Training attention toward positive stimuli improves depressives’ decision making
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Introduction

- Decision making deficits are observed in depressed individuals1,2.
- A potential contributor to these decision-making deficits may be attentional biases associated with depression.
- Depressed individuals show a bias for negative stimuli relative to neutral stimuli3 and a lack of bias for positive stimuli4.
- Depression is also associated with decreased sensitivity to rewards5 and hypersensitivity to punishment6.
- Recent work7 reported that training attention away from negative stimuli reduced this bias and reduced depressive symptoms.
- We hypothesize that attention toward positive stimuli will improve depressive’s ability to maximize reward during decision making.
- The goal of the current project is to use attention training to improve performance on a decision making task.

Participants

75 University of Texas undergraduates who received course credit for their participation

<table>
<thead>
<tr>
<th>No Training</th>
<th>Placebo Training</th>
<th>Active Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Depressive</td>
<td>Depressive</td>
<td>Depressive</td>
</tr>
<tr>
<td>CES-D M=7.70</td>
<td>CES-D M=33.23</td>
<td>CES-D M=35.20</td>
</tr>
<tr>
<td>n=33</td>
<td>n=22</td>
<td>n=20</td>
</tr>
</tbody>
</table>

Attention Training

- 3 blocks of 168 trials; 504 trials total
- 2 minutes of rest between each block
- Neutral and positive valence words from the Affective Norms for English Words list (ANEW) matched for letter length and frequency use in the English language.

<table>
<thead>
<tr>
<th>Probe Location</th>
<th>Placebo Training</th>
<th>Active Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behind Positive</td>
<td>50%</td>
<td>85%</td>
</tr>
<tr>
<td>Behind Neutral</td>
<td>50%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Decision Making Task

Participants chose between two options on each trial (left) for 150 trials. Rewards were independent of previous response history (right).

Modeling

Basic Softmax RL Model:

Reward prediction errors, δ, are used to update the expected value (EV) each time an option is chosen:

\[ \delta = r(t) - EV_i \] (1)
\[ EV_{i,t+1} = EV_{i,t} + \alpha \delta \] (2)

Where \( r(t) \) is the reward received on trial \( t \)
\( \alpha \) is the degree to which EV is updated based on the most recent reward

EVs are used to determine the probabilities for selecting each option by the Softmax decision rule8:

\[ P(a_i,t) = \frac{e^{\theta \cdot EV(a_i,t)}}{\sum_{j=1}^{2} e^{\theta \cdot EV(a_j,t)}} \] (3)

\( \theta \) is the degree to which option with highest EV is chosen.

Extended RL Model:

Separate learning rates when \( \delta \) is positive (\( \alpha_{pos} \)) or negative (\( \alpha_{neg} \))

EVs are represented by distributions. The Noise (N) around the mean is updated on each trial:

\[ N_{i,t+1} = N_{i,t} + \alpha_N \beta^2 \cdot N_{i,t} \] (4)

Where \( \alpha_{pos/neg} \) is a recency parameter and \( N_0 \) is initial uncertainty.

\( N \) and the mean of each EV factor into the decision rule:

\[ P(a_e) = \frac{e^{\theta \cdot EV_{a,e} + \theta_N \cdot N_{a,e}}}{\sum_{j=1}^{2} e^{\theta \cdot EV_{a,j} + \theta_N \cdot N_{a,j}}} \] (5)

Baseline Model:

Assumes fixed choice probabilities and has one free parameter that denotes the probability of selecting option A on any trial.

Results

Behavioral Results

Model Comparison and Parameters

Simulations using Extended RL Model

Conclusions

- Depressive individuals who received placebo training performed worse than non-depressives, but this deficit was attenuated with training toward positive stimuli.
- Depressive individuals who received placebo training also switched between options more than non-depressives.
- The Extended RL model was the best fitting model and simulations were very similar to the observed results.
- The placebo training group learned more from negative prediction errors than positive prediction errors, but this difference was alleviated with attention training.

References