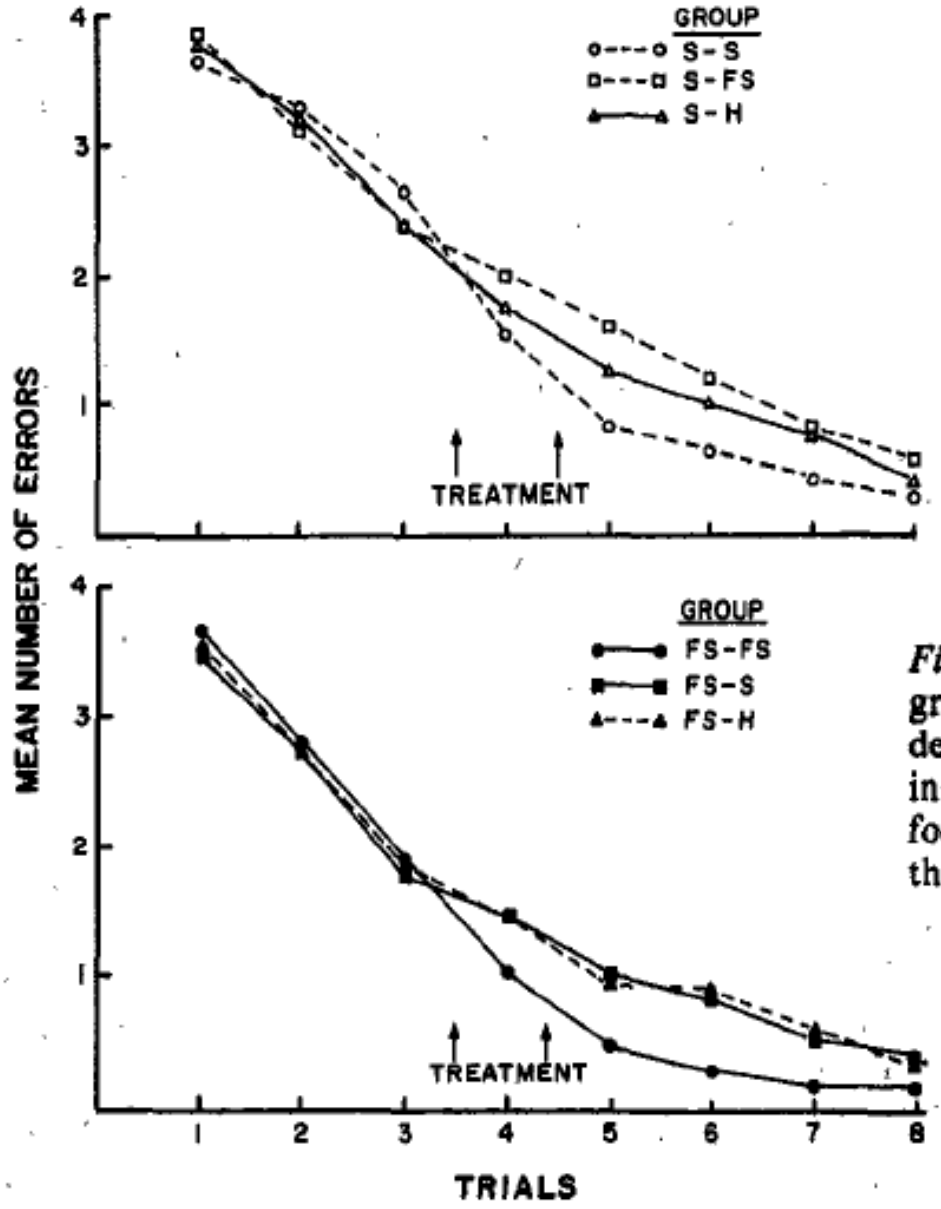


Figure 4. Choice performance over trials by treatment groups in Experiment 3. (The first FS or S in the group designation denotes footshock or sucrose reinforcement in the maze; the second FS, S, or H indicates extramaze footshock, sucrose, or handling-only given midway into the intertrial interval following Trials 3 and 4.)

Experiment 3: Results and discussion

Basic result

•The enhancing effects of RT were specific to the reinforcer used in training.

Discussion: Main interpretation and alternatives

•Failure of RT to affect learning in Groups FS-S and S-FS suggest that not just any RT would affect learning.

•This suggests that it is appropriate to refer to these RTs as reminder treatments (i.e., reminders of some aspect intrinsic to original training).

•The two RTs used here were too dissimilar to produce a cross-facilitatory effect. Would more similar RTs lead to cross facilitation?

Experiment 4: Reinstatement with apparatus cues

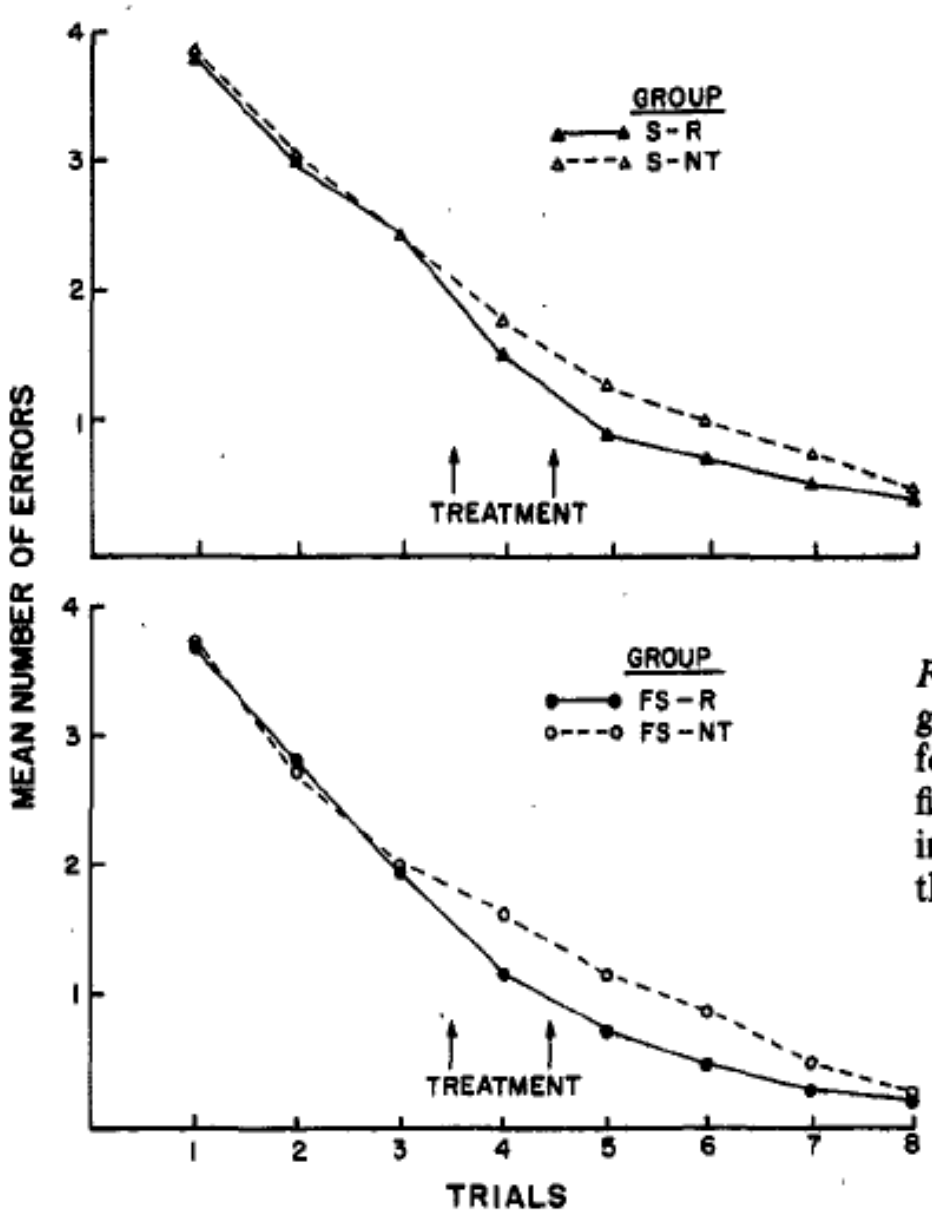


Figure 5. Choice performance over trials by treatment groups in Experiment 4. (FS and S denote training with footshock and sucrose, respectively. R groups were confined to the start box at the maze for 30 sec midway into the intertrial interval following Trials 3 and 4, and the NT groups received no intertrial treatment.)

Experiment 4: Results and discussion

Basic result

•The RT based on exposure to the context enhanced learning in the aversive case, although its effect was nonsignificant in the appetitive case.

Discussion: Main interpretation and alternatives

•Early acquisition serve as true learning, whereas later trials serve as retrieval practice.

Experiment 5: Reinstatement with long intertrial intervals

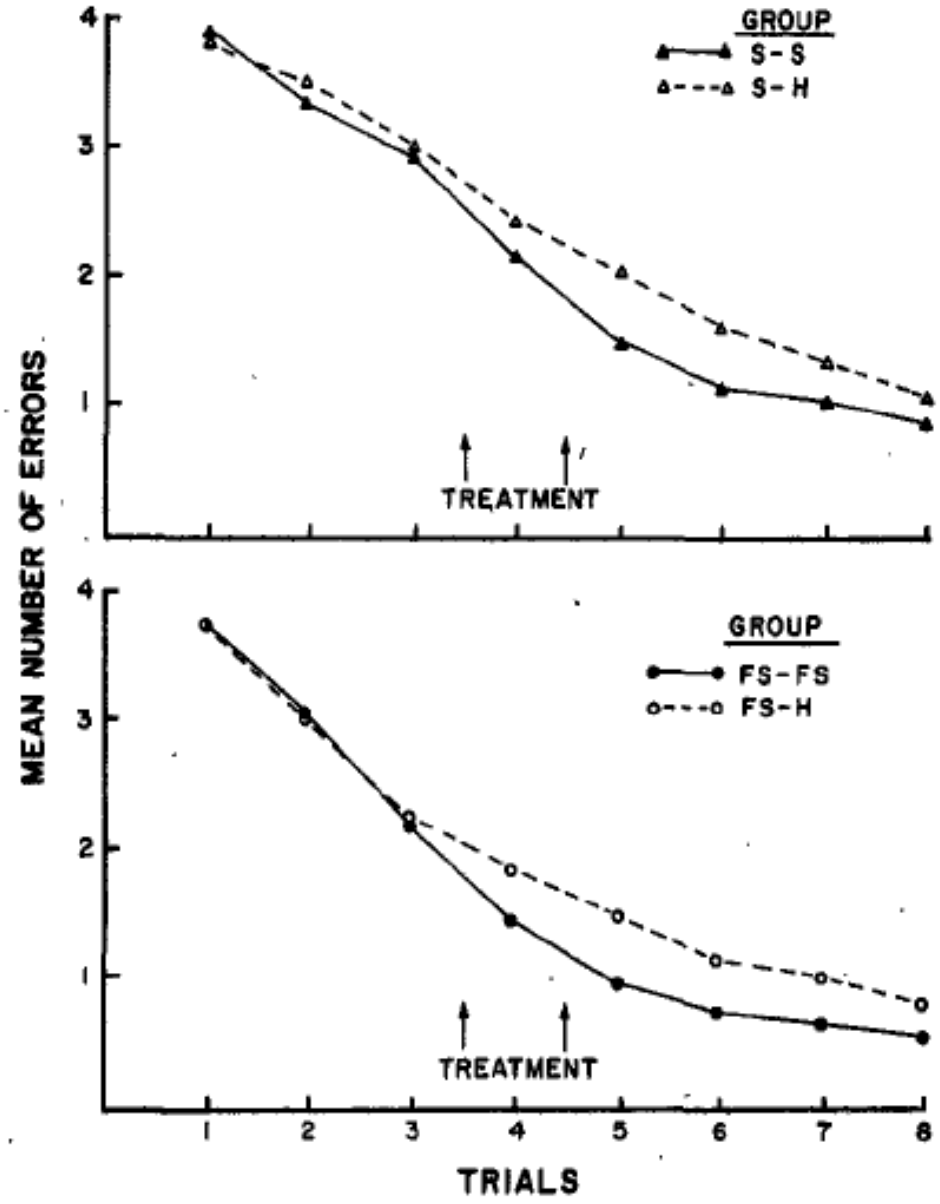


Figure 6. Choice performance over trials by treatment groups in Experiment 5. (The intertrial interval in this study was 48 hr rather than 5 min. FS and S denote training with footshock and sucrose, respectively. All animals spent 30 sec in the shuttle box 24 hr after Trials 3 and 4. At this time Group FS-FS received footshock, Group S-S received sucrose, and the H groups received only equivalent handling.)

Experiment 5: Results and discussion

Basic result

•RT enhanced learning when the ITI was 48 h and the RT was administered 24 h after and before successive trials.

Discussion: Main interpretation and alternatives

•RTs do not need to be administered closed in time to training trials, therefore working when traces of previous trials are not active.

•These results may be due not to the enhancing effects of the RTs, but to extinction of associations between handling and either the reinforcer or responding in the maze. But Experiments 1 and 2 showed that RT groups differed from nonhandled controls.

•It is unclear whether the present RTs reflect:
- •Information learned but not behaviorally manifested, or
- •Information not accessible due to forgetting from long ITIs.

Experiment 6: Time of reinstatement within the intertrial interval

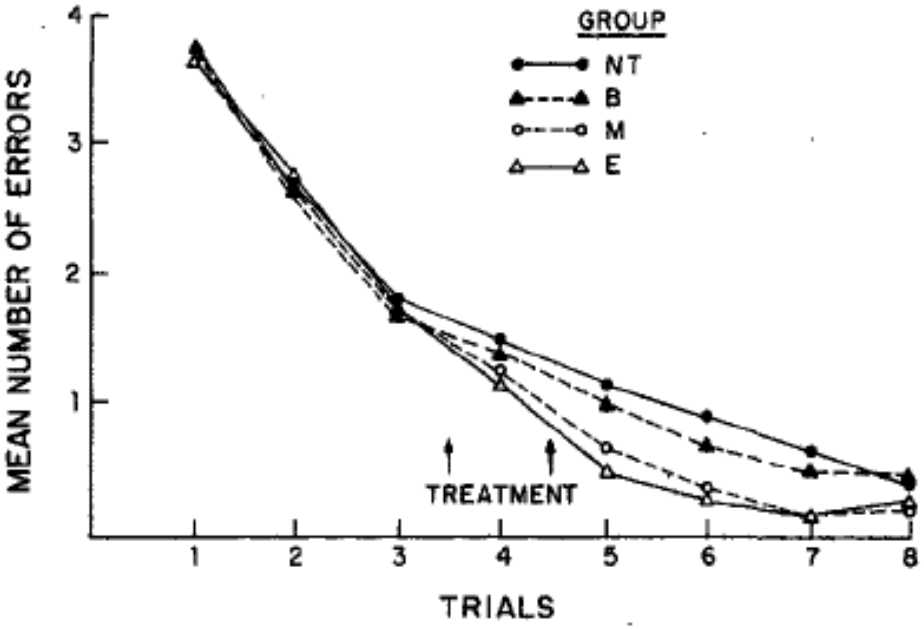


Figure 7. Choice performance over trials by treatment groups in Experiment 6. (Treatment consisted of two response-independent footshocks given outside the maze in which footshock-escape training took place. One shock occurred after Trial 3 and the other after Trial 4. Group designations denote whether the intertrial footshock was given at the beginning [B], at the middle [M], or at the end [E] of the intertrial interval. Group NT received no intertrial shock.)

Basic result

•RT enhanced learning when administered in the middle or end of the ITI, but not when administered at the beginning of the ITI.

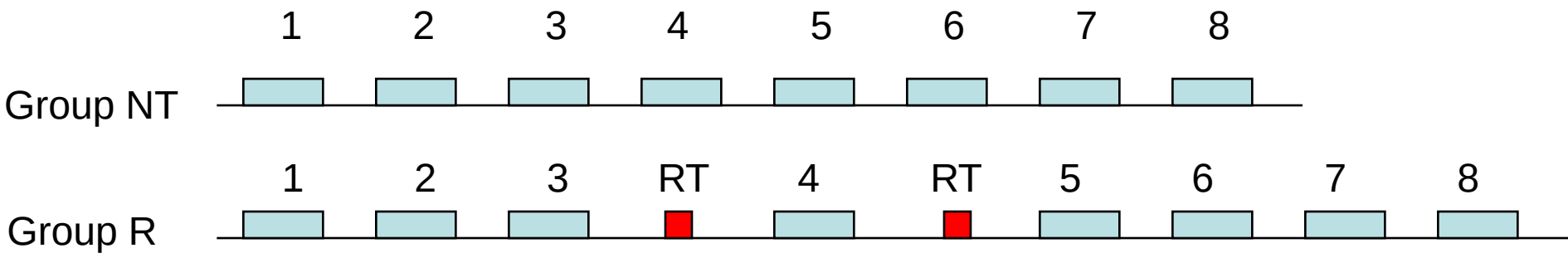
Discussion: Main interpretation and alternatives

•RTs are less effective when administered immediately after a training trial.

•Immediately after a training trial, the traces relevant to the task are in active memory and thus the RT does not initiate the retriaval process that enhances learning in subsequent trials.

•RT immediately before a trial is most effective.

Experiment 9: Does reinstatement arrest or reverse forgetting?



(1) If RT stops further forgetting, these groups should perform equally because RT in Group R should stop forgetting just like a trial would do in Group NT.

(2) If RT only partially decreases the rate of forgetting, Group NT should perform better than Group R because of the shorter ITI than Group R.

(3) If RT reverses prior forgetting, Group R should perform better than Group NT because of the RT.

Results

Group R shows enhanced performance relative to Group NT—support for (3).

Miller (1982): Conclusions

- Although any one of the present experiments is subject to several interpretations, only the retrieval-enhancement hypothesis explains all the data.

- What is commonly called an "acquisition" curve is in fact a performance curve reflecting:
  - Past acquisition, and
  - Current retrievability of information.

- It is reasonable to suspect that the same sort of rehearsal-like processes that occurs immediately following reinstatement also occurs immediately following acquisition.

- There are two broad classes of learning models:
  - Many view performance deficits as arising from a failure to learn (e.g., Rescorla-Wagner).
  - Others view performance deficits as arising from memory impairments, including retrieval failure.

- Perhaps "acquisition" curves should be called "shaping" curves.