Measuring and Modeling Shared Visual Attention

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Workshop on Computational and Mathematical Models in Vision
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My collaborator

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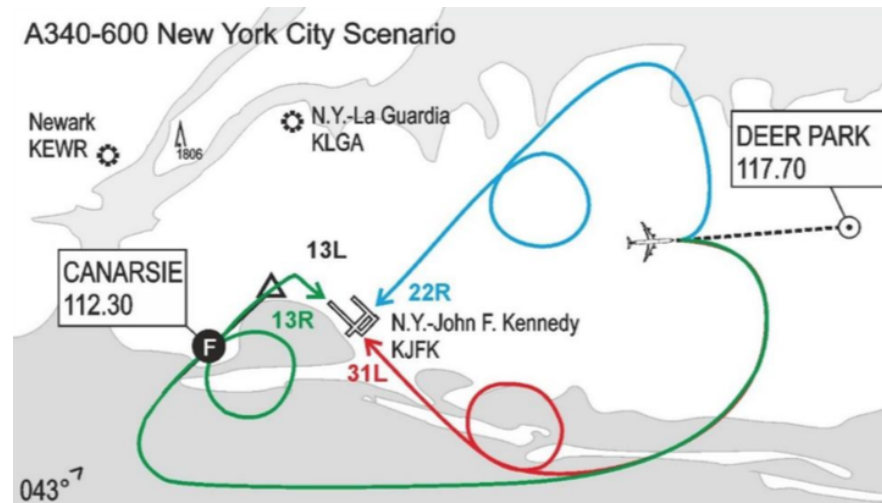
Patrick's experiment

Simulated approach to NYC/JFK with multiple problems

Crews rated by instructor(s)

Objective measures: fuel consumption, time spent/remaining, etc.

High-level goals:
 - determine what styles of crew coordination
     lead to successful outcomes
 - use results to inform
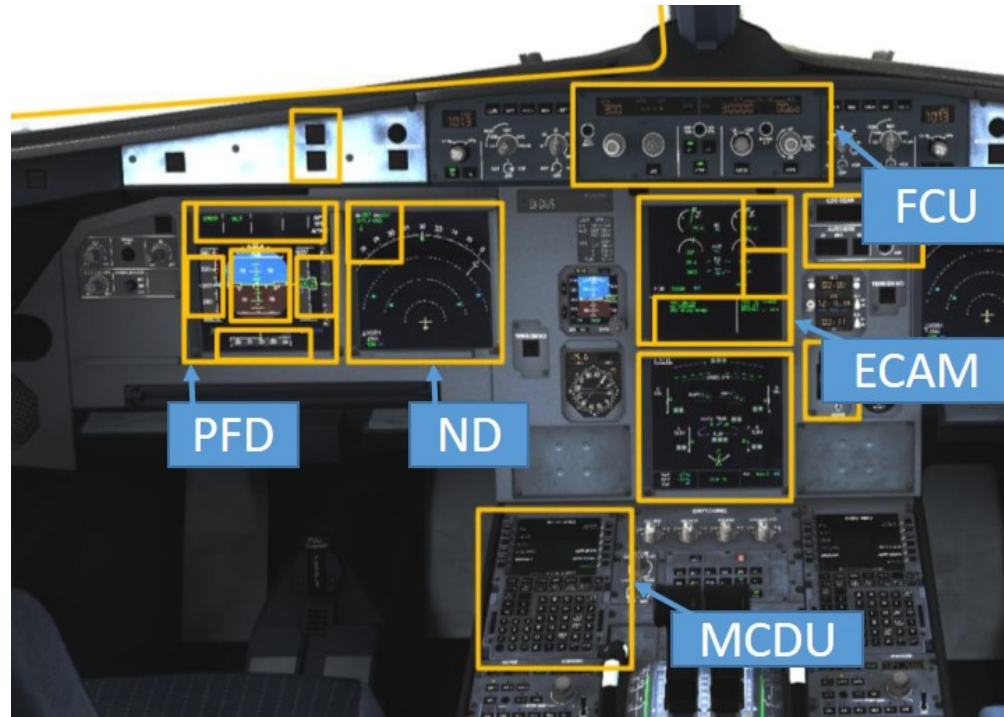

A340-600 New York City Scenario

training

Haslbeck, A., Gontar, P. & Schubert, E. (2014). How Can Procedures and Checklists Help Pilots in Abnormal Flight Situations? In N. A. Stanton, S. J. Landry, G. Di Bucchianico & A. Vallicelli (Eds.), Advances in Human Aspects of Transportation. Part II (S. 456-461). AHFE International.

Eye gaze as a proxy for attention
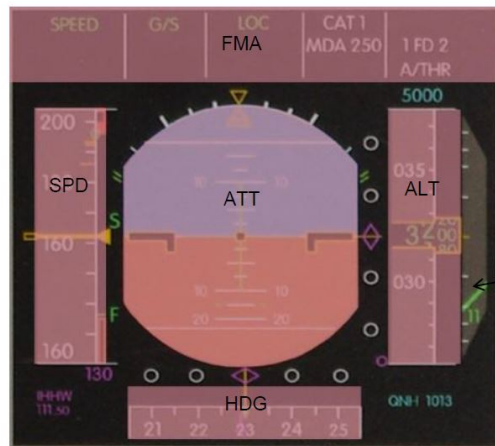
# Format of the "raw" data

Index	UseCase	Area	StartFrame	StartTime	EndFrame	EndTime	Duration
1	Anfang - Ende	MCDU	334	00:00:13.360	340	00:00:13.600	00:00:00.240
2	Anfang - Ende	MCDU	811	00:00:32.440	844	00:00:33.760	00:00:01.320
3	Anfang - Ende	MCDU	848	00:00:33.920	867	00:00:34.680	00:00:00.760
4	Anfang - Ende	MCDU	891	00:00:35.640	925	00:00:37.000	00:00:01.360
5	Anfang - Ende	MCDU	967	00:00:38.680	975	00:00:39.000	00:00:00.320
6	Anfang - Ende	MCDU	986	00:00:39.440	1016	00:00:40.640	00:00:01.200

...

Data sorted by "UseCase" (phase of flight) and "Area"
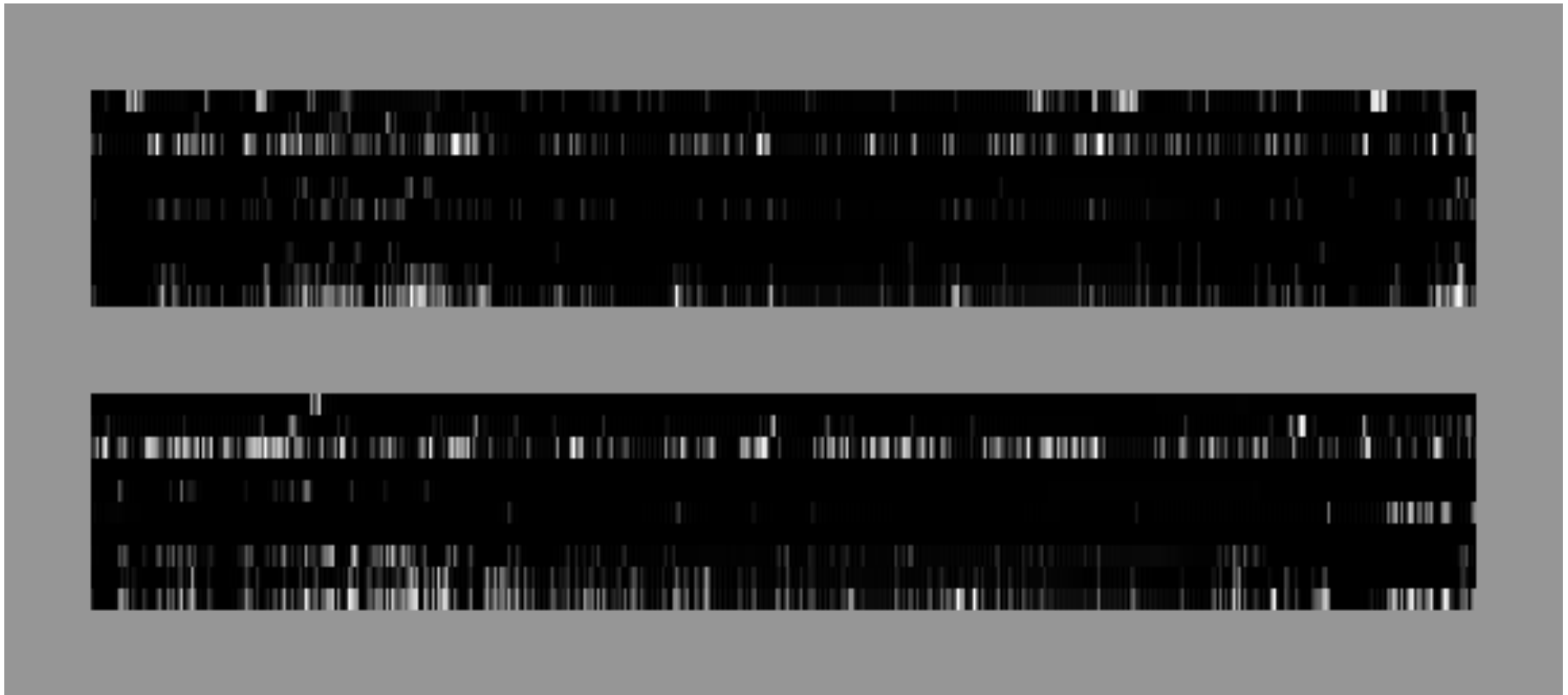
Converting the data back to a time series
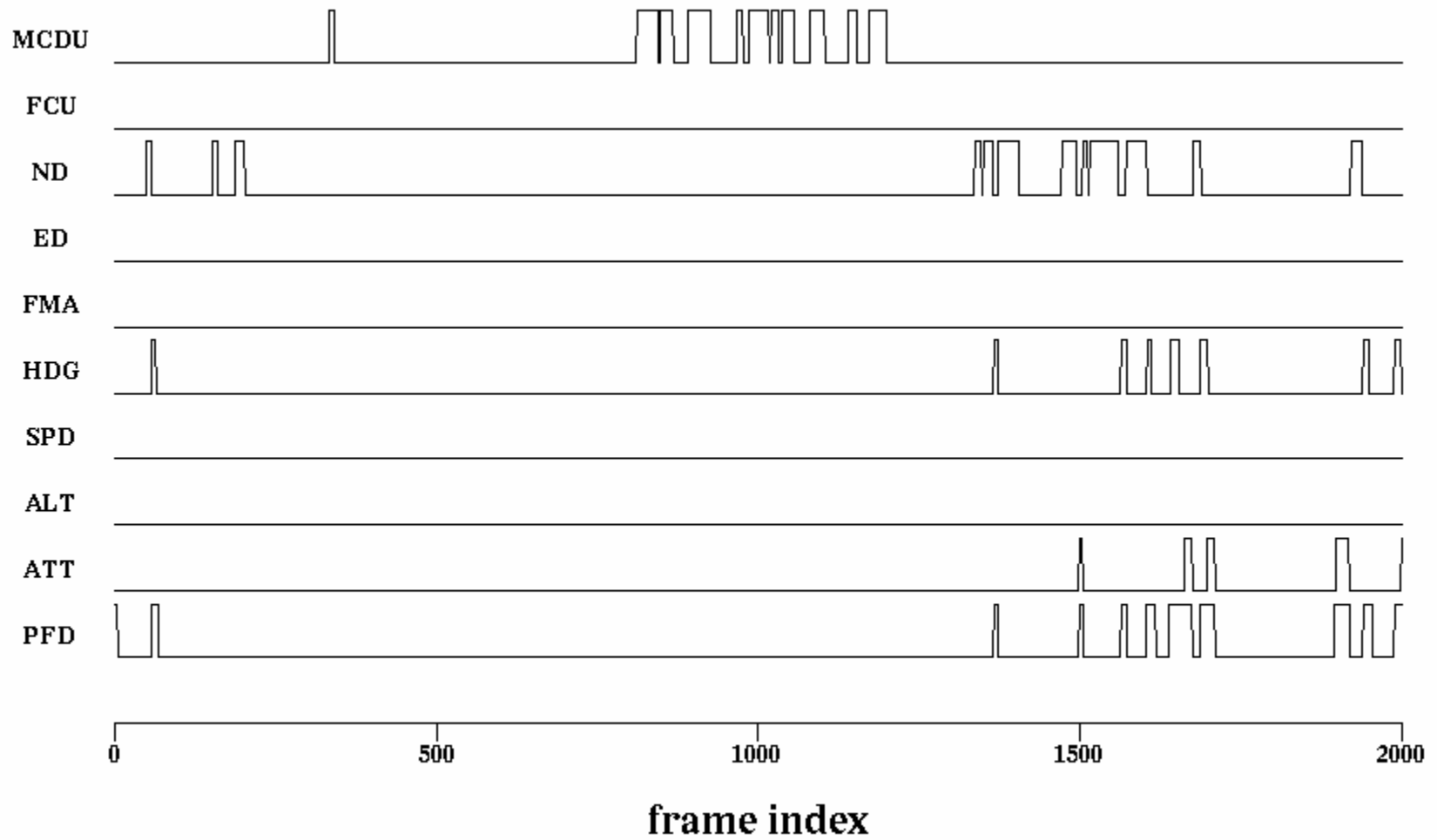
A graphical representation
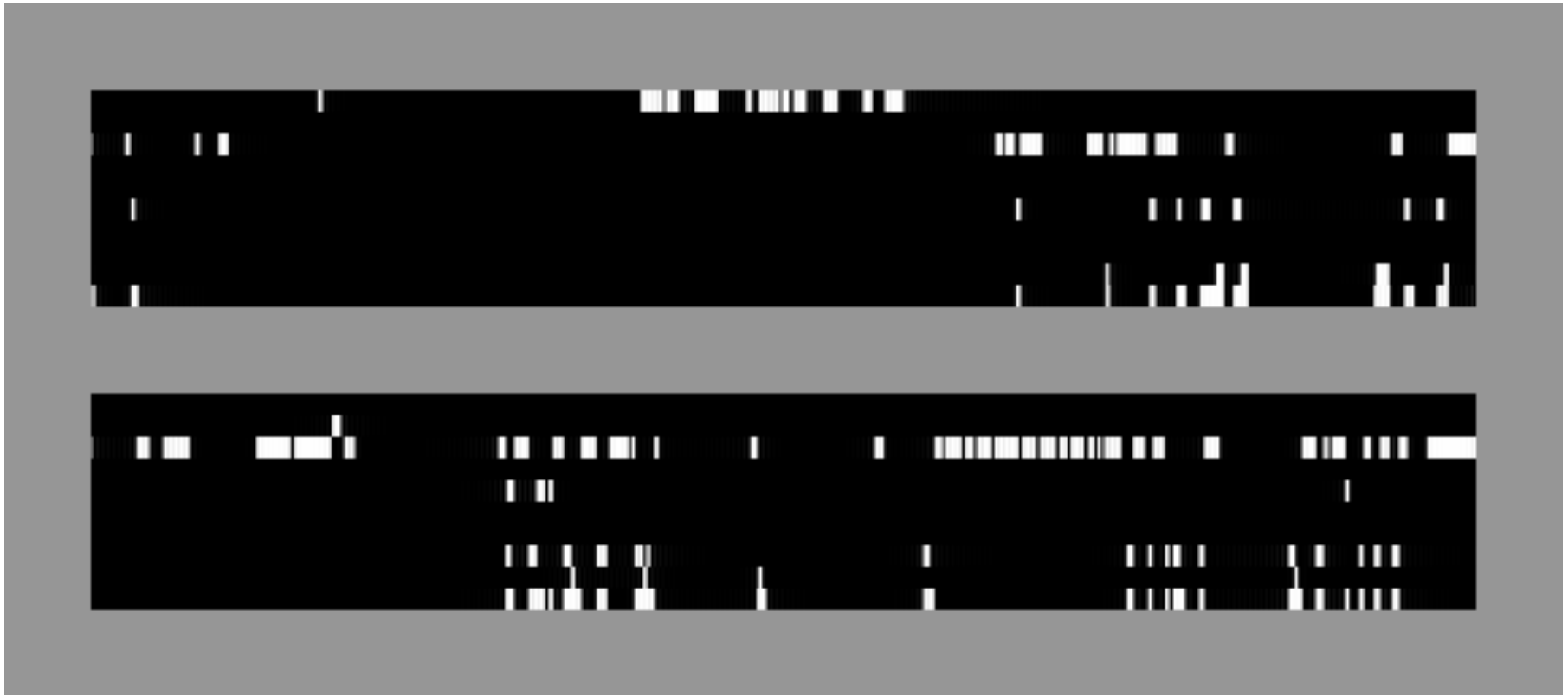
82 seconds
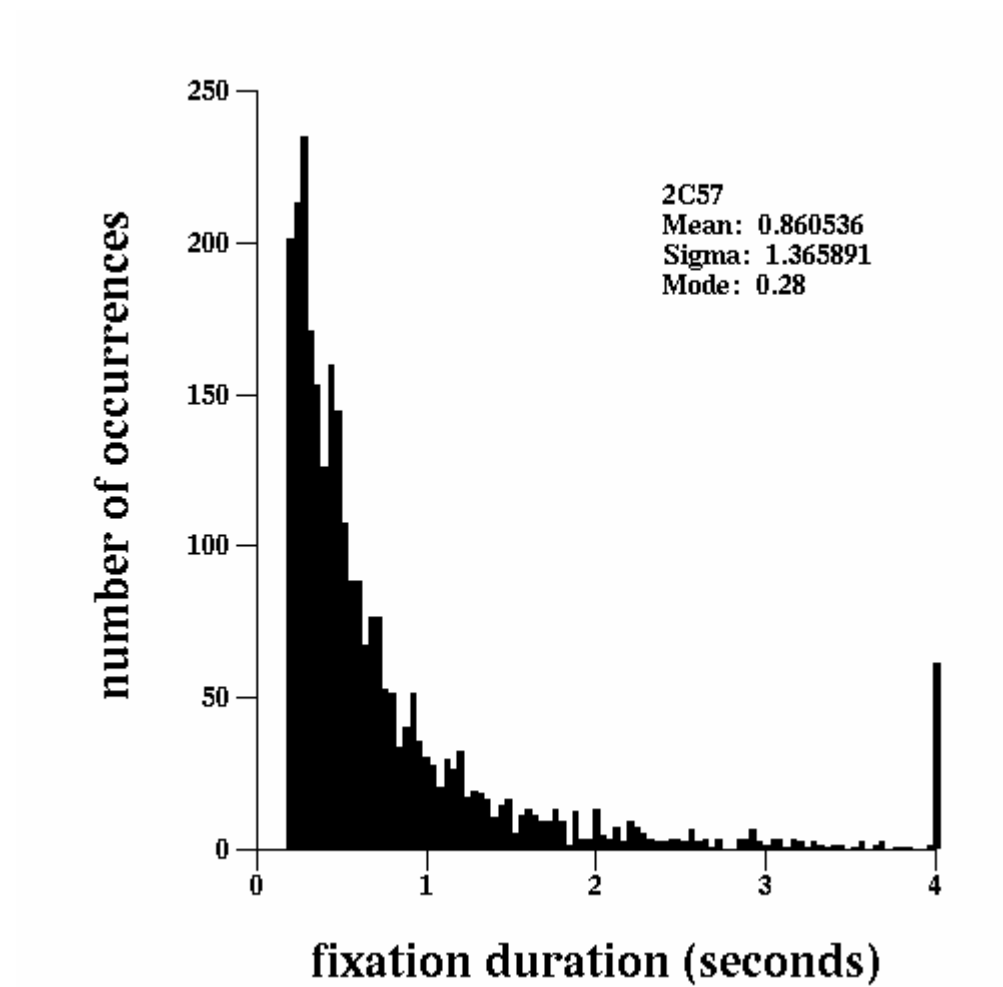
A graphical representation

21.8 minutes

Chi-square approach (thanks to A. Ahumada)

- Null hypothesis: observations drawn from same distribution

- Choose time window

- Convert from time series to fixation counts

    (using average fixation duration)

Observed fixation durations

A 21 second example

	2F57	2C57	total	frac.	expected	
PFD	12	13	25	0.338	8.108	16.892
ATT	1	2	3	0.041	0.973	2.027
ALT	3	6	9	0.122	2.919	6.081
HDG	3	1	4	0.054	1.297	2.703
FMA	4	2	6	0.081	1.946	4.054
ND	0	22	22	0.297	7.135	14.865
SP	1	0	1	0.014	0.324	0.676
Wind	0	4	4	0.054	1.297	2.703
total	24	50	74			

$$s = \sum_i \frac{(o_i - e_i)^2}{e_i} = 23.85 \qquad p = 0.0012$$

A Markov model of fixation sequences

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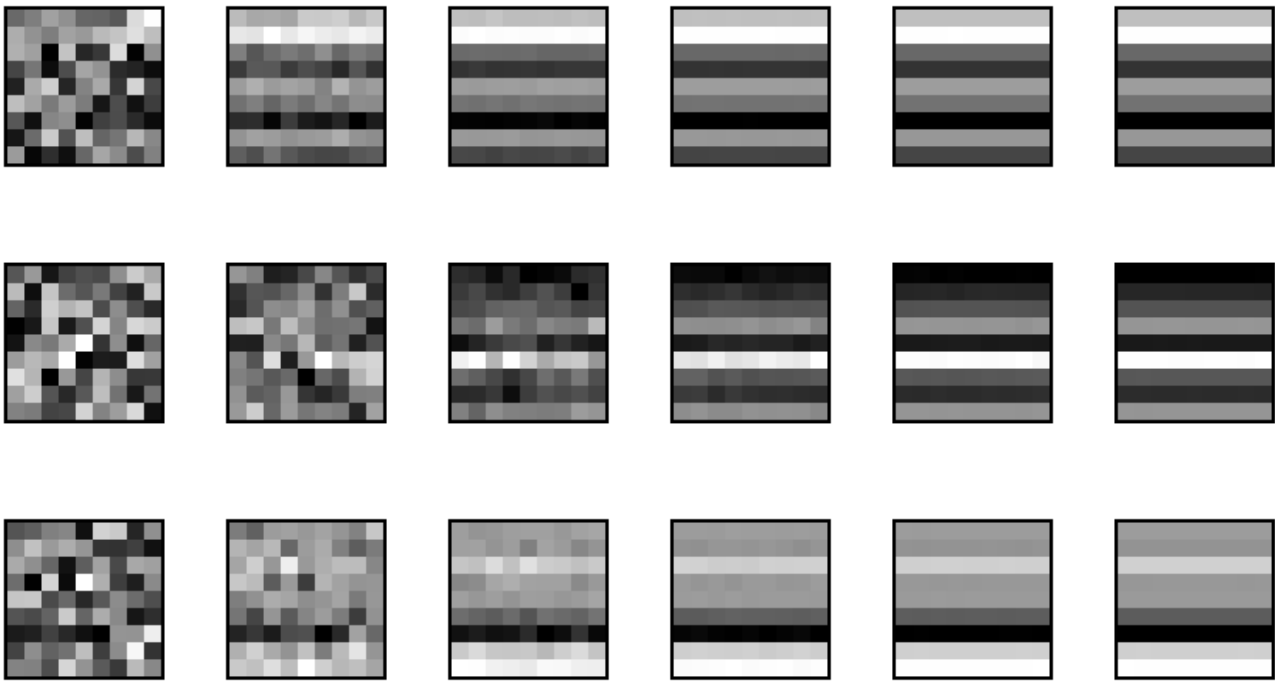- Probability of next state depends only on current state

$$P(\ s(t+1) = i \mid s(t) = j\ ) = m_{ij}$$

$$P(\ s(t+2) = i \mid s(t) = j\ ) = \sum_{k=1}^{N} m_{ik} m_{kj}$$

Example Markov models

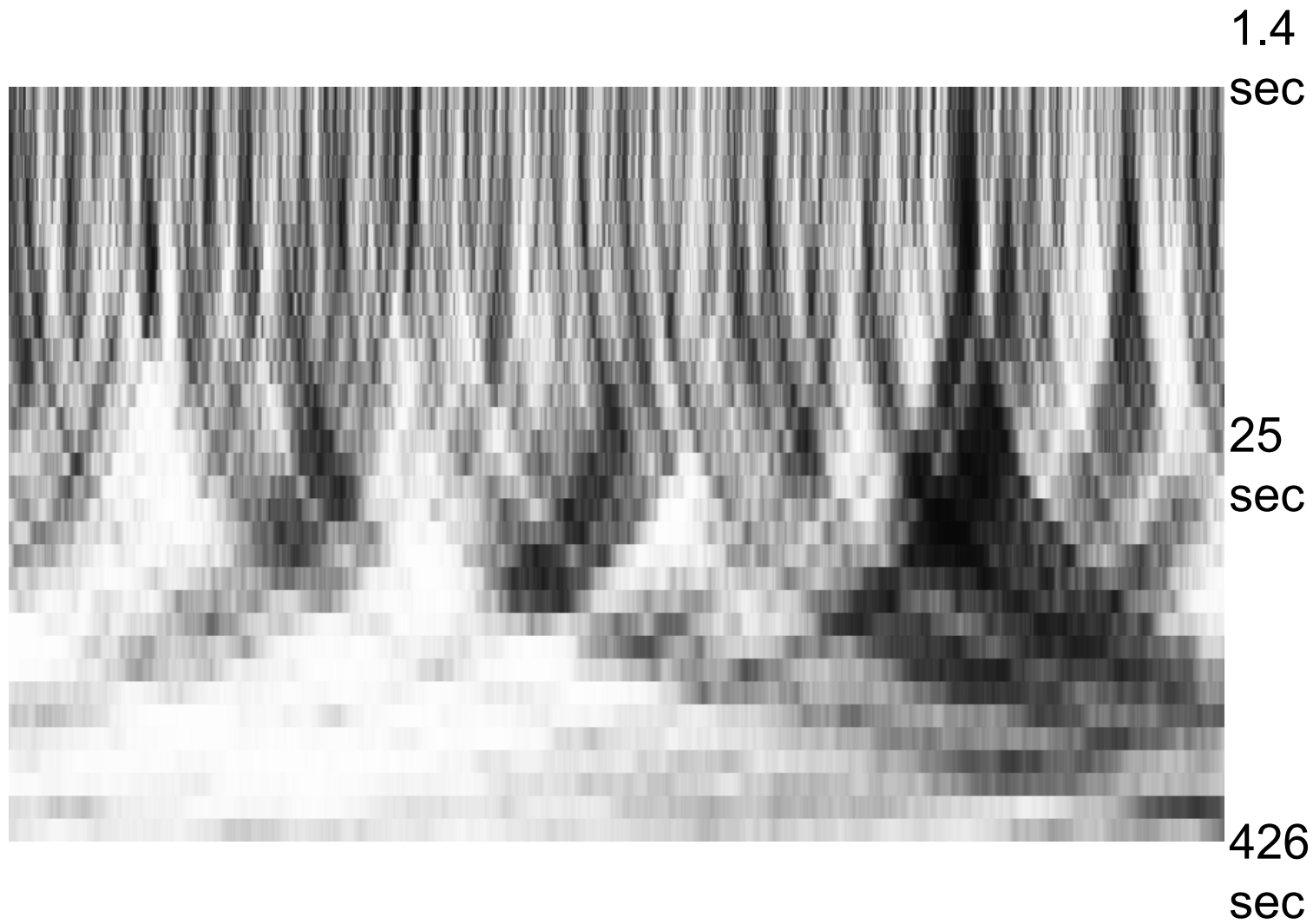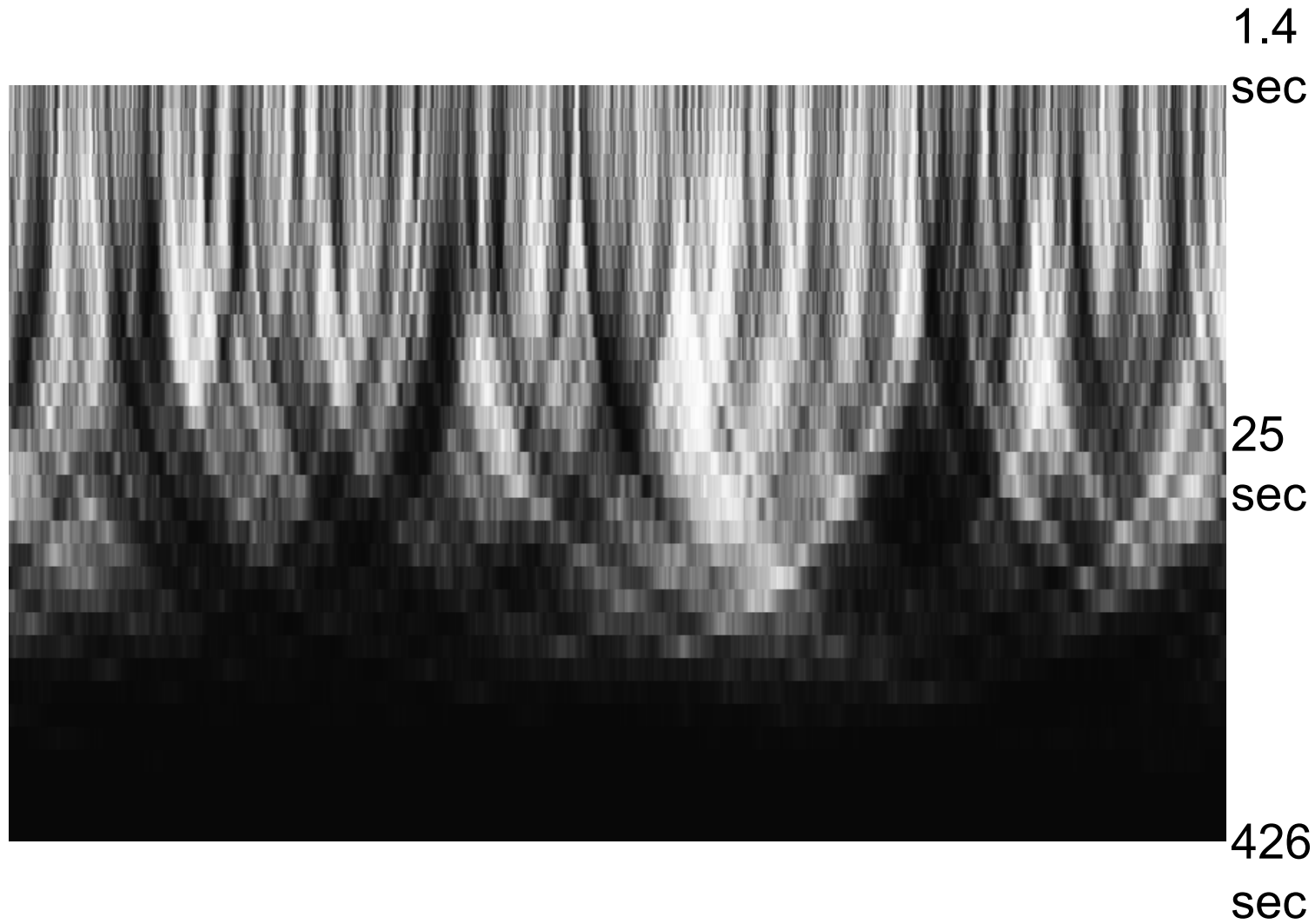$$M \qquad M^2 \qquad M^3 \qquad M^4 \qquad M^5 \qquad M^6$$

Synthetic data experiment details

- 10 randomly generated activities

- 2 sample records for each activity
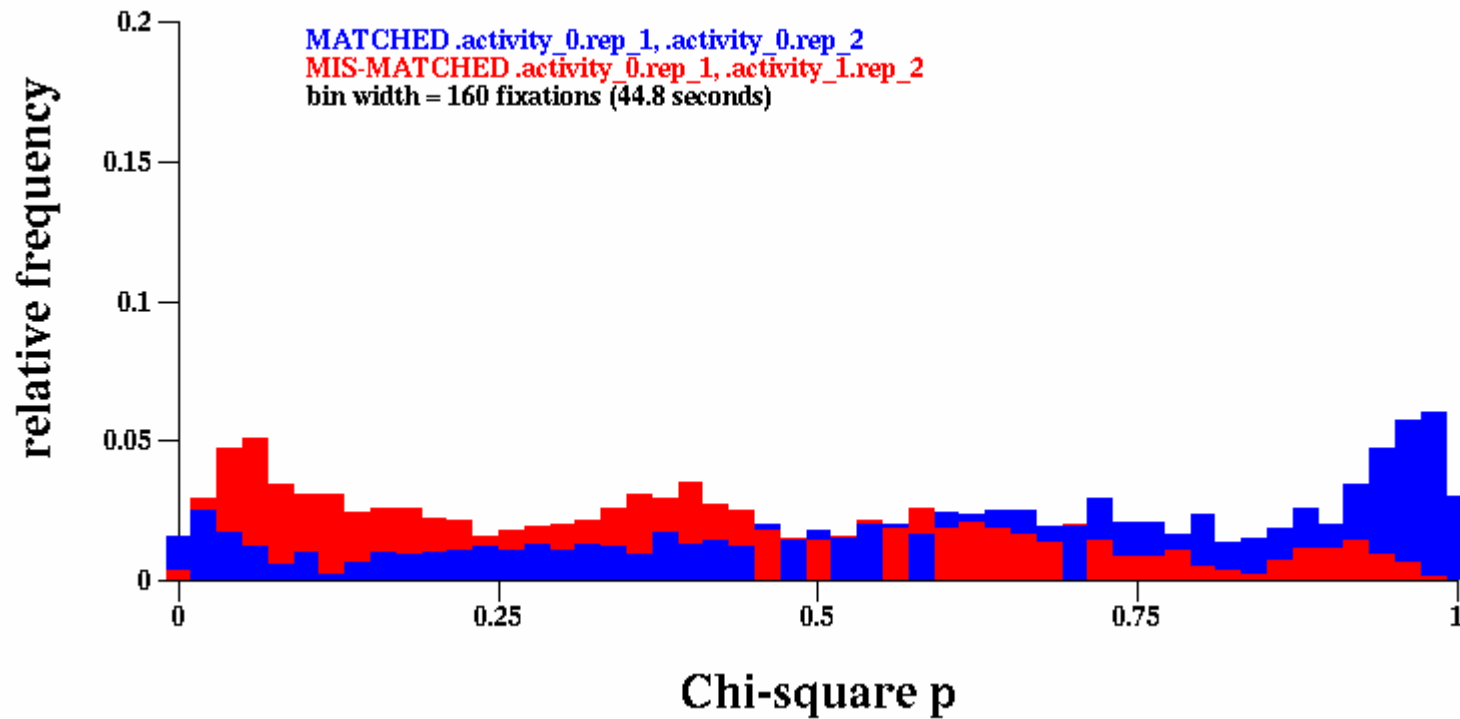
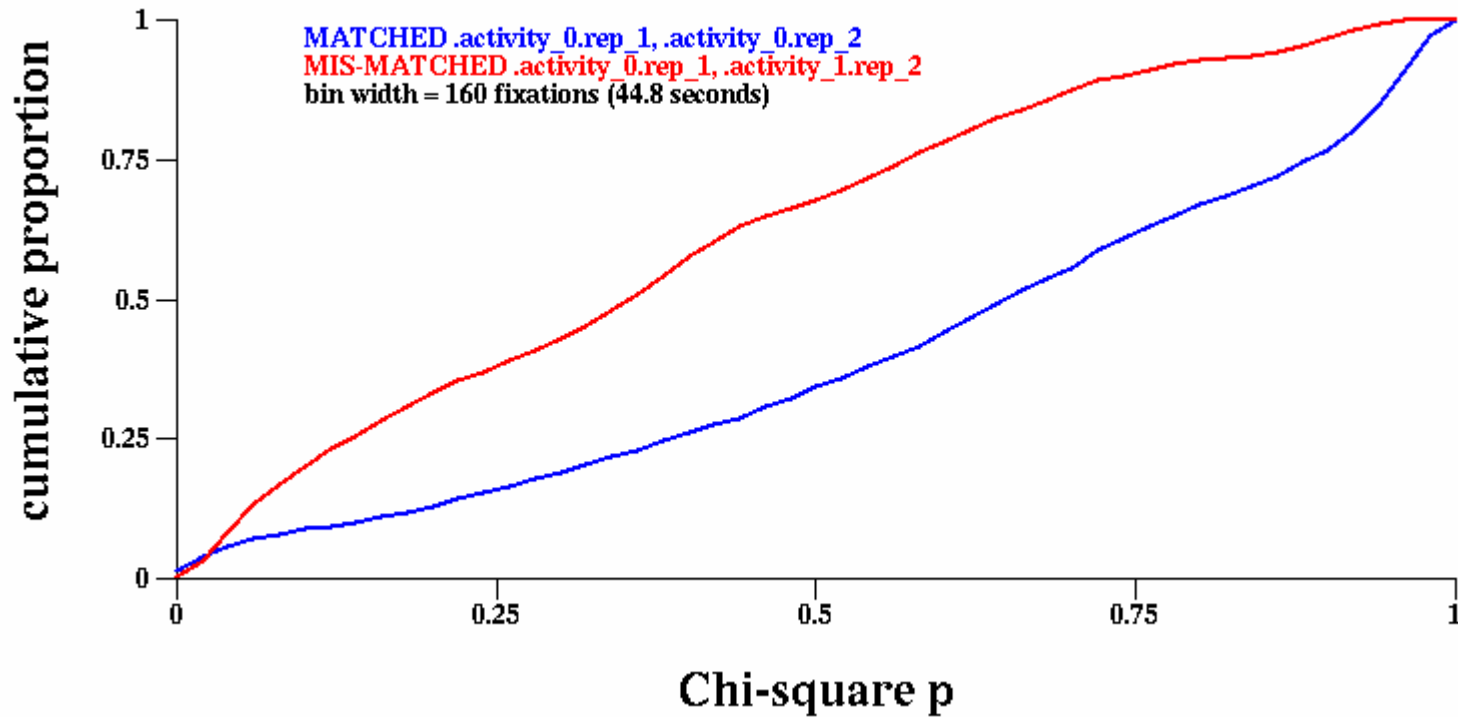- Compare statistics of matched/unmatched pairs
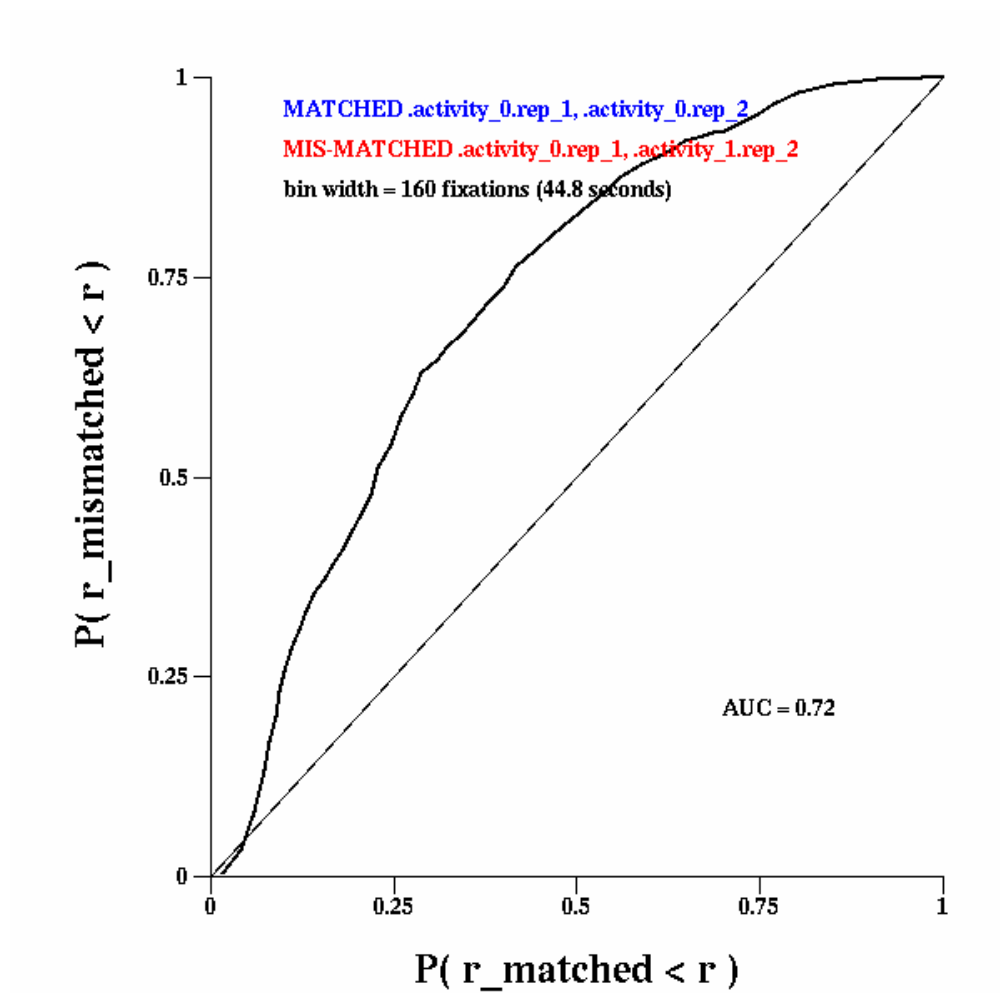
A scale-space image of Chi-squared p

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1.4 sec

25 sec

426 sec

A scale-space image of Chi-squared p

1.4 sec

25 sec

426 sec

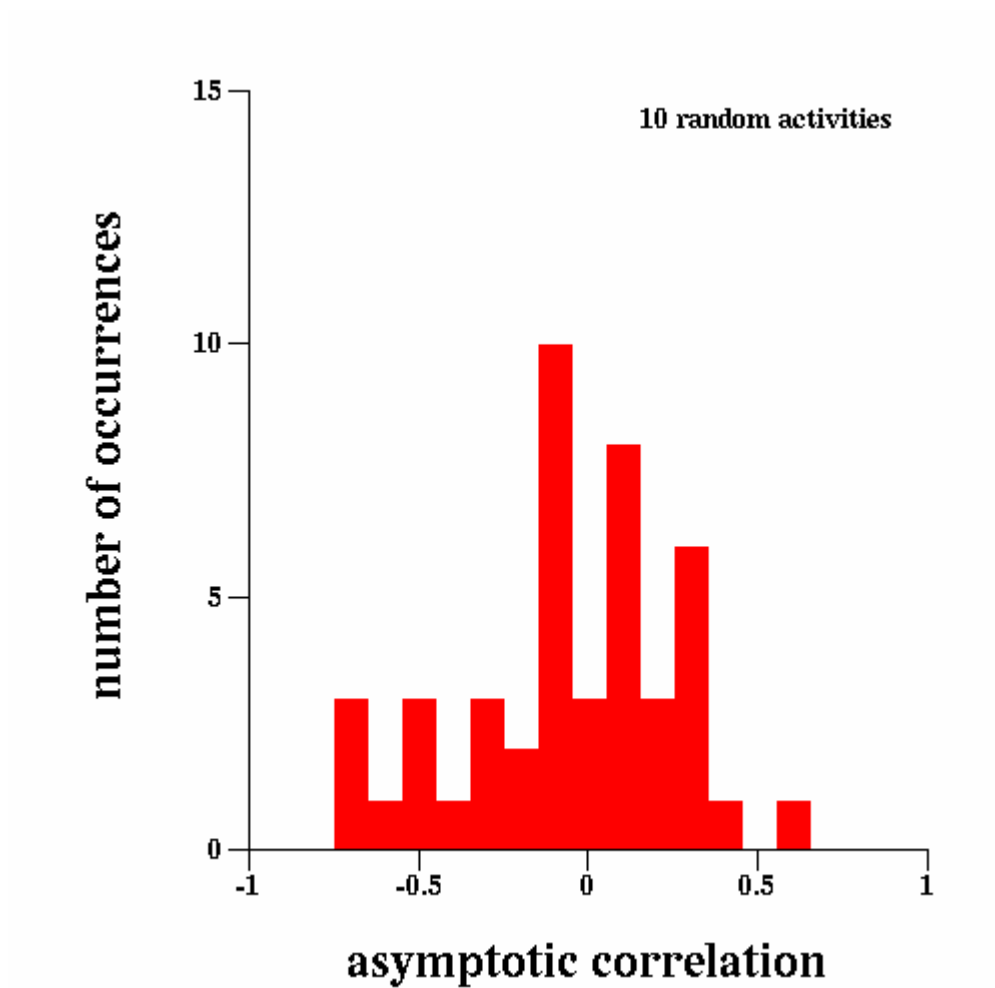# Histograms of p-values

Cumulative distributions of p-values
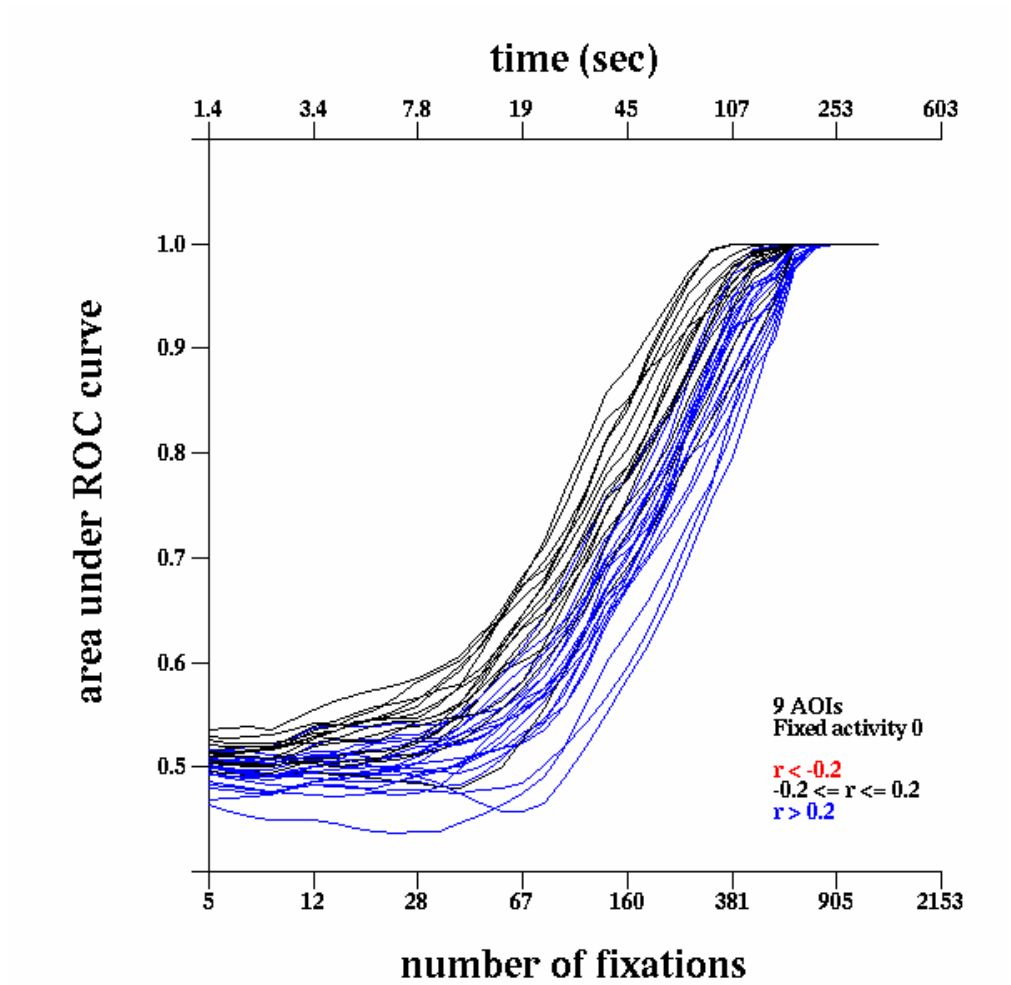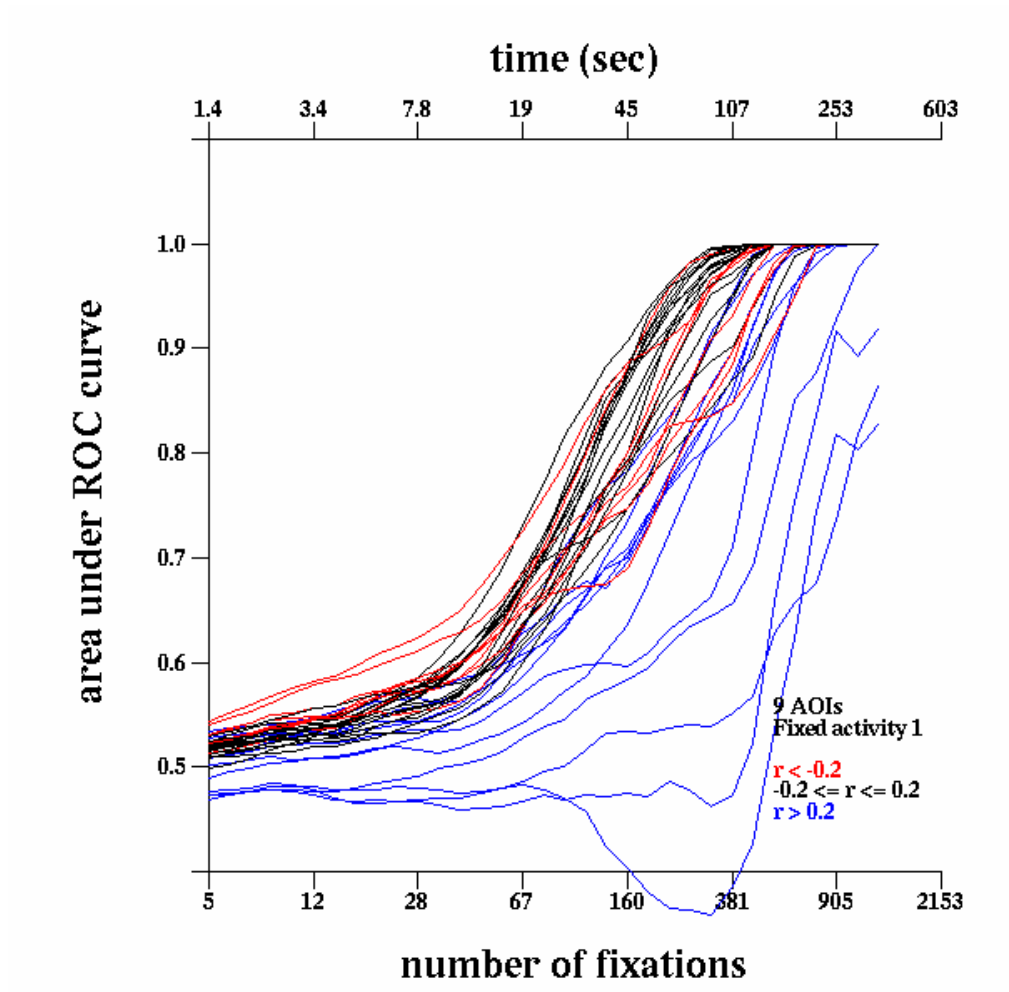
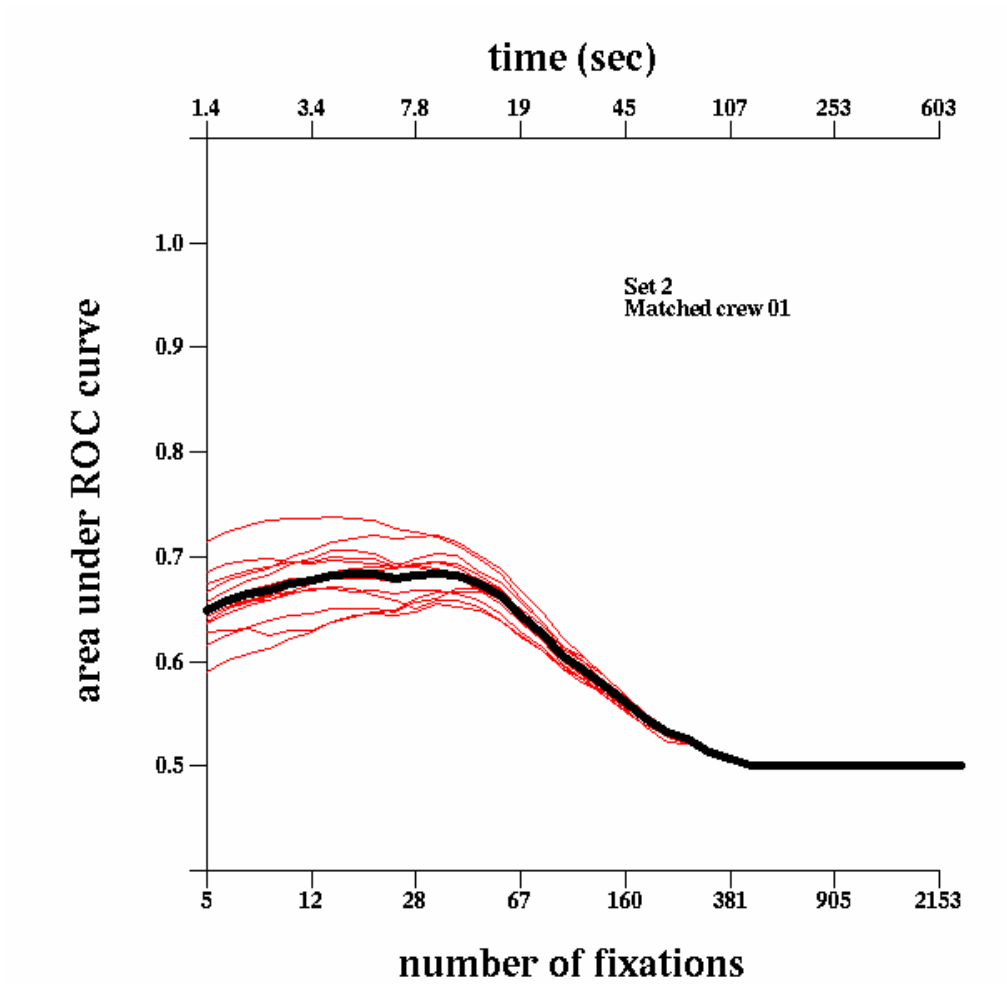# An ROC curve

AUC vs. scale
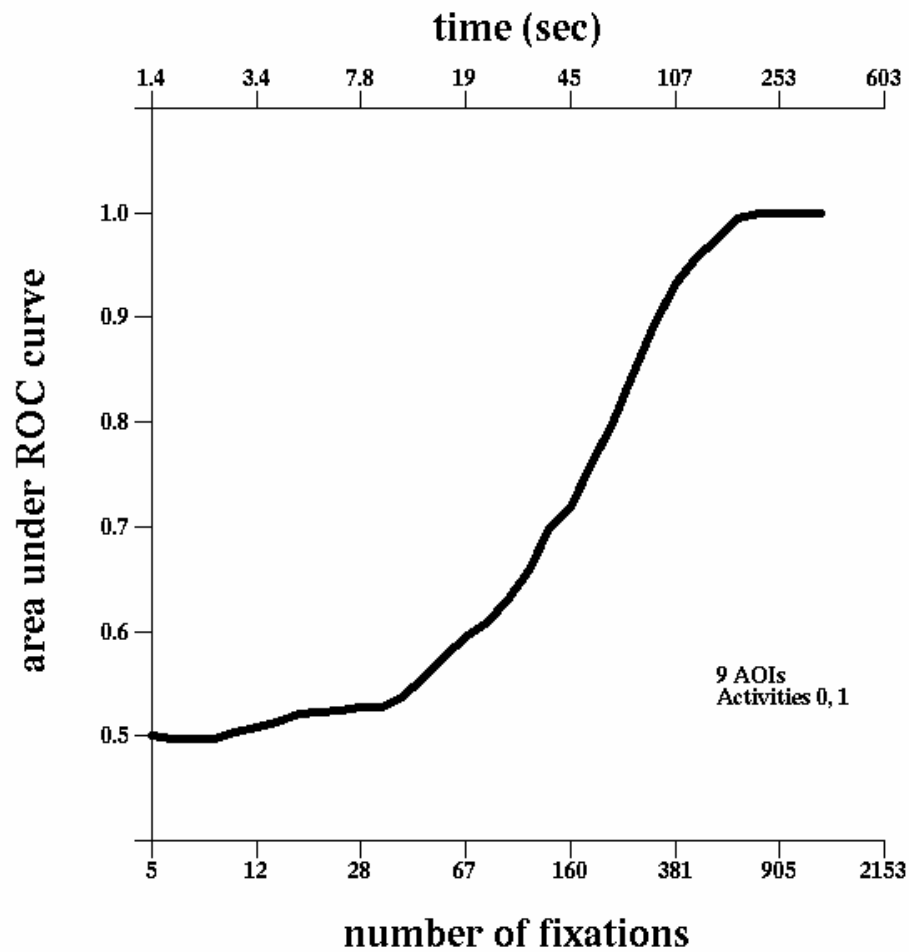
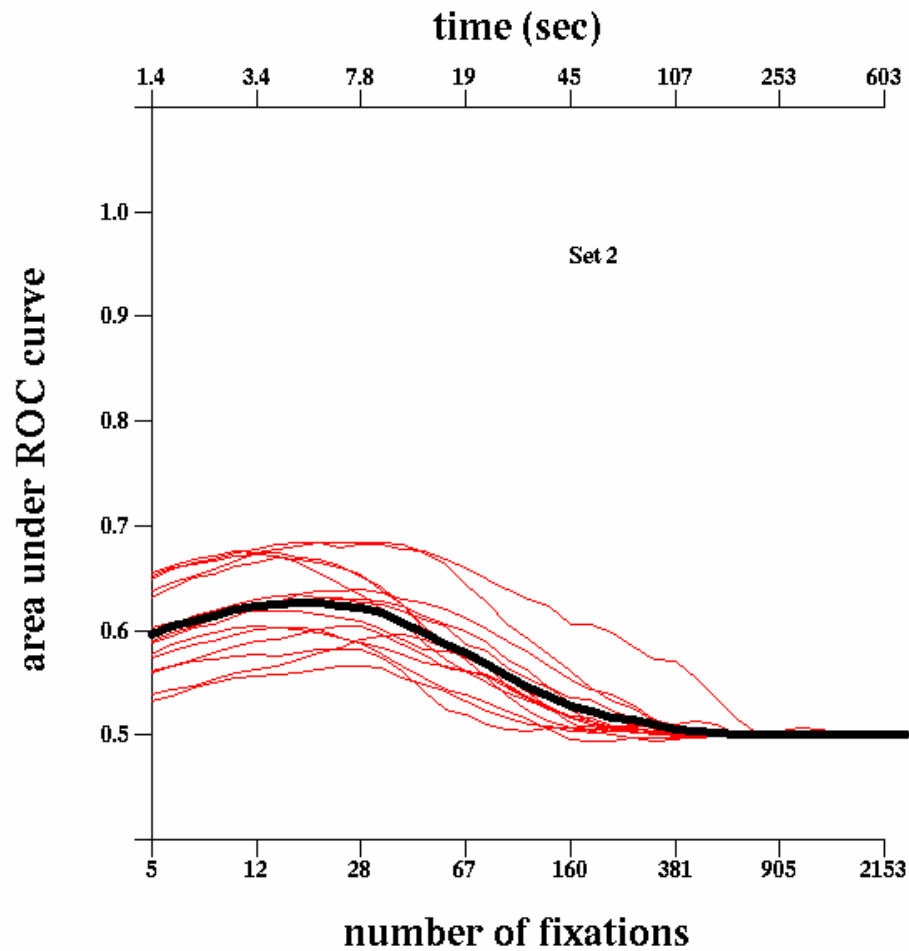# Between-activity correlations

AUC vs. scale

AUC vs. scale
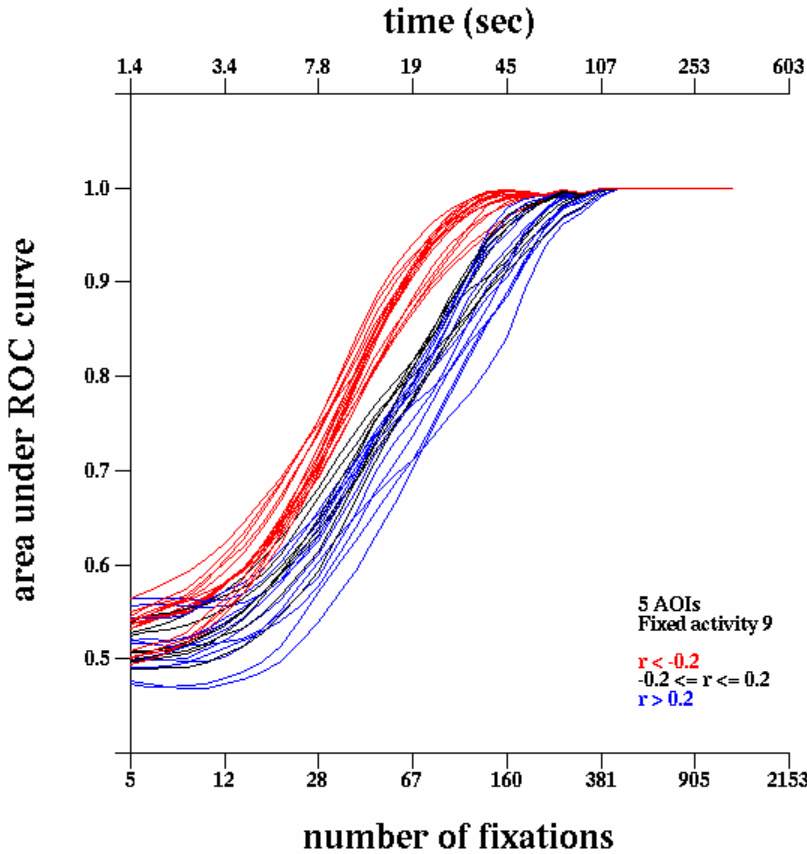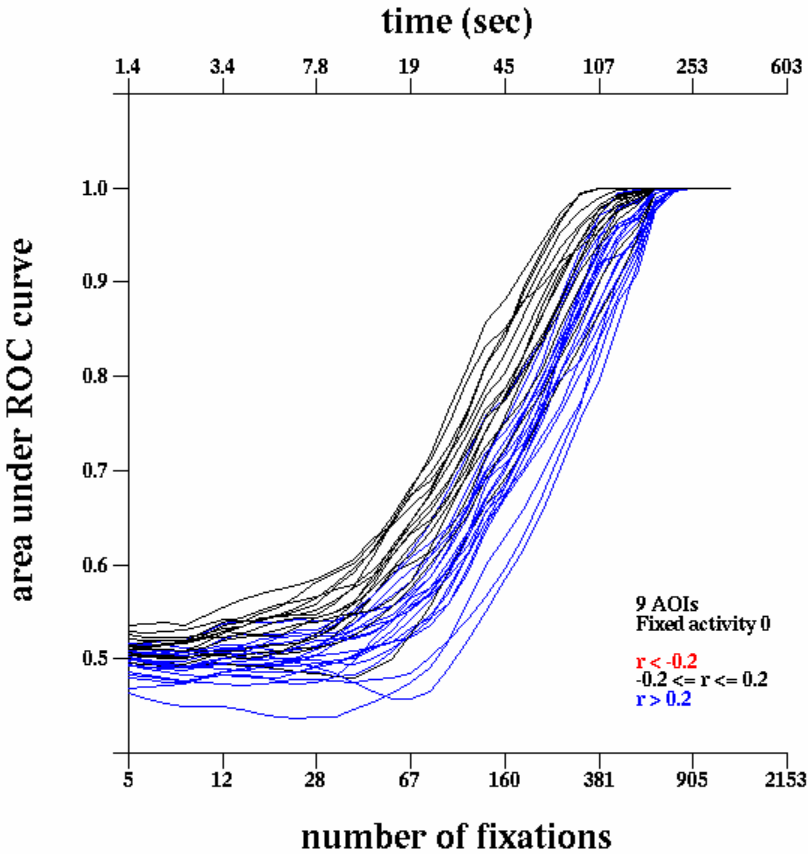
Human data

Average of all crews

What to make of the human data?

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- Very low p values at long time windows

- Suggests pilot and first officer average behaviors differ

- Suggests simple Markov model is a poor description

AUC vs. scale

Conclusions

- Chi-square statistics can be used to compare scan paths

- Results suggest that shared attention in the cockpit
  is limited to intervals < 1 minute

- Human activities in the cockpit are poorly described
  by random Markov processes

- Real activities are likely to involve small numbers of AOIs

- THANK YOU!