CONTEMPORARY THEORY AND RESEARCH

THEORIES OF CONDITIONING

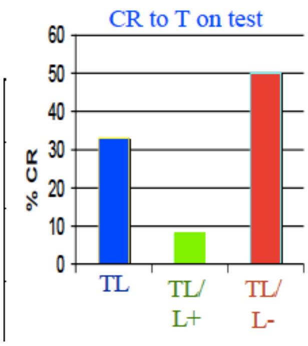
RELATIVE SIGNAL VALIDITY (WAGNER ET AL., 1968)

- Learning occurs when CS has predictive validity of US, relative to other cues
- Learning is not just based on contingency i.e. contingency not necessary for conditioning
    - Evidence: When shock (US) equally predicted by tone (CS1) and light (CS2), P(US|CS) = P(US|$\overline{CS}$) BUT, learning still acquired reliably as both CS are good predictors of US (Durlach)

Experiment 1 (Wagner)

1. TL: T + L → US
2. TL/L+: T + L → US and L → US
3. TL/L-: T+ L → US and L → nothing
4. Test: T

- Results: Most conditioning in TL/L-
    - TL → overshadowing
    - TL/L+ → similar to blocking effect
    - TL/L- → suggests T is much better predictor than L
- Limitations:
    - No. of presentations of US and L/T not controlled between groups
        - Group 2 has higher no. of shocks
        - Group 2 + 3 have higher no. of L presentations

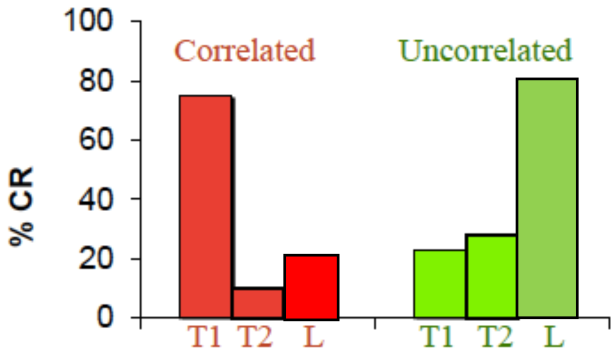


Experiment 2

1. Correlated: T1 + L → US, T2 + L → nothing
    a. Type of tone correlated w/ US vs nothing i.e. T1 has high signal validity for US, T2 has high signal validity for no US
    b. L equally paired w/ US vs nothing (50%) → lower signal validity than T1/T2
2. Uncorrelated: T1 + L → US/nothing (50%), T2 + L → US/nothing (50%)
    a. Type of tone uncorrelated w/ US vs nothing (50%) i.e. both have poor signal validity
    b. L equally paired w/ US vs nothing (50%) → not lower signal validity than T1/T2, actually bit better as paired with all US presentations

3. Test: T1, T2, L

- Controlled for no. of presentations of US, T1, T2, L
- L equally paired w/ US/nothing in both groups (50%) but signal validity of other CS differed between groups
- Results:
    - Correlated: T1 > L > T2
        - Less CR to L as T1 had high signal validity for US
        - Least CR to T2 as never paired with US
    - Uncorrelated: L > T2/T1
        - Most CR to L as paired w/ US the most times, although all paired w/ US at 50% i.e. most trials of 'partial reinforcement'



MODELS OF LEARNING

VARIATION IN ATTENTION TO CS (MACKINTOSH): FOCUS ON CS

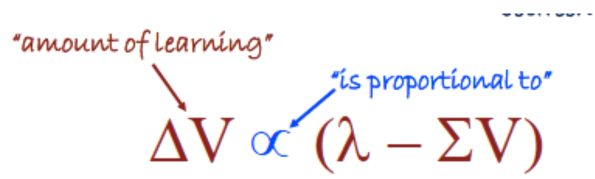
- Attention is limited resource which requires allocating
- Overshadowing effect depends on salience of accompanying CS
    1. Higher intensity of CS e.g. louder noise → more overshadowing
    2. More important CS w/ more usefulness as predictor → more attention allocated compared to other CS
        - Explains overshadowing vs blocking, and Wagner's signal validity experiment
- Limitations:
    - Does not work with every phenomenon → decreased prominence over years

VARIATIONS IN PROCESSING OF US (KAMIN): FOCUS ON US

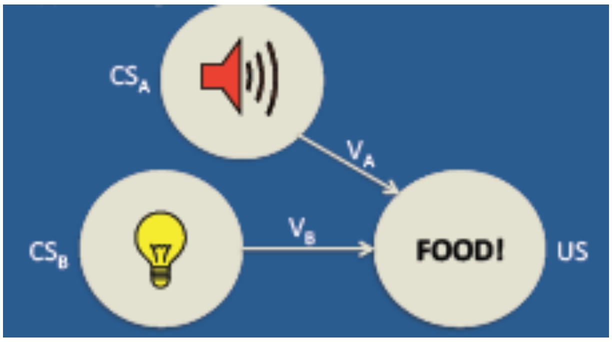
- Learning occurs when event is unexpected/differs from expectations e.g. US occurs when unexpected → expectancy model is updated
- E.g. in blocking, US is anticipated due to pre-conditioning with CS so no learning occurs

RESCORLA-WAGNER MODEL

- Numerical equation following Kamin's model of expectancy
- Describes when learning occurs and rate of learning → can predict learning in paradigm

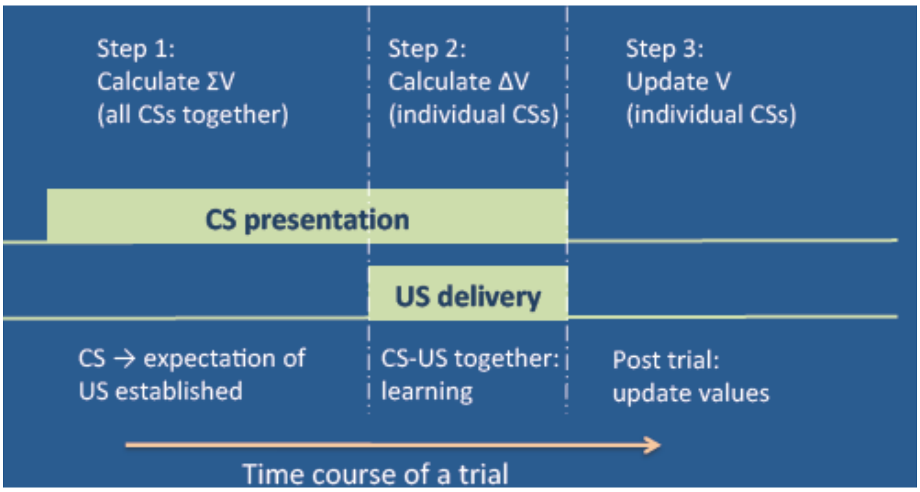


$$\Delta V = \alpha \times \beta \times (\lambda - \Sigma V)$$



- V = knowledge of CS-US association (specific to each CS)
  - Updated each trial as each trial = opportunity to learn
- ΔV = Change in knowledge of CS-US association i.e. amount of learning
- ΣV = Expectation of US, given associative strength of **all CS** present i.e. total knowledge of associations
  - Begins with 0 at first trial w/o any prior learning
- λ = Experience of US i.e. max learning supported by given US
  - Determines final level of learning (after infinite trials)
  - Typically 1 when US present, 0 when absent in extinction
- (λ - ΣV) = Prediction error – discrepancy between what occurs and what's expected
  - >0 = +ve prediction error; US occurs unexpectedly
  - <0 = -ve prediction error; US does not occur when expected
- Psychological parameters: Regulate rate of learning – without them, learning would occur on first trial
  - α = Salience of CS ($0<\alpha\leq1$)
  - β = Salience of US ($0<\beta\leq1$)

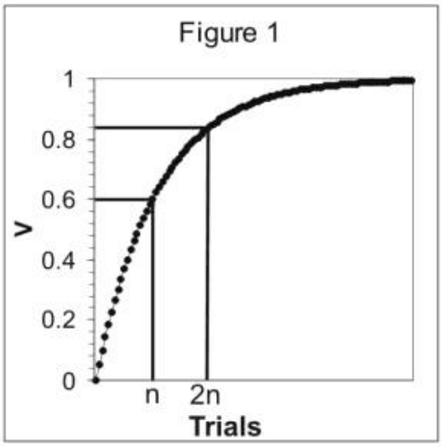
STEPS TO USING RESCORLA-WAGNER MODEL



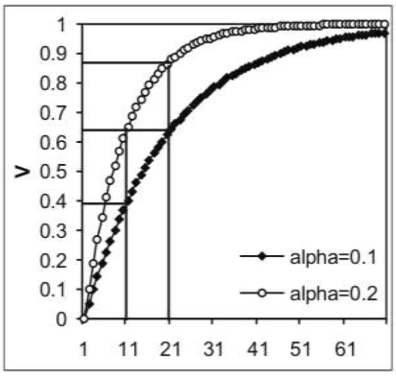
1. Calculate ΣV of all CS together

2. Calculate ΔV for individual CS
3. Update V for individual CS (Vnew = Vold + ΔV)
4. Repeat with each trial

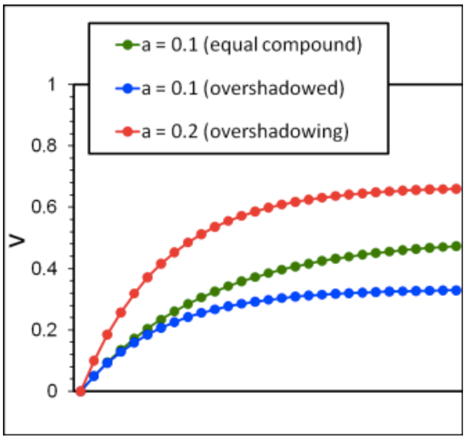
LEARNING IN RESCORLA-WAGNER MODEL

- Analogy: λ is a pie – each trial, CS takes a slice proportional (α x β) to amount of pie left i.e. ΔV
- Learning: Prediction error decreases, ΔV decreases and V increases across trials → deceleration of learning until asymptote λ (max learning)
    - ΣV = 0 in first trial
    - ΣV = V + ΔV each following trial
    - 

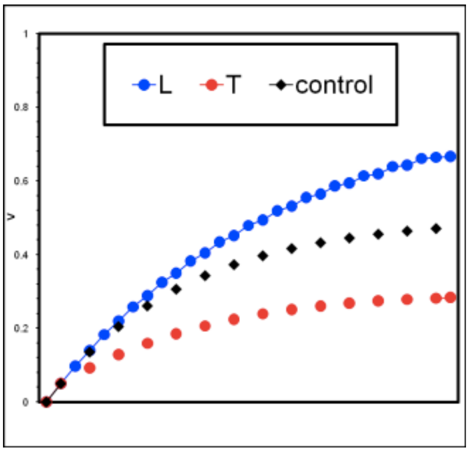
- Larger α → larger ΔV each trial → reach same λ quicker (steeper)



- Overshadowing: When 2 CS share V
    - More salient CS (larger α) has higher rate of learning than less salient CS
        - Takes larger slice of pie than the other CS on each trial
    - Learning to individual CS (V) is less than if conditioned by itself (on same trial) as have to share
        - But ΣV (all CS) is same and reaches same λ

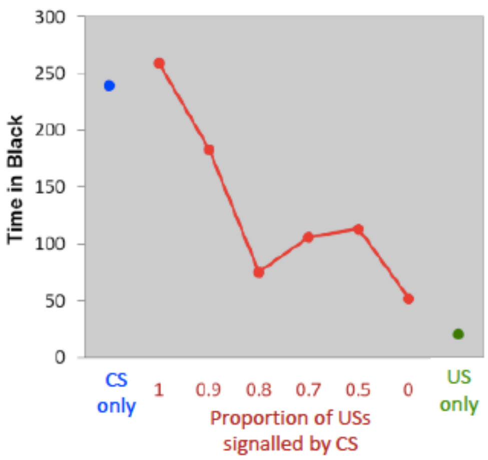


- Blocking: Pre-trained CS_1 has high V_1 prior to training → high ΣV (total V for all CS) at start → small ΔV on each trial
  - Less of pie left to be shared
- Relative signal validity: TL → US and L → US trials; conditioning to L occurs w/o sharing with T and overall ΣV grows faster
  - L takes slice of pie w/o sharing with T



RESCORLA-WAGNER MODEL AND CONTINGENCY

- Good conditioning occurs when CS-US paired but poor when on random schedule
  - Wagner: Context can function as a CS i.e. it predicts US → **blocks** conditioning to CS as it is more useful predictor
- Odling-Smee (1975): Presenting shock w/o CS → conditioning to context
  - Tone (CS) + shock (US) in black box
  - Controls: CS w/o US, and US w/o CS
  - 6 groups w/ 10 CS + 10 US presentations but varying proportions of US signaled by CS

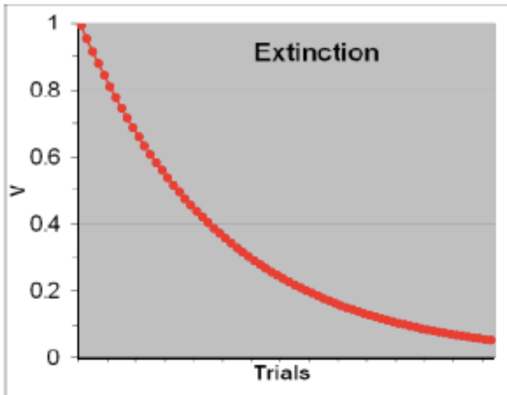


  - Results: Decreasing proportion of US signaled by CS → conditioning to context → less time spent in black box
- Durlach (1983): Using another CS (CS2) to signal extra US → rescued conditioning to CS1
  - Works because any CS is more salient than ambient context → take up better signal

EXTINCTION

EXTINCTION AS UNLEARNING IN RESCORLA-WAGNER MODEL

- Extinction: Reduction in CR when CS is no longer paired w/ US
- Extinction in Rescorla-Wagner model:
  - $\lambda = 0$ as US not presented
  - $\Sigma V = 1$ w/ max learning
  - → $\Delta V = \alpha \times \beta \times (\lambda - \Sigma V) = \alpha \times \beta \, (-1) < 0$
  - V decreases and approaches 0 i.e. 'unlearning' association

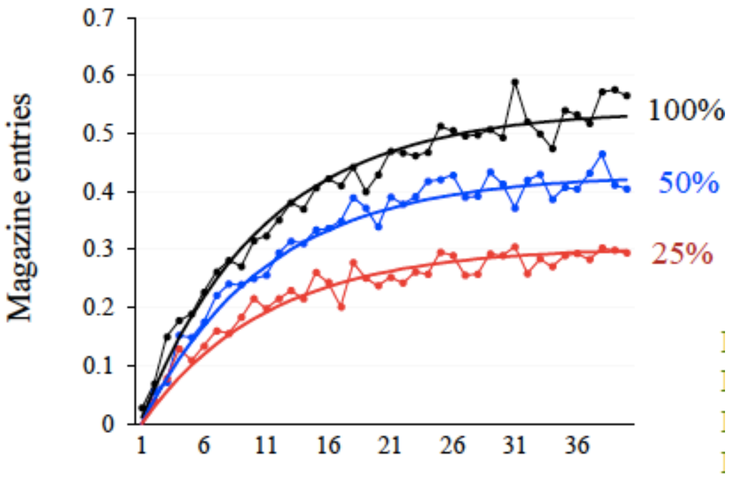


PARTIAL REINFORCEMENT

- Partial reinforcement: US does not always follow CS
- RW model can model partial reinforcement schedules using 'extinction' on non-reinforced trials
  - V increases on reinforced trials as $\Delta V = \alpha \times \beta \times (1 - \Sigma V) > 0$

- V decreases on non-reinforced trials as $\Delta V = \alpha \times \beta \times (0 - \Sigma V) < 0$

- Maximum amount of learning depends on % of trials where CS is followed by US



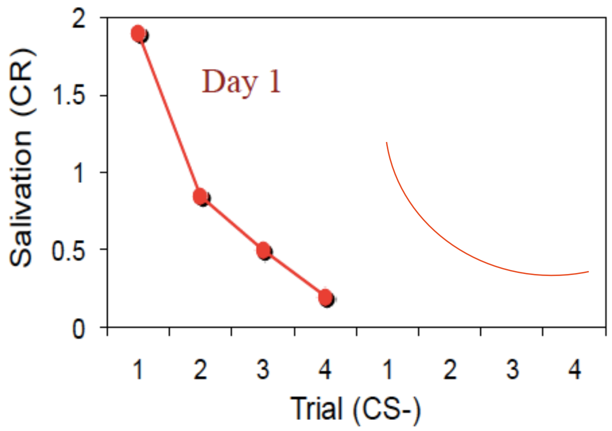
- Partial reinforcement extinction effect (PREE): Slower extinction with partial reinforcement schedule
  - RW model incorrectly predicts extinction: Longer time to extinguish in higher rft schedule as more learning attained (higher asymptote) but not true
  - Reasons for PREE:
    - In 100% reinforcement schedule: Training + extinction phase easily distinguished
    - In partial rft schedule: Harder to distinguish training + extinction phase as unsure whether extinction or non-reinforced trial → slower to learn US doesn't follow CS

EXTINCTION =/= UNLEARNING

- Spontaneous recovery: CR can recover over passage of time

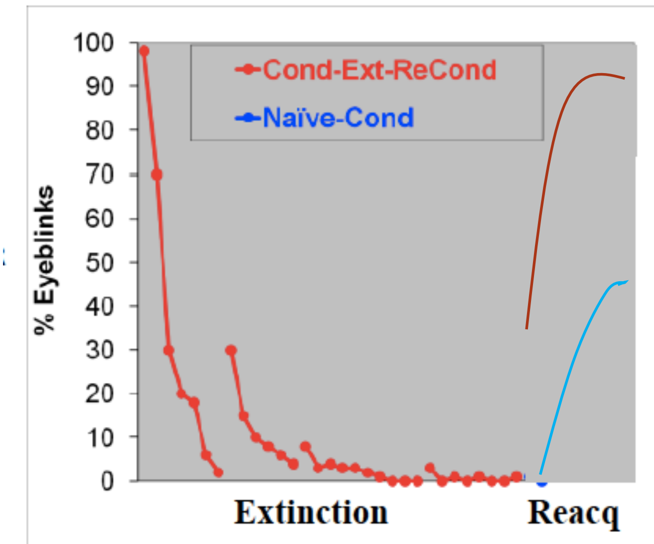
Conditioning	Extinction	Test1 (same day)	Test2 (next day)
CS1 → US	CS1 –	CS1?	
CS2 → US	CS2 –		CS2?

  - Higher CR to CS2 tested on day after extinction than CR to CS1 tested on same day as extinction
  - Amount of spontaneous recovery:
    - Decreases w/ more extinction trials, over more days
    - Increases w/ more time elapsed between extinction and test



- Rapid reacquisition: CR learnt faster after extinction than before during training (steeper curve)

Condition	Extinction	Re-condition
CS → US	CS –	CS → US
		CS → US

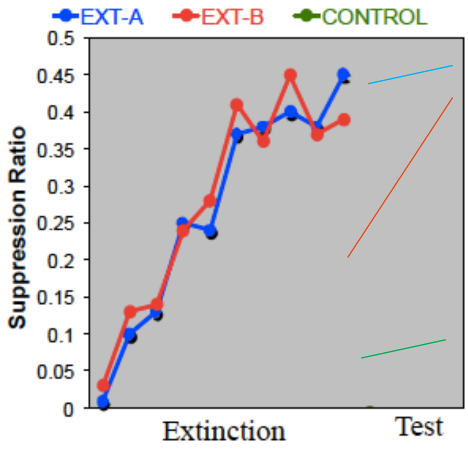


- Renewal: CR occurs when CS presented in different context to extinction

Group	Condition	Extinction	Test
Ext-A	A: CS → US	A: CS –	A: CS?
Ext-B	A: CS → US	B: CS –	A: CS?
Control	A: CS → US	B: –	A: CS?

  - Ext-A (AAA): Extinction + test in conditioning context → most extinction w/ least CR
  - Ext-B (ABA): Extinction in diff context, test in conditioning context → less extinction w/ more CR (lower suppression ratio)

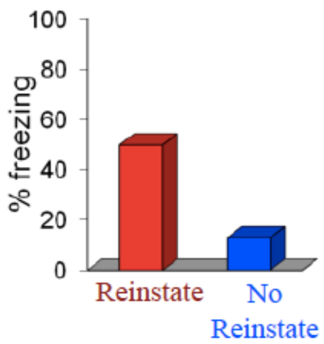
- Control: Exposed to B without extinction, test in conditioning context → no extinction



- Application: Relapse in fear response in real world context after exposure therapy/extinction in clinic → need extinction in multiple contexts

- Reinstatement: Responding reinstated if US presented alone

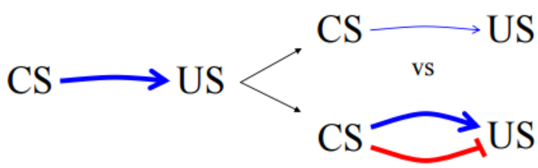
Group	Con	Ext	Re-instate	Test
Re-instate	CS ↓ US	CS–	US	CS?
No Re-instate	CS ↓ US	CS –	–	CS?



Westbrook et al (2002)

THEORIES OF EXTINCTION

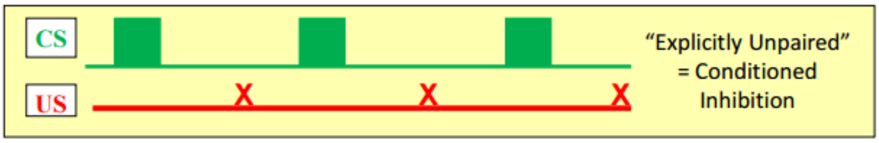
1. Rescorla & Wagner: Extinction = unlearning of CS-US association
    - Phenomena suggest that extinction =/= unlearning of CS-US association, but rather additional learning
2. Creation of (excitatory) CS-no US association/memory (Bouton)
    - Formation of conflicting memories
    - Training: Memory of CS → US (not context-specific)
    - Extinction: Memory of CS → no US (context-specific)
    - CR determined by type of memory retrieved in testing: Depends on time and context
        i. Spontaneous recovery: Over time, forget memory of CS → no US
        ii. Renewal: In different environment than extinction context, CS-US memory retrieved
        iii. Reinstatement: US reminds them of CS-US memory
3. Extinction as inhibition: Creation of inhibitory link between CS and US which suppresses CR from original CS-US association



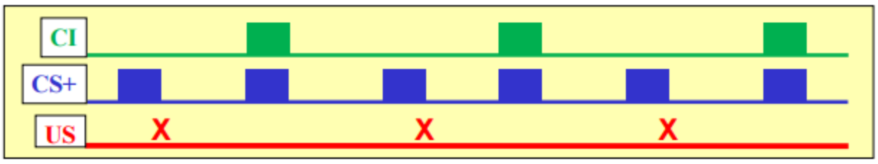
CONDITIONED INHIBITION

INHIBITORY LEARNING AND CONTINGENCY

- Conditioned inhibition = Negative contingency: $P(US|CS) < P(US|\overline{CS})$
- Two paradigms:
  1. CS and US are explicitly unpaired
     - Originally used as 'control' for less contiguity



  2. CI paradigm: CI, when paired w/ excitatory CS (CS+) does not lead to US



  - CI = Safety signal (when aversive US) or frustrative signal (when appetitive US)

TESTS FOR CONDITIONED INHIBITION

1. Summation test: S reduces responding to another CS+ (not previously paired), as S associated w/ no US
   1) Conditioning: A → US, B → US
   2) Conditioned inhibition: B + light → no US i.e. light becomes CI
   3) Test: A (CS+) + light (CI) → lower CR
2. Retardation test: Subsequent learning of excitatory S-US association is impaired, as S associated w/ inhibition

CONDITIONED INHIBITION AND RW MODEL

1. CI, when paired with CS+ does not lead to US
   - Excitatory CS (A) paired w/ new CS (X) without US i.e. AX-
     - $V_A = 1$, $V_X = 0$, $\lambda = 0$
     - $(\lambda - \Sigma V) = 0 - \Sigma V$ i.e. <0
     - Therefore $V_A \rightarrow 0$, V_X increasingly -ve over trials
   - As $Vx < 0$, X becomes conditioned inhibitor
2. CI and US are explicitly unpaired: X not paired w/ US, US occurs when X not present
   - –ve discrepancy i.e. $(\lambda - \Sigma V) < 0$ as context acts as CS+ and leads to expectancy of US
   - → X becomes conditioned inhibitor with $V<0$

CORRECT PREDICTIONS OF RW MODEL`

- Protection from extinction: CI prevents CS+ from extinction

Group	Conditioning	Extinction	Test
Control - extinction	A → US; B → US X (CI) + A → no US	B → no US	B? → less CR (extinction)
Protection – CI + CS+	A → US; B → US X (CI) + A → no US	X + B → no US	B? → no decrease in CR i.e. X protects B from extinction

  - As $V_x < 0$, there is less or no prediction error/discrepancy i.e. $\Sigma V = 0 \rightarrow (0 - \Sigma V) = 0$, $\Delta V = 0$

- Super-conditioning: CI, when paired w/ neutral stimulus/CS+ and US → higher V for CS+ than if conditioned by itself (higher CR when tested alone afterwards)

Conditioning	Test
Y → US	Y? → CR
X (CI) + Y → US	Y? → higher CR

  - As $V_x < 0$, ΣV is smaller → $(1 - \Sigma V)$ is larger → ΔV is larger → V_Y is >1

- *Overexpectation: Compound conditioning of 2 CS+ after independent conditioning → decrease in V; lower V for more salient stimulus*
  - $(\lambda - \Sigma V) = 1 - 2 = -1 \rightarrow \Delta V < 0$
  - ΔV for more salient stimulus is larger → lower V

INCORRECT PREDICTIONS OF RW MODEL

- Extinction of CI: When CI is presented on its own w/o US, RW predicts extinction
  - $\Delta V = \alpha \times \beta \times (0 - (-V)) > 0$
  - V increases towards 0 i.e. extinction
  - But this does not occur
- Pairing neutral CS w/ CI w/o US → conditioning of CS-US association
  - $\Delta V = \alpha \times \beta \times (0 - (-V)) > 0$ for both CI and CS
  - V for neutral CS increases → +ve i.e. excitatory CS
  - This does not occur

THEORIES OF INHIBITION

- Inhibitory association formed which inhibits memory of US (whilst excitatory association primes memory of US)
- Excitatory association between CS and 'no US' (Bouton)
- Excitatory conditioning to generate opposite motivational state
  - E.g. CI as safety signal → relief rather than fear when US = shock

- CI as frustrative signal → frustration rather than hedonic response when US = food