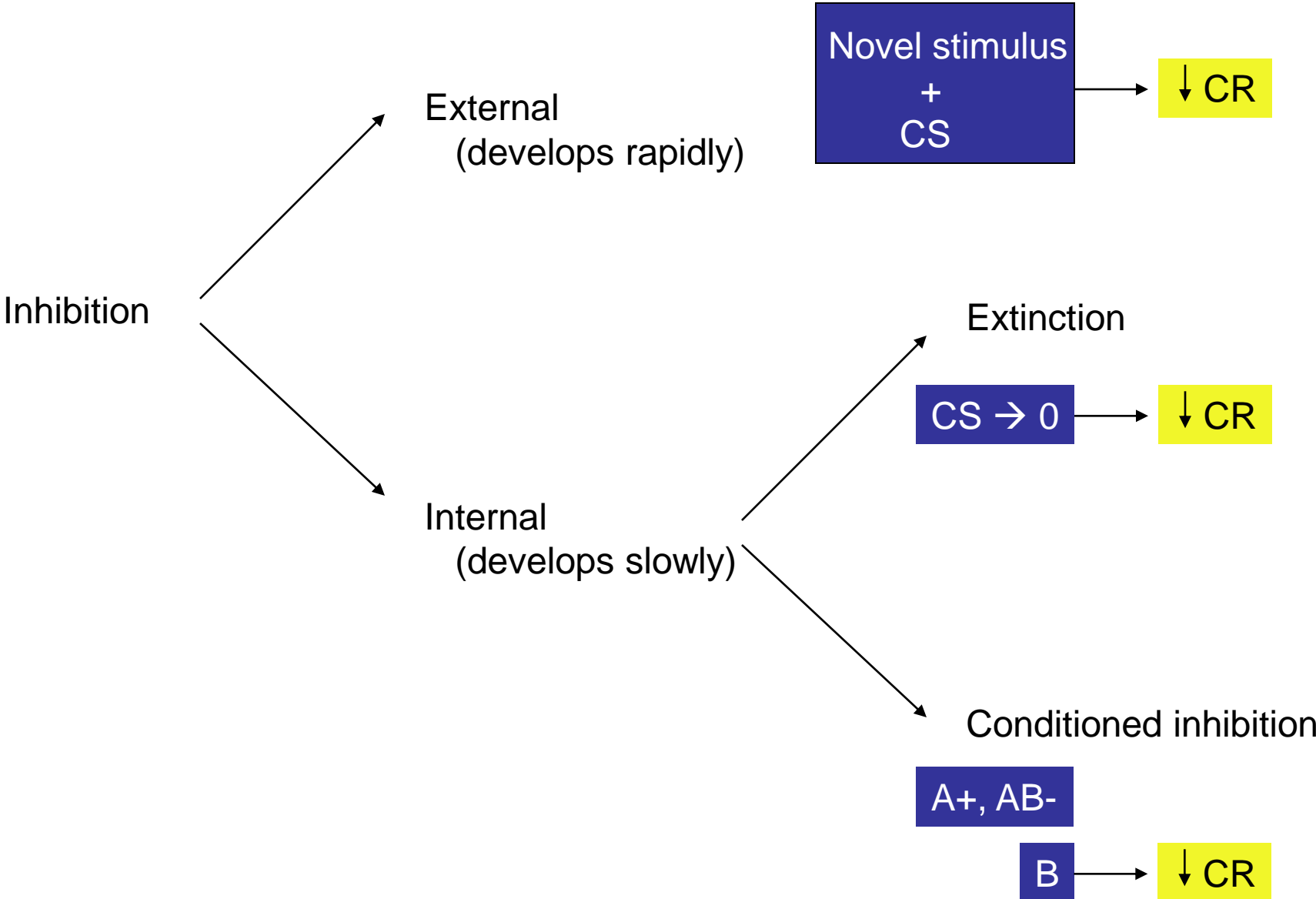
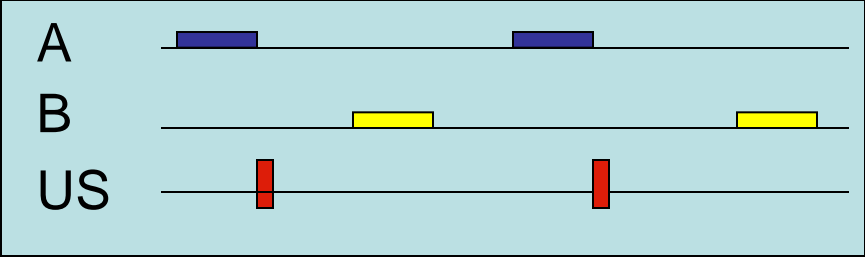


# Pavlov's classification of inhibitory processes

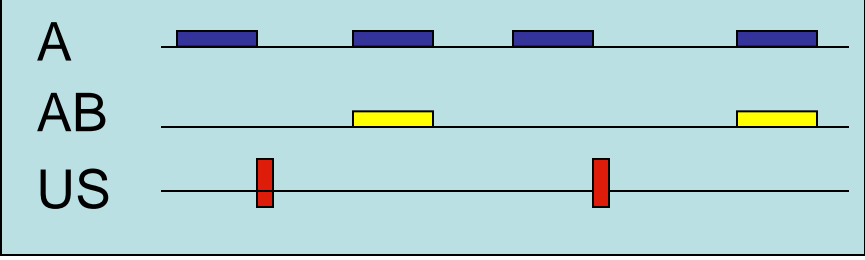


Putative IC treatments

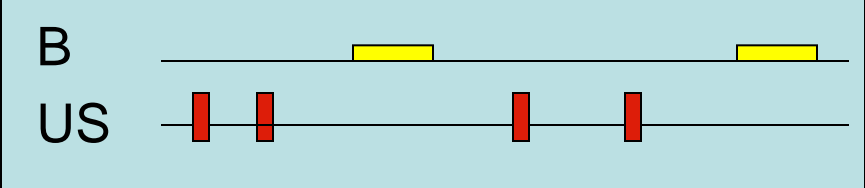
•Differential conditioning: A+, B-



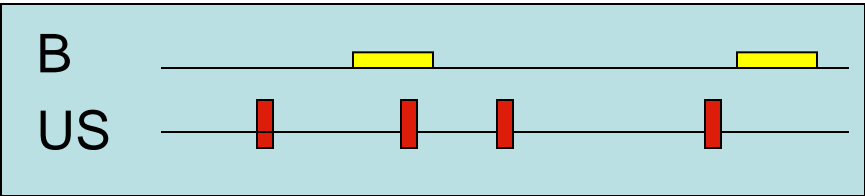
•Conditioned inhibition: A+, AB-



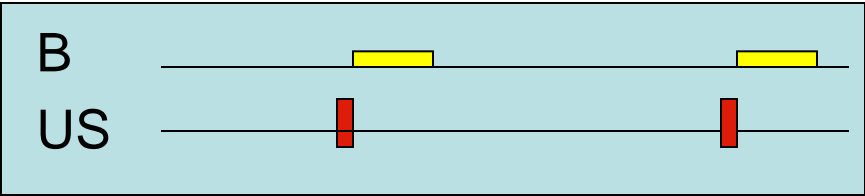
•Explicitly unpaired training: +, B-



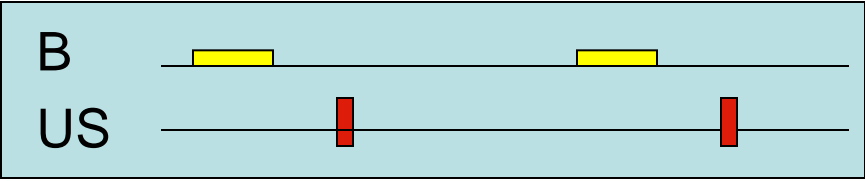
•Negative contingency



•Backward conditioning: +B



•Trace conditioning: B\_+

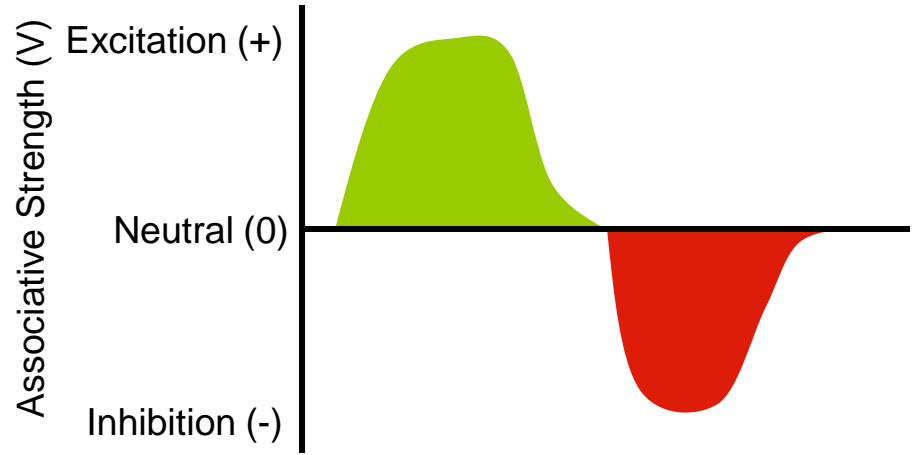


# Excitatory (EC) and inhibitory conditioning (IC)

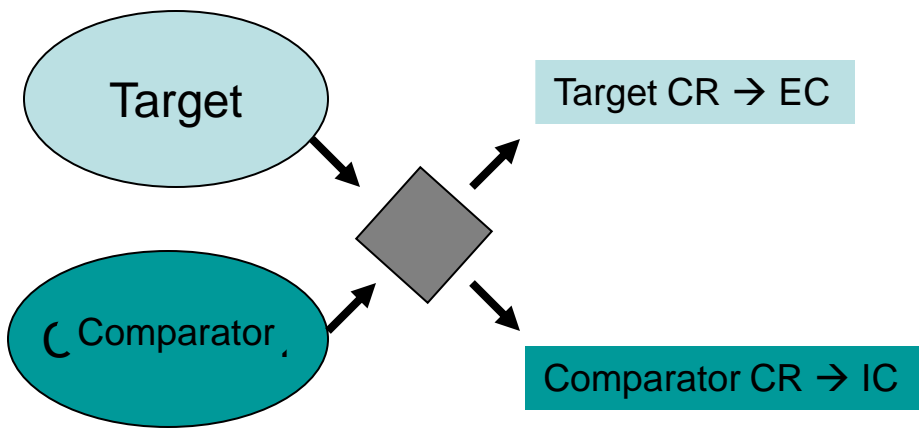
- Pavlov:
  - Extinction is one example of IC.
  - IC and EC coexist in parallel.



- RW:
  - Extinction does not involve IC.
  - IC and EC are mutually exclusive.



- Comparator hypothesis:
  - There is no IC in the sense of a process.
  - All associations are excitatory.
  - Behavioral inhibition occurs because of target-comparator relationships.



WHAT DO ALL THEORIES HAVE IN COMMON?

**(1) IC is the opposite of EC.**

**(2) IC is generated and measured in the context of EC.**

Notice that (2) implies that latent inhibition is really not an instance of IC (despite its name!!!) because preexposure to the CS occurs before any EC.

# Fundamental problem of IC: Measurement

- How is IC detected?
- Direct behavioral elicitation: Approach-withdrawal from the CS.

| Group   | Context     | CS          |                |       |
|---------|-------------|-------------|----------------|-------|
|         | Preexposure | Preexposure | Acquisition    | Test  |
| EUP     | X:- / Y:-   | X:A- / Y:-  | X: A-, + / Y:- | X: A? |
| Control | X:- / Y:-   | X:A- / Y:-  | X: A- / Y:+    | X: A? |

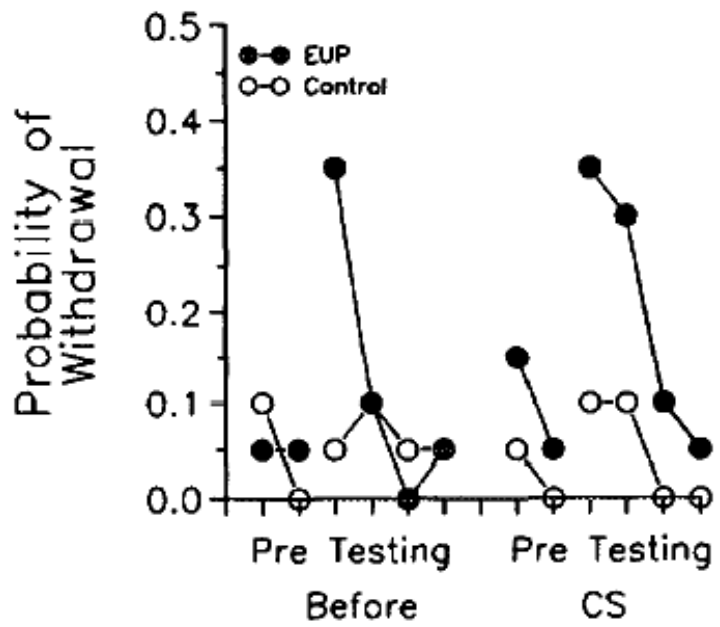
US: food pellets

CS: light

X: regular box

Y: tilted floor

Dep Var: head withdrawal assessed from videotapes



# Indirect measurement of IC: the two-test strategy

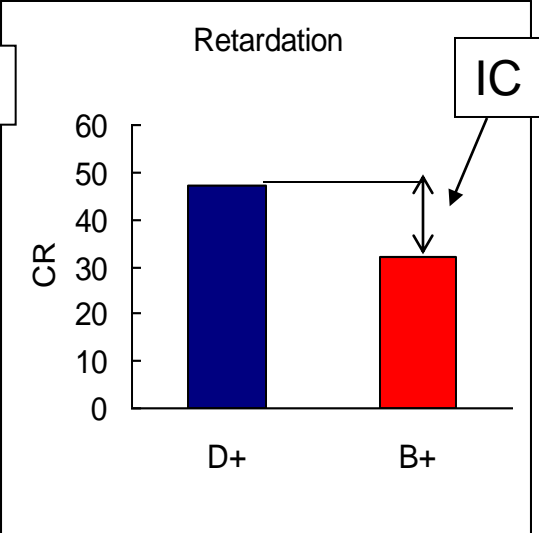
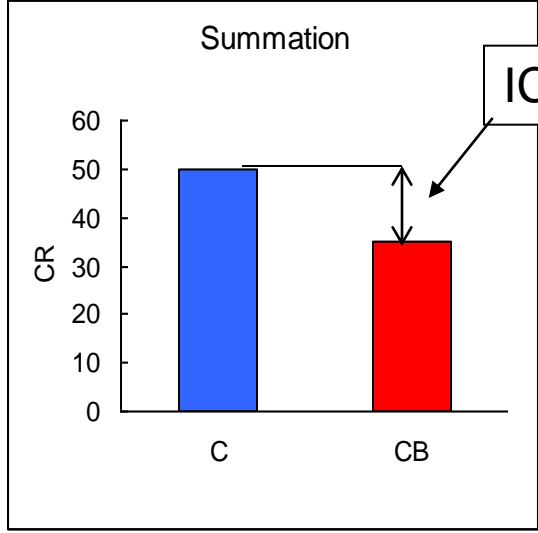
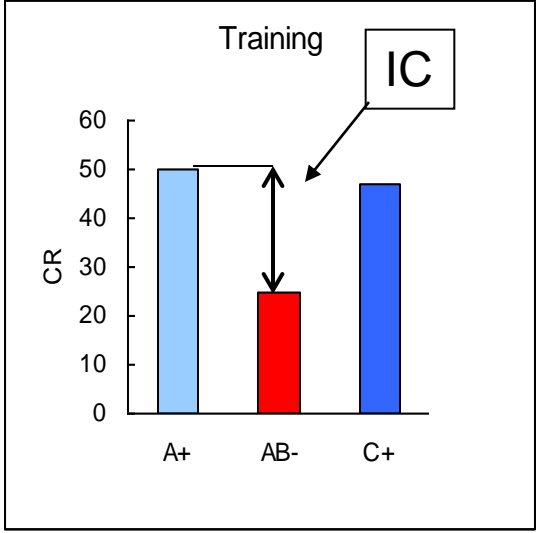
| Group | Putative IC treatment        | Summation Test          | Retardation Test |
|-------|------------------------------|-------------------------|------------------|
| IC    | X: A+, AB <sup>B-</sup> , C+ | X: C?, CB <sup>B?</sup> | X: B+, D+        |

B becomes inhibitory

C is a nontarget CS to be used in summation

B transfers its putative inhibitory properties to C

D is a novel CS



## Interpreting the summation test

- $CB < C$  because B inhibits excitation induced by C.

OR

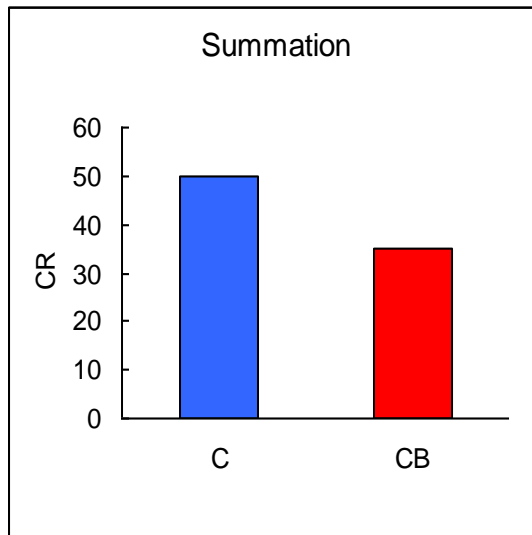
- $CB < C$  because A+, AB- training enhances attention to B, which then redirects attention away from C in the summation test.

OR

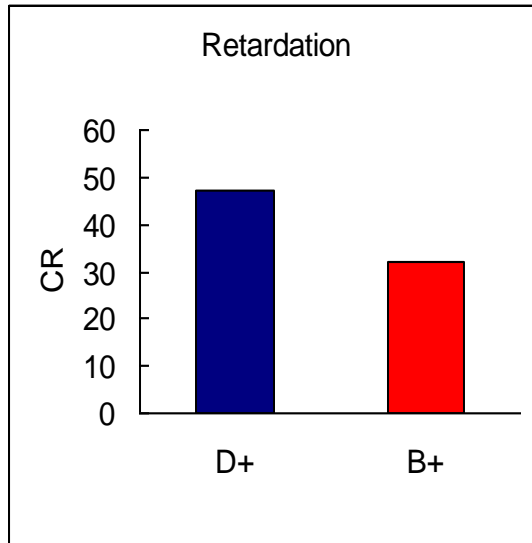
- $CB < C$  because the novelty of the CB compound increases attention, thus disrupting the CR.

OR

- $CB < C$  because of generalization decrement (CR goes down because the animal perceives CB as being different from C).



# Interpreting the retardation test



- $B < D$  because B acquired IC and thus it takes more trials to acquire EC.

OR

- $B < D$  because of greater reduction in generalized excitation from A due to nonreinforced AB- trials in phase 1 (i.e., at the start of retardation, D is more excitatory than B).

# A classification of control procedures

- Novel-stimulus control

- The testing stimulus is novel at the time of testing.

| Group   | Training | Test |
|---------|----------|------|
| IC      | A+, AB-  | B?   |
| Control | A+, AD-  | B?   |

- Contrasting-treatment control

- A different training treatment assumed to produce less inhibition or no inhibition at all.

| Group   | Training | Test |
|---------|----------|------|
| IC      | A+, AB-  | B?   |
| Control | A+, B-   | B?   |

- Hybrid control

- Different training treatment AND the testing stimulus is novel at the time of testing.

| Group   | Training | Test |
|---------|----------|------|
| IC      | A+, AB-  | B?   |
| Control | A+, A-   | B?   |

## Alternatives to inhibition mentioned in Papini & Bitterman (1993)

- External inhibition (caused by a novel stimulus)
- Reduced generalized excitation (caused by CS- training)
- Differential generalization of excitation (failure to counterbalance)
- Differential excitation (partial reinforcement of excitatory CS)
- Attentional enhancement (feature-negative discrimination)
- Attentional decrement (latent inhibition)
- Contextual blocking (unsignaled USs)
- Generalization decrement (novel compound)

# Novel-stimulus experiments

## Novel-stimulus experiments

- Miller et al. (1991): CER (operant baseline, Pavlovian training)

| Group | Phase 1 | Phase 2 | Test |
|-------|---------|---------|------|
| 1     | C+      | A+, B-  | BC?  |
| 2     | C+      | A+, D-  | BC?  |

1BC < 2BC

**Reduced generalized excitation (RGE):** 1B < excitatory than 2B

**External inhibition:** 2B may have suppressed baseline because of novelty

| Group | Phase 1 | Test |
|-------|---------|------|
| 1     | A+, B-  | B+   |
| 2     | C+      | B+   |

Hyb

1B+ < 2B+

**RGE:** 1B < excitatory than 2B at the start of retardation test.

**External inhibition:** 2B may have suppressed baseline because of novelty.

**Differential generalization (no counterbalance):** from A → B < from C → B

# Novel-stimulus experiments

- Lambert et al. (1989): CTA

CT

| Group | Phase 1   | Test    |
|-------|-----------|---------|
| 1     | A+, B-    | A vs AB |
| 2     | A±, B-, + | A vs AB |

1A > 1AB  
2A ~ 2AB

**Partial reinforcement:** 1A was more excitatory than 2A, thus more influenced by generalization decrement in AB trials

| Group | Phase 1 | Test   |
|-------|---------|--------|
| 1     | A+, B-  | B+, D+ |

B+ < D+

**RGE:** B < excitatory than D at the start of retardation test.

# Novel-stimulus experiments

- Schachtman et al. (1987): CER

| Group | Phase 1 | Phase 2 | Test |
|-------|---------|---------|------|
| 1     | B±, ++  | C+      | CB?  |
| 2     | B±, ++  | C+      | C?   |
| 3     | D±, ++  | C+      | CB?  |

1CB < 3CB

**Attentional enhancement:** B enhanced directs attention away from C in Group 1 (B less excitatory than C in Groups 1 and 3)  
**External inhibition:** novel B suppresses excitation induced by C in Group 3

Hyb

| Group | Phase 1   | Phase 2 | Test  |
|-------|-----------|---------|-------|
| 1     | X: B±, ++ | X: C+   | X: B+ |
| 2     | Y: +      | X: C+   | X: B+ |

1B+ < 2B+

**Contextual blocking:** X > excitatory in Group 1 than in Group 2

# Novel-stimulus experiments

•Gokey & Collins (1980): Autoshaping

| Group | Phase 1  | Phase 2 | Test     |         |
|-------|----------|---------|----------|---------|
| 1     | A+, AB-  | C+      | C vs CB? | C ~ CB  |
| 1     | A+, B→A- | C+      | C vs B→C | C > B→C |

No control

**Generalization decrement:** C modified by the presence or trace of B

| Group | Phase 1  | Test   |         |
|-------|----------|--------|---------|
| 1     | A+, AB-  | B+, D+ | B+ ~ D+ |
| 1     | A+, B→A- | B+, D+ | B+ < D+ |

**RGE:** from A to B, rather than D  
**Differential generalization (no counterbalance):** From A to B < from A to D

# Novel-stimulus experiments

- Hallam et al. (1990): CER

| Group | Phase 1 | Phase 2 | Test |
|-------|---------|---------|------|
| 1     | A+, AB± | C+      | CB?  |
| 2     | A+, AB± | C+      | C?   |
| 3     | A+, AD± | C+      | CB?  |

1CB < 3CB

**Attentional enhancement:** greater attention to B in Group 1 than in Group 3

| Group | Phase 1 | Phase 2 | Test |
|-------|---------|---------|------|
| 1     | A+, AB± | C+      | B+   |
| 2     | A+, AD± | C+      | B+   |

1B+ < 2B+

**External inhibition:** 2B may have suppressed baseline because of novelty.  
**RGE:** From A to B in Group 1, but not in Group 2

# Hybrid experiments

# Hybrid experiments

- Rescorla (1979): CER

| Group         | Phase 1 | Phase 2 | Phase 3 | Test S  | Test R |
|---------------|---------|---------|---------|---------|--------|
| 1             | C+      | A+      | AB-     | C vs CB | B+     |
| Hyb→<br>CT→ 2 | C+      | A+      | A-      | C vs CB | B+     |
| 3             | C+      | ---     | AB-     | C vs CB | B+     |

1CB < 2CB ~ 3CB

**Attentional enhancement:** greater attention to B in Group 1

1B+ < 2B+ ~ 3B+

**RGE:** explains 1B < 2B, but not 1B < 3B  
**External inhibition:** explains 1B < 2B, but not 1B < 3B  
**US habituation:** explains 1B < 3B, but not 1B < 2B  
**Contextual blocking:** explains 1B < 3B, but not 1B < 2B



# Hybrid experiments

- Witcher & Ayres (1980): CER

| Group | Phase 1 | Phase 2 | Test    |
|-------|---------|---------|---------|
| 1     | +, B-   | C+      | C vs CB |
| 2     | B-      | C+      | C vs CB |
| 3     | ---     | C+      | C vs CB |

1CB < 2CB ~ 3CB

**Attentional enhancement:** greater attention to B in Group 1

| Group | Phase 1 | Test |
|-------|---------|------|
| 1     | +, B-   | B+   |
| 2     | B-      | B+   |
| 3     | ---     | B+   |

CT→  
Hyb→

1B+ < 2B+ ~ 3B+

**US habituation:** greatest in Group 1

**Contextual blocking:** unsignaled USs in Group 1

**Attentional enhancement:** counteracted by previous two mechanisms

# Hybrid experiments

- Hinson & Siegel (1986): Pentobarbital-induced hypothermia

|      | Group | Phase 1 | Test |
|------|-------|---------|------|
|      | 1     | X+, Y-  | Y+   |
| CT→  | 2     | X-, Y-  | Y+   |
| Hyb→ | 3     | Z+      | Y+   |
| Hyb→ | 4     | Z-      | Y+   |

First trial taken as a summation test

1Y < 2Y ~ 3Y ~ 4Y

**US habituation and attentional decrement:** summation in Group 1 (these effects do not show up separately in Groups 2 and 3, but together they affect retardation in Group 1)

# Hybrid experiments

- Nieto (1984): CER

| Group | Phase 1 | Phase 2 | Test S  | Test R |
|-------|---------|---------|---------|--------|
| 1     | C+      | A+, AB- | C vs CB | B+     |
| 2     | C+      | A+      | C vs CB | B+     |

1B < 2B

N.S. in Summation

**RDG:** B- training in Phase 2 reduced excitation generalized from C and A in Group 1, but not in Group 2, which had minimal exposure to B- during the summation test.

# Hybrid experiments

- Kremer (1978): CER

| Group | Phase 1 | Phase 2      | Test |
|-------|---------|--------------|------|
| 1     | A+, C+  | A+, C+, ACB+ | B+   |
| 2     | A+, C+  | AC+          | B+   |

First trial taken as a summation test

$1B < 2B$

**US habituation:** In Phase 2, Group 1 received more shocks than Group 2.  
**Contextual blocking:** same as above.

## Hybrid experiments

- Rescorla (1971): CER

| Group | Phase 1 | Phase 2 | Test    |      |
|-------|---------|---------|---------|------|
| 1     | B-      | C+      | C vs CB | N.S. |
| 2     | ---     | C+      | C vs CB |      |

This is a latent inhibition experiment. LI itself constitutes the retardation test. Thus, this summation test was meant to determine (using the two-test logic) whether LI involves “true IC” or just attentional decrement.

The absence of a summation effect was taken as evidence that LI is an attentional effect and does not involve IC.

# Contrasting-treatment experiments

# Contrasting-treatment experiments

- Taukulis & Revusky (1975): conditioned taste aversion

| Group | Phase 1 | Phase 2 | Test S | Test R |
|-------|---------|---------|--------|--------|
| 1     | A+, AB- | C+      | CB?    | B+     |
| 2     | A+, AB- | C+      | C?     |        |
| 3     | A-, AB- | C+      | CB?    | B+     |

$1CB < 2C$   
 $1CB < 3CB$

**Generalization decrement:** 1B modifies 1C relative to 2C.  
**Attentional decrement:** Group 3 is a LI control, thus, LI to B may have attenuated generalization decrement in summation test.

$1B < 3B$

**US habituation:** Group 1 received more LiCl injections than Group 3.  
**Contextual blocking:** same as above.

# Contrasting-treatment experiments

- Baker (1977): CER

| Group | Phase 1 | Phase 2 | Test     |
|-------|---------|---------|----------|
| 1     | +, B-   | C+      | C vs CB? |
| 2     | TRC     | C+      | C vs CB? |

1CB < 2CB

**Differential excitation:** occasional B+ pairings during TRC training in Group 2 made 2B more excitatory than 1B, thus counteracting generalization decrement otherwise produced in CB relative to C.

| Group | Phase 1 | Test |
|-------|---------|------|
| 1     | +, B-   | B+   |
| 2     | TRC     | B+   |

1B < 2B

**Differential excitation:** occasional pairings during TRC training in Group 2 made 2B more excitatory than 1B.

## Contrasting-treatment experiments

- Marchant et al. (1972): rabbit's nictitating membrane conditioning

| Group | Phase 1 | Phase 2 | Test    |                      |
|-------|---------|---------|---------|----------------------|
| 1     | A+, AB- | C+      | C vs CB | 1C > 1CB<br>2C ~ 2CB |
| 2     | A±, AB± | C+      | C vs CB |                      |

**Generalization decrement:** In Group 1, C is modified by B in test.

**Differential excitation:** in Group 2, generalization decrement is masked by excitation from B+ pairings in Phase 1.

| Group | Phase 1 | Test |         |
|-------|---------|------|---------|
| 1     | A+, AB- | B+   | 1B < 2B |
| 2     | A±, AB± | B+   |         |

**Differential excitation:** B is more excitatory in Group 2 because of B+ pairings in Phase 1.

# Contrasting-treatment experiments

- Hoffman & Fitzgerald (1982): heart-rate conditioning

Summation yielded N.S. results

| Group | Phase 1 | Test |
|-------|---------|------|
| 1     | A+, AB- | B+   |
| 2     | A+, B-  | B+   |
| 3     | AB-, +  | B+   |

1B ~ 3B < 2B

**Attentional reduction:** discarded given A+,AB- training.

**RGE:** while greater excitation should generalize from A to B in Group 2 than in Group 1 (because A was partially reinforced in Group 1), B- should lead to greater reduction than AB- trials because of greater generalization decrement in AB than in B.

**CS & US exposures:** equated in Groups 1 and 2.

**Contextual blocking:** Group 3's retardation caused by unsignaled USs.



# Contrasting-treatment experiments

- Cunningham (1979): CER

| Group | Phase 1 | Phase 2 | Test S   | Test R |
|-------|---------|---------|----------|--------|
| 1     | A+, C+  | AB-, D- | CB vs CD | B+     |
| 2     | A+, C+  | AD-, B- | CB vs CD | B+     |

1B < 2B

N.S. in Summation

**Attentional reduction:** discarded given A+,AB- training.

**Generalized excitation:** it should have been similar in both groups.

**CS & US exposures:** equated in Groups 1 and 2.





# Conclusions

# Conclusions

- Much of the evidence for IC is unconvincing.
- Alternatives may be offered in terms of:
  - \* Generalization
  - \* US habituation
  - \* Contextual conditioning
  - \* Attentional modification
  - \* Generalization decrement
  - \* External inhibition
- Alternatives may seem unconvincing, but these concepts are needed to explain other results.
- The best evidence came from:
  - \* Retardation tests
  - \* A+, AB- (conditioned inhibition training)
- Are summation tests intrinsically biased?

# Proposed experiments

| Group | Phase 1 | Test R |
|-------|---------|--------|
|-------|---------|--------|

---

|   |                  |       |
|---|------------------|-------|
| 1 | X: A+, B- / Y: - | Z: B+ |
|---|------------------|-------|

|   |               |       |
|---|---------------|-------|
| 2 | X: A+ / Y: B- | Z: B+ |
|---|---------------|-------|

---

| Group | Phase 1 | Test R |
|-------|---------|--------|
|-------|---------|--------|

---

|   |                 |       |
|---|-----------------|-------|
| 1 | X: +, B- / Y: - | Z: B+ |
|---|-----------------|-------|

|   |              |       |
|---|--------------|-------|
| 2 | X: + / Y: B- | Z: B+ |
|---|--------------|-------|

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