SURGE 2021 Midterm Report

Name: Khyathi Vagolu
SURGE Application number: 2130538
Professor: Arjun Ramakrishnan (Mentor: Peeusa Mitra)
Date: 02/08/2021
Project title: Identifying the suboptimalities in neuroethological decision-making under stress and anxiety

Introduction:

Mental health conditions such as anxiety disorder and depression that manifest as a result of continual stress interfere with decision-making. Foraging, a neuroethological paradigm, has been studied extensively to understand the correlation between decision-making and behavioral changes caused due to stress.

To study this correlation further, we reviewed several papers and hypothesized that anxiety and depression result in suboptimal foraging behavior. Specifically, overexploitation can be associated with trait anxiety, while early leaving of the patch can be associated with state anxiety. In the case of depression, participants tend to make more exploratory decisions.

To test our hypothesis, we're designing a virtual patch foraging task for human subjects and conducting a self-assessment survey to analyze stress and anxiety levels. The participants' foraging strategies would then be analyzed and compared using various models.

Approach:

<u>Paper reading:</u>

1. Formulating the hypothesis*: Lenow et al., 2017; Addicott et al., 2017*
2. Designing the task: *Hayden et al., 2011; Constantino et al., 2015; Addicott et al., 2015*
3. Analyzing the data collected: *Zachary et al., 2020; Lenow et al., 2017*
4. Understanding the neural correlates of decision-making in foraging tasks: *Hayden et al., 2011; Le Heron et al., 2020*

<u>Getting familiar with PsychoPy by implementing some simple games:</u>

1. *The attentional blink task*: An attentional paradigm that shows the inability to detect two targets presented in quick succession (RSVP) within the time frame of 200-500ms.
   Result: As expected, only six out of the thirty-four participants could see both targets.
2. *The Posner cueing task:* A neurophysiological task to assess the ability of participants to perform an attentional shift.
   Result: As expected, the average response times of six participants were 0.899s and 1.037s on correct and wrong cues, respectively.

<u>Designing the sequential patch foraging task on PsychoPy:</u>

The task we're designing (based on the one designed for macaques in *Hayden et al., 2011*) consists of two parallel columns of patches. At each stage, the participant (at the center) must decide whether to stay by clicking on the patch (on the right/left) or leave the patch by clicking on the rectangle (on the opposite side) to move forward (see *Fig. 1*). The task is time-bound, and the goal is to maximize the reward obtained during that time.

***Foraging at the same patch*:** On each trial, the reward at a patch, starting at a fixed value, is decremented by small amounts. The decrement is linear and Gaussian noise is added so that the learning rate of the reward decay pattern is low.

***Moving to a new patch*:** The task has three environments with travel times of 4s, 8s, and 12s, respectively, between consecutive patches. The motion of the trees is animated by specifying the position of the patch at each instance.

Reward collection: Total reward is the sum of rewards obtained at each of the patches in all the environments in the given time.

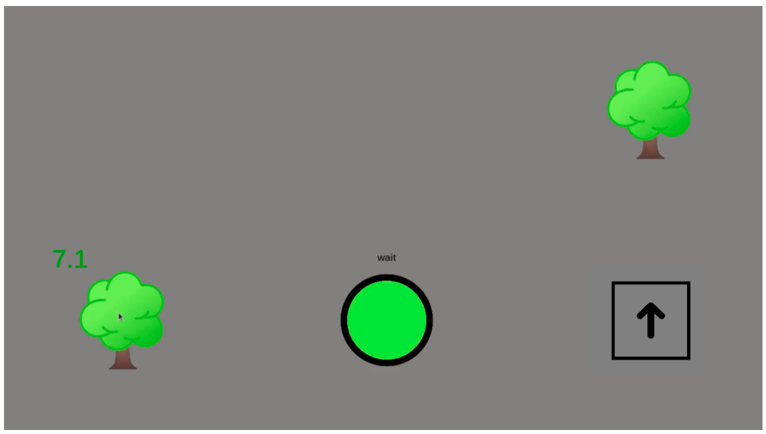

Fig 1. The spatial design of the foraging task.

Keywords: Decision-making, foraging behavior, stress, anxiety disorder, depression

Future work:

We plan on completing the task design and floating it online in the next few days. The task would also include the self-assessment questionnaire based on the State-Trait Anxiety Inventory (STAI), the Generalised Anxiety Disorder Assessment (GAD-7), and the Patient Health Questionnaire (PHQ-9) to assess stress and anxiety levels of the participants. We would also record COVID-related stress levels through the survey. Finally, we would analyze the data collected using mathematical models such as the Marginal Value Theorem (MVT) and Reinforcement Learning algorithms such as Q-learning and TD-Learning.

References:

1. Addicott, M., Pearson, J., Sweitzer, M. *et al.* A Primer on Foraging and the Explore/Exploit Trade-Off for Psychiatry Research. *Neuropsychopharmacol* 42, 1931–1939 (2017). https://doi.org/10.1038/npp.2017.108
2. Hayden, B., Pearson, J. & Platt, M. *Nat Neurosci* 14, 933–939 (2011). Neuronal basis of sequential foraging decisions in a patchy environment.

https://doi.org/10.1038/nn.2856

3. Jennifer K. Lenow, Sara M. Constantino, Nathaniel D. Daw, Elizabeth A. Phelps. Chronic and acute stress promote overexploitation in serial decision-making. Journal of Neuroscience 7 June 2017, 37 (23) 5681-5689; https://doi.org/10.1523/JNEUROSCI.3618-16.2017
4. Constantino, S.M., Daw, N.D. Learning the opportunity cost of time in a patch-foraging task. Cogn Affect Behav Neurosci 15, 837–853 (2015). https://doi.org/10.3758/s13415-015-0350-y
5. Addicott, M. A., Pearson, J. M., Kaiser, N., Platt, M. L., & McClernon, F. J. (2015). Suboptimal foraging behavior: a new perspective on gambling. Behavioral neuroscience, 129(5), 656–665. https://doi.org/10.1037/bne0000082
6. Zachary P Kilpatrick, Jacob D Davidson, Ahmed El Hady (2020). Normative theory of patch foraging decisions. bioRxiv 2020.04.22.055558; https://doi.org/10.1101/2020.04.22.055558
7. Campbell Le Heron, Nils Kolling, Olivia Plant, Annika Kienast, Rebecca Janska, Yuen-Siang Ang, Sean Fallon, Masud Husain, Matthew A.J. Apps. Dopamine Modulates Dynamic Decision-Making during Foraging. Journal of Neuroscience 1 July 2020, 40 (27) 5273-5282; https://doi.org/10.1523/JNEUROSCI.2586-19.2020