Moxon NHP Lab – Joystick Task

Updated April 27, 2021 KM

The documents provides an overview of the training procedure for the joystick task and how the task is intended to progress. The goal of the training is to have the animals pull and hold a joystick for a specific temporal intervals depending on a cue.

Overview and Logistics

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| Training Phases |
| * 1. Transporting |
| * 1. Cage side joystick – encourage to hold for long time |
| * 1. Painting hand |
| * 1. Chair Training |
| * 1. Head Restraints |
| * 1. Hand in Home-Zone |
| * 1. Go Cue |
| * 1. Hold for Long duration |
| * 1. Add second cue for shorter duration |
| * 1. Add a third cue for additional duration |
| * 1. Add a fourth cue |

After monkeys have been chair trained and allow painting on their hand they will be trained to perform the Joystick task. In parallel, they are also being acclimated to head-restraining pads Task training will take place at least once per day, last no longer than 4 hours, Monday through Friday, in TB-144, room SS2016 of the CNPRC. Training is broken down into 9 Phases:

During training, the animal will be positioned in the chair and yoked with or without his head restrained, with the joystick within reaching distance of his extended forelimb. A reach-blocking plate on the chair will be used to permit reaching from either the monkey’s left or right side. The distance of the joystick from the chair will be positioned will be adjusted to accommodate different reach lengths of different monkeys. Monkeys may be trained to perform the task using limbs on either (or both) their left and/or right sides. Because neurons in motor cortex have been well documented to modulate their activation levels depending on the direction of reach (directional tuning) the animal will be required to start the task from a consistent (across trials) home position. Because motor preparation is also of interest, the animal will be required to wait for a go cue before initiating the joystick pull.

To guide the task, distinct auditory and visual cues will be presented. Visual cues are presented on flat-screen monitor within the monkey’s visual field. Auditory cues are played over speakers.

Definitions

**Trial** – a trial begins when the animal puts its paw in the home position. A trial ends when the animal either gets a reward or makes an incorrect response as defined below

**Home position** – the placement of the paw at the start of the trial where the marker on the animal’s paw is in the home zone

**Home zone** – a region defined by the Plexon video software. The software can monitor when the paw is in the home position by monitoring whether the marker on the back of the hand is in the home zone.

Task Parameters – parameters in blue are generated by the program, parameters in black are give by the user in the config file.

thome – the amount of time the animal must keep its paw in the home position for that trial. This number is a random variable, calculated by the program, selected from a uniform distribution between t­min and tmax

t­min – the minimal time the user wants the animal to keep its paw in the home position

tmax  - the maximum time the user wants the animal to keep its paw in the home position

tlow thigh the precision with which the animal must hold his hand in home zone on each trial given by the user. For the Interval Cue Presentation step (see below) the animal must keep its paw in the home zone for at least thome - tlow. For the Reach Production step (see below) the animal must remove its paw from the home zone within thome + thigh

thpactual – the length of time the animal kept its paw in the home position, determined by the program

*for intervals*

number of intervals – the number of temporal intervals the program selects from to present as cues for the animal. Currently the number of intervals can be to 1, 2 or 3 to allow 1, 2 or 3 intervals. Or the number of intervals can be set to 0 and the program ends, giving the monkey a reward if he keeps his paw in the home position for thome

tpullmax  and tpullmin – user defined minimums and maximums, define by the user for each interval, that the defines the range within which the monkey has to pull the joystick for a reward

e.g. tpullmin1 tpullmax1 tpullmin2 tpullmax2 tpullmin3 tpullmax3

tpull – the actual length of time the monkey pulled the joystick for – the joystick was in the activated state

trelease – the amount of time the program waits after the animal releases the joystick before a reward is delivered

Task progression

1. The monkey must have the marker on his responding hand positioned within the home zone to start a trial. This defines the start of a trial.

When a trial starts, the program randomly selects the cue from the user’s list of possible cues and calculates thome

1. Interval Cue presentation: Presentation of the interval occurs at the beginning of each trial as soon as the animal puts its paw in the home position. The particular cue presented (e.g. shape on the screen) indicates the duration of the joystick pull that will be rewarded.
2. Go cue: Animal must learn to hold its paw in the home position for the required period of time, from thome - tlow to thome + thigh. A correct response at this stage of the task is hand in home position the minimal amount of time thome - thome - tlow). An incorrect response at this stage is when the animal removes his hand from the home position early
   1. Correct Reponses -> program place a red circle around the interval cue (go cue) and continues to next step
   2. Incorrect response -> trial ends, blooper tone sounds, screen goes blank until monkey puts paw back into home position and then a new trial starts. Trial data are written to a file (trial number, t­min, tmax , thome, tlow thigh thpactual )
3. Reach production: The monkey must move its paw out of the home position within thome + thigh for a correct response. If the monkey leaves it paw in the home position for more than thome + thigh then it is an incorrect response
   1. Correct Reponses -> program continues to next step
   2. Incorrect response -> trial ends, blooper tone sounds, screen goes blank until monkey puts paw back into home position and then a new trial starts. Trial data are written to a file (trial number, t­min, tmax , thome, tlow thigh thpactual )

NOTE: if the number of intervals = 0, the program ends here. For a correct response the animal gets its reward and trial data are written to a file (trial number, t­min, tmax , thome, tlow thigh thpactual )

1. Interval production: The monkey must pull the joystick to the “on” position, keeping the mechanism in the activated state continuously for the cued duration. The cued duration is defined by the user as an interval between a max and min value, one set for each cue. An auditory tone sounds when the joystick is in on position (Hold Tone). On release, one of two cases will occur:
   1. Correct Response: The monkey releases the joystick within the specified time window about the target time between tmin and tmax for that interval. Program continues.
   2. Incorrect response: The monkey releases the button outside of the specified time window between tmin and tmax for the seleted interval. Trial ends, blooper tone sound, screen goes blank until monkey puts paw back into home zone and then new trial starts. Trial data are written to a file (trial number, t­min, tmax , thome, tlow thigh thpactual, interval number (1,2,or 3), tmin for that interval, tmax for that interval and tpull for the trial.)
2. Reward Event: An auditory tone sounds and a reward is delivered based on the pull interval (see below) trelease after the joystick is released. The trial is labelled a success, the trial ends and trial data are written to a file (trial number, t­min, tmax , thome, tlow thigh thpactual, interval number (1,2,or 3), tpullmin for that interval, tpullmax for that interval and tpull for the trial.)

Variants of this task are described in Knudsen,…,Moxon, J. Neurosci. 2014 and Zarco,…,Merchant J. Neurophys. 2009. Wang, …, Jazayeri, Nature Neuroscience

2018.

Auditory Stimuli

We plan to incorporate auditory stimuli into the to facilitate task acquisition and guide attention. Two or three distinct auditory stimuli--each comprised of a distinct pitch or timbre--would be generated from a nearby speaker at an intensity no louder than 80 decibels to signal:

1. During-hold: when the button or lever is in the activated (e.g. depressed or pulled) state.

2. Successful trial completion

3. Reward delivery

Visual Stimuli

A unique stimulus (computer graphics that can vary in terms of number shape and/or color) will code for each interval duration that a monkey must produce on a given trial to receive a reward. We plan on training at most six distinct interval-duration ranges, with corresponding visual stimuli, with values between 0.2 to 6 seconds.

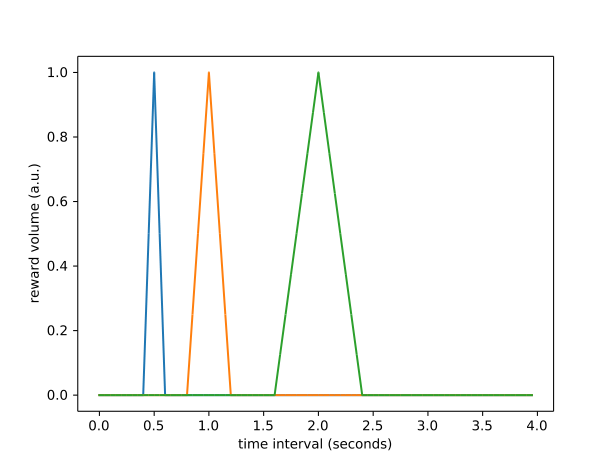
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Task acquisition

To train monkeys on the task, we will first gradually and imperceptibly increase the required duration that a monkey must keep paw in home zone to receive a reward. Once this is working well (what does ‘well’ mean). The reach to pull joystick for durations part of task will start.

Second, we will gradually increase the duration in order to receive reward until the max pull duration is achieved. Initially, the stimulus associated with the longest duration will be shown on the screen in front of the animal. Once the monkey regularly produces intervals of maximum duration (6 seconds), shorter duration trials, and their associated stimuli, will be introduced in a randomized sequence along with the long duration trials. Task acquisition will be evaluated statistically: that is, when an interval produced for the presented cue occurs at a frequency significantly greater than chance. If an animal reaches a max pull duration >2s but less than 6, a decision will be made to move on to a second duration.

Reward scaling

  
Figure 1: **Reward volume as a function of produced interval.** Target intervals in this example are located at the center of each peak at 0.5, 1.0 and 2.0 seconds. Widths of peaks increase linearly with duration of target interval.

Because production of long intervals requires more effort and attention than short intervals, we could have monkeys receive greater reward (e.g. greater volume of applesauce) for successful completion of long intervals. Volume of sauce reward will scale with duration of the produced interval. This follows methods described in Zarco, …, Merchant J. Neurophys 2009.

Alternatively, amount of reward could also be delivered as a multi-peak function emphasizing interval precision; that is, with each peak located at the location of each target interval to be produced and with peaks about longer target intervals having greater width. See figure 1. below illustrating hypothetical reward volume as a function of produced interval according to this paradigm. A similar reward paradigm is described in Wang, …, Jazayeri, Nature Neuroscience 2018.

Weber’s Law

We expect variability of timed interval responses from monkeys to observe Weber’s law: standard deviation of the distribution of produced intervals is directly proportional to the average duration of those intervals. Therefore, rewarded ranges about long target intervals will be set comparatively wider than rewarded ranges for shorter target intervals (e.g. if the range of rewarded intervals about target interval t = 0.5 is [0.4, 0.6], the rewarded range about target interval t = 1.5 might be [1.25, 1.75]).

Performance shaping – this did not work well for us

~~Once task acquisition has been demonstrated, press durations will be further shaped by gradually and imperceptibly reducing the range of durations that are rewarded about the target duration. For example, for a desired press duration of t = 2 seconds, the range of rewarded press durations on these trials will be gradually reduced from between 1 to 3 seconds to 1.5 to 2.5 seconds. Range limits will be adjusted in increments of +or- 0.05 sec for every 100 trials completed.~~

~~To maximize the number of presses made by monkeys during training, and subsequent testing, the ratio of number of correct presses to number of rewards will be gradually and imperceptibly increased under a variable reinforcement schedule. Specifically, the reward ratio will be increased by 0.01 for every 200 correct trials completed, starting at 1:1 until the reaching a possible maximum of 6:1. The end goal of SPHT training is for a monkey to perform a series of presses, ranging between 0.2 to 6 seconds for no less than 200 trials per session.~~