Slowed reacquisition of a previously extinguished response: The effect of partial extinction in human contingency learning

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Extinction of a fear response
Limitations of extinction

- Relapse phenomena:
  - Renewal, reinstatement, spontaneous recovery, rapid reacquisition...

- How to improve extinction?
Partial extinction slowed later reacquisition

- Bouton et al. (2004, 2007) found:
  - Reacquisition of a previously extinguished response (i.e., either conditioned or operant) slowed down when reinforced trials were included as part of the extinction treatment (i.e., partial extinction)
  - Partial extinction as a way to *mitigate* this form of relapse
Partial extinction slowed later reacquisition

Bouton et al. (2004)’s results:
- After conditioning and extinction phases, reacquisition session in Experiment 1:

From the extinction phase:
- **Extinction:**
  - CS-  CS-  CS-  CS-  CS-  CS-  CS-  CS-

- **Partial extinction:**
  - CS-  CS+  CS-  CS-  CS-  CS-  CS+  CS-
Why slowed reacquisition?

- Bouton’s explanation:

  Conditioning
  
  CS → US

  Partial Extinction
  
  CS → US
  Ctx

  Re-acquisition
  
  CS → US
  Ctx

CS-US....
Objective

- Will an equivalent slow reacquisition effect be found in human contingency learning?
  - In the aversive domain (a mild aversive noise)
  - Focusing on participants’ beliefs about the extent to which they think the aversive noise will take place (cognitive component of a fear response)
## Experiment 1

- **Design:**

<table>
<thead>
<tr>
<th>Group</th>
<th>Acquisition</th>
<th>Extinction</th>
<th>Re-acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial Extinction</td>
<td>A (18 +)</td>
<td>A (12 + / 42 –)</td>
<td>A (18 +)</td>
</tr>
<tr>
<td>(22.2%)</td>
<td>B (18 –)</td>
<td>B (54 –)</td>
<td>B (18 –)</td>
</tr>
<tr>
<td>Extinction</td>
<td>A (18 +)</td>
<td>A (54 –)</td>
<td>A (18 +)</td>
</tr>
<tr>
<td></td>
<td>B (18 –)</td>
<td>B (54 –)</td>
<td>B (18 –)</td>
</tr>
</tbody>
</table>

+ Refers to a brief (500ms) mildly aversive noise ($\approx 85$dB)

– Refers to the absence of any stimulus
Contingency learning task

Response:
*How likely is the noise?*
Results

Acquisition:

![Graph showing expectancy ratings over trials for different groups.]

Cue x Trial, $F(5.23, 224.98) = 43.76, p < .001, \eta^2_p = .504$
Results

- **Extinction:**

  - Group x Cue x Trial, $F(9.94, 427.69) = 2.52, \ p = .005, \ \eta^2_p = .055$
  
  - Within Cue A: Group x Trial, $F(11.86, 581.38) = 2.36, \ p = .006, \ \eta^2_p = .046$
Results

- **Re-acquisition:**

![Graph showing expectancy ratings over trials for different groups and cues.](image)

**Group x Cue x Trial**, $F(6, 258.17) = 6.15$, $p < .001$, $\eta^2_p = .125$

**Within Cue A**: Group x Trial, $F(5.34, 229.87) = 8.09$, $p < .001$, $\eta^2_p = .158$
Discussion

- Extinction was complete in the Extinction but not in the Partial Extinction group.
- Re-acquisition was slower in the Partial Extinction than in the Extinction group.

Would these re-acquisition results generalize to a more uncertain situation?

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<td>B (18 –)</td>
</tr>
<tr>
<td>Extinction</td>
<td>A (18 +)</td>
<td>A (54 –)</td>
<td>A (18 +)</td>
</tr>
<tr>
<td></td>
<td>B (18 –)</td>
<td>B (54 –)</td>
<td>B (18 –)</td>
</tr>
</tbody>
</table>
## Experiment 2

### Design:

<table>
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<th>Extinction</th>
<th>Re-acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial Extinction (12.5%)</td>
<td>A (7+ / 1-)</td>
<td>A (3+ / 21-)</td>
<td>A (10+)</td>
</tr>
<tr>
<td></td>
<td>B (8-)</td>
<td>B (24-)</td>
<td>B (10-)</td>
</tr>
<tr>
<td></td>
<td>C (1+ / 7-)</td>
<td>C (3+ / 21-)</td>
<td>C (9+ / 1-)</td>
</tr>
<tr>
<td>Extinction</td>
<td>A (7+ / 1-)</td>
<td>A (24-)</td>
<td>A (10+)</td>
</tr>
<tr>
<td></td>
<td>B (8-)</td>
<td>B (8-)</td>
<td>B (10-)</td>
</tr>
<tr>
<td></td>
<td>C (1+ / 7-)</td>
<td>C (3+ / 21-)</td>
<td>C (9+ / 1-)</td>
</tr>
</tbody>
</table>

### Task as in Experiment 1:
- Cue C was added
Results

- **Acquisition:**

\[
\begin{align*}
\text{Cue x Trial, } F(7.82, 445.55) &= 20.77, \ p < .001, \ \eta^2_p = .267
\end{align*}
\]
Results

**Extinction:**

![Graph showing expectancy ratings over trials for different conditions]

**Within Cue A:**
- Group, $F(1, 57) = 27.39, p < .001, \eta^2_p = .325$
- Group x Trial, $F(11.42, 651.11) = 1.92, p = .033, \eta^2_p = .033$
Results

Re-acquisition:

Group x Cue x Trial, $F(9.59, 546.4) = 2.27, p = .014, \eta_p^2 = .038$

Within Cue A: Group x Trial, $F(5.02, 286.33) = 5.47, p < .001, \eta_p^2 = .088$
Discussion

- Again, re-acquisition was slower in the Partial Extinction than in the Extinction group.
  - And yet, in a more uncertain task; and reducing the number of reinforced trials in the partial extinction group.
- As in Experiment 1, extinction was complete in the Extinction but not in the Partial Extinction group.
- **How to make extinction complete in the Partial Extinction group?**
## Experiment 3

### Design:

<table>
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<th>Re-acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial Extinction</td>
<td>A (8 +) B (10 –)</td>
<td>A (9 + / 47 –) B (54 –)</td>
<td>A (10 +) B (10 –)</td>
</tr>
<tr>
<td>Extinction</td>
<td>A (10 +) B (8 –)</td>
<td>A (56 –) B (54 –)</td>
<td>A (10 +) B (10 –)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(9 + / 47 –):</th>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Block 4</th>
<th>Block 5</th>
<th>Block 6</th>
<th>Block 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>–</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>% Reinforced</td>
<td>62.5</td>
<td>37.5</td>
<td>12.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Results

**Acquisition:**

```
Cue x Trial, \( F(2.87, 181.307) = 135.14, p < .001, \eta^2_p = .682 \)
```
Results

**Extinction:**

- **Within Cue A:**
  - Group, $F(1, 63) = 250.94$, $p < .001$, $\eta^2_p = .799$
  - Group x Trial, $F(11.42, 651.11) = 29.92$, $p < .001$, $\eta^2_p = .033$
Results

Re-acquisition:

Group x Cue x Trial, $F(3.83, 243.3) = 5.27, p = .014, \eta^2_p = .038$

Trial 2 and Trial 3: $t(61.15) = 3.12, p = 0.003$ and $t(63) = 2.10, p = 0.04$
Discussion

- Extinction was also complete in the Partial Extinction group.
- And still, the partial extinction treatment produced a slower reacquisition compared to a standard Extinction group.
Experiments 1-3 showed that partially reinforced extinction produced a slowed reacquisition effect compared to standard extinction, equivalent to the effect found in animal conditioning.

Experiment 2 showed that the effect could also be obtained in uncertain situations.

Experiment 3 showed that the effect could still be found even when extinction, prior to the re-acquisition phase, was complete in the Partial extinction group.
Future directions

- Will the partially extinction effect generalize to more aversive situations or to other fear responses such judgments of fear, skin conductance, or startle responses?

- Will this form of relapse reduction generalize to the clinical domain?:
  - Will a scarce exposure to the feared stimulus in exposure-based therapies reduce relapse?
Thanks!

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Best-fitting curve adjustment

**Experiment 1 (n=49):**

\[ y = 100 - \left( \frac{100}{a + x^b} \right) \]

- Partial Extinction: \( a=0.363; \, b=0.759 \)
- Extinction: \( a=0.061; \, b=1.409 \)
Best-fitting curve adjustment

- **Experiment 2 (n=59):**
  
  Partial Extinction: \[ a=0.291; b=0.668 \]
  
  Extinction: \[ a=0.003; b=0.996 \]
Best-fitting curve adjustment

**Experiment 3 (n=65):**

- Partial Extinction: $a = -0.020; b = 1.268$
- Extinction: $a = 0.040; b = 1.718$

$$y = 100 - \left( \frac{100}{a + x^b} \right)$$