Associations Between Decision Making and Hedonic Responses to Odor

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Background:
- Olfaction, or the sense of smell, is facilitated by specialized sensory cells, called olfactory sensory neurons, which are directly connected directly to the brain.
- The limbic system is a set of brain structures located on both sides of the thalamus. The limbic circuitry supports a variety of functions, including emotion, behavior, motivation, long-term memory, and olfaction. The olfaction bulb is connected to the amygdala and the hippocampus. The anterior limbic and related structures including the orbitofrontal cortex and amygdala are involved in emotion, reward valuation, and reward-related decision-making (but not memory), with the value representations transmitted to the anterior cingulate cortex for action-outcome learning. (Rolls, E. T. 2015)
- Olfaction and executive measures have a common neural substrate in prefrontal and orbitofrontal cortex, and suggest that olfaction might be a reliable cognitive marker in psychiatric and neurologic disorders. (Fagundo, A. B. 2015)
- Activation of emotional neural substrates might alter the dual cognitive dorsolateral prefrontal cortex and emotional orbitofrontal prefrontal cortex circuits that interact during decision-making. (Overman, W.H. 2011)
- Sex-related performance differences on this task: males perform significantly better than females on decision-making in the Iowa Gambling Task. (Reavis and Overman, 2001).

Specific Aims:
- Investigate associations between total money earned in a gambling task and pleasantness and unpleasantness ratings of odors
- Examine associations between draws from advantageous/disadvantageous and low-risk/high-risk card decks with pleasantness and unpleasantness ratings of odors

Hypotheses:
- I predict that if participants rate pleasant odors higher on a hedonic scale, then they will also win more money on the Iowa Gambling Task.
- I predict that if participants rate unpleasant odors higher on a hedonic scale, then they will also be more likely to select from disadvantageous decks on the IGT.

Methods:
Sample:
- 51 undergraduate female n = 44) students from a mid-sized, private Midwestern University participated in this study for research credit.

Measures:
- Sniffin’ Sticks Threshold Test: (Burghart Instruments, Wedel, German) used to assess odor detection acuity. The test utilizes pen-like odor dispensing devices, 32 containing only water and 16 containing varying concentrations of alcohol. (Burghart Instruments, Wedel, German)
- Sniffin’ Sticks Identification Test: (Burghart Instruments, Wedel, Germany) was used to assess smell identification. The test utilizes 36 pen-like devices to deliver common odorants (e.g. orange, lilac, onion) with a 4 choice response format. (Figure 1. a.)
- Olfactory Hedonics: Ratings of odor pleasantness and Unpleasantness were assessed following the administration of each Sniffin’ Sticks Identification odorant using two five-point Likert scales. (Figure 1. b.)
- Iowa Gambling Task II: (Iowa Gambling Task, Version 2, Antione Bechara, PhD) Used to assess decision-making. Participants are told to earn as much hypothetical money as possible by choosing cards from four card decks. The pair of advantageous decks (C and D) and the pair of disadvantageous decks (A and B) of the standard IGT each consists of one deck with frequent low punishments (C and A) and one deck with infrequent high punishments (D and B). The task is sensitive to orbitofrontal cortex abnormalities. (Figure 2)

Data Analysis:
- Pearson Correlation was used to find linear relationships between hedonic ratings and variables from the Iowa Gambling Task. Spearman’s Rho was used for Deck C. Deck C was advantageous, but came with frequent low punishments. Deck C was ordinal compared to the other decks.

Results:
Primary Analysis (N = 51):
- Total money won (r = -0.332, p = 0.017) was associated with lower unpleasantness odor ratings across all odors.
- Number of draws from the high risk and low reward deck (r = -0.368, p = 0.008) was correlated with higher total unpleasantness ratings across all odors.
- Net total (r = -.238, p = 0.093), draws from the high risk and high reward (r = 0.133, p = 0.352), low risk and high reward C (r = 0.040, p = 0.781), and low risk low reward (r = -0.143, p = 0.317) were not significantly correlated with unpleasantness ratings across all odors.

Table 1a.) Correlations of Pleasant and Unpleasant Ratings and Variables of the Iowa Gambling Task

<table>
<thead>
<tr>
<th></th>
<th>Total Pleasantness</th>
<th>Total Unpleasantness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>p</strong></td>
<td><strong>p</strong></td>
<td><strong>p</strong></td>
</tr>
<tr>
<td>Net Total</td>
<td>0.107</td>
<td>0.050</td>
</tr>
<tr>
<td>Total Money Won</td>
<td>0.207</td>
<td>0.145</td>
</tr>
<tr>
<td>Deck A</td>
<td>-0.106</td>
<td>0.460</td>
</tr>
<tr>
<td>Deck B</td>
<td>-0.076</td>
<td>0.587</td>
</tr>
<tr>
<td>Deck C*</td>
<td>-0.031</td>
<td>0.992</td>
</tr>
<tr>
<td>Deck D</td>
<td>0.129</td>
<td>0.367</td>
</tr>
</tbody>
</table>

(* Deck C was screened, Spearman’s Correlation (rho) was used.)

Conclusions:
- Poor decision-making, as indicated by choosing more cards from the high risk and low reward deck was related to higher ratings of unpleasant odors. This result suggests that those who reported more odors as unpleasant, were experiencing negative emotions in the prefrontal cortex, which inhibited decision-making.
- Participants who won more money reported lower ratings of total unpleasantness. This finding suggests that participants who rated more odors as pleasant were experiencing positive emotions in the prefrontal cortex, which facilitated decision making.

Future Directions:
- Examine sex-differences once the male sample is adequately powered.

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