# Introduction

#### **Data for reproducing analyses**: In this github repository are codes to generate results in CavanaghLam2020. The raw data for reproducing the analyses can be found in [].

* The analyses of subject experimental behaviour were performed in Matlab. The figures were produced in Python. The following functions can be run to reproduce the analyses:
  + ‘StandardSessions.m’
    - This function reproduces the results for **Figures 2-4**
    - The data is organised into a structure, ‘DataStructureSessions’ (explained below)
  + ‘DrugSessions.m’
    - This function reproduces the results for **Figure** **8**
    - The data is organised into a structure, ‘DrugDayStructure’ (explained below)

Both of these functions can be called from within ‘NewMasterFunction\_Aug2020.m’. To use this script, you must edit ‘MainDirectory’ to the location where you save the main folder

* The simulations of the spiking-circuit models and the mean-field model were using the Python-based Brian2 neural simulator. Examples of the simulation script can be found in the ‘Simulation\_codes’ folder:
  + Spiking-circuit model: ‘main.py’
  + Mean-field model: ‘MFmodel\_Sim.py’
* The analyses of the circuit models’ behaviour were performed in Matlab. The following scripts can be run to reproduce the analyses:
  + ‘MasterFunction\_model.m’ (which calls ‘StandardSessions\_model.m’)
    - This script reproduces the results for **Figures 5-7**
    - ‘StandardSessions\_model.m’ follows the general structure of ‘StandardSessions.m’.
  + Some basic analysis are performed in python (together with the figure-generating codes, please see next point). This includes some mean-field model results (figure6C-H) and model comparison (Figures 8S4,5).
* All figures were produced in Python. The following scripts can be run to reproduce the figures.
  + ‘figure\_spikes\_final\_fast.py’ (for main figures)
  + ‘figure\_spikes\_final\_fast\_Supp\_a.py’, ‘figure\_spikes\_final\_fast\_Supp\_b.py’, ‘figure\_spikes\_final\_fast\_Supp\_c.py’ (for supplementary figures)

# Variable Explanations

## NewMasterFunction\_Aug2020.m

### Editable Variables

* Path location of the main directory (Line 3)
  + Please update this with the directory location where you save the main folder
* SubjectToTest (Lines 4 to 7)
  + This determines which Subjects’ choices to run the behavioural analyses on

## ‘StandardSessions.m’

### Optional Editable Variables

* n\_kcv\_runs (Line 3)
  + This determines how many cross-validation runs are used. Note, in the paper, this was set to 100. It has been set to 10 here to decrease computing time.

### DataStructureSessions

* This variable is loaded in by ‘StandardSessions.m’
* It is a structure, with an entry for each behavioural session. It is where the key behavioural data for the Standard sessions is stored
* The structure contains the following fields:

|  |  |  |  |
| --- | --- | --- | --- |
| Field Name | Type | Dimensions | Explanation |
| MGS\_TrialByCodes | Logical | 1 x Number of Trials in That Session | Each element indicates whether the trial was a memory guided saccade trial (1 if true, 0 if false). Short blocks of these trials were performed between the main choice trials (see Methods section). |
| Stim1Samples | Matrix | Number of Trials in That Session x 8 | Each row indicates the heights of the bars presented on the left-hand side of the screen for the respective trial. The column order indicates the order in which the stimuli were presented. |
| Stim2Samples | Matrix | Number of Trials in That Session x 8 | Each row indicates the heights of the bars presented on the right-hand side of the screen for the respective trial. The column order indicates the order in which the stimuli were presented. |
| DiscardTrials | Logical | 1 x Number of Trials in That Session | Each element indicates whether the trial must be excluded from the analyses (1 if true, 0 if false). Reasons for a trial to be discarded here are that it was a memory guided saccade trial, or that it was not completed. |
| TrialType | Matrix | 1 x Number of Trials in That Session | A reference number for the type of trial used:  1. Regular trials  16. HalfHalf:LeftHighLow RightLowHigh  A half-half trial, where the left-sided option has its first half of samples drawn from the higher mean distribution, and its second half of samples drawn from the lower mean distribution. The right-sided option has the opposite pattern.  17. HalfHalf:LeftLowHigh RightHighLow  A half-half trial, where the left-sided option has its first half of samples drawn from the lower mean distribution, and its second half of samples drawn from the higher mean distribution. The right-sided option has the opposite pattern.  18. BroadLow\_Versus\_NarrowHigh  A narrow-broad trial, where the left-sided option has its samples drawn from a broad distribution with a lower mean. The right-sided option has its samples drawn from a narrow distribution with a higher mean.  19. BroadHigh\_Versus\_NarrowLow  A narrow-broad trial, where the left-sided option has its samples drawn from a broad distribution with a higher mean. The right-sided option has its samples drawn from a narrow distribution with a lower mean.  20. BroadBalanced\_Versus\_NarrowBalanced  A narrow-broad trial, where the left-sided option has its samples drawn from a broad distribution. The right-sided option has its samples drawn from a narrow distribution. Both distributions have a similar mean.  21. NarrowHigh\_Versus\_BroadLow  A narrow-broad trial, where the left-sided option has its samples drawn from a narrow distribution with a higher mean. The right-sided option has its samples drawn from a broad distribution with a lower mean.  22. NarrowLow\_Versus\_BroadHigh  A narrow-broad trial, where the left-sided option has its samples drawn from a narrow distribution with a lower mean. The right-sided option has its samples drawn from a broad distribution with a higher mean.  23. NarrowBalanced\_Versus\_BroadBalanced  A narrow-broad trial, where the left-sided option has its samples drawn from a narrow distribution. The right-sided option has its samples drawn from a broad distribution. Both distributions have a similar mean.  See the Methods section for a full explanation of the generating process for each of these trial types. |
| resp\_trials | Logical | Number of Trials in That Session x 1 | Each element indicates whether the trial was completed with a behavioural response to one of the two choice options (1 if true, 0 if false). |
| CompletedTrialType | Matrix | 1 x Number of Completed Trials in That Session | Trial type, as explained above, but only for completed trials. |
| ChosenTarget | Matrix | 1 x Number of Completed Trials in That Session | Option chosen (1 if left, 2 if right). |
| EvidenceUnitsA | Matrix | Number of Completed Trials in That Session x 8 | Each row indicates the evidence values of the bars presented on the left-hand side of the screen for the respective trial. The column order indicates the order in which the stimuli were presented. Evidence values are the heights of the bars on ‘ChooseTall’ trials, and 1 minus the heights of the bars on ‘ChooseShort’ trials. |
| EvidenceUnitsB | Matrix | Number of Completed Trials in That Session x 8 | Each row indicates the evidence values of the bars presented on the right-hand side of the screen for the respective trial. The column order indicates the order in which the stimuli were presented. Evidence values are the heights of the bars on ‘ChooseTall’ trials, and 1 minus the heights of the bars on ‘ChooseShort’ trials. |
| HighTrial | Logical | 1 x Number of Trials in That Session | Each element indicates whether the goal of the trial was to choose the stimuli with higher average heights (1 if true, 0 if false). |
| TrialError | Matrix | Number of Trials in That Session x 1 | Each element indicates the trial code assigned by MonkeyLogic to the trial:   1. Subject chose the correct answer 2. Subject did not respond in the choice phase   3. Subject broke fixation  4. Subject did not complete pre-trial fixation  5. Subject broke fixation  6. Subject chose the incorrect answer  8. Subject did not begin pre-trial fixation |
| LongSampleTrial | Matrix | 1 x Number of Trials in That Session | Each element indicates whether the trial had 8 stimulus samples on each side (1 if true, 0 if false – in which case there were only 4). |

## ‘DrugSessions.m’

### Optional Editable Variables

* AnalysisList (Line 3)
  + This cell array lists the different analyses that will be run. It can be reduced to decrease computing time, should you only wish to run a subset of the analyses
  + The default ({'PK';'StratReg';'PVB';'SlidingPVB'}) is to run all of the analyses
    - ‘PK’ refers to the psychophysical kernel analyses (**Figure 8G;** **Figure 8-figure supplement 1E, J; Figure 8-figure supplement 2C, F)**
    - 'StratReg' refers to the regression analyses to determine the subjects’ decision strategy (**Figure 8-figure supplement 1D, I; Figure 8-figure supplement 2B, E)**
    - 'PVB' refers to the regression analyses to determine the subjects’ pro-variance bias (**Figure 8D-F; Figure 8-figure supplement 1C, H; Figure 8-figure supplement 2A, D)**
    - 'SlidingPVB' refers to the regression analyses to determine the subjects’ pro-variance bias at each timepoint relative to the infection (**Figure 8-figure supplement 3)**
* BootStrapNo (Line 4)
  + Bootstrap number to generate error estimates for parameters in the lapsing models. Note, in the paper, this was set to 10000. It has been set to 10 here to decrease computing time.
* noPermutations (Line 5)
  + Permutation number to compare ketamine and saline parameter estimates for parameters in the lapsing models. Note, in the paper, this was set to 10000. It has been set to 10 here to decrease computing time.
* LoadResultsFromOldHypothesisTests (Line 6)
  + When set to 1 (default), the previous permutations and bootstraps will be loaded.

### DrugDayStructure

* This variable is loaded in by ‘DrugSessions.m’
* It is a structure, with an entry for each behavioural session. It is where the key behavioural data for the pharmacological sessions is stored
* The structure contains the following fields:

|  |  |  |  |
| --- | --- | --- | --- |
| Field Name | Type | Dimensions | Explanation |
| BhvFileName | String | N/a | The name of the MonkeyLogic behavioural file saved for the session. It contains information about the subject name and the session date. |
| resp\_trials | Logical | Number of Trials in That Session x 1 | Each element indicates whether the trial was completed with a behavioural response to one of the two choice options (1 if true, 0 if false). |
| TrialStarTimeHours | Matrix | Number of Trials in That Session x 1 | Hour that the trial started. |
| TrialStarTimeMins | Matrix | Number of Trials in That Session x 1 | Minutes past the hour that the trial started. |
| TrialStarTimeSecs | Matrix | Number of Trials in That Session x 1 | Seconds past the minute the trial started. |
| CompletedTrialType | Matrix | 1 x Number of Completed Trials in That Session | A reference number for the type of trial used on completed trials:  1. Regular trials  16. HalfHalf:LeftHighLow RightLowHigh  A half-half trial, where the left-sided option has its first half of samples drawn from the higher mean distribution, and its second half of samples drawn from the lower mean distribution. The right-sided option has the opposite pattern.  17. HalfHalf:LeftLowHigh RightHighLow  A half-half trial, where the left-sided option has its first half of samples drawn from the lower mean distribution, and its second half of samples drawn from the higher mean distribution. The right-sided option has the opposite pattern.  20. BroadBalanced\_Versus\_NarrowBalanced  A narrow-broad trial, where the left-sided option has its samples drawn from a broad distribution. The right-sided option has its samples drawn from a narrow distribution. Both distributions have a similar mean.  23. NarrowBalanced\_Versus\_BroadBalanced  A narrow-broad trial, where the left-sided option has its samples drawn from a narrow distribution. The right-sided option has its samples drawn from a broad distribution. Both distributions have a similar mean.  45. Control trials  A small proportion of trials were included where all of the bars on each side of the screen were the same height – so that the subject was not required to accumulate evidence across time.  See the Methods section for a full explanation of the generating process for each of these trial types. |
| ChosenTarget | Matrix | 1 x Number of Completed Trials in That Session | Option chosen (1 if left, 2 if right). |
| EvidenceUnitsA | Matrix | Number of Completed Trials in That Session x 6 | Each row indicates the evidence values of the bars presented on the left-hand side of the screen for the respective trial. The column order indicates the order in which the stimuli were presented. Evidence values are the heights of the bars on ‘ChooseTall’ trials, and 1 minus the heights of the bars on ‘ChooseShort’ trials. |
| EvidenceUnitsB | Matrix | Number of Completed Trials in That Session x 6 | Each row indicates the evidence values of the bars presented on the right-hand side of the screen for the respective trial. The column order indicates the order in which the stimuli were presented. Evidence values are the heights of the bars on ‘ChooseTall’ trials, and 1 minus the heights of the bars on ‘ChooseShort’ trials. |
| DrugGivenTime | Matrix | 1 x 2 | Time in hours (1st element) and minutes (2nd element) the subject received the injection. |
| DrugDay | Logical | 1 x 1 | Drug given to the subject (1 if ketamine, 0 if saline). |
| TrialError | Matrix | Number of Trials in That Session x 1 | Each element indicates the trial code assigned by MonkeyLogic to the trial:   1. Subject chose the correct answer 2. Subject did not respond in the choice phase   3. Subject broke fixation  4. Subject did not complete pre-trial fixation  5. Subject broke fixation  6. Subject chose the incorrect answer  8. Subject did not begin pre-trial fixation |