Methods

**Participant Screening**

Participants were recruited through flyers, listings on campus newsletters, and advertisements on online boards (e.g. Nextdoor, Reddit, etc.). If any participants did not meet criteria for MRI scanning safety, they were excluded. Participants were screened using a modified Fear Survey Schedule (cite) and were required to endorse fear levels of a 3 or 4 for at least two animals available in our image dataset to be eligible. Participants meeting these criteria were then interviewed using the ADIS-V (cite) by a trained staff member and reviewed for consensus with the Principal Investigator. Additional details of diagnostic screening can be found in Supplemental Methods.

23 participants (insert mean ages and gender distribution) meeting criteria for at least two animal phobias were enrolled to undergo multi-voxel neuro-reinforcement after undergoing the informed consent process as approved by the Institutional Review Board of the University of California, Los Angeles and were randomly assigned to 1, 3, or 5 days of multi-voxel neuro-reinforcement. From the 23 participants, two were unable to complete the full treatment. Out of the remaining 21 who completed treatment, one was excluded for nausea and two did not complete the “fear test” amygdala response task, leaving 18 participants with complete amygdala response data. However, seven of these 18 participants did not have complete pre-post resting state scan data (due to scanning time limitations) as required for our group ICA method, leaving a total of 11 participants analyzed.

**Decoder Construction**

A between-subject machine learning decoder was constructed using hyperalignment, a functional alignment method, from healthy controls (N = 22) prior to neuro-reinforcement. Healthy controls viewed a standardized image set of 3600 comprising 40 categories of animals and objects (e.g. spiders, sharks, frogs, bees) while participants meeting for specific phobias viewed a modified image set that excluded images of their diagnosed phobic animals. For neuro-reinforcement, subject-specific decoders were constructed using surrogate data (see Supplemental Methods for details).

**Resting State Scans**

Resting state scans were collected at participants’ initial visit for decoder construction as well as their final post-treatment assessment visit. MRI scans were acquired on a 3-T whole body scanner (Siemens, MODEL NAME?) with a 32-channel head coil. WHAT ARE THINGS TO LIST? BASED ON PREPRINT SUPPLEMENT? NEED TO ADD? WHERE TO FIND INFORMATION?

**Multi-voxel Neuro-reinforcement**

**Pre-/Post-Neuro-Reinforcement Assessments**

Phobic participants completed pre- and post-treatment fMRI assessments in which they completed a fear test while their BOLD signals were recorded. Each trial of the task began with a 3 – 7 second presentation of the fixation cross followed by a static image for 6 seconds. The images shown were chosen from either their target phobic animal, control phobic animal, or a randomly selected non-phobic animal or object as determined by diagnostic interview. Afterwards, participants saw a blank screen for 4 – 12 seconds before being prompted to rate how fearful they found the image to be on a 7-point Likert scale. Each administration of the task consisted of two runs of 15 images each, composed of 5 target phobic images, 5 control phobic images, and 2 – 3 images from a neutral animal/object, with the remaining photos randomly selected from the aforementioned categories.