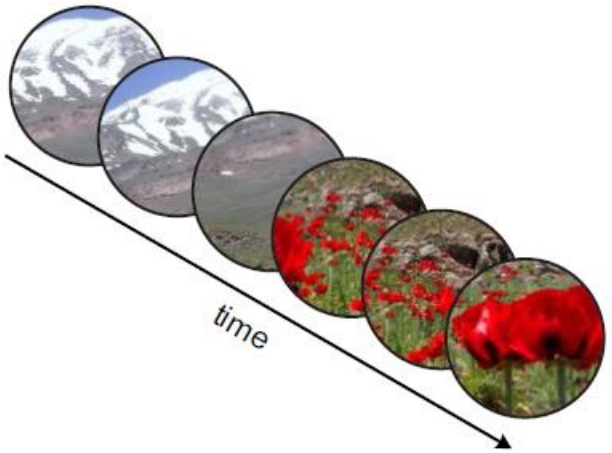
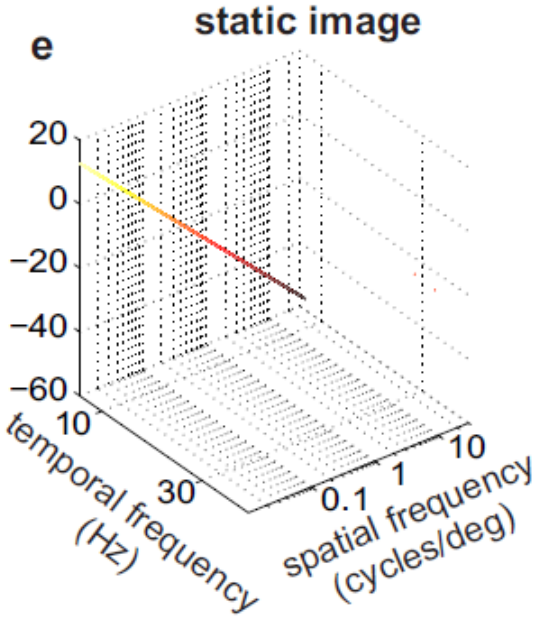
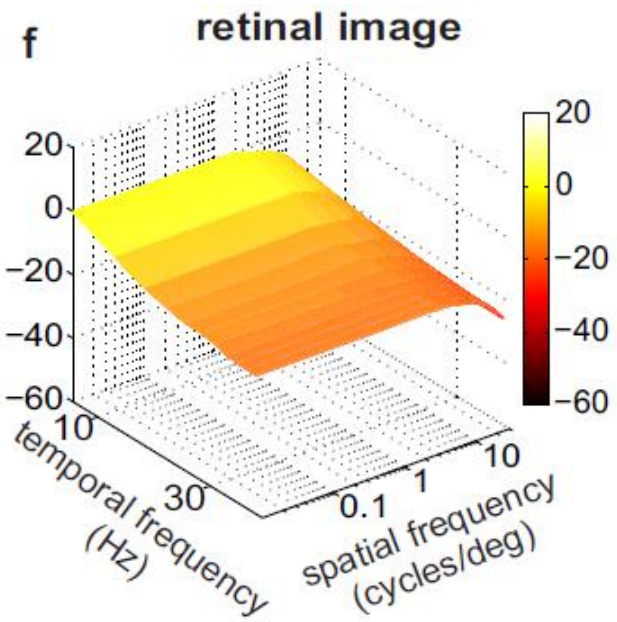
Visual functions of saccade temporal transients

3-18-15

Spatiotemporal input to the visual system

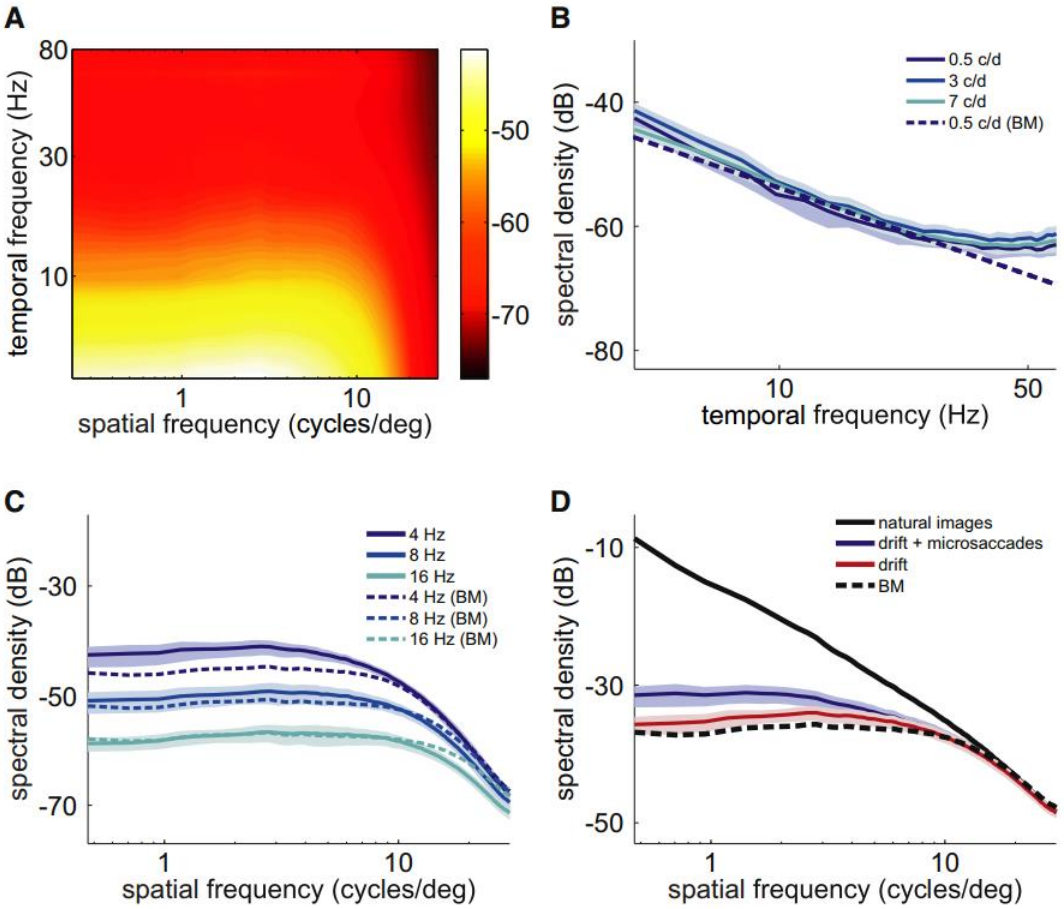






Fixational eye movements as a mean of encoding space in time

- Fixational eye movements spread the spatial power of the stimulus across temporal frequencies away from zero frequency.

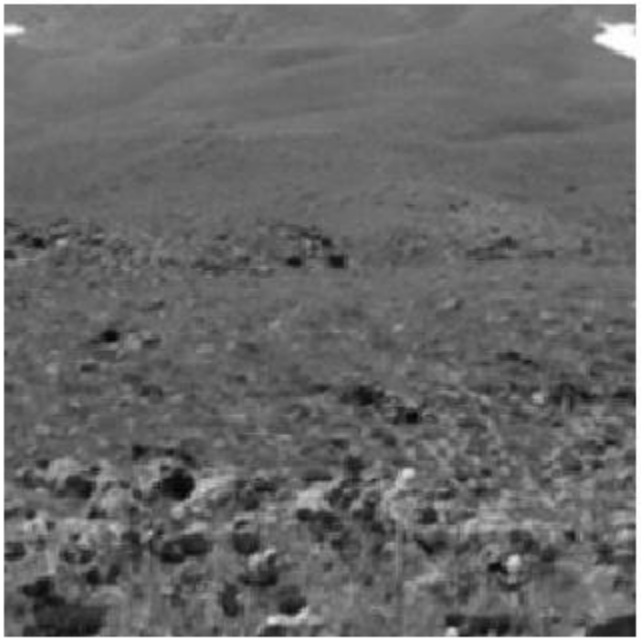


Rucci, 2007; Kuang, 2012

Study objective:

study the consequences of the temporal transients introduced by saccades in reformatting external spatial information into a spatiotemporal input to the retina.

1 ms



Methods:

1) Recorded eye movements from 14 subjects viewing natural scenes.

Eye movement database:

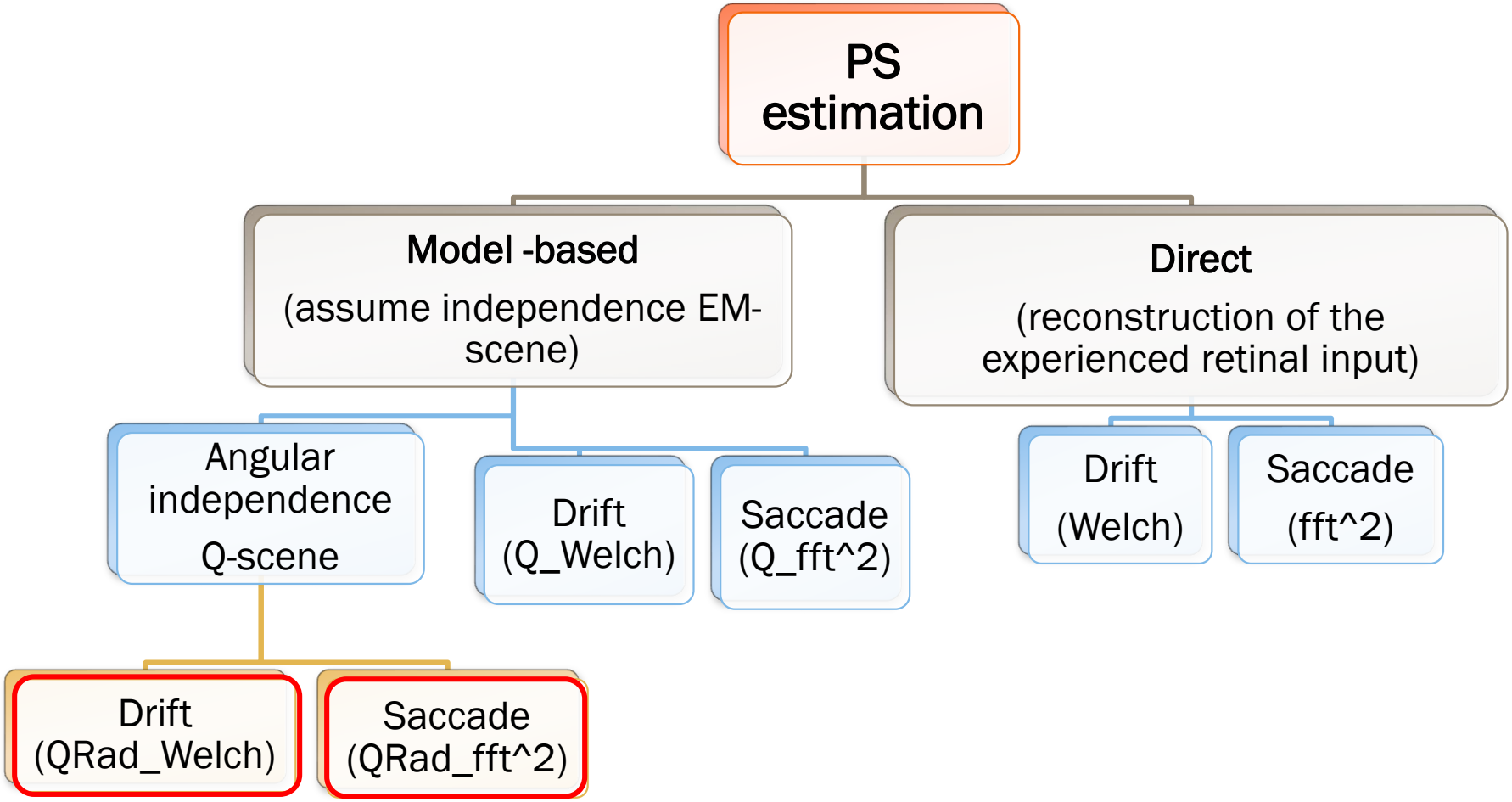
Amp(deg):	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-inf	Drift
Subj1	65	80	57	40	26	22	10	4	6	72
Subj2	19	56	148	143	127	86	61	43	71	21
Subj3	20	40	55	37	29	20	4	7	15	29
Subj4	44	92	193	159	117	71	43	32	37	263
Subj5	64	63	80	33	26	16	12	5	15	21
Subj6	42	93	196	222	226	171	143	88	194	99
Subj7	51	102	311	304	226	168	112	61	82	306
Subj8	59	80	88	70	49	45	29	9	17	45
Subj9	86	103	286	218	185	128	60	40	44	93
Subj10	21	51	132	152	142	132	109	69	113	105
Subj11	114	320	594	381	195	115	56	34	52	92
Subj12	114	203	316	208	153	143	109	81	168	43
Subj13	37	121	376	347	225	167	122	83	153	51
Subj14	24	43	90	80	98	64	66	46	138	34
# of subjects	10	14	14	14	11	11	10	10	10	11
Total number of traces	676	1447	2922	2394	1743	1290	881	577	1052	1203

Methods:

1) Recorded eye movements from 14 subjects viewing natural scenes.

2) Performed spectral analysis of the retinal input at the time of saccades and drifts.

Methods

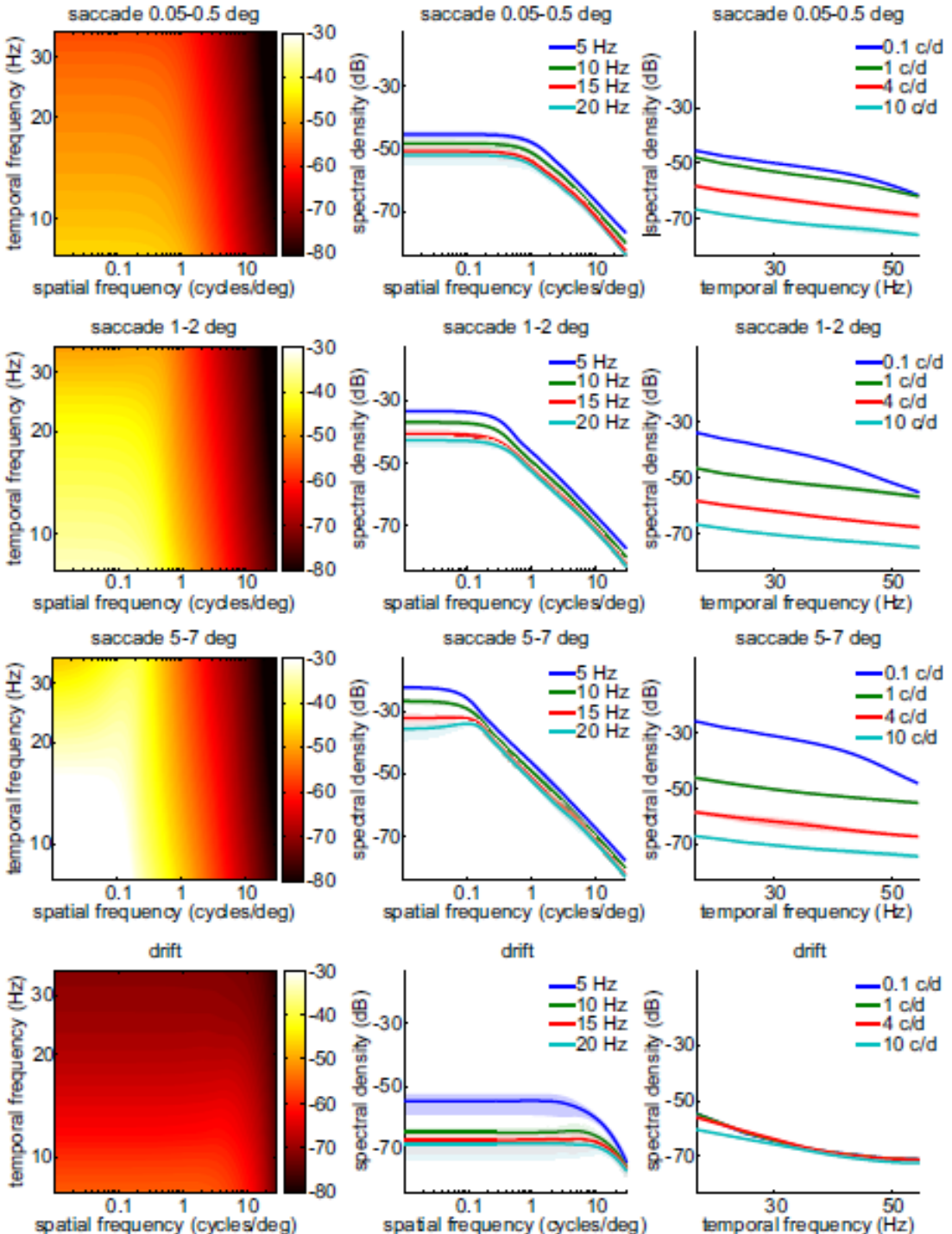


Main assumptions:

- Eye movements are independent of the observed images.
- The observed scene is homogenous (radially symmetric in all directions).

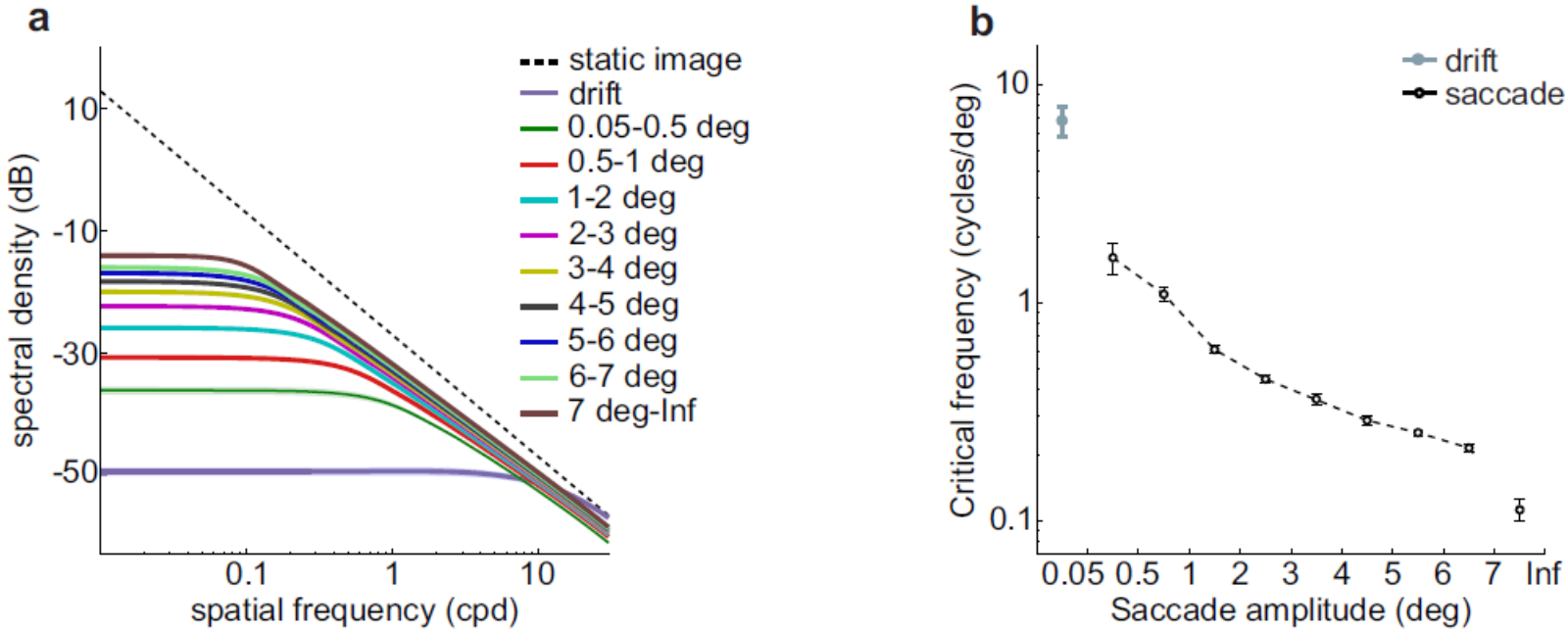
Time frequency analysis of the retinal input relative to the occurrence of saccades and drift.

saccades, like ocular drift, redistribute the spatial power of natural images in temporal domain.



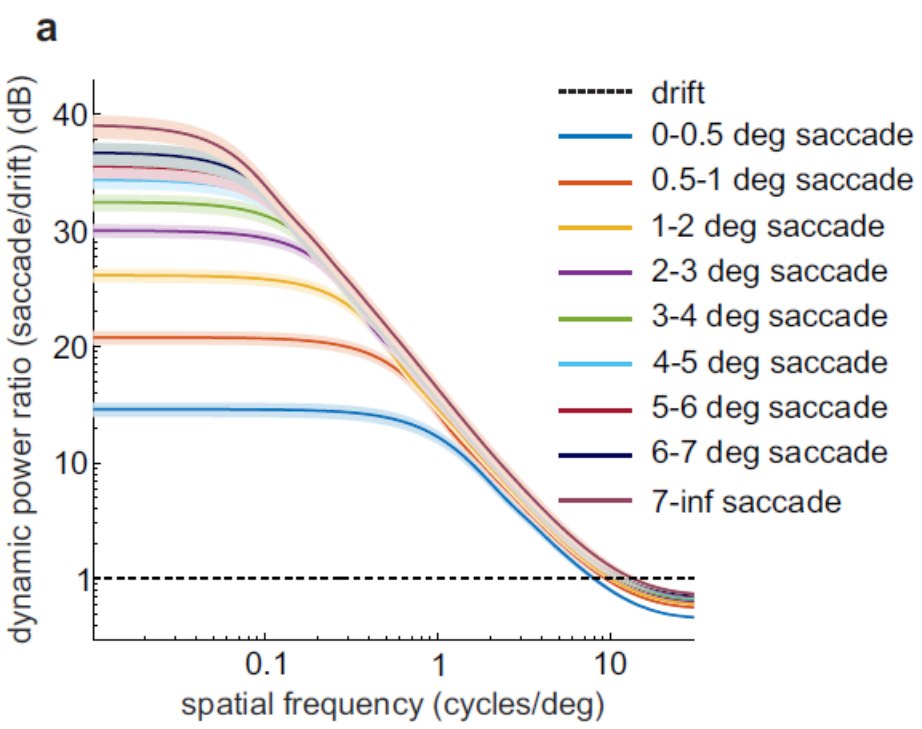
Spectral consequences of the temporal transients resulting from saccades and ocular drift:

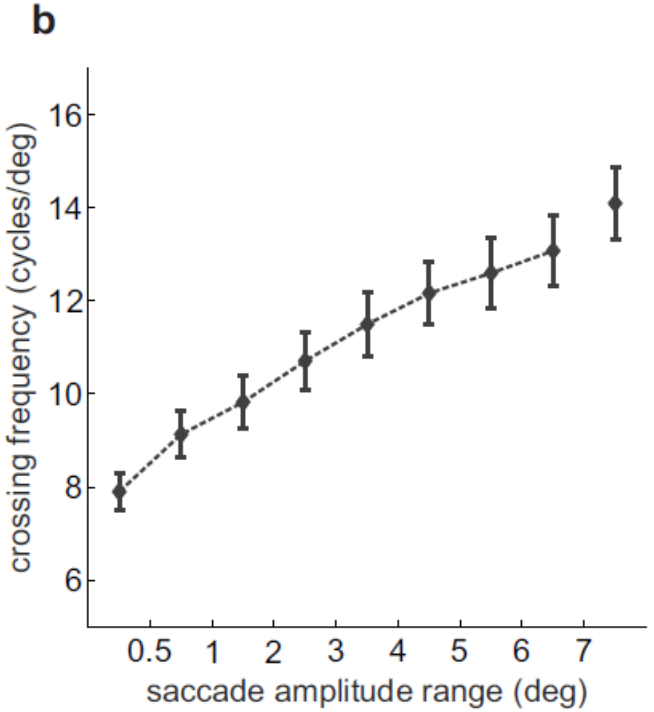
1. For any given saccade amplitude, there is a critical spatial frequency below which saccades spatially whitens natural images. That is, like ocular drift, they remove the correlations in the observed retinal stimulus. Above this critical frequency, however, all spatial frequencies contribute approximately equally to temporal modulations.
2. The range of whitening is smaller for saccades compared to drift and continues to shrink as the size of the saccade increases.



Spectral consequences of the temporal transients resulting from saccades and ocular drift:

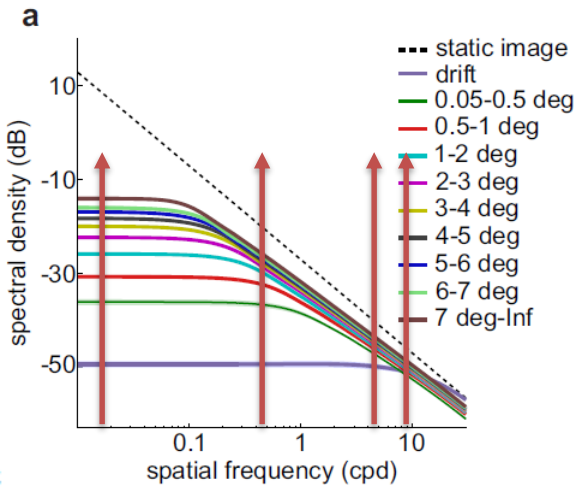
1. saccades contribute more temporal power than ocular drift below a “crossing frequency".
2. The crossing frequency increases with larger saccades *i.e*: larger saccades yield more temporal power compared to drift over a wider range of spatial frequencies.

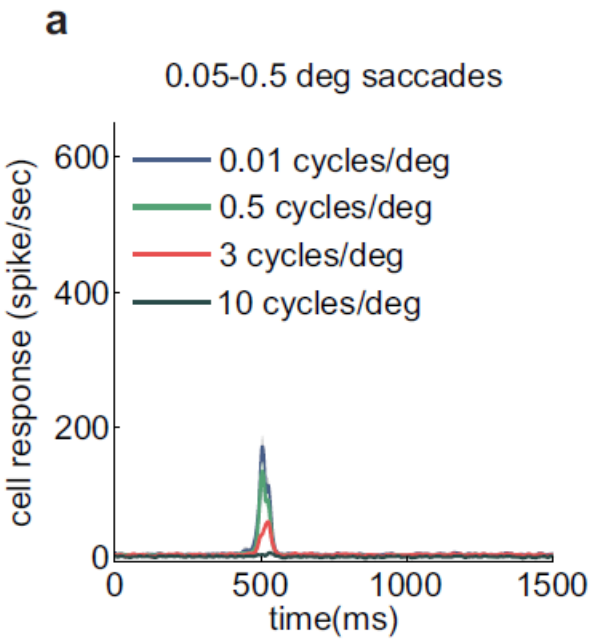


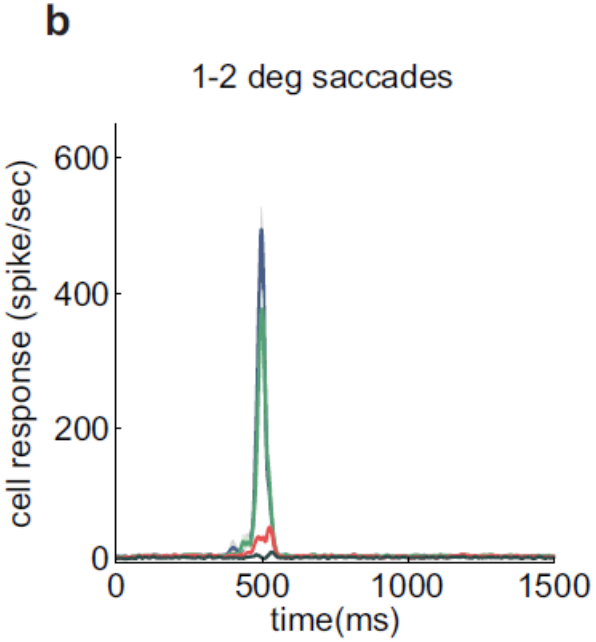


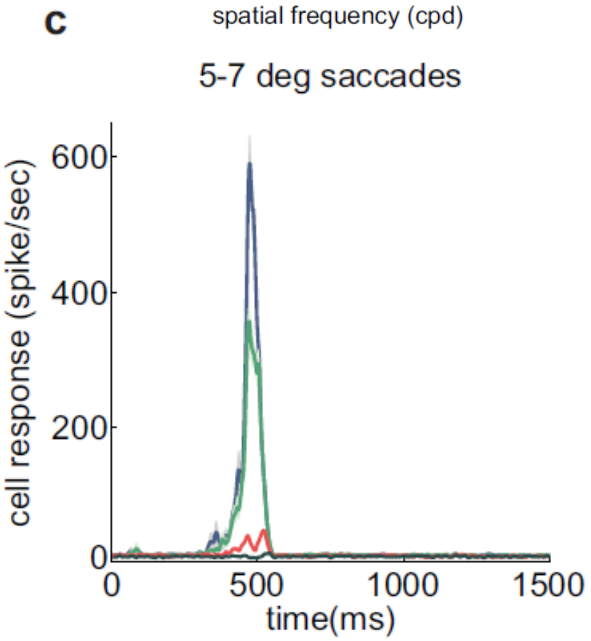
Temporal consequences of the temporal transients resulting from saccades and ocular drift:

simulated the response of simple V1 cells with different spatial frequency selectivity to 1/f noise pattern moved with traces of drift+saccade with different amplitude ranges.

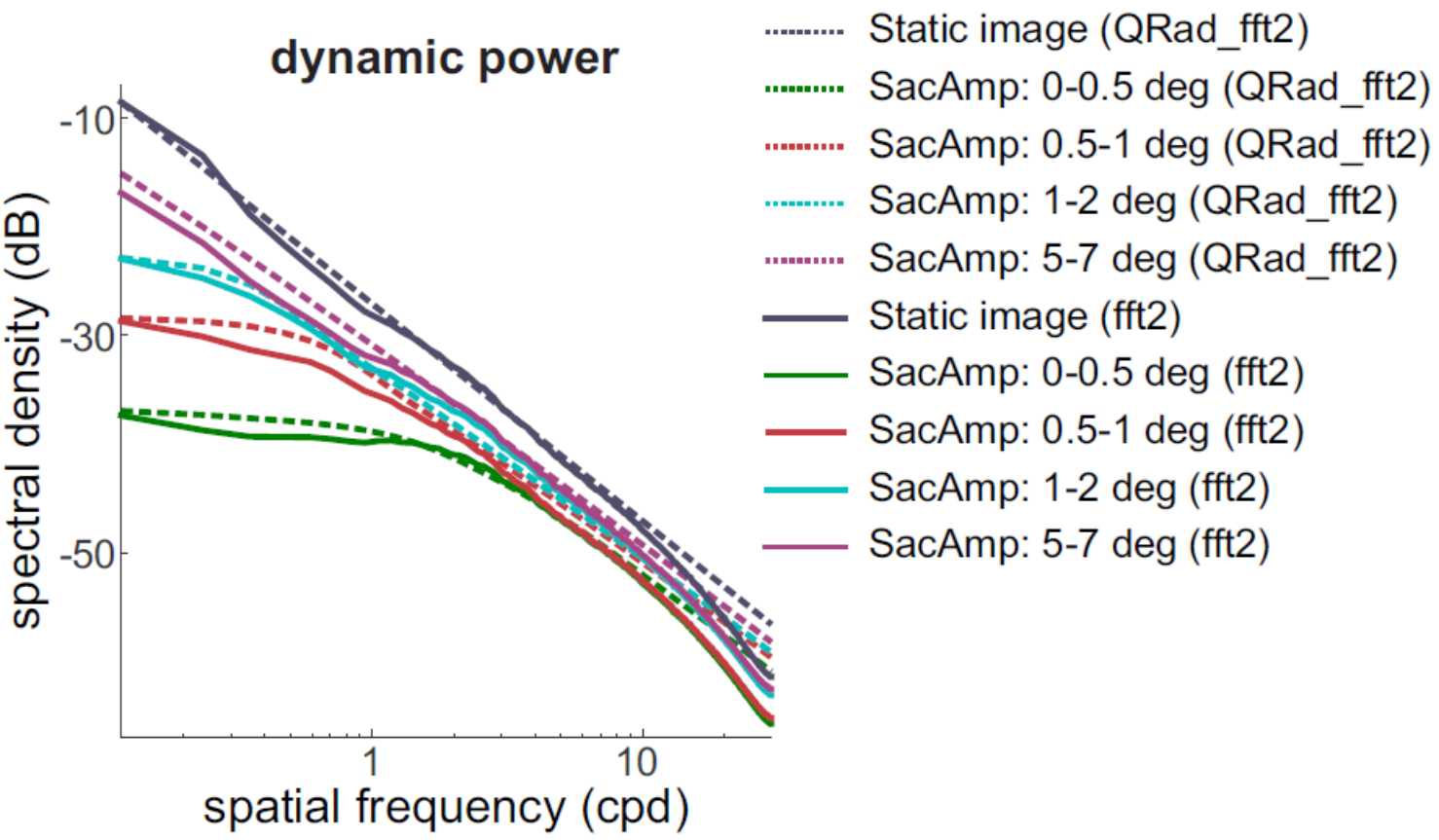








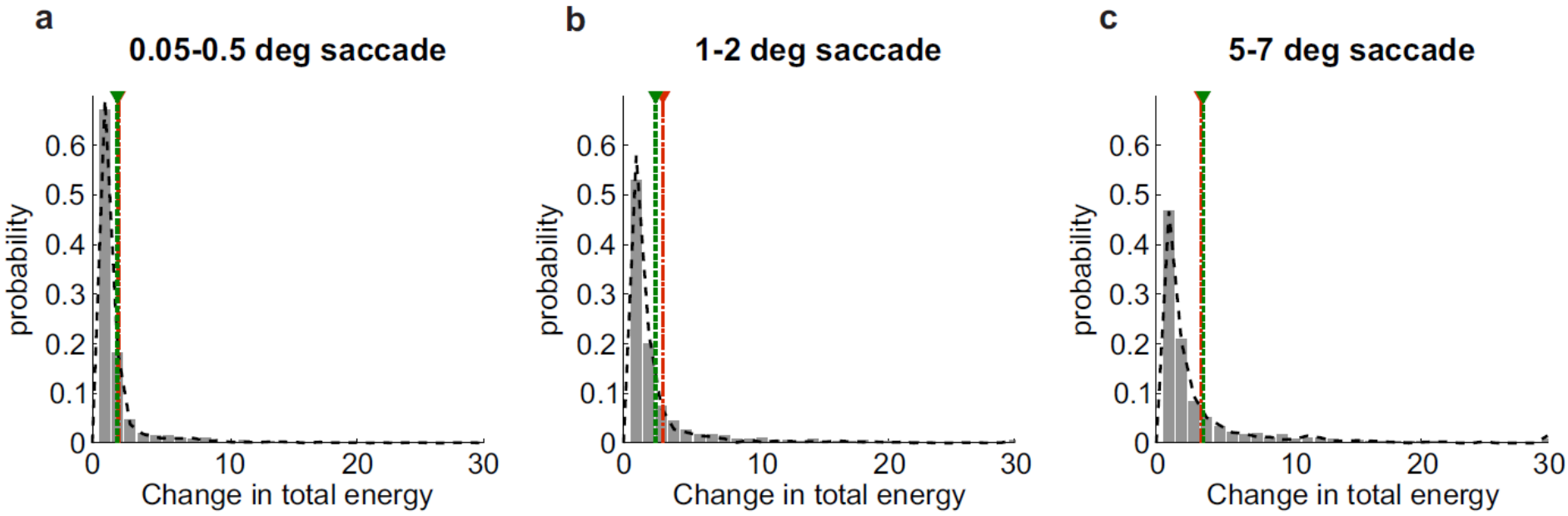
Justification of the spectral analysis method:



Eye movement database:

Amp(deg):	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-inf
Subj1	252	139	411	423	321	231	175	130	249
Subj2	637	500	577	310	279	218	172	139	337
Subj3	420	258	317	194	155	133	79	56	194
Total	1309	897	1305	927	755	582	426	325	780

Justification of the spectral analysis method:



How does the modulation of retinal stimulus due to saccade transients affect our perception?