Learning, Mood, and Music
Depression, anxiety, and stress reflect processing biases in positive and negative chord sequences

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INTRODUCTION

- Mood disorders bias processing of emotional stimuli [1].
- Invasive questions in current screening tools of mood disorders lead to response biases [2].
- Assessing implicit information processing biases may offer a way to screen non-invasively for mood disorders.
- We used a statistical learning task to test whether depression, anxiety, and stress scores predict implicit learning of musical sequences based on their emotional association.

Sixty participants performed a probabilistic, continuous Statistical Learning task. A long sequence of four possible states (called ‘A’, ‘B’, ‘C’, ‘D’) was generated using the transitional probability matrix below.

<table>
<thead>
<tr>
<th>State n+1</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>.75</td>
<td>.25</td>
<td>.25</td>
<td>.125</td>
</tr>
<tr>
<td>B</td>
<td>.25</td>
<td>.75</td>
<td>.25</td>
<td>.075</td>
</tr>
<tr>
<td>C</td>
<td>.25</td>
<td>.25</td>
<td>.75</td>
<td>.125</td>
</tr>
<tr>
<td>D</td>
<td>.125</td>
<td>.075</td>
<td>.125</td>
<td>.75</td>
</tr>
</tbody>
</table>

Table 1. Transitional Probability Matrix. The bold transition indicates high-probability pathways. The dependent variable of this study was how often the participant selected the high-probability choice (CHPC).

Stimuli. Each of the states was instantiated by a flashing dot and one of four musical chords, from one of two chord sets (major or minor key). A pilot test confirmed that sequence segments using the two chord sets were perceived as Positive or Negative in valence.

![Positive chord set (A major)](image1)

![Negative chord set (A minor)](image2)

Figure 1. The two chord sets used (left side) as well as pilot data (right side) showing that the sequence segments generated from the positive and negative chord set elicited matching ratings of emotional valence.

![Task schematic example from the Negative block. Chords and flashing dots occurred simultaneously, in accordance with the transitional probability matrix.](image3)

Figure 2. Task schematic example from the Negative block. Chords and flashing dots occurred simultaneously, in accordance with the transitional probability matrix.

Statistical Learning Task. The sequence passed every 15 to 23 chords (one segment), and participants clicked on which dot (chord) they thought would come next. Participants gave 75 responses in both the Positive and the Negative blocks (order randomised). The dot layout (square or diamond) was also randomised between the two valence blocks.

Mood assessment. Depression, Anxiety and Stress Scale - 21 items (DASS-21)

RESULTS

Figure 3: Participants were able to extract the underlying transitional probability matrix, as the cumulative number of high-probability choices (CHPC) exceeded the 95% CI around chance performance. There were no overall differences between learning rates in Positive and Negative blocks.

![Bayesian mixed effects models revealed strong evidence that the depression, anxiety, and stress subscales all predicted learning rates and interacted with stimulus valence.](image4)

Figure 4: Main findings and Evidence Ratios (ER).

- Higher Depression scores predicted slower learning ($\text{ER} = 9599$). This effect was stronger in the Negative compared to the Positive block ($\text{ER} = 945$).
- Higher Anxiety did not predict learning in the Positive block ($\text{ER} = 1.2$), but it predicted faster learning in the Negative block ($\text{ER} = 9992$).
- Higher Stress scores predicted faster learning ($\text{ER} = 2065$). This effect was stronger in the Positive compared to the Negative block ($\text{ER} = 21$).

CONCLUSION

- Mood scores predicted differences in information processing of Positive and Negative chord sequences.
- No mood-congruency effect was observed on the Depression subscale (higher scores did not predict faster learning in Negative compared to Positive blocks).
- However, anxiety scores showed a mood-congruency effect: higher scores predicted better learning in Negative blocks (and not in Positive blocks).
- Stress may be a positive predictor of learning, however, prior literature strongly suggests that this is not a sustainable learning strategy.
- This methodology shows promise for developing a musical tool to screen non-invasively for mood disorders.

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REFERENCES


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