Chapter 5: Finishing up Classical Conditioning

Underlying Processes: Rescorla-Wagner Theory

Lecture Outline

• Underlying processes in Pavlovian conditioning
  – S-R vs. S-S learning
  – Stimulus-substitution vs. Preparatory-response theory
  – Compensatory response model
  – Rescorla-Wagner model

• Practical applications of Pavlovian conditioning
  – Understanding the nature of phobias
  – Treating phobias
  – Aversion therapy
Problem with the S-S theories

• While they can explain simple conditioning phenomena, they can’t explain

Rescorla-Wagner Model

• Began looking more in-depth at what is happening to the actual association between the CS and the US during the process of conditioning (after each trial).

• Driven to find an explanation for blocking phenomenon.
Rescorla-Wagner Model

- Assumptions of Rescorla-Wagner Model
  - US must be
    - The effectiveness of US depends on how different it is from what is expected
    - The amount of learning on a given trial is a function of the surprise value of the US (more surprise than more conditioning)
    - Example: if I ring a bell and you get shocked right now, you will learn a lot. If I ring a bell and you get someone taps you on the shoulder you’ll learn less (not as surprising in class).
  - A given US is limited in the
  - The amount of conditioning is
    - The expectation of the US is related to all CSs that precede the US

Example

light(NS): shock (US) → fear (UR)

- Learning association of light and shock
- Trial 1: association started
  - CS Node: L → US node: S
- Trial 2: association stronger
  - CS Node: L → US node: S
- Trial 3: association stronger
  - CS Node: L → US node: S
- Trial 4: association stronger
  - CS Node: L → US node: S
Rescorla-Wagner Theory

- These concepts were incorporated into a mathematical formula:
  - Change in the associative strength of a stimulus depends on the
  - If existing associative strength is low,
  - If existing associative strength is high, then
  - The speed and asymptotic level of learning is determined by the

Rescorla-Wagner Model

- The equation for the model:
  \[ \Delta V = k(\lambda - V) \]
  - Where:
    \[ \Delta V = \]
    \[ V = \]
    \[ k = \]
    \[ \lambda = \text{“lambda” represents the} \]
    \[ (\lambda - V) = \text{surprise value of the US} \]
  - The equation is applied once for each learning trial, to see how much learning will happen on each trial.
\[ \Delta V = k(\lambda - V) \]

- The learning curve:
  - If CS-US pairings repeated
    the associative strength (V)
  - Increase in V is not
    consistent over trials
    - Trial 1 – substantial
    - Subsequent Trials –
      progressively smaller (less
      surprise)
    - Eventually V approaches
      stable value (\( \lambda \))
  - \( \Delta V \) – represents change in
    associative strength on a
    given trial

- Quantifying surprise:
  - Focus on relationship between V and \( \lambda \)
  - Beginning of conditioning V is much less than
    \( \lambda \) (-----)
  - At the beginning, the
    participant does not expect US
    and considerable learning
    occurs
  - Over trials, the occurrence of
    the US is progressively less
    surprising, and V approaches
    \( \lambda \)
  - Index of surprise = (\( \lambda \) – V)
Rescorla-Wagner Model cont.

• Parameter 1:
  – The overall shape of the learning curve (increasing over trials, but at a declining rate) is uniform
  – BUT…
    • Taste version conditioning develops quickly
    • Salivary conditioning develops slowly
    • To account for variations in the speed of conditioning a constant is added to the equation
      \[ \Delta V = k(\lambda - V) \]
    • The greater the value of \( k \).

Rescorla-Wagner Model cont.

• Parameter 2:
  – The asymptote reached can vary
    \[ \Delta V = k(\lambda - V) \]
  – Affected by CS-US belongingness; strength of CS; strength of US etc

- Example: (US)
  - 25 volt electric shock vs
  - 500 volt electric shock

- Example: (CS)
  - Low light vs
  - bright light
- Both parameter values remain the same
  - e.g., trials
- Parameter values differ
  - e.g., different CS-US combinations, different contexts

Rescorla-Wagner Model cont.

• Evaluation:
  – To calculate the model’s predictions for learning on a given CS-US trial, need to estimate values of k & λ
  – Could run pilot test but extremely complex (Hull, 1943)
  – Can just use arbitrary values!!!
    • Precludes quantitative data (e.g., how much saliva on a given trial)
    • Can make qualitative predictions (e.g., whether saliva will increase or decrease on a given trial)
Rescorla-Wagner Model cont.

• Acquisition
  – \( k = 0.30 \) (parameter for salience of the CS-US)
  – \( \lambda = 1.00 \) (maximum associative value)
  – \( V = \) associative strength on trial 1 = 0.00

Trial 1
\[ \Delta V = k(\lambda - V) = 0.30 (1.00 - 0.00) = 0.30 \]

Trial 2
\[ \Delta V = k(\lambda - V) = 0.30 (1.00 - 0.30) = 0.21 \]

<table>
<thead>
<tr>
<th>Trial</th>
<th>( V )</th>
<th>( \Delta V = k(\lambda - V) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00</td>
<td>( \Delta V = 0.30 (1.00 - 0.00) = )</td>
</tr>
<tr>
<td>2</td>
<td>0.30</td>
<td>( \Delta V = 0.30 (1.00 - 0.30) = )</td>
</tr>
<tr>
<td>3</td>
<td>0.51</td>
<td>( \Delta V = 0.30 (1.00 - 0.51) = )</td>
</tr>
<tr>
<td>4</td>
<td>0.66</td>
<td>( \Delta V = 0.30 (1.00 - 0.66) = )</td>
</tr>
</tbody>
</table>

Rescorla-Wagner Model cont.

• Extinction
  – With repeated extinction trials \( \lambda \) will = 0 (maximum associative value)
  – Use same parameters but insert \( \lambda = 0 \)

Trial 1
\[ \Delta V = k(\lambda - V) = 0.30 (0.00 - 0.66) = -0.198 \]

Trial 2
\[ \Delta V = k(\lambda - V) = 0.46 (0.00 - 0.46) = -0.138 \]

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<th>( V )</th>
<th>( \Delta V = k(\lambda - V) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.66</td>
<td>( \Delta V = 0.30 (0.00 - 0.66) = -0.198 )</td>
</tr>
<tr>
<td>2</td>
<td>0.46</td>
<td>( \Delta V = 0.30 (0.00 - 0.46) = -0.138 )</td>
</tr>
<tr>
<td>3</td>
<td>0.32</td>
<td>( \Delta V = 0.30 (0.00 - 0.32) = -0.096 )</td>
</tr>
<tr>
<td>4</td>
<td>0.22</td>
<td>( \Delta V = 0.30 (0.00 - 0.22) = -0.014 )</td>
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After More Extinction Trials \( V = 0 \)
Rescorla-Wagner and Compound Stimuli

- Competitive learning:
  - The total amount of learning available, $\lambda$, must be shared by each stimulus in a compound.
  - The total amount of learning to each stimulus is less in a compound than if that stimulus is alone.
  - Rescorla-Wagner predicts overshadowing and blocking accurately.

Rescorla-Wagner & Overshadowing

- Overshadowing
  - Stronger conditioning to the
  - Whenever there are multiple stimuli or a compound stimulus, then $V = V_{cs_1} + V_{cs_2}$

- Trial 1:
  - $\Delta V_{noise} = .2 (1 - 0) = (.2)(1) = .2$
  - $\Delta V_{light} = .3 (1 - 0) = (.3)(1) = .3$
  - Total $V = current V + \Delta V_{noise} + \Delta V_{light} = 0 + .2 + .3 = .5$

- Trial 2:
  - $\Delta V_{noise} = .2 (1 - .5) = (.2)(5) = .10$
  - $\Delta V_{light} = .3 (1 - .5) = (.3)(5) = .15$
  - Total $V = current V + \Delta V_{noise} + \Delta V_{light} = .5 + .1 + .15 = .75$
Overshadowing cont.

![Diagram showing overshadowing cont.]

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Rescorla-Wagner & Blocking

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>[Light + Tone] : Shock</td>
<td>Tone ???</td>
</tr>
<tr>
<td>Group 2</td>
<td>Light : Shock</td>
<td>[Light + Tone] : Shock</td>
</tr>
</tbody>
</table>

- Phase 1
  - Group 2 the light (CS) perfectly predicts the shock (US) in phase 1
  - Conditioning reaches the asymptote

- Phase 2
  - Compound stimuli (Light + Tone) presented with US
  - No learning to Tone because light perfectly predicts US

- Associative strength is shared between CSs
Blocking cont.

\[ \text{Phase 1} \quad \text{Phase 2} \quad \text{Test} \]
\begin{tabular}{lll}
Group 1 & [Light + Tone] : Shock & Test 1 \\
Group 2 & Light : Shock & [Light + Tone] : Shock & Test 2 \\
\end{tabular}

- Clearly, the trials in Phase 1 will result in

Problems with Rescorla-Wagner

- Model focuses exclusively on CS-US association but cannot account for

- Problem 1:
  - CS preexposure produces slower conditioning to CS later (latent inhibition).
    - Example: play a tone a number of times before it is paired with a shock. (have a harder time conditioning the tone)
  - Latent inhibition is not predicted by Rescorla-Wagner
    - unless you assume that preexposure lowers the learning rate \( k \) by lowering salience.
Problems with Rescorla-Wagner

- Problem 2:
  - Occasion setting (context that indicates the CS-US pairing will occur, and different context that indicates the CS won’t be followed by a US)

  - Example:
    - If in a dim Room= tone:shock
    - If in a bright Room= tone is not followed by shock

  - Rescorla-Wagner says

- But, it has been the “best” theory of Classical Conditioning