Notes for Ben & Ryan

==

Folders and filenames:
8 mice, one folder per Mouse, multiple sessions per Mouse
Session name format: **MouseName_yyyymmdd_r0_**processed.mat
Typically, there is only one training session per day, so sessions will get automatically get sorted chronologically. Rarely, there may be two training sessions on a given day - in those cases, the individual training sessions can be distinguished as **_r0**, **_r1** etc.
_____

==

Visualising any particular session:
Use Smellocator_DataViewer.m to plot any session in the same format as those in my data slides.
_____

==

General Info:
All behavior data was sampled at 500 Hz.

Task structure:
ITI - Trial Initiation - Trial ON - Reward or TimeOut - ITI

Odor location and Lever are always in closed loop irrespective of the task/trial phase. In other words, the physical assembly (odor manifold) always moves in accordance with the lever. However, the exact mapping changes from trial to trial.
In addition, air/odor flow through the odor manifold is gated according to trial phase. The manifold has one main channel (to deliver the actual odor) and 16 flanking channels on either side (these form the air curtain).

During **ITI**, the flanking channels are OFF and the main channel delivers clean air (this is just to continuously flush the channel - otherwise there will be odor lingering from the previous trial). Absence of air flow from the flanking channels signals the animal that it needs to initiate a trial

To **initiate a trial**, the lever needs to be pulled towards the body (Lever value >= 4.8 V) and held in place for a certain amount of time for each trial. This hold time is called 'TriggerHold' and is randomly drawn from a trigger distribution for that session. Average TriggerHold value for expert mice is ~300 ms.
If the mouse successfully holds the Lever close to the body (Lever value >= 4.8 V) for t

>= **TriggerHold**, Airflow turns ON from the flanking channels and the main channel switches from delivering clean air to Odor (**OdorStart**). The identity of the odor used is defined in TrialInfo.Odor or in Traces.TrialState.

If the mouse releases the Lever prematurely (Lever value < 4.8 V, t < TriggerHold), nothing happens, the mouse just needs to pull the lever back up and try a fresh initiation.

Post successful Initiation (air/odor flow is ON), the mouse can start a trial by releasing the lever (Lever value < 4.8 V). This marks the start of the trial or the **Trial ON** phase. From this point, the mouse has ~5 seconds to find the target zone, and fulfil the required reward criterion. Note that **Trial ON** is defined as the time after trial initiation when the mouse actively moves the Lever away the body. This is different from **OdorStart** which happens as soon as the time for **TriggerHold** is crossed. Thus, in principle, a mouse can take time to assess the location of the odor at the start of the trial and make an educated guess about the location of the target zone.

Reward criterion: Once the animal starts a Trial, it has ~5 seconds to get to the target zone and receive rewards. The animal can enter and exit the target zone as many times as it likes, but in order to get a reward, it must fulfil one of two hold criterion.

Individual Stay > TargetHold: If the individual duration of any contiguous stay in the target zone equals or exceeds the TargetHold.

Cumulative Stay > CumulativeTargetHold: combined duration of all stay periods in the target zone equals or exceeds the CumulativeTargetHold, even though no individual stay crossed the TargetHold.

If any of the above criteria are met, Reward is delivered and the Trial terminates. Task phase changes to ITI (no flanking air flow, clean air through the main channel).

If the none of the above criteria are met within 5 seconds from Trial ON, the trial is considered unsuccessful and is also terminated. Task phase changes to ITI (no flanking air flow, clean air through the main channel).

ITI: Shortly after a trial terminates, we impose a small dead time during which a new trial will can not be initiated, even if the animal pulls and holds the lever up to initiate a trial. This is just to allow enough time during neuronal activity from the previous trial to decay to baseline before the next trial begins. This dead time can vary from 0.2s to 1s, across animals and sessions. The exact value is indicated in the 4th column of TrialInfo.HoldSettings for every trial.

Lever-Odor Mapping: This updates every trial. For all animals except O3, the mapping updates right after the first initiation attempt (irrespective of whether the initiation is successful or not). So, once the lever is pulled up after ITI, the odor location may abruptly jump a few units as the same Lever position now maps on to a different Odor location.

For O3, the mapping updates only after a successful Trial Initiation, i.e. at the same time as OdorStart.

Licking: Unlike most tasks, licking does not gate the delivery of reward. Rewards will be dispensed as soon as the trial hold criterion are met, irrespective of whether the animal licks or not. In other words, licks only serve to collect the dispensed rewards in our task. Along the same lines, licks are also not penalized. The mouse can therefore Lick whenever it likes - in anticipation or just out of superstition.

Rewards: Typically, rewards are delivered only if the animal fulfils the reward criterion. However, during the first few days, we may at times deliver free water (outside the Trial periods) to keep the animal interested. Traces.Rewards includes both actual rewards and free water.

Training strategy: As such, from day 1, the animal has to do the same sequences of events - ITI-initiation-Trial-TargetHold-ITI. However, to modulate task difficulty from naive to expert, we play with the temporal criterion for the various holds (TriggerHold, TargetHold, CumulativeTargetHold) both within and across sessions. On day 1, we start with very small holds ~5 ms. This means that simply pulling up the Lever (no explicit holding) will initiate a trial. Likewise, simply swiping across the Target Zone (or just passing by a few times) will trigger reward. At each success, the TargetHold automatically increases such as to constantly push the difficulty level. Trigger Holds are incremented manually - they usually don't require that much adjustment - many mice can hold the Lever close to the body for >100 ms even on day 1.

_____

==
Contents of each .mat file: Traces, TrialInfo, TargetZones, SampleRate, startoffset
_____

==
Traces
This is a matlab struct that contains trial-chunked (explained later) behavioral data traces. The various trace types (eg. Lever, Odor location, Respiration ..) are in different fields that are named accordingly.
Each field is simply a cell array {1 x trials}, where n-th element is the trace for the n-th trial.
    Eg. Traces.Lever{1} is a vector containing all samples for Trial 1.

Trial chunking:
If t1 marks the start of trial 1 and t2 of trial t2 and so on, the chunked trace for trial n contains data samples from (tn - 1 second) to (tn+1).
In other words, from 1 second preceding that trial's start and upto next trial's start. As a result subsequently chunks have a 1 second overlap.
If you simply want contiguous traces, run the script ConcatenateTraces2Matrix.m with

Traces as the input and that will give a matrix with continuous traces.

>> [TracesOut, TraceNames] = ConcatenateTraces2Matrix (Traces);

Info about various trace types:

Lever: 0 to 5 Volts, 5 = lever positioned closest to body, 0 = lever positioned farthest away

OdorLocation: -100 to 100, 0 = centered on the nose, -8 to 8 are rewarded locations, -100 is approximately 50 mm to the left of mouse, 100 is ~50 mm to the right

Sniffs: arbitrary units, minimas should correspond to the time of peak inhalation in the respiration cycle. Depending on the implant quality, this signal may be choppy. Also, amplitude tends to drift - might need low pass filtering. In general, trust the dynamics, not the absolute amplitude of this signal.

TrialState: TrialState>0 indicates odor ON periods, 0 = Trial OFF. When ON, Absolute value indicates the identity of the odor being used for that particular trial (1, 2 or 3).

Rewards: 1 = water valve ON, 0 = OFF

Licks: 1 = Lick event. This data field should not be taken too seriously. We are unable to register all licks - so there can be false negatives. Also, there will be false positives - any contact with the lick spout eg. paw touches will also be registered as a lick event. However, one can typically identify the latter as true lick bouts tend to be rhythmic (~10 Hz).

Timestamps: Actual acquisition timestamps for each data sample in seconds. Sometimes, the acquisition pipeline can drop data packets. In such cases, contiguous samples may not be regularly spaced in time. While this is usually not a concern, due to a technical bug, in some sessions, a small data chunk of 50 ms (25 samples) got dropped just at the start of some trials. I have explicitly flagged these trials in the associated struct **TrialInfo** (explained next) or you can identify them easily but running a diff on the actual timestamps.

If regular temporal spacing is of concern, we may need to interpolate. In addition, true data from those gap periods can also be made available on request (just requires some extra work on my side).

_____

===
TrialInfo
This is a matlab struct that contains additional information about each trial. Some of this can be constructed from the data traces themselves, some not.

Info about various fields in TrialInfo:
n = no. of trials
TrialID: [n x 1]: Trial number
Odor: [n x 1]: Identity of the odor used for that trial (can also be retrieved from the absolute value of Traces.TrialState)
OdorStart: [n x 1]: Time (in seconds) at which the odor turned ON - with respect to trial

start.

By construction, Trial Start happens t = 1 sec (501st sample) in each of the chunked traces. By design, odor start always precedes Trial start (see general info to understand this better). Therefore, OdorStart is < 0.

TargetZoneType: [n x 1]: Indicates the trial type (1 to 12) as defined by the location of the target zone in 'Lever' space. Actual Lever values that define the target zone can be indexed from the matrix **TargetZones** (included in the .mat file)

Success: [n x 1]: 0 or 1, indicates whether or not the animal passed the hold requirements for a given trial and was therefore rewarded.

HoldSettings: [n x 4]: [TriggerHold, TargetHold, CumulativeTargetHold, minimumITI]: Hold times (in seconds) for Trial initiation (trigger hold), and for reward acquisition (TargetHold, CumulativeTargetHold). Also, dead time after a trial during which the mouse cannot successfully initiate a trial (see general info).

TimeStampsDropped: [n x 1]: 0 or 1 flag indicating if any timestamps were dropped on this trial. Can also be computed from Traces.Timestamps.

InZone: {n x 1 cell}: Each element contains the timestamps (in seconds, w.r.t. Trial Start) of target zone entry and exit. In other words, they mark the periods during which the mouse successfully positions the Lever in the target zone. When the individual duration of any such stay crosses the reward criterion (TargetHold) for that trial, the mouse will get a reward. Alternatively, rewards can also be acquired when the combined duration of all such stays in a trial crosses cumulative reward criterion (CumulativeTargetHold).

Perturbation: {n x 1}: Ignore for now

_____

==

TargetZones
[12 x 4]
Each row contains the target zone definition in Lever space i.e. Upper boundary, Mid point and Lower boundary of the target zone, and the total number of trials of that particular target zone type in the data set.

_____

==

SampleRate
Behavioral data sampling rate - this is fixed at 500 Hz for all of the data

_____

==

startoffset
Duration (in seconds) before Trial Start that defines the chunking of each trial trace in Traces.

_____