

# Manual

Mohammad Khani, February 2022

## 1 Structure of the repository

This repository contains data from 20 sessions of multi-electrode array recordings (60 or 252 channels) from half or whole-mount mouse retinas that were stimulated with different chromatic patterns of light. The data accompanies the manuscript by Khani and Gollisch (2017): "Diversity in spatial scope of contrast adaptation among mouse retinal ganglion cells".

Each .rar file in the **Raw Data** folder contains the data from one experiment and is named in the following format: YYYY-MM-DD\_YY\_ZZ.rar

- YYYY-MM-DD defines the recording date in year-month-day format.
- YY is either *fr* or *sr*, referring to either first or second retina.
- ZZ is either *fp* or *sp*, referring to first piece or second piece of the used retina.

For example, the file 20130424\_fr\_sp refers to a recording that took place on 24<sup>th</sup> of April 2013, using the second piece (*sp*) from the animal's first studied retina (*fr*).

Each .rar file comprises one recording session including the following files and folders:

- **spiketimes** spike times of all spike-sorted units (also containing bad units)
- **stimulusparameters** folder containing text files that show the parameters used for the stimuli that was displayed during the experiment
- **frametimes** folder containing text files with time stamps of specific frames for each stimulus
- [list\\_of\\_good\\_cells.txt](#) table of identifiers for good units of spike-sorted data
- [stimuli\\_names.txt](#) list of the names of the stimuli used in each experiment

The script [example\\_load\\_rgc\\_data.m](#) in the repository folder **Analysis** contains a minimal example of how to extract spike times and frame times in Matlab. The same folder also contains functions for analysing retinal ganglion cell responses to the spatial contrast adaptation stimulus.

Details of the applied stimuli and their reconstruction can be found in Section 2.

### 1.1 Frame times

In order to align recorded spike times and the timing of the stimulus, the time of appearance of specific stimulus frames for each stimulus is saved in the folder **frametimes**. For each recorded stimulus inside this folder, there is a .txt file. The name of the file is defined as:

*<stimulus number>\_<stimulus name and parameters>\_frametimings.txt*

Frame times (or "pulses") were saved in seconds. An offset of 25 ms has already been added for alignment with the spike times because of an internal delay between the graphics card and the display device. The list of recorded stimulus names for each session is stored inside [stimuli\\_names.txt](#) file.

## 1.2 Spike times

The folder **spiketimes** contains the spike times of each spike-sorted unit in seconds. The list of the labels for the good units can be found in [list\\_of\\_good\\_cells.txt](#) where the first column is the first channel of a 4-channel grouping and the second is the number of the specific cluster extracted from that channel. All the units included in the [list\\_of\\_good\\_cells.txt](#) file are the ones with clear refractory period and a well-separated cluster of voltage traces. The spikes of each unit in response to a certain stimulus can then be found in the file:

*<stimulus number>\_SP\_C<channel number><2-digit cluster number>.txt*

## 1.3 Stimulus Parameters

To recreate and visualize each stimulus and access detailed parameters used in each experiment, a text (.txt) file with a designated name per recorded stimulus is saved in the **stimulusparameters** folder. This text file can be used to access parameters needed to analyse the response of the cells to a specific stimulus. The name of the stimulus parameters file is defined as:

*<stimulus number>\_<stimulus name and parameters>\_parameters.txt*

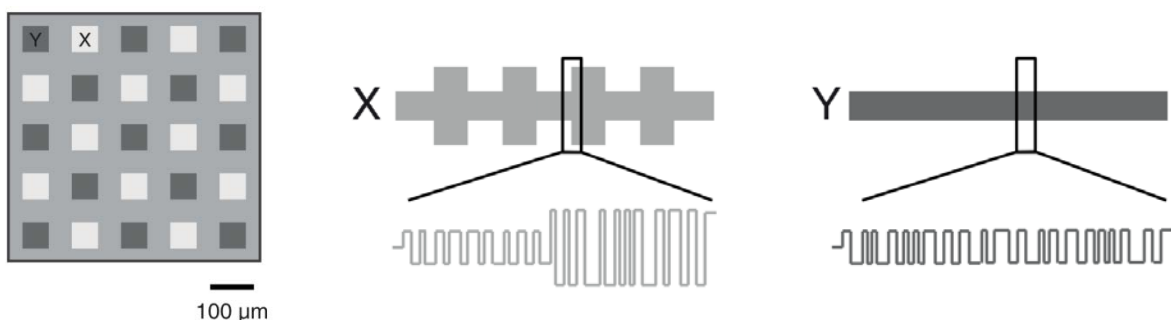
## 2 Stimulus details and reconstruction

Three visual stimuli were used to characterize and analyse the diversity of spatial contrast adaptation in mouse retinal ganglion cells:

- *Spatial Contrast Adaptation*
- *Spatial Contrast Adaptation with Alternating Contrasts*
- *Spatio-temporal Binary White Noise*

### 2.1 Spatial Contrast Adaptation stimulus

To assess the spatial scope of contrast adaptation within the receptive field of each recorded retinal ganglion cell, we used a stimulus layout with two sets of alternately arranged square-shaped spatial subfields, denoted as locations X and Y as shown below. Subfields were 60  $\mu\text{m}$  wide and separated by corridors of the same width at the background light level. The subfield size was chosen so that each ganglion cell receptive field typically spanned multiple stimulus subfields. Two independent white-noise sequences of light intensities were used as stimuli at locations X and Y so that stimuli were identical at locations from the same set, but independent across the two sets.



For each set of locations, the white-noise sequence was drawn from a binary distribution with values  $I_{high}$  and  $I_{low}$  at 60 Hz. The mean light intensity  $(I_{high} + I_{low})/2$  was always set equal to the background

level. The contrast level, defined as  $C = (I_{high} - I_{low}) / (I_{high} + I_{low})$ , was set to either a high value,  $C=100\%$ , or a low value,  $C=20\%$ . The stimulus contrast levels were switched every 40 s between a high-low condition, with high contrast at locations X and low contrast at locations Y, and a low-low condition, with low contrast at both sets of locations (Figure above, right panel). The 40 s correspond to 2400 displayed frames. The frame times denote the occurrence of every new frame (at 60 Hz).

To regenerate the sequence of per-frame contrast values for both locations X and locations Y in this stimulus, check the function [Spatial\\_Contrast\\_Adaptation\\_Stimulus.m](#) from the **Analysis** folder. This can be used for calculating the spike-triggered average (STA) and the accompanying nonlinearity function for each contrast range separately. The stimulus recreation gives lists of contrast values (at 60 Hz), with each value being either -1 or 1, according to the applied binary distribution. Whether these values were applied at high contrast (corresponding to  $\pm 100\%$  contrast) or at low contrast ( $\pm 20\%$ ) has to be determined by counting the number of displayed frames, knowing that the contrast condition switched every 2400 frames. Stimulation started with the low-low condition.

To visualize the response of an example recorded ganglion cell, it is possible to call the function [Analyze\\_Spatial\\_Contrast\\_Adaptation\\_Stimulus.m](#) from the **Analysis** folder. This function allows selecting any cell from the list of available experiments and plotting the response of that specific cell to the spatial contrast adaptation stimulus.

## 2.2 Spatial Contrast Adaptation with Alternating Contrasts

This stimulus is very similar to the spatial contrast adaptation stimulus. The only difference between this stimulus and the spatial contrast adaptation stimulus is the contrast values presented at the locations Y. The contrast values for this stimulus switch between the high-low condition and a low-high condition, with the latter presenting low contrast at locations X and high contrast at locations Y. Similar to the stimulus without alternating contrasts one can re-create the alternating contrasts stimulus by calling the function [Spatial\\_Contrast\\_Adaptation\\_Stimulus.m](#). Similar to above, it is also possible to visualize the response of an example ganglion cell by calling the function [Analyze\\_Spatial\\_Contrast\\_Adaptation\\_Stimulus.m](#) from the **Analysis** folder.

## 2.3 Spatio-temporal Binary White-Noise Stimulus

A spatio-temporal binary white-noise stimulus of black and white squares (100% contrast), which was displayed on a checkerboard layout with squares of 60  $\mu\text{m}$  to the side, was used to estimate a cell's receptive field. Each square was randomly assigned to black (0) or white (1) with a probability of 50% each. Spatial patterns were updated with a frequency of either 30 or 60 Hz. Frame times come at (approximately) 30 Hz and mark every new spatial pattern for the 30 Hz version and every second new spatial pattern for the 60 Hz version. In the latter case, the intermediate stimulus update time should be obtained by averaging the two surround frame times.

To visualize or recreate the Spatio-temporal binary white-noise stimulus, call the function [SpatioTemporal\\_Binary\\_White\\_Noise\\_Stimulus\(\)](#) provided in the **Stimulation** folder. This automatically displays the stimulus with a set of default parameters. To check the list of available parameters for this function, call the help option with the following command: [SpatioTemporal\\_Binary\\_White\\_Noise\\_Stimulus\('help',true\)](#). To recreate any Spatio-temporal binary white-noise stimulus used during the experiments provided in the **Raw Data** folder, it is possible to select an experiment-specific stimulus parameter text file. To do so, use the 'selecttextfile' option in the stimulus function.

For example, `SpatioTemporal_Binary_White_Noise_Stimulus('selecttextfile',true)` will open a prompt window to select the stimulus parameter text file provided in the **stimulusparameters** folder inside each experiment folder. Additionally, it is possible to use this function with a list of independent parameters inserted as a series of strings and values to check other possible variations of the spatio-temporal binary white noise stimulus.

For example: `SpatioTemporal_Binary_White_Noise_Stimulus('stixelwidth',10, 'stixelheight',10)` displays a variation of the stimulus where each square of the checkerboard is 10 pixels to the side. Note that the `SpatioTemporal_Binary_White_Noise_Stimulus()` is provided for the purpose of visualizing and recreating the spatio-temporal binary white-noise stimulus. For this purpose and also for simplicity, operations such gamma-correction of the contrast values were removed from this function. Additionally, the time scale of the stimulus presentation may vary due to variations in MATLAB performance on different machines or operating systems. This list of parameters used in this function is as follows:

Parameter	Default	Usage
selecttextfile	false	Browse prompt to select the parameters text file
stixelwidth	6	Width of each pixel of the checkerboard defined in monitor pixel units
stixelheight	6	Height of each pixel of the checkerboard defined in monitor pixel units
blackwhite	true	Option to switch between binary and Gaussian white-noise (Not available)
contrast	1	Contrast of black & white stimulus.
meanintensity	0.5	Mean intensity value used to define contrast
seed	-1000	Starting value for random number generator (should always be negative)
nblinks	2	Number of frames to hold the stimulus on screen (2 is 30 Hz stimulus)
screenize	800 x 600	Screen resolution, default value is the resolution of the stimulation device
refreshrate	60	Screen refresh rate in Hz
fullscreen	false	Option to display the stimulus in full-screen mode
help	false	Option to check the list of available parameters
lmargin	0	Margins from left side of the screen (not available for this stimulus)
rmagin	0	Margins from right side of the screen (not available for this stimulus)
tmargin	0	Margins from top of the screen (not available for this stimulus)
bmargin	0	Margins from bottom of the screen (not available for this stimulus)