Local Image Correlations & FEM

Janis Intoy

Updated: November 26, 2018

Contents

Proposed next steps: - Updated August 22

1. (with pilot results on large stimuli) Analyze eye movements - example: Do microsaccades go towards the bar location?

2. (with new, smaller, bandpassed stimuli)

    - With new threshold, compare performance in normal/stabilized conditions - now all conditions, but still correlated target, uncorrelated background stim only

1 Introduction

How do transients from FEM contribute to the processing of spatial correlations in images?

This study will examine whether FEM contribute to human sensitivity to local image correlations using binary bitmaps in which 1-dimensional correlations are introduced.

> The basic hypothesis is that horizontal stabilization will reduce sensitivity to horizontal correlations, and vertical stabilization will reduce sensitivity to vertical correlations[1][2]

JV's e-mail: I think theres a very interesting possibility here under normal viewing conditions, thresholds for positive and negative correlations are equal. But I will bet that with stabilization, this will not be the case, since the negative correlations have much more power at high spatial frequencies.[3]

1.1 Stimulus

The stimuli are 640×640 pixel in size, with each check being 10×10 pixels in size. JV has previously presented these so that each check was 14arcmin-sq in size.

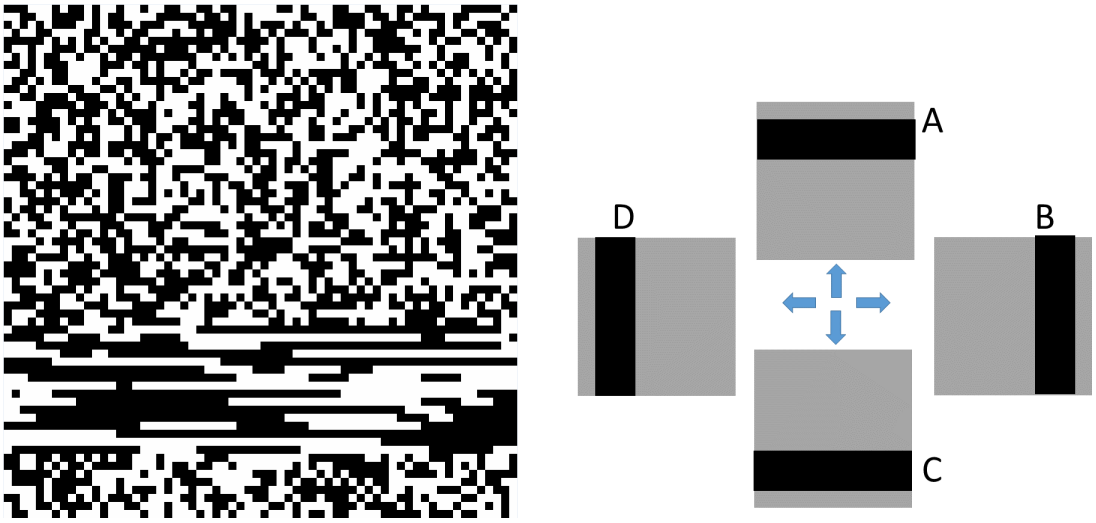


Figure 1: LEFT: example stimulus with random noise background and highly correlated bar in the bottom position. RIGHT: 4-AFC for bar position (up-A, right-B, down-C, or left-D)

Stimuli come in four main categories (see table below) and 10 correlation levels (0.1, 0.2, ..., 1.0).

[1] from JV's e-mail

[2] JI: MR and I have some concerns about using partial stabilization as it has not given consistent results in the past. And, the quality of stabilization may be compromised with this kind of stimulus which contains many sharp edges even at low contrast

[3] JI: This question relies less on partial stabilization.

		Correlation Sign	
		Positive (p)	Negative (n)
Correlation Orientation	Horizontal (b)	bp	bn
	Vertical (c)	cp	cn

Table 1: 4 main stimulus categories - horizontal or vertical correlations that are positive or negative in sign

Also note that the stimulus can come in one of two forms which are otherwise not distinguished: structured bar and noise background (as shown in Fig 1) or the reverse - noise bar and structured background.

(See JV's note fem_beta_pilot.docx in Documents for more details about the stimuli)

1.2 Stimulus: Power Spectra

JV has computed the analytical power spectra of these stimuli (see beta_power_notes.pdf in shared folder):

$$\tilde{c}(\omega) = \frac{1 - c^2}{1 + c^2 - 2c\cos\omega s}$$

where c is the local pairwise correlation and s is the check size.

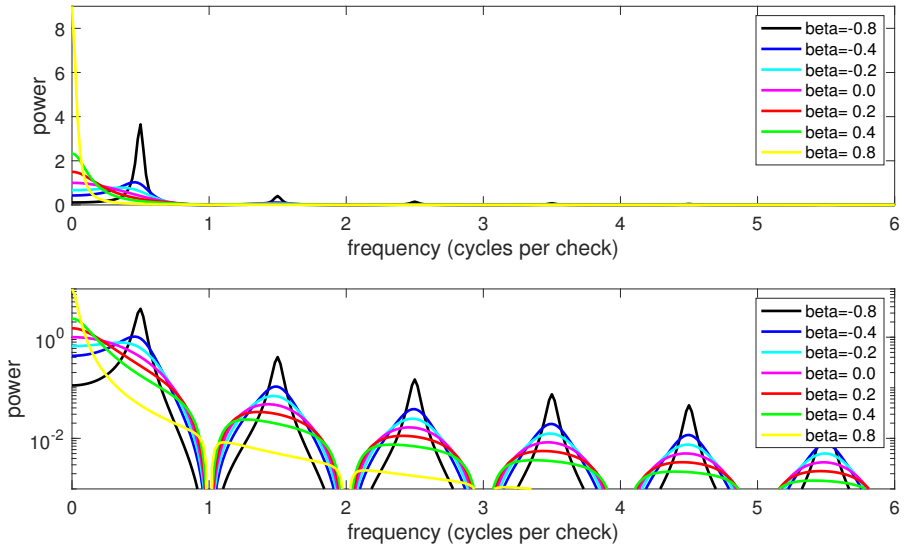
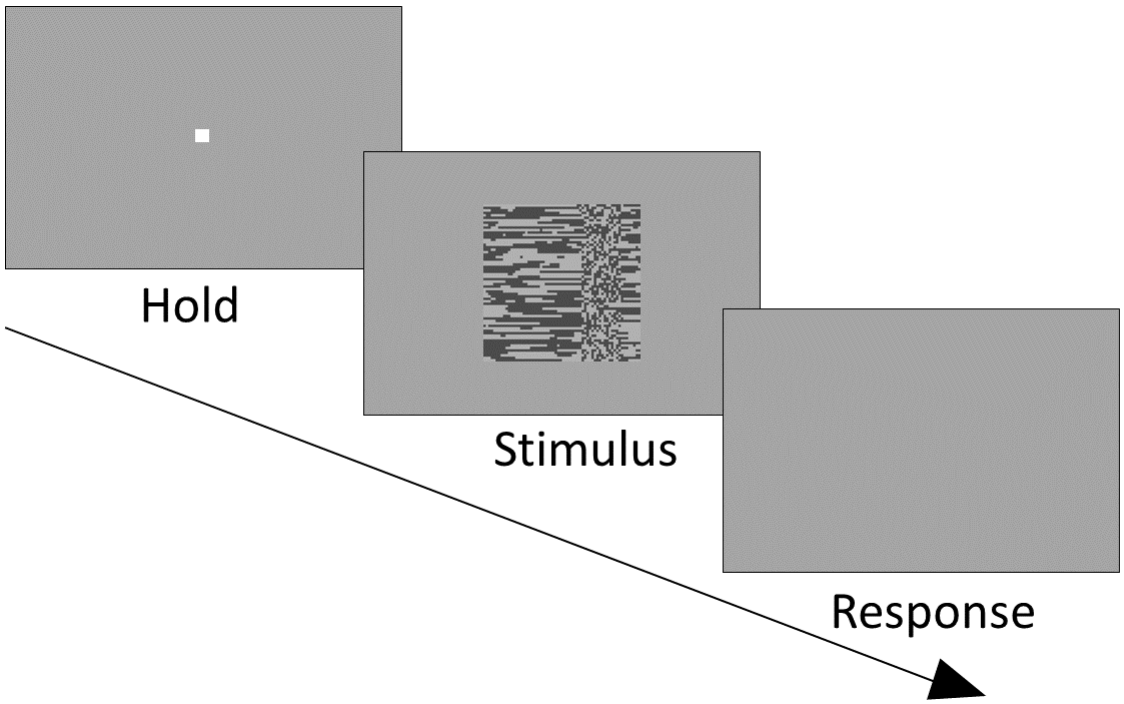


Figure 2: TOP: power in linear scale. BOTTOM: power in log scale. Note that x-axis is in cycles per check.

2 Pilot (no eye tracking - June 29, 2018)

2.1 Experiment parameters



Pilot data collected as of **June 29, 2018** had the following parameters:

- Spatial envelope: none or a raised cosine bell, I couldn't see a difference (a cosine bell hid the outer edges of the stimulus but made the bar more difficult to see)
- Trial Timing:
  - Hold Time: 300ms
  - Stimulus Ramp: 800ms (linear)
  - Stimulus Plateau: 000
  - Response Time: 2s (or until button press)
- Monitor/Contrast Settings:
  - ASUS 278, Brightness 0, Contrast 0
  - 900 x 1440 pixel resolution at approx. 160cm distance (0.8 arcmin / pixel)
  - stimulus size was about 8.5 deg^2
  - NVIDIA gamma corrections: 2.1, 2.17, 2.58 (RGB)
  - fixed contrast = 30 (black and white portions of stimulus were shown as 127± contrast)

2.2 Results

I collected data in two sessions (from myself) with my left eye patched and glasses on. In the second session I attempted to fixate near the center of the monitor to see if the eccentricity of the bar would make a difference (does not seem to) using only correlation levels from 0.1 to 0.6.

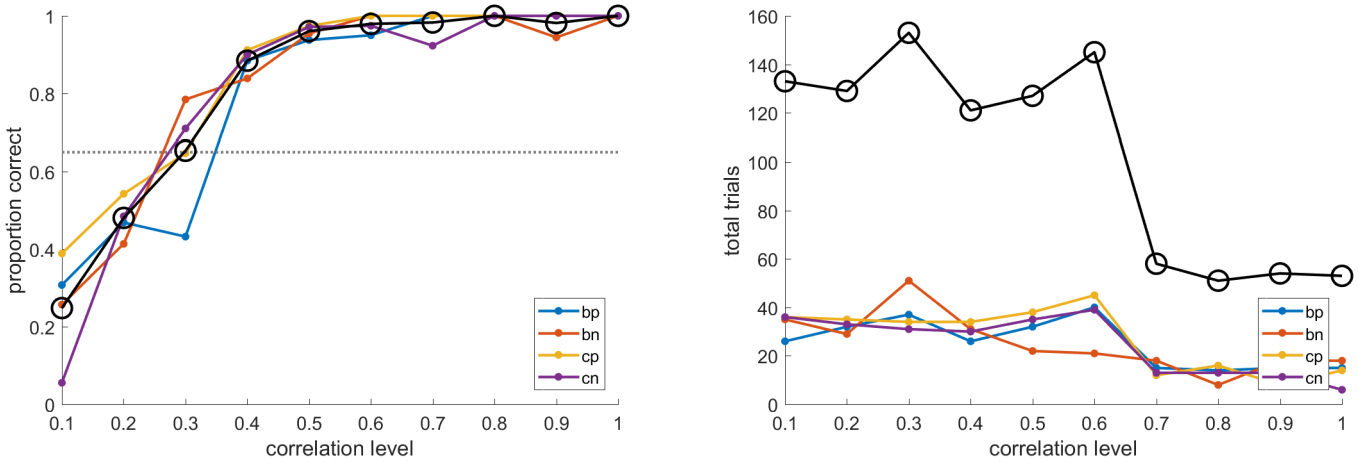


Figure 3: Janis: LEFT - Performance in 4 conditions and on average (black) across both sessions. RIGHT - number of trials at each level

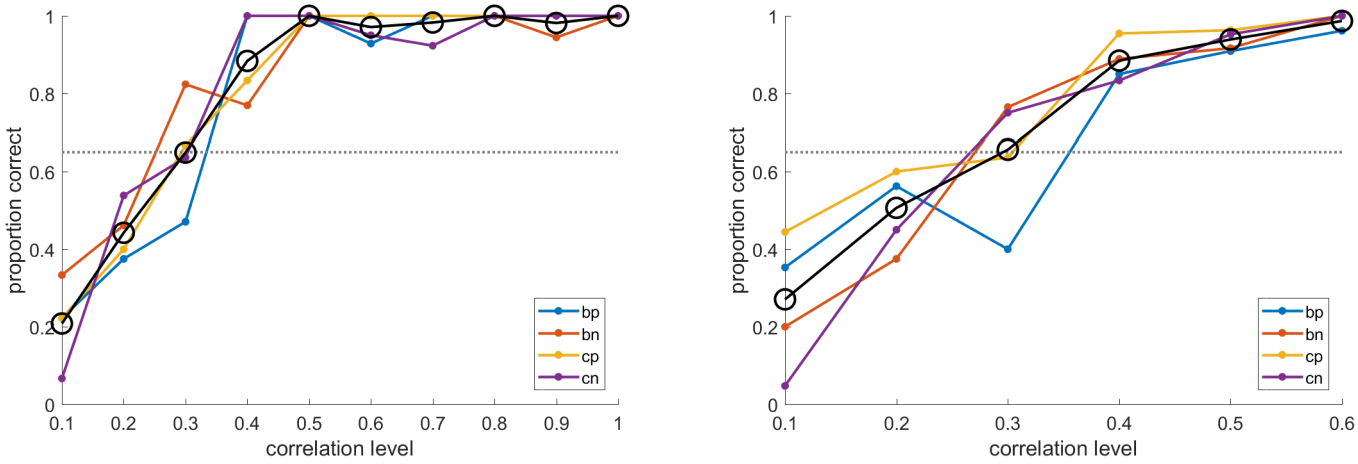


Figure 4: Janis: Performance in 4 conditions and on average (black) across both sessions. LEFT: first session free view, RIGHT: second session - attempted fixation

3 Pilot (normal vs stabilized - August 7, 2018)

Experimental parameters were the same as in the previous pilot (see section 2) with the following changes:

- All stimuli had a 30% correlation level. (-.3 or .3)
- Normal and stabilized viewing trials were interleaved within a block.
- One subject (Janis) attempted to maintain fixation at all times.

Subject	Total	Drift Only	Microsaccades	Saccades	Blink/NT
Janis	1592	180	943	98	369

Table 2: Trial counts - trials with saccades, blinks, or no-tracks were excluded from analysis.

	Proportion Correct		# Trials	
Condition	Normal	Stabilized	Normal	Stabilized
Microsaccades Allowed				
bp	0.515±0.085	0.600±0.083	134	135
bn	0.580±0.081	0.580±0.085	143	131
cp	0.532±0.079	0.616±0.079	154	146
cn	0.483±0.080	0.527±0.086	151	129
all	0.527±0.041	0.582±0.042	582	541
Drift Only				
bp	0.471±0.237	0.700±0.201	17	20
bn	0.636±0.201	0.542±0.199	22	24
cp	0.417±0.197	0.600±0.192	24	25
cn	0.455±0.208	0.577±0.190	22	26
all	0.494±0.106	0.600±0.099	85	95

Table 3: 95% confidence intervals on performance as shown in Figure 5 [4]and number of trials in each condition.

[4] $\hat{p} \pm z\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$

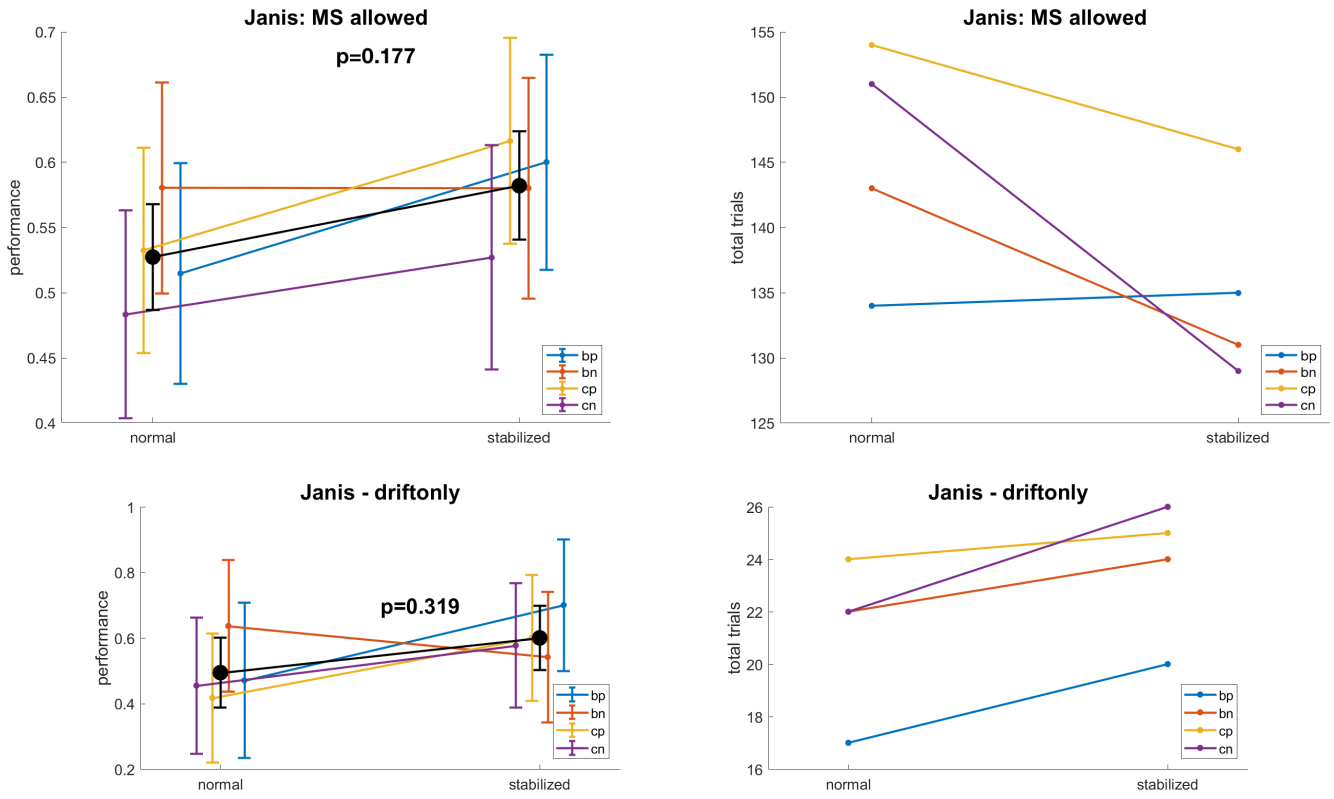


Figure 5: Janis's performance in normal and stabilized viewing conditions. Trials with microsaccades (top row) are shown since there are not enough drift-only trials for analysis (bottom row).

4 Bandpass filtered stimuli

4.1 August 13 update

No change in performance under stabilization suggests that performance in this task is linked to low spatial frequencies. One idea is to bandpass the stimuli to remove dependencies on low spatial frequencies and effects of errors in stabilization (>30cpd).

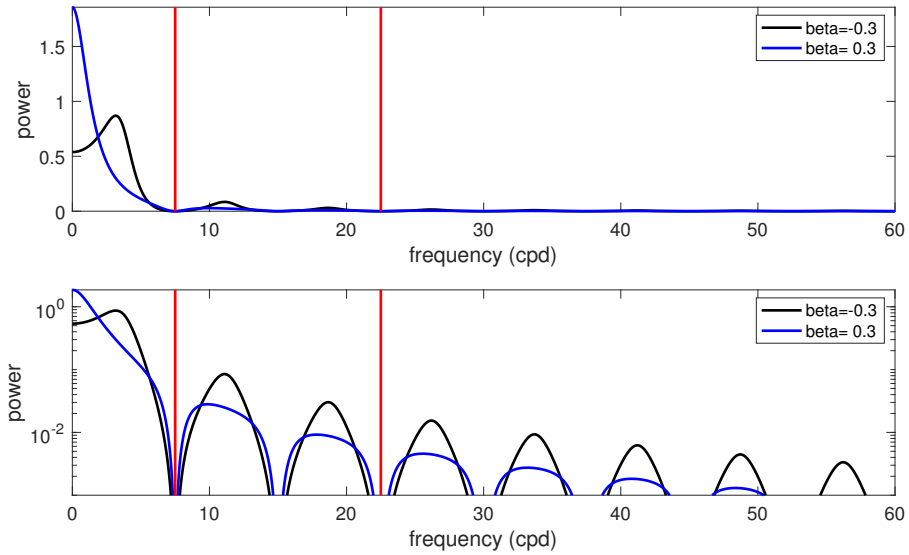


Figure 6: Power spectra of 30% correlation images. Red lines show the cutoffs for the proposed bandpass filter.

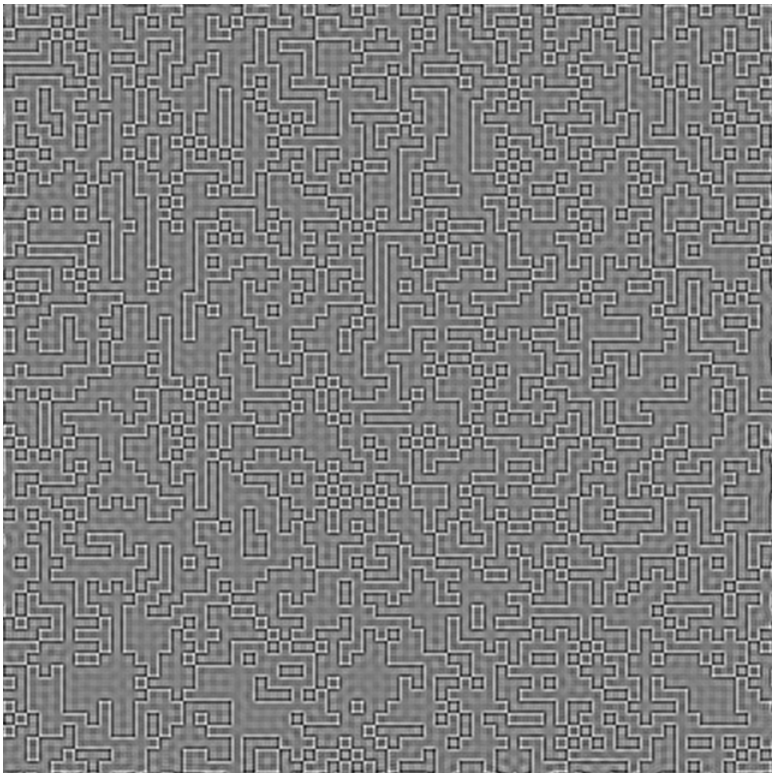


Figure 7: Example of bandpass filtered stimulus (ideal filter with cutoffs at 7.5 and 22.5). Edges are emphasized but this is very difficult to see at low contrast. Furthermore, the peripheral, now-high-frequency bar is difficult detect.

4.2 August 22 Discussion

We would still like to use the bandpass filtered stimuli as above, but change the stimulus parameters so that the task is still possible without eye movements.

- Check size will remain the same (8arcmin)
- Stimuli will be 24×24 checks (or 3.2×3.2 deg)
- Targets will be 6×24 checks within the stimuli.

This should leave the spectrum of the stimuli unchanged (except at very low spatial frequencies).

4.3 Small, Bandpassed Stimuli - Pilot

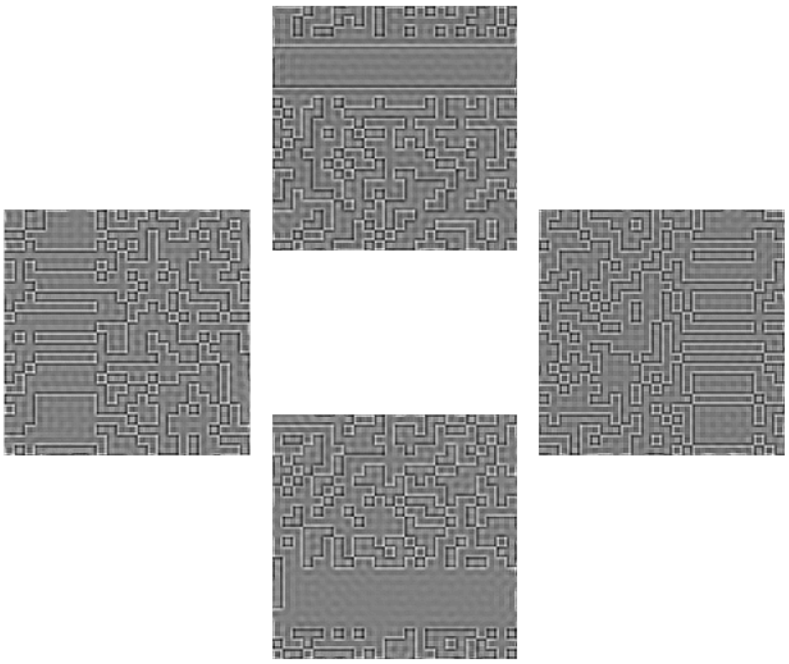


Figure 8: Examples of smaller stimuli with high correlation value. In the following experiments, only stimuli with horizontal correlations in the bar were included.

Implementation updates:

- A spatial mask is now presented after the stimulus and is used to indicate the response period.

4.3.1 Eye Movement Analysis

4.4 Pilot Results (Nov 11)

Data has been collected with two naive subjects (A021). Again, subjects were instructed to maintain fixation near the center of the monitor. Both subjects were introduced to more difficult stimuli over time so that the task was easier to learn during the initial normal viewing only blocks.

NOTE: Data collected before Oct 29 had a bug in which the previous trials stabilized trace was replayed to the subject during normal viewing so that the stimulus was moving in all trials. The data collected to measure correlation threshold did not have this error because no trials were stabilized.

Implementation note: All trials were run on the ACER 272 @ 200Hz with a pixel angle of 0.8. The stimulus contrast ramped up over a period of 1200ms.

Subject	Thr Correlation
A021	0.8
A047	0.6

4.4.1 Number of Trials

Subject	Total Trials	drift only	microsaccades	saccades	Blink/No-track
A021	879	110	407	286	61
A021_v4_08	1451	788	605	35	23
A047	1118	88	227	656	130
A047_v4_06	790	92	112	88	498

Table 4: Number of trials for two subjects. Each subject is tested first in the v3 stimuli (different correlation levels, unstabilized), then on v4 stimuli under unstabilized and stabilized viewing with a single correlation level. The first row for each subject is for v3. Note that trials with no-response are not counted in the subcategories but do contribute to the total number of trials. Note also that the monitor was not refreshing properly during one session for A047 and those trials were excluded from analysis in the "no-track" category.

4.4.2 Correlation thresholds

All trials were of the 'bp' type: positive, horizontal correlations in the bar with unstructured background.

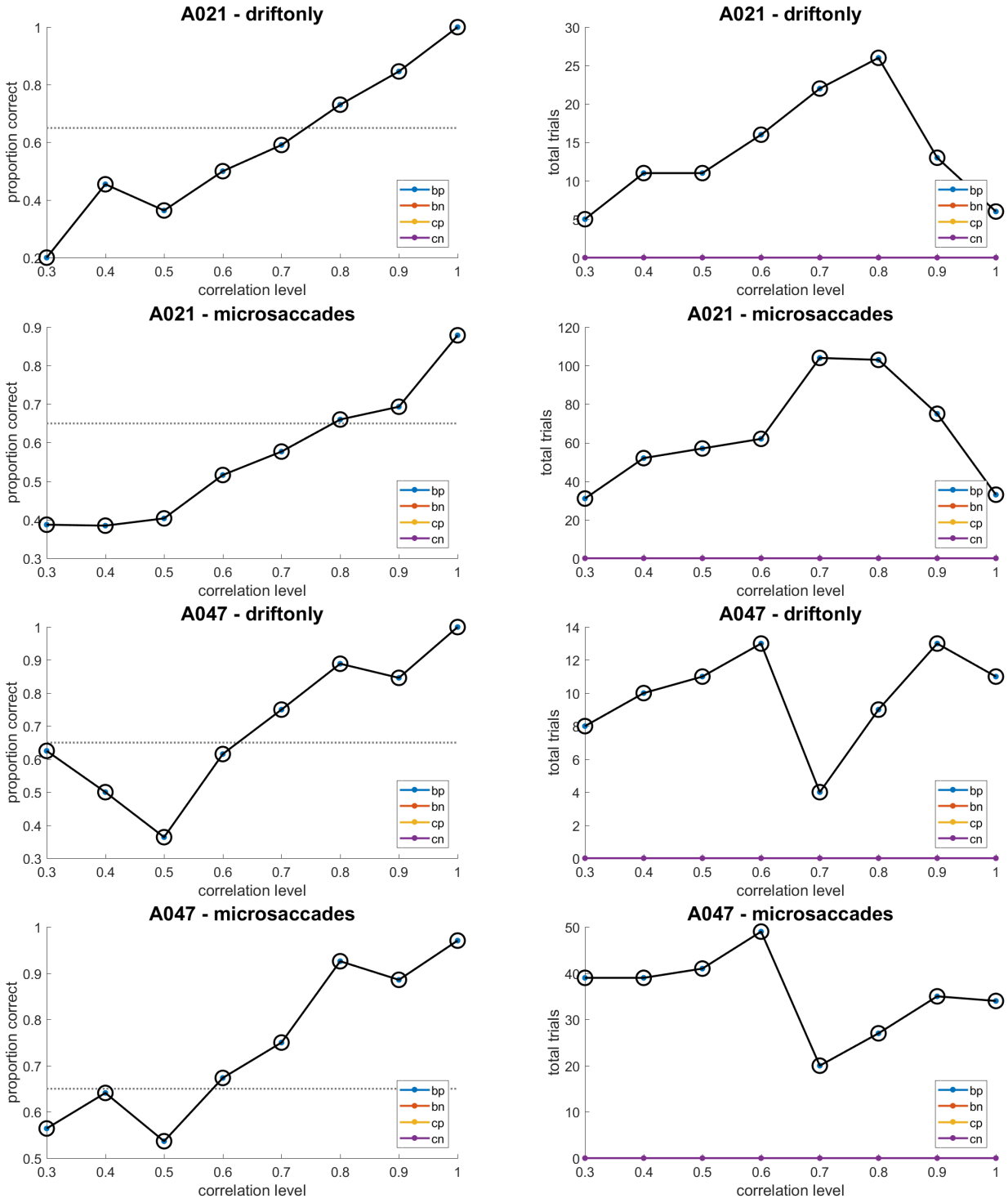


Figure 9: A021 (top two rows) and A047 (bottom two rows) results with different eye movement filters. (by row: drift only, microsaccades allowed) From top to bottom more and more trials are included in the analysis. Here we measure correlation thresholds to use in the normal vs stabilized portion.

4.4.3 Normal vs Stabilized Viewing

Implementation Notes:
Stimuli now contain both 'bp' and 'cp' types (positive correlation, horizontal and vertical). A021 was run with one session of 'bp' only before this was implemented (and hence has more trials for the 'bp' condition than 'cp').

		Positive Correlation				Negative Correlation			
		Normal		Stabilized		Normal		Stabilized	
Subject	EM filter	# cr	tot	# cr	# tot	# cr	# tot	# cr	# tot
A021 v4 08	driftonly	189	205	195	220	97	169	114	194
A021 v4 08	microsaccades	336	362	327	361	193	317	212	353
A021 v4 08	saccades	342	370	335	371	199	329	217	358
A021 v4 08	all	348	376	339	375	200	336	220	362
A047 v4 06	driftonly	20	24	24	30	17	21	12	17
A047 v4 06	microsaccades	48	53	62	70	31	44	26	37
A047 v4 06	saccades	74	81	82	93	46	61	42	57
A047 v4 06	all	170	184	192	211	137	202	130	184

Table 5: Counts of # correct responses (cr) and total # of trialsb y condition and eye movement filter. "Microsaccades" and "saccades" mean trials with microsaccadic events or microsaccadic and saccadic events were included in analysis along with drift only trials.

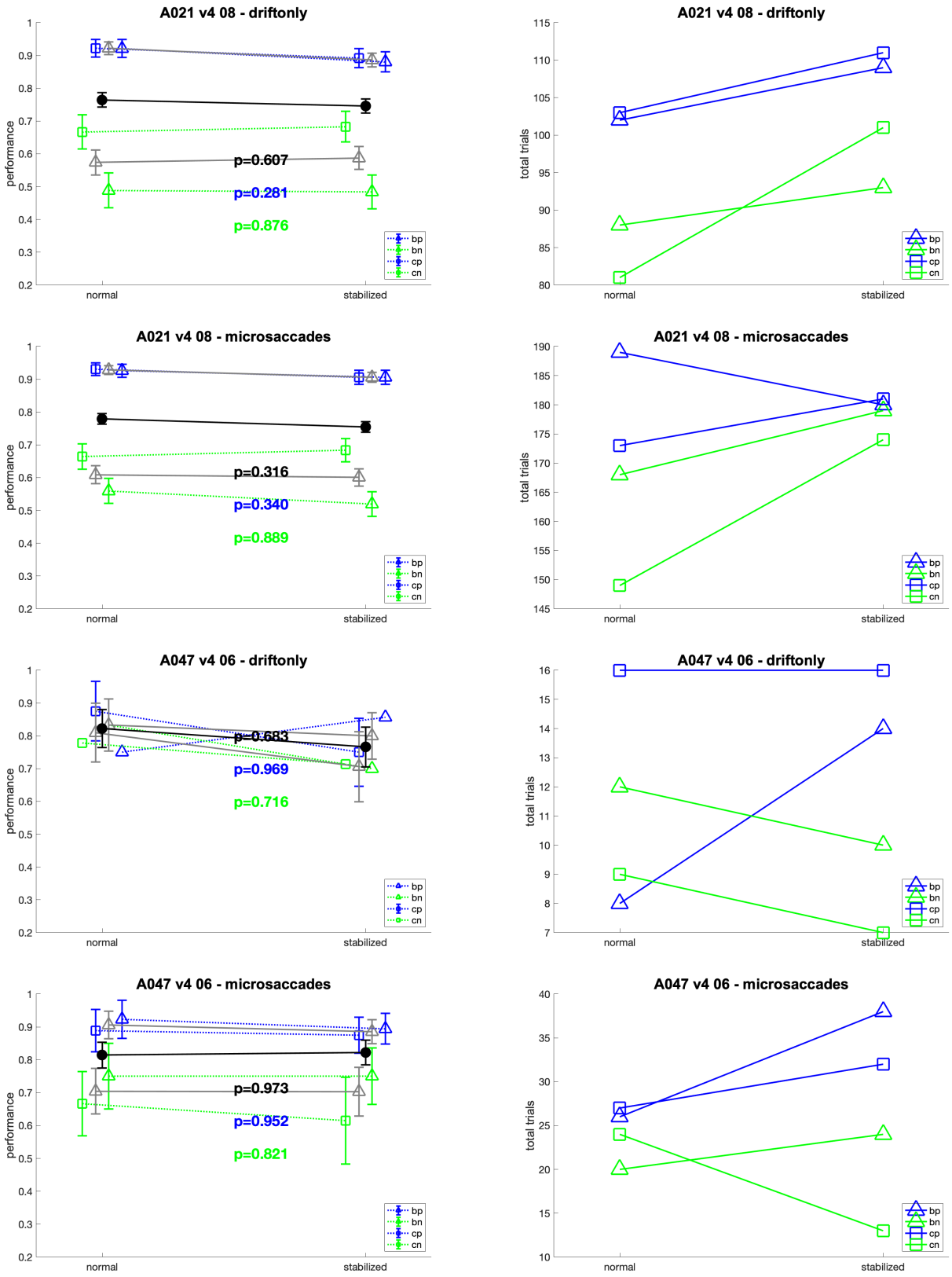


Figure 10: A021 (top two rows) and A047 (not shown yet) results with different eye movement filters. (by row: drift only, microsaccades allowed) . Left column shows performance, right column shows corresponding number of trials. Blue and green show results for positively (blue) or negatively (green) correlations broken down by horizontal/vertical correlations. The gray lines show the average within correlation signs. The black is the overall performance in the normal vs stabilized conditions. p-values from Z-test between normal and stabilized including both positive (blue) and negative (green) trials are shown.

4.4.4 effect of behavior on performance

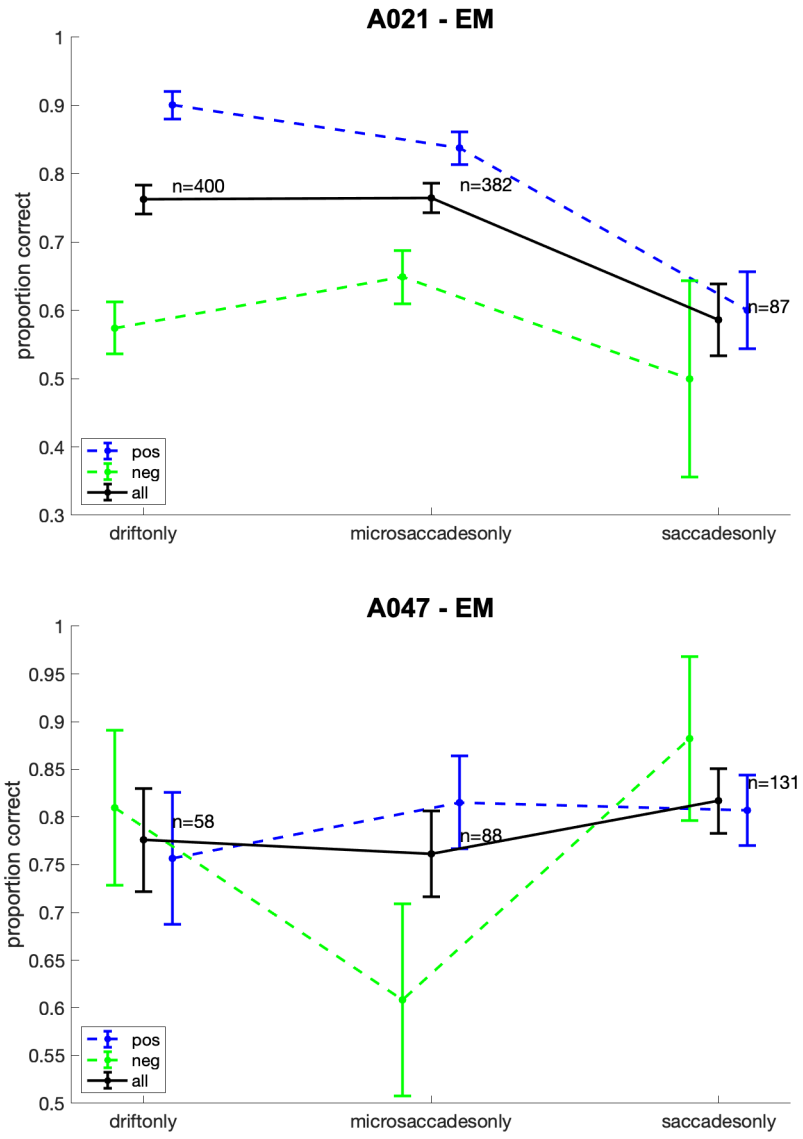


Figure 11: Performance in normal viewing when trials included drift only, microsaccades only, and saccades only. For A021, average performance for saccades-only is significantly different from drift-only and microsaccades only ($p < .01$, Z-test). This holds for the positive correlation (blue), but not the negative correlation (green). For A047, there are no signficant differences in performance due to eye movements.

5 Resources

Data, stimuli files, and documents are available on Google Drive

Code is available on GitLab

Janis, here are your local paths (on windows) because I have a feeling you will forget:

- Local copies of stimuli: `C:/Users/jintoy/GoogleDrive/APLab/FEM_beta_pilot_JV/Stimuli`
- Data & Saved Figures
  - Local copy: `C:/Users/jintoy/GoogleDrive/APLab/FEM_beta_pilot_JV/Data`
  - backup: `//opus.cvs.rochester.edu/JanisData/LocalImageCorrelation/Data`
- python script to generate stimulus envelope on gitlab and in dropbox
- Experiment Code:
  - Currently implemented on DPI system with binocular PC: `D:/Janis/LocalImageCorrelation`
  - copy of important scripts at gitlab and in your dropbox folder
- Matlab Code for data analysis from Gitlab are in your dropbox!