Overview

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Between May and October 2024, Jin Yong Park recorded from different cell types with the `DS_probe_protocol` in the G4 ephys setup.

These experiments were run based on the prior analysis conducted by Judith Hoeller of theoretical receptive field properties of the different cell types, which suggested that they would display directionally selective responses to moving bars in specific orientations.

The aim of these experiments was to test these predictions and to characterise the direction selectivity of the different cell types.

1 Protocol overview

> **i** Quick summary:
>
> 3 repetitions of light and dark moving bars, edges, gratings and full field flashes. This protocol is run through the `G4_experiment_conductor` GUI.

> **i** Aim:
>
> To characterise the direction selectivity and temporal frequency tuning of different cell types in Drosophila visual system.

Bar stimuli moving in multiple orientations - horizontal, vertical, and diagonal (45° and -45°) - presented at two different speeds (20 and 100 degrees per second). These bars come in two spatial sizes (2 and 6 pixels wide) and are shown in both standard and flipped (reverse contrast) versions.

Edge stimuli featuring ON and OFF edges moving horizontally and vertically, also presented in standard and reversed directions. These edge stimuli are designed to isolate responses to luminance boundaries.

Grating stimuli with 12-pixel spatial wavelength, oriented vertically, horizontally, and diagonally. These gratings are presented at multiple temporal frequencies ranging from 0.5 Hz up to 64 Hz, allowing characterization of temporal frequency tuning. Each grating orientation includes both standard and phase-flipped versions.

Flash stimuli presented at various temporal frequencies (0.5 Hz to 64 Hz) to examine responses to uniform field flicker without spatial structure.

Pixel intensity values The protocol's patterns are `gs_val = 4` (intensity values can be 0-15). The protocol first presents all dark stimuli (intensity 1/15) and then runs through all stimuli again with light stimuli (intensity 12/15). Each stimulus is presented 3 times.

2 Protocol description

Table 1: Description of patterns, functions and their durations (in minutes) for the "DS_probe_protocol" used in G4 ephys recordings.

ID	Pattern	Function	Duration
1	0042_2pix_H_bar_1bar_4bkg_G4	0187_2px_H_bar_20dps_G4	2.9
2	0042_2pix_H_bar_1bar_4bkg_G4	0188_FLIP_2px_H_bar_20dps_G4	2.9
3	0042_2pix_H_bar_1bar_4bkg_G4	0189_2px_H_bar_100dps_G4	0.8

ID	Pattern	Function	Duration
4	0042_2pix_H_bar_1bar_4bkg_G4	0190_FLIP_2px_H_bar_100dps_G4	0.8
5	0041_6pix_H_bar_1bar_4bkg_G4	0191_6px_H_bar_20dps_G4	3.1
6	0041_6pix_H_bar_1bar_4bkg_G4	0192_FLIP_6px_H_bar_20dps_G4	3.1
7	0041_6pix_H_bar_1bar_4bkg_G4	0193_6px_H_bar_100dps_G4	0.8
8	0041_6pix_H_bar_1bar_4bkg_G4	0194_FLIP_6px_H_bar_100dps_G4	0.8
9	0011_2pix_V_1bar_4bkg_G4	0001_V_bar_20dps_81-175_G4	5.6
10	0011_2pix_V_1bar_4bkg_G4	0002_FLIP_V_bar_20dps_81-175_G4	5.6
11	0011_2pix_V_1bar_4bkg_G4	0003_V_bar_100dps_81-175_G4	1.4
12	0011_2pix_V_1bar_4bkg_G4	0004_FLIP_V_bar_100dps_81-175_G4	1.4
13	0012_6pix_V_1bar_4bkg_G4	0005_V_bar_6pix_20dps_77-175_G4	5.9
14	0012_6pix_V_1bar_4bkg_G4	0006_FLIP_V_bar_6pix_20dps_77-175_G4	5.8
15	0012_6pix_V_1bar_4bkg_G4	0007_V_bar_6pix_100dps_77-175_G4	1.4
16	0012_6pix_V_1bar_4bkg_G4	0008_FLIP_V_bar_6pix_100dps_77-175_G4	1.4
17	0033_6pix_bar_45_1bar_4bkg_G4	0009_D_bar_6pix_20dps_9-84_G4	4.5
18	0033_6pix_bar_45_1bar_4bkg_G4	0010_FLIP_D_bar_6pix_20dps_9-84_G4	4.5
19	0033_6pix_bar_45_1bar_4bkg_G4	0011_D_bar_6pix_100dps_9-84_G4	1.1
20	0033_6pix_bar_45_1bar_4bkg_G4	0012_FLIP_D_bar_6pix_100dps_9-84_G4	1.1
21	0034_6pix_bar_flip_45_1bar_4bkg_G4	0013_-D_bar_6pix_20dps_40-115_G4	4.5
22	0034_6pix_bar_flip_45_1bar_4bkg_G4	0014_FLIP_-D_bar_6pix_20dps_40-115_G4	4.5
23	0034_6pix_bar_flip_45_1bar_4bkg_G4	0015_-D_bar_6pix_100dps_40-115_G4	1.1
24	0034_6pix_bar_flip_45_1bar_4bkg_G4	0016_FLIP_-D_bar_6pix_100dps_40-115_G4	1.1
25	0022_OFF_edge_V_1edge_4bkg_G4	0017_V_Edge_20dps_81-175_G4	5.6
26	0038_OFF_edge_V_1edge_4bkg_Reverse_G4	0022_REV_V_Edge_20dps_18-115_G4	5.8
27	0022_OFF_edge_V_1edge_4bkg_G4	0018_V_Edge_100dps_81-175_G4	1.3
28	0038_OFF_edge_V_1edge_4bkg_Reverse_G4	0021_REV_V_Edge_100dps_18-115_G4	1.3
29	0026_OFF_edge_H_1edge_4bkg_G4	0090_horizontal_bar_20dps_2-76s_49fr_0st_G4	2.8

ID	Pattern	Function	Duration
30	0037_OFF_edge_H_1edge_4bkg_Re-verse_G4	0090_horizontal_bar_20dps_2-76s_49fr_0st_G4	2.8
31	0026_OFF_edge_H_1edge_4bkg_G4	0092_horizontal_bar_100dps_0-55s_49fr_0st_G4	0.6
32	0037_OFF_edge_H_1edge_4bkg_Re-verse_G4	0092_horizontal_bar_100dps_0-55s_49fr_0st_G4	0.6
33	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0129_V_Gratings_0-5Hz_40fr_G4	3.3
34	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0130_FLIP_V_Gratings_0-5Hz_40fr_G4	3.3
35	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0131_V_Gratings_1Hz_40fr_G4	3.3
36	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0132_FLIP_V_Grat-ings_1Hz_40fr_G4	3.3
37	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0133_V_Gratings_4Hz_40fr_G4	3.3
38	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0134_FLIP_V_Grat-ings_4Hz_40fr_G4	3.3
39	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0135_V_Gratings_8Hz_40fr_G4	3.3
40	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0136_FLIP_V_Grat-ings_8Hz_40fr_G4	3.3
41	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0137_V_Gratings_16Hz_40fr_G4	3.3
42	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0138_FLIP_V_Grat-ings_16Hz_40fr_G4	3.3
43	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0139_V_Gratings_32Hz_40fr_G4	3.3
44	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0140_FLIP_V_Grat-ings_32Hz_40fr_G4	3.3
45	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0141_V_Gratings_64Hz_40fr_G4	3.3
46	0057_Grat-ings_12pix_V_1bar_4bkg_G4	0142_FLIP_V_Grat-ings_64Hz_40fr_G4	3.3
47	0059_Grat-ings_12pix_H_1bar_4bkg_G4	0143_H_Gratings_0-5Hz_41fr_G4	3.3
48	0059_Grat-ings_12pix_H_1bar_4bkg_G4	0144_FLIP_H_Gratings_0-5Hz_41fr_G4	3.3
49	0059_Grat-ings_12pix_H_1bar_4bkg_G4	0145_H_Gratings_1Hz_41fr_G4	3.3

ID	Pattern	Function	Duration
50	0059_Gratings_12pix_H_1bar_4bkg_G4	0146_FLIP_H_Gratings_1Hz_41fr_G4	3.3
51	0059_Gratings_12pix_H_1bar_4bkg_G4	0147_H_Gratings_4Hz_41fr_G4	3.3
52	0059_Gratings_12pix_H_1bar_4bkg_G4	0148_FLIP_H_Gratings_4Hz_41fr_G4	3.3
53	0059_Gratings_12pix_H_1bar_4bkg_G4	0149_H_Gratings_8Hz_41fr_G4	3.3
54	0059_Gratings_12pix_H_1bar_4bkg_G4	0150_FLIP_H_Gratings_8Hz_41fr_G4	3.3
55	0059_Gratings_12pix_H_1bar_4bkg_G4	0151_H_Gratings_16Hz_41fr_G4	3.3
56	0059_Gratings_12pix_H_1bar_4bkg_G4	0152_FLIP_H_Gratings_16Hz_41fr_G4	3.3
57	0059_Gratings_12pix_H_1bar_4bkg_G4	0153_H_Gratings_32Hz_41fr_G4	3.3
58	0059_Gratings_12pix_H_1bar_4bkg_G4	0154_FLIP_H_Gratings_32Hz_41fr_G4	3.3
59	0059_Gratings_12pix_H_1bar_4bkg_G4	0155_H_Gratings_64Hz_41fr_G4	3.3
60	0059_Gratings_12pix_H_1bar_4bkg_G4	0156_FLIP_H_Gratings_64Hz_41fr_G4	3.3
61	0031_12pix_grating_45_1bar_4bkg_G4	0157_D_12pix_Gratings_05Hz_12fr_G4	3.3
62	0031_12pix_grating_45_1bar_4bkg_G4	0158_FLIP_D_12pix_Gratings_05Hz_12fr_G4	3.3
63	0031_12pix_grating_45_1bar_4bkg_G4	0159_D_12pix_Gratings_1Hz_12fr_G4	3.3
64	0031_12pix_grating_45_1bar_4bkg_G4	0160_FLIP_D_12pix_Gratings_1Hz_12fr_G4	3.3
65	0031_12pix_grating_45_1bar_4bkg_G4	0161_D_12pix_Gratings_4Hz_12fr_G4	3.3
66	0031_12pix_grating_45_1bar_4bkg_G4	0162_FLIP_D_12pix_Gratings_4Hz_12fr_G4	3.3
67	0031_12pix_grating_45_1bar_4bkg_G4	0163_D_12pix_Gratings_8Hz_12fr_G4	3.3
68	0031_12pix_grating_45_1bar_4bkg_G4	0164_FLIP_D_12pix_Gratings_8Hz_12fr_G4	3.3
69	0031_12pix_grating_45_1bar_4bkg_G4	0165_D_12pix_Gratings_16Hz_12fr_G4	3.3

ID	Pattern	Function	Duration
70	0031_12pix_grating_45_1bar_4bkg_G4	0166_FLIP_D_12pix_Gratings_16Hz_12fr_G4	3.3
71	0031_12pix_grating_45_1bar_4bkg_G4	0167_D_12pix_Gratings_32Hz_12fr_G4	3.3
72	0031_12pix_grating_45_1bar_4bkg_G4	0168_FLIP_D_12pix_Gratings_32Hz_12fr_G4	3.3
73	0031_12pix_grating_45_1bar_4bkg_G4	0169_D_12pix_Gratings_64Hz_12fr_G4	3.3
74	0031_12pix_grating_45_1bar_4bkg_G4	0170_FLIP_D_12pix_Gratings_64Hz_12fr_G4	3.3
75	0032_12pix_grating_flip_45_1bar_4bkg_G4	0157_D_12pix_Gratings_0-5Hz_12fr_G4	3.3
76	0032_12pix_grating_flip_45_1bar_4bkg_G4	0158_FLIP_D_12pix_Gratings_0-5Hz_12fr_G4	3.3
77	0032_12pix_grating_flip_45_1bar_4bkg_G4	0159_D_12pix_Gratings_1Hz_12fr_G4	3.3
78	0032_12pix_grating_flip_45_1bar_4bkg_G4	0160_FLIP_D_12pix_Gratings_1Hz_12fr_G4	3.3
79	0032_12pix_grating_flip_45_1bar_4bkg_G4	0161_D_12pix_Gratings_4Hz_12fr_G4	3.3
80	0032_12pix_grating_flip_45_1bar_4bkg_G4	0162_FLIP_D_12pix_Gratings_4Hz_12fr_G4	3.3
81	0032_12pix_grating_flip_45_1bar_4bkg_G4	0163_D_12pix_Gratings_8Hz_12fr_G4	3.3
82	0032_12pix_grating_flip_45_1bar_4bkg_G4	0164_FLIP_D_12pix_Gratings_8Hz_12fr_G4	3.3
83	0032_12pix_grating_flip_45_1bar_4bkg_G4	0165_D_12pix_Gratings_16Hz_12fr_G4	3.3
84	0032_12pix_grating_flip_45_1bar_4bkg_G4	0166_FLIP_D_12pix_Gratings_16Hz_12fr_G4	3.3
85	0032_12pix_grating_flip_45_1bar_4bkg_G4	0167_D_12pix_Gratings_32Hz_12fr_G4	3.3
86	0032_12pix_grating_flip_45_1bar_4bkg_G4	0168_FLIP_D_12pix_Gratings_32Hz_12fr_G4	3.3
87	0032_12pix_grating_flip_45_1bar_4bkg_G4	0169_D_12pix_Gratings_64Hz_12fr_G4	3.3
88	0032_12pix_grating_flip_45_1bar_4bkg_G4	0170_FLIP_D_12pix_Gratings_64Hz_12fr_G4	3.3
89	0028_Flash_OFF_4_1_G4	0122_Flash_0-5Hz_4fr_G4	3
90	0028_Flash_OFF_4_1_G4	0123_Flash_1Hz_4fr_G4	3
91	0028_Flash_OFF_4_1_G4	0124_Flash_4Hz_4fr_G4	3

ID	Pattern	Function	Duration
92	0028_Flash_OFF_4_1_G4	0128_Flash_8Hz_4fr_G4	3
93	0028_Flash_OFF_4_1_G4	0125_Flash_16Hz_4fr_G4	3
94	0028_Flash_OFF_4_1_G4	0126_Flash_32Hz_4fr_G4	3
95	0028_Flash_OFF_4_1_G4	0127_Flash_64Hz_4fr_G4	3
96	0044_2pix_H_bar_12bar_4bkg_G4	0187_2px_H_bar_20dps_G4	2.9
97	0044_2pix_H_bar_12bar_4bkg_G4	0188_FLIP_2px_H_bar_20dps_G4	2.9
98	0044_2pix_H_bar_12bar_4bkg_G4	0189_2px_H_bar_100dps_G4	0.8
99	0044_2pix_H_bar_12bar_4bkg_G4	0190_FLIP_2px_H_bar_100dps_G4	0.8
100	0043_6pix_H_bar_12bar_4bkg_G4	0191_6px_H_bar_20dps_G4	3.1
101	0043_6pix_H_bar_12bar_4bkg_G4	0192_FLIP_6px_H_bar_20dps_G4	3.1
102	0043_6pix_H_bar_12bar_4bkg_G4	0193_6px_H_bar_100dps_G4	0.8
103	0043_6pix_H_bar_12bar_4bkg_G4	0194_FLIP_6px_H_bar_100dps_G4	0.8
104	0013_2pix_V_12bar_4bkg_G4	0001_V_bar_20dps_81-175_G4	5.6
105	0013_2pix_V_12bar_4bkg_G4	0002_FLIP_V_bar_20dps_81-175_G4	5.6
106	0013_2pix_V_12bar_4bkg_G4	0003_V_bar_100dps_81-175_G4	1.3
107	0013_2pix_V_12bar_4bkg_G4	0004_FLIP_V_bar_100dps_81-175_G4	1.3
108	0014_6pix_V_12bar_4bkg_G4	0005_V_bar_6pix_20dps_77-175_G4	5.8
109	0014_6pix_V_12bar_4bkg_G4	0006_FLIP_V_bar_6pix_20dps_77-175_G4	5.8
110	0014_6pix_V_12bar_4bkg_G4	0007_V_bar_6pix_100dps_77-175_G4	1.4
111	0014_6pix_V_12bar_4bkg_G4	0008_FLIP_V_bar_6pix_100dps_77-175_G4	1.4
112	0035_6pix_bar_45_12bar_4bkg_G4	0009_D_bar_6pix_20dps_9-84_G4	4.5
113	0035_6pix_bar_45_12bar_4bkg_G4	0010_FLIP_D_bar_6pix_20dps_9-84_G4	4.5
114	0035_6pix_bar_45_12bar_4bkg_G4	0011_D_bar_6pix_100dps_9-84_G4	1.1
115	0035_6pix_bar_45_12bar_4bkg_G4	0012_FLIP_D_bar_6pix_100dps_9-84_G4	1.1
116	0036_6pix_bar_flip_45_12bar_4bkg_G4	0013_-D_bar_6pix_20dps_40-115_G4	4.5
117	0036_6pix_bar_flip_45_12bar_4bkg_G4	0014_FLIP_-D_bar_6pix_20dps_40-115_G4	4.5
118	0036_6pix_bar_flip_45_12bar_4bkg_G4	0015_-D_bar_6pix_100dps_40-115_G4	1.1
119	0036_6pix_bar_flip_45_12bar_4bkg_G4	0016_FLIP_-D_bar_6pix_100dps_40-115_G4	1.1
120	0015_ON_edge_V_12edge_4bkg_G4	0017_V_Edge_20dps_81-175_G4	5.6

ID	Pattern	Function	Duration
121	0039_ON_edge_V_12edge_4bkg_Re-verse_G4	0022_REV_V_Edge_20dps_18-115_G4	5.8
122	0015_ON_edge_V_12edge_4bkg_G4	0018_V_Edge_100dps_81-175_G4	1.3
123	0039_ON_edge_V_12edge_4bkg_Re-verse_G4	0021_REV_V_Edge_100dps_18-115_G4	1.3
124	0023_ON_edge_H_12edge_4bkg_G4	0090_horizontal_bar_20dps_2-76s_49fr_0st_G4	2.8
125	0040_ON_edge_H_12edge_4bkg_Re-verse_G4	0090_horizontal_bar_20dps_2-76s_49fr_0st_G4	2.8
126	0023_ON_edge_H_12edge_4bkg_G4	0092_horizontal_bar_100dps_0-55s_49fr_0st_G4	0.6
127	0040_ON_edge_H_12edge_4bkg_Re-verse_G4	0092_horizontal_bar_100dps_0-55s_49fr_0st_G4	0.6

3 Experiment Log

Table 2: Number of recordings by cell type

cell_type	# recordings
Cm10	9
Dm4	4
T4T5	4
Tm24	4
Tm5Y	4
TmY13	7
TmY18	7
TmY3	8

Table 3: Comprehensive experiment log

ID	cell_type	date_str	date_to_process
1	TmY3	05_23_2024	05_23_2024
2	TmY3	05_28_2024	05_28_2024_1
3	TmY3	05_28_2024	05_28_2024_2
4	TmY3	05_29_2024	05_29_2024_1
5	TmY3	05_29_2024	05_29_2024_2
6	TmY3	05_30_2024	05_30_2024

ID	cell_type	date_str	date_to_process
7	TmY3	05_31_2024	05_31_2024_1
8	TmY3	05_31_2024	05_31_2024_2
9	TmY13	05_24_2024	05_24_2024
10	TmY13	06_03_2024	06_03_2024
11	TmY13	06_04_2024	06_04_2024_1
12	TmY13	06_04_2024	06_04_2024_2
13	TmY13	06_05_2024	06_05_2024
14	TmY13	06_06_2024	06_06_2024
15	TmY13	06_07_2024	06_07_2024
16	TmY18	06_10_2024	06_10_2024
17	TmY18	06_13_2024	06_13_2024
18	TmY18	06_14_2024	06_14_2024
19	TmY18	06_17_2024	06_17_2024
20	TmY18	06_18_2024	06_18_2024_1
21	TmY18	06_18_2024	06_18_2024_2
22	TmY18	06_21_2024	06_21_2024
23	Cm10	07_26_2024	07_26_2024
24	Cm10	07_30_2024	07_30_2024
25	Cm10	07_31_2024	07_31_2024_2
26	Cm10	08_01_2024	08_01_2024
27	Cm10	08_05_2024	08_05_2024_1
28	Cm10	08_05_2024	08_05_2024_2
29	Cm10	08_06_2024	08_06_2024_1
30	Cm10	08_06_2024	08_06_2024_2
31	Cm10	08_08_2024	08_08_2024
32	Dm4	08_26_2024	08_26_2024
33	Dm4	08_28_2024	08_28_2024_2
34	Dm4	08_29_2024	08_29_2024
35	Dm4	08_30_2024	08_30_2024
36	Tm24	09_03_2024	09_03_2024_1
37	Tm24	09_03_2024	09_03_2024_2
38	Tm24	09_04_2024	09_04_2024_2
39	Tm24	09_05_2024	09_05_2024
40	Tm5Y	09_06_2024	09_06_2024
41	Tm5Y	09_10_2024	09_10_2024
42	Tm5Y	09_12_2024	09_12_2024
43	Tm5Y	09_13_2024	09_13_2024
44	T4T5	10_03_2024	10_03_2024
45	T4T5	10_04_2024	10_04_2024_1
46	T4T5	10_04_2024	10_04_2024_2

47	T4T5	10_08_2024	10_08_2024

4 Fly Strains

Table 4: Fly strains

Male	Female	Neuron Type	Effector
SS00395	w+(DL);;pJFRC28-10XUAS-IVS-GFP-p10(attP2)	TmY3	cytoplasmic GFP
SS14770	w+(DL);;pJFRC28-10XUAS-IVS-GFP-p10(attP2)	TmY13	cytoplasmic GFP
SS02701	w+(DL);;pJFRC28-10XUAS-IVS-GFP-p10(attP2)	TmY18	cytoplasmic GFP
SS02582	w+(DL);;pJFRC28-10XUAS-IVS-GFP-p10(attP2)	Cm10	cytoplasmic GFP
SS00297	w+(DL);;pJFRC28-10XUAS-IVS-GFP-p10(attP2)	Dm4	cytoplasmic GFP
SS02044	w+(DL);;pJFRC28-10XUAS-IVS-GFP-p10(attP2)	Tm24	cytoplasmic GFP
SS03722	w+(DL);;pJFRC28-10XUAS-IVS-GFP-p10(attP2)	Tm5Y	cytoplasmic GFP
GR_42F06	w+(DL);;pJFRC28-10XUAS-IVS-GFP-p10(attP2)	T4T5	cytoplasmic GFP
GR_42F06	w;pJFRC28-10XUAS-IVS-GFP-p10 (su(Hw)attP5)	T4T5	cytoplasmic GFP

5 Analysing the data

To analyse a folder of data from running this protocol, run the script `process_ds_probe_protocol_data` that can be found here. This script will process all the data in the specified folder and save the results in a new folder called `processed_data` within the same directory. The script will also generate a summary figure for each recording, which will be saved in the `processed_data` folder.

6 Code availability

The code for analysing the DS_Probe_protocol can be found in this repository.

7 Data availability

The data from these experiments can be found on the Reiser Lab prfs group drive in the folder `/Volumes/reiserlab/burnettl/Ephys_experiments/Jinyong/DS_probe_protocol_1REP_RightHemi_20Hz_0 22-24_09-09-09`.

8 Notes

In retrospect, we should have recorded from the T4T5 driver first (as these cells are well studied) to validate the protocol before moving on to the less well characterised cell types. I would advise anyone wishing to continue with this project to start with T4T5 recordings to ensure the protocol is working as expected and to provide a benchmark against which to compare the responses of the other cell types.