

On the nature of Rhythm, Time & Memory

Auditory Group (PI: Tim Griffiths)

Wellcome Trust Centre for Neuroimaging

<http://www.fil.ion.ucl.ac.uk/~steki>

Outline

- **Memory for time**
- **Models of working memory**
- **Rhythm and memory for time**
- **Discussion**

I. Memory for time

Working memory for time



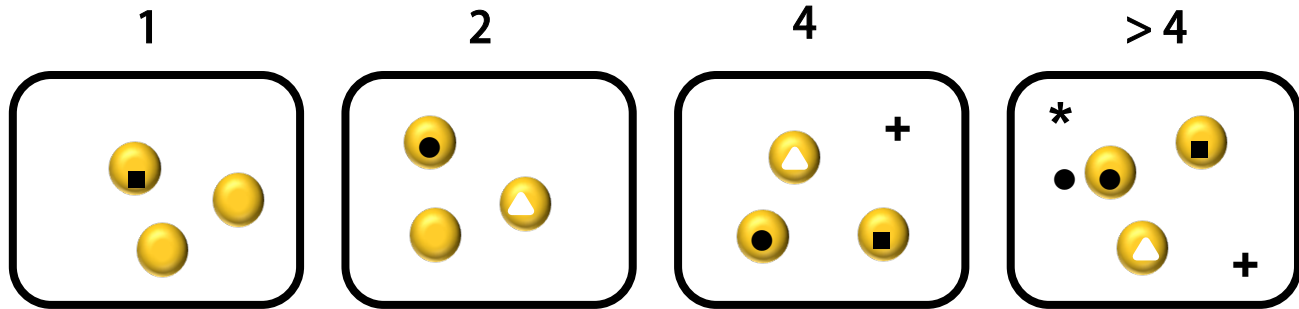
- discrimination task
- binary/categorical measure
- no variation of memory load
- isolated intervals; no temporal context like in speech and music

II. Models of Working Memory

Models of Working Memory

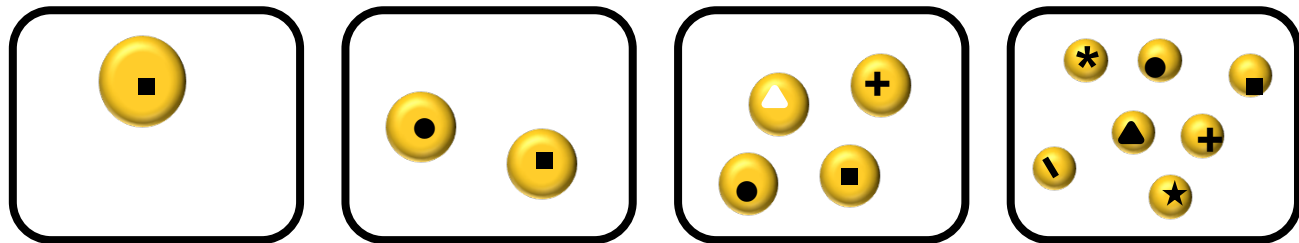
No. of items

**Slot
model**



Luck & Vogel (1997) *Nature*

**Resource
model**

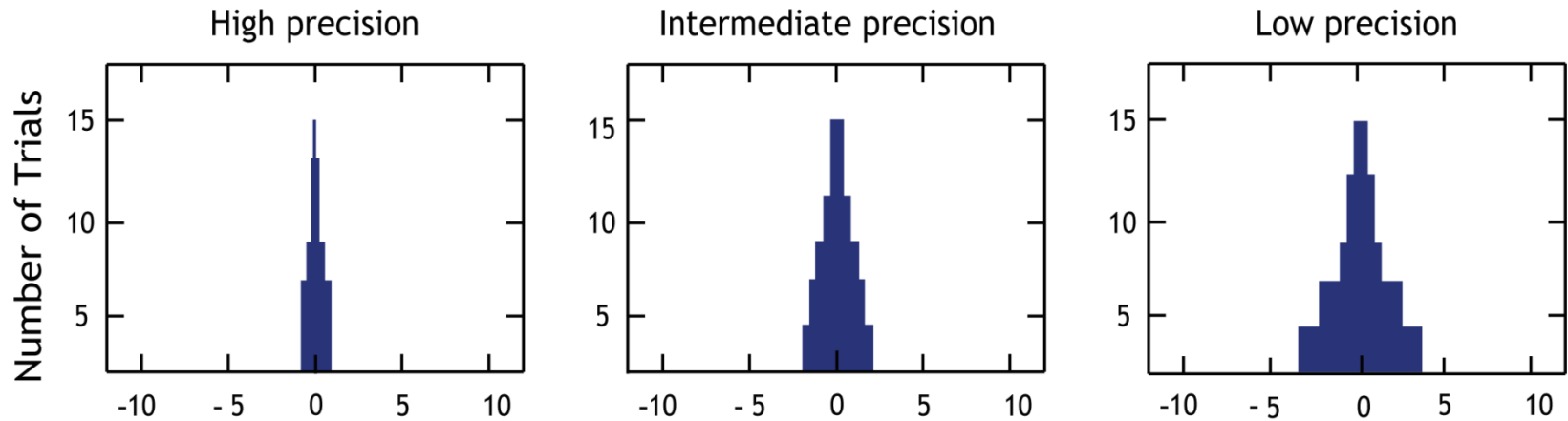


Bays & Husain (2008) *Science*
Bays et al. (2009) *J Vision*
Kumar et al. (2012) *Cog Neurosci*

Precision

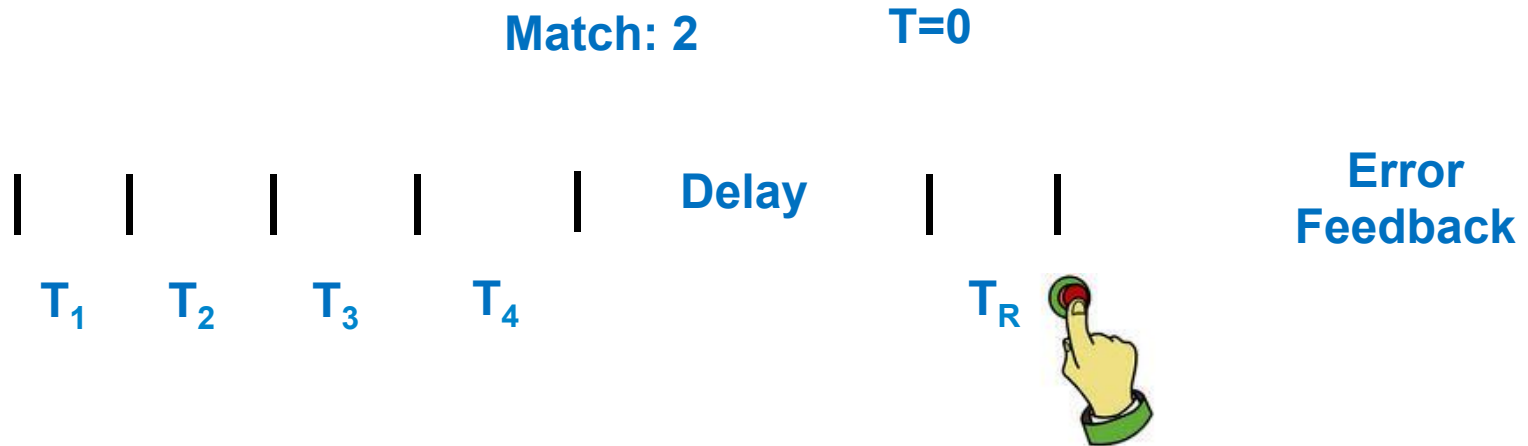
Precision: a continuous index that quantifies the fidelity of memory

Precision = 1 / standard deviation



III. Rhythm and Memory for Time

Paradigm



Perceptual time matching response

$$= T_R$$

Error response

$$= T_R - T_{\text{probe}}$$

Precision of WM for time

$$= 1/\text{STD} (T_R - T_{\text{probe}})$$

Experiments

1: 'SUB'

- No. of intervals: 4
- IOI: 500-600 ms
- Jitter levels: 5-10%, 20-25%, 35-40%, 50-55%

2: 'SUPRA'

- No. of intervals: 4
- IOI: 1.0 - 1.2 s
- Jitter levels: 5-10%, 20-25%, 35-40%, 50-55%

3: 'WM'

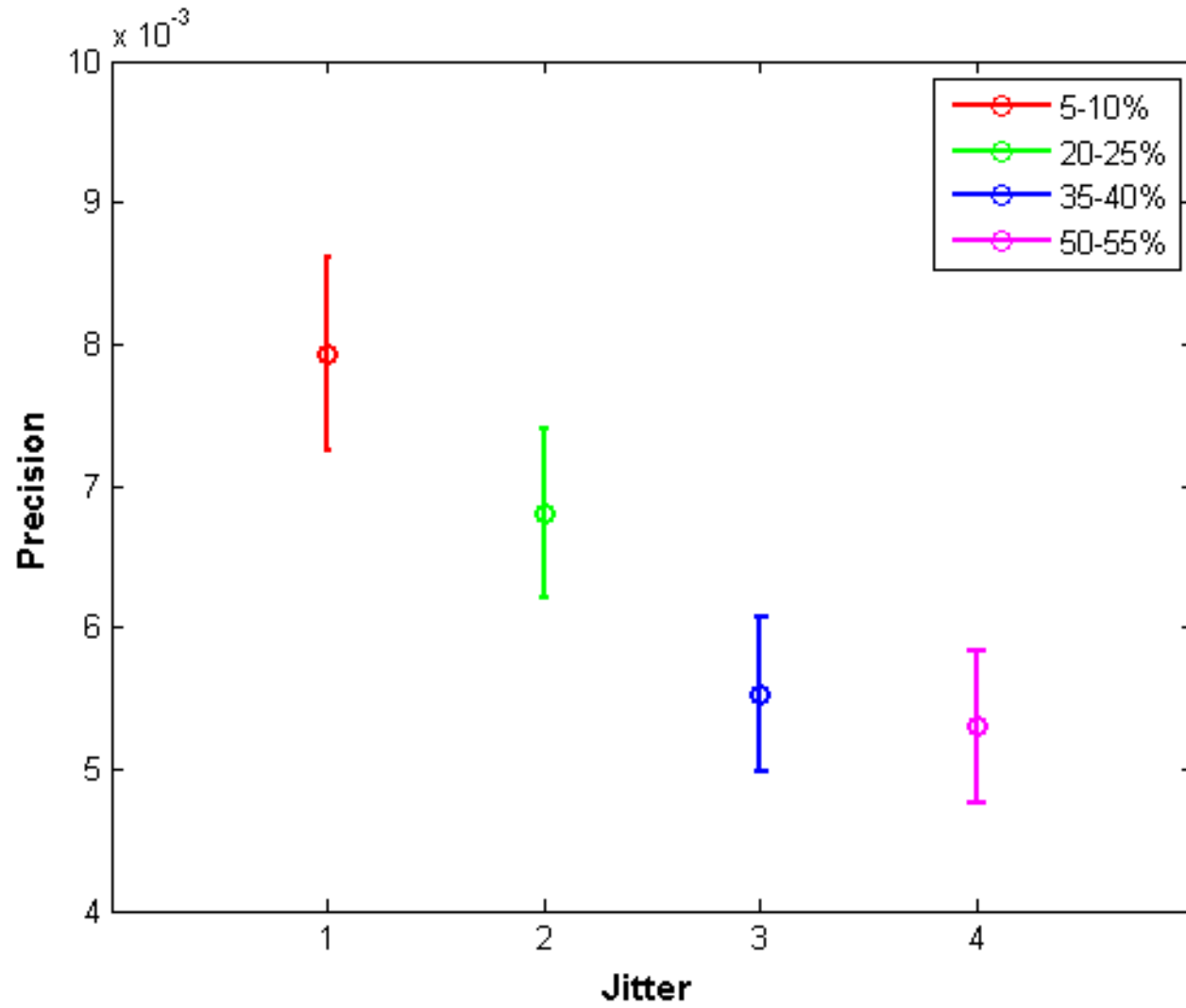
- No. of intervals: 1 - 4
- IOI: 500-600 ms
- Jitter levels: 5-10%, 20-25%, 35-40%, 50-55%

4: 'CUED'

- No. of intervals: 4
- IOI: 500-600 ms
- Jitter levels: 5-10%
- Cue: Valid (56.2%), Invalid (18.8%), Neutral (25%)

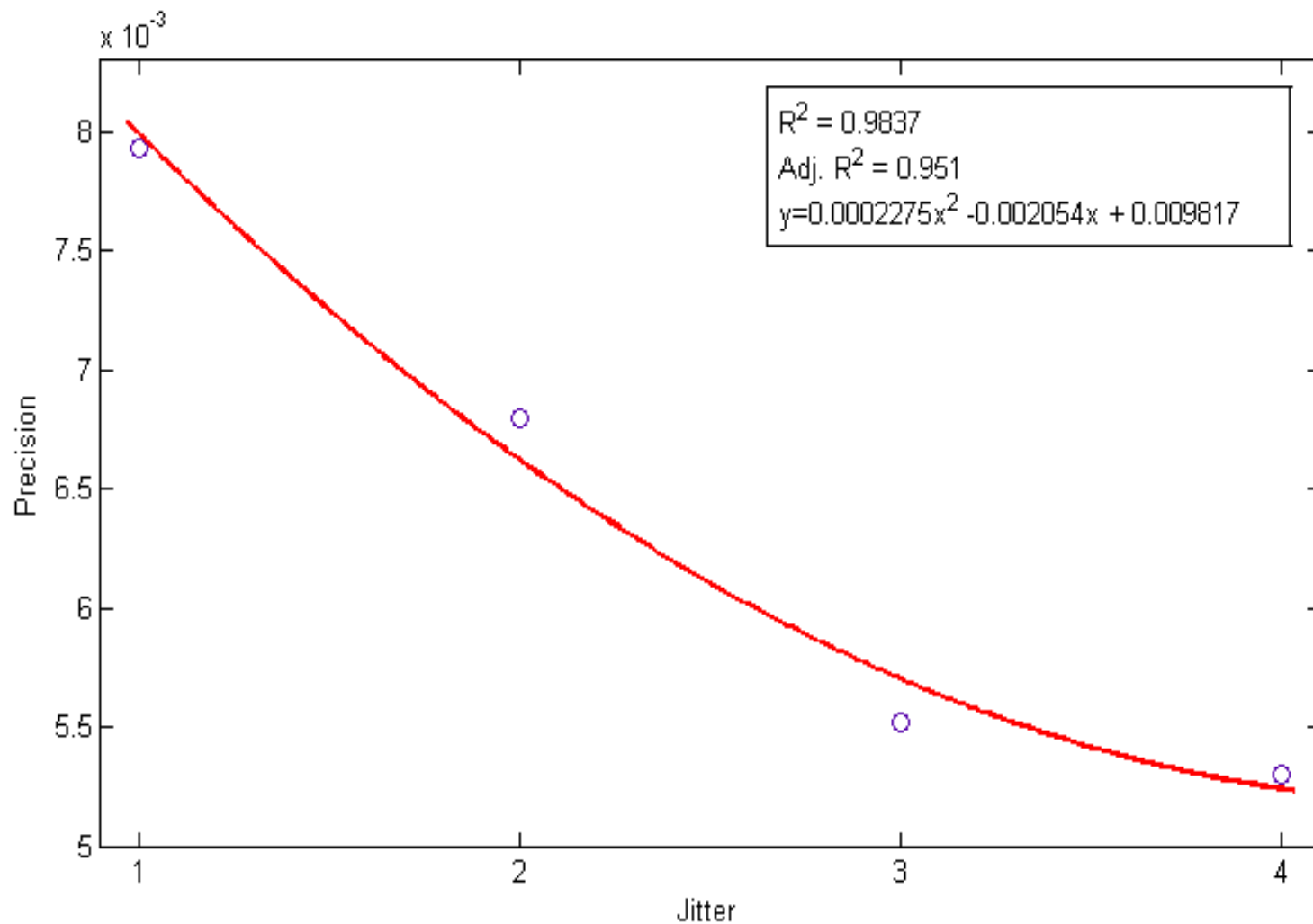
Experiment 1: 'SUB'

Precision vs. Jitter



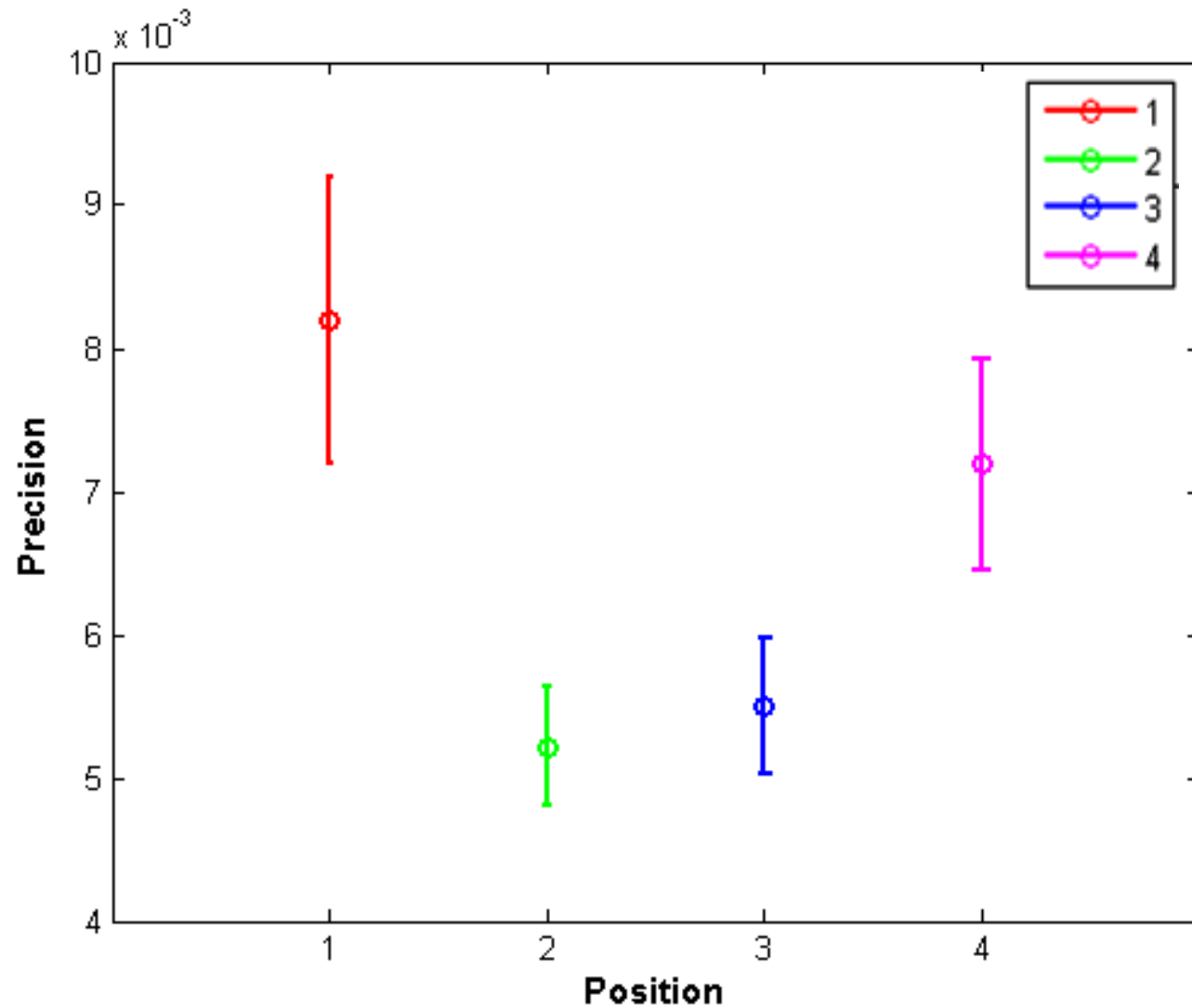
• Main effect of jitter: $p < 0.02$; ($n=10$)

Nonlinear fit



• Quadratic decay

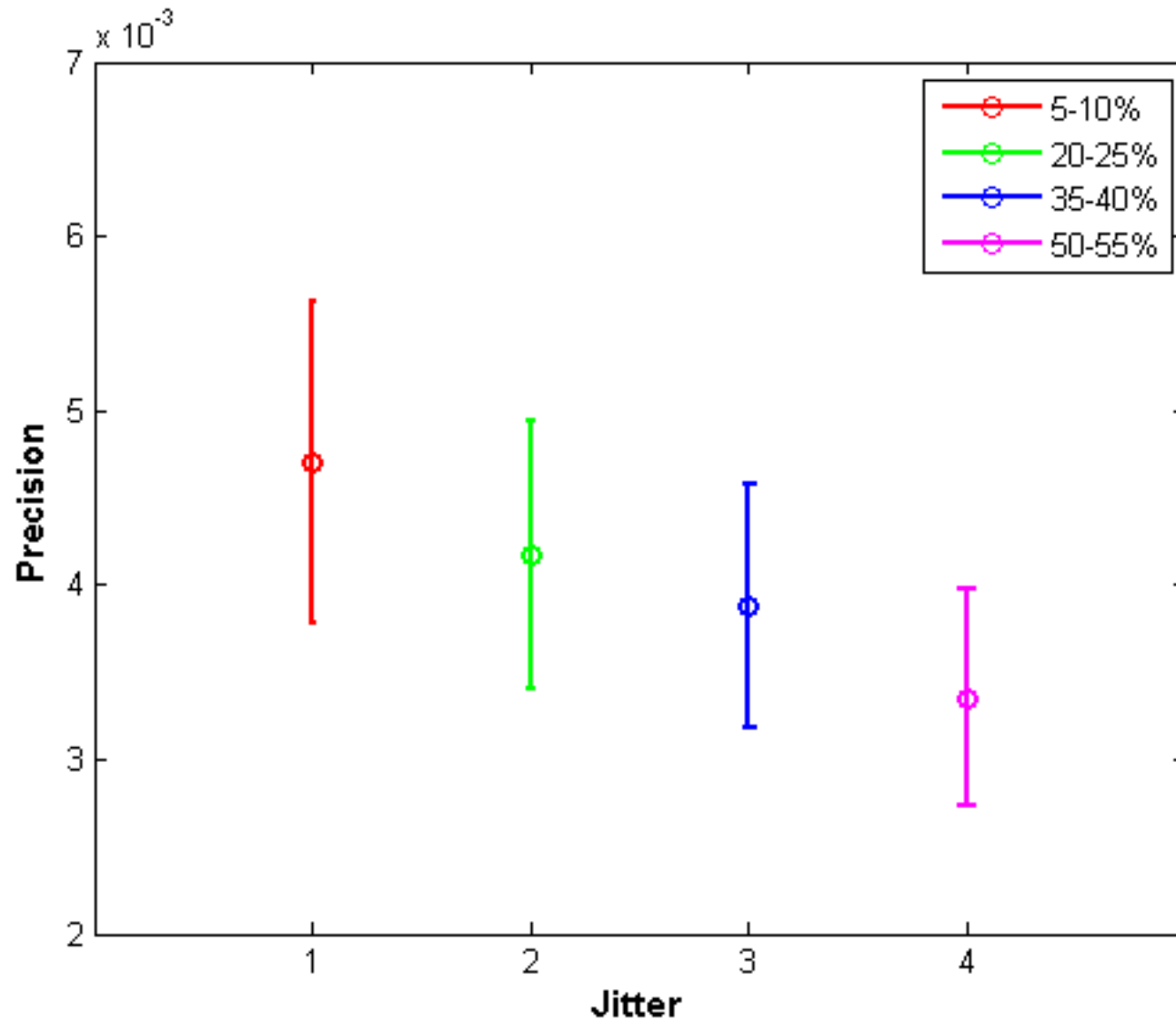
Precision vs. Position



- Primacy and recency effect

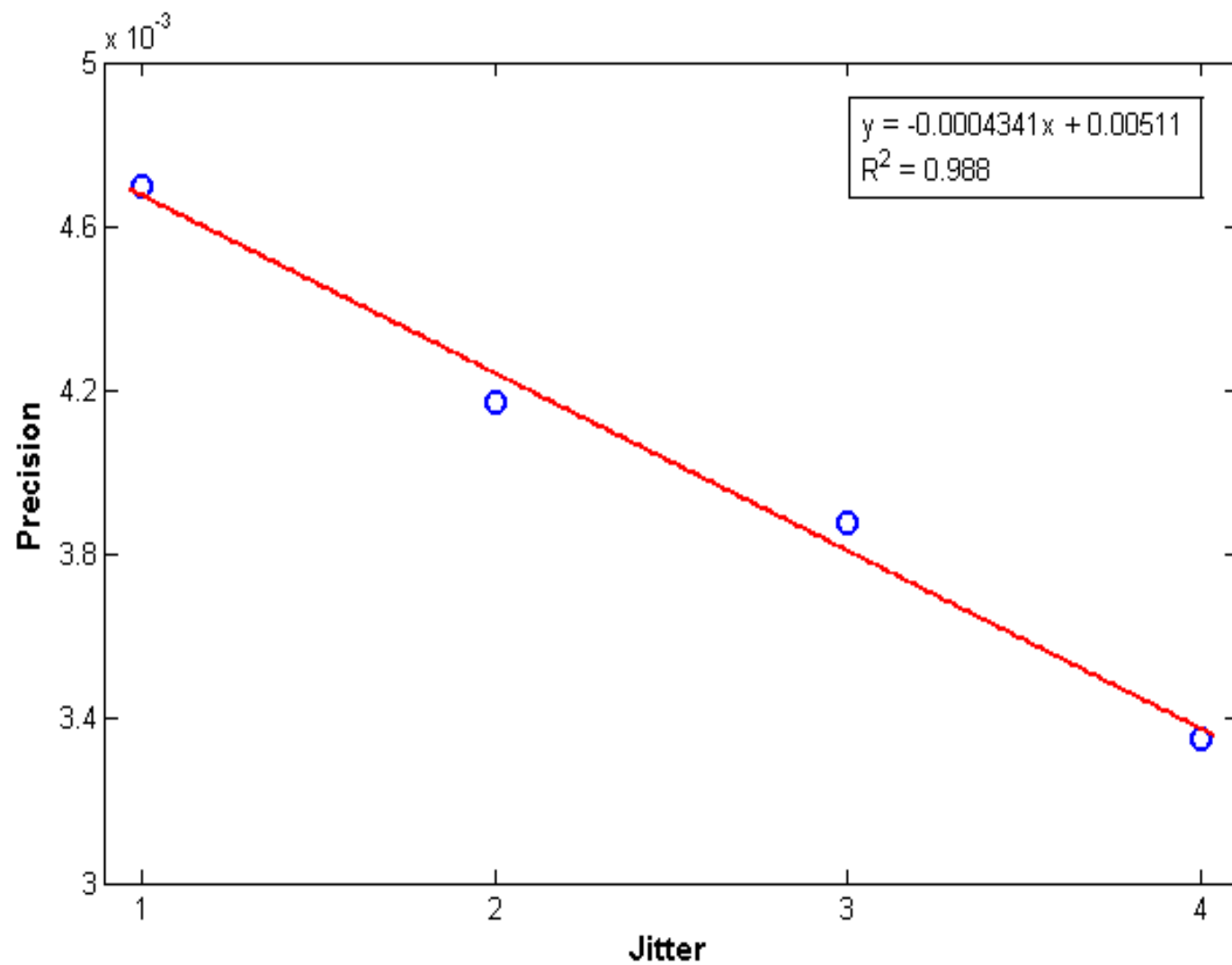
Experiment 2: 'SUPRA'

Precision vs. Jitter



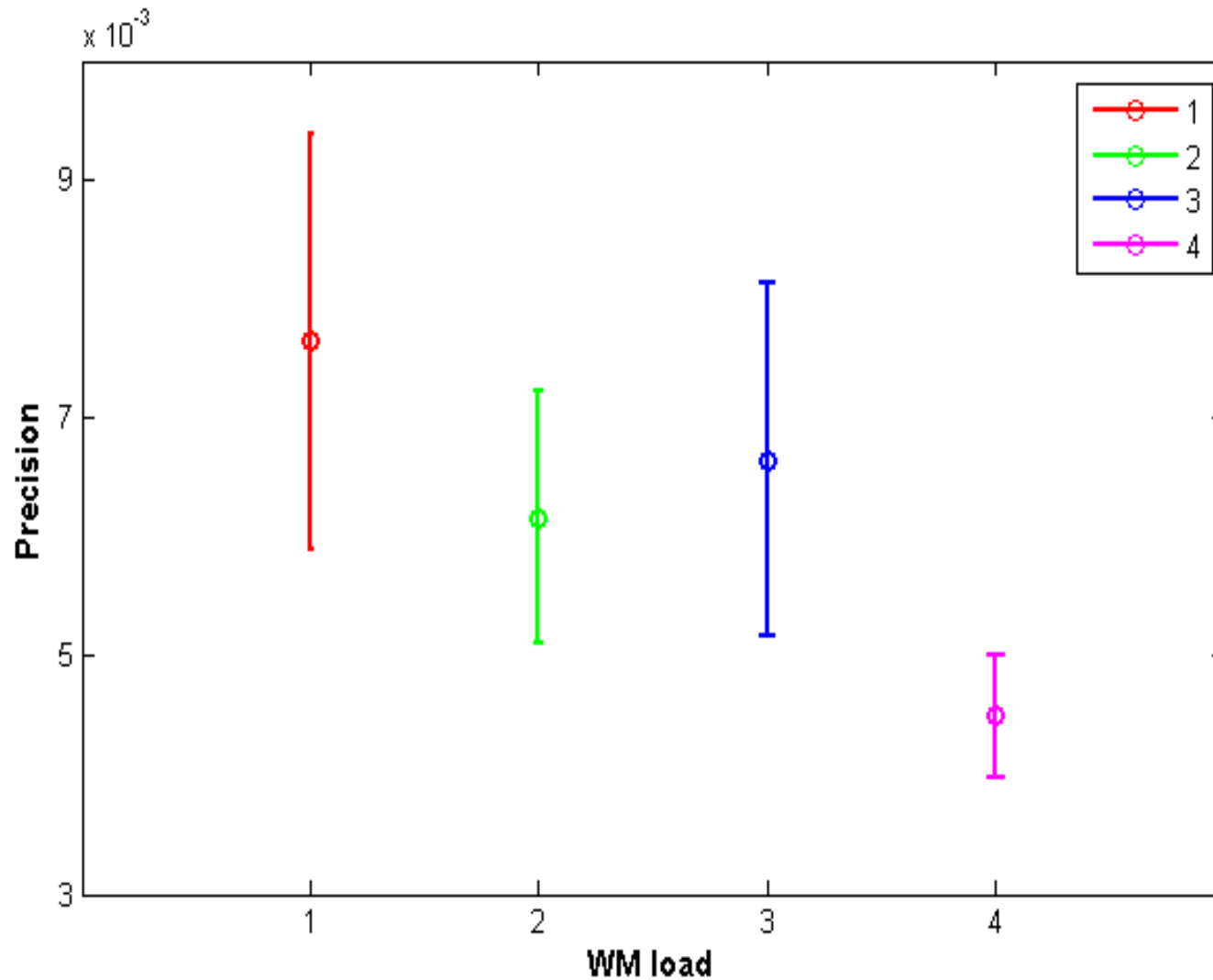
- No significant effect of jitter: $p > 0.5$ ($n=10$)
- Precision ~ 64% lower than in 'SUB'

Linear fit



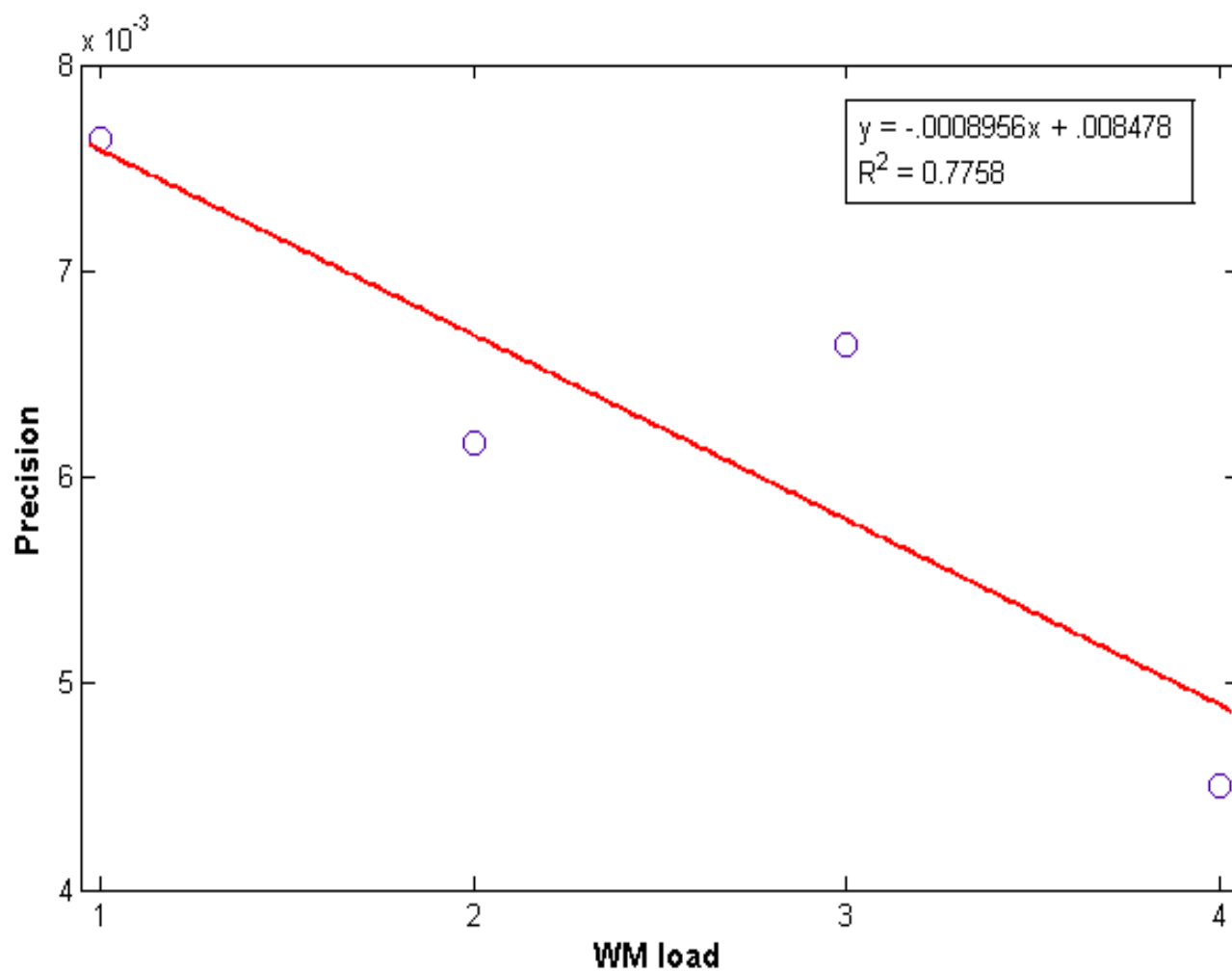
Experiment 3: 'WM'

Precision vs. WM load



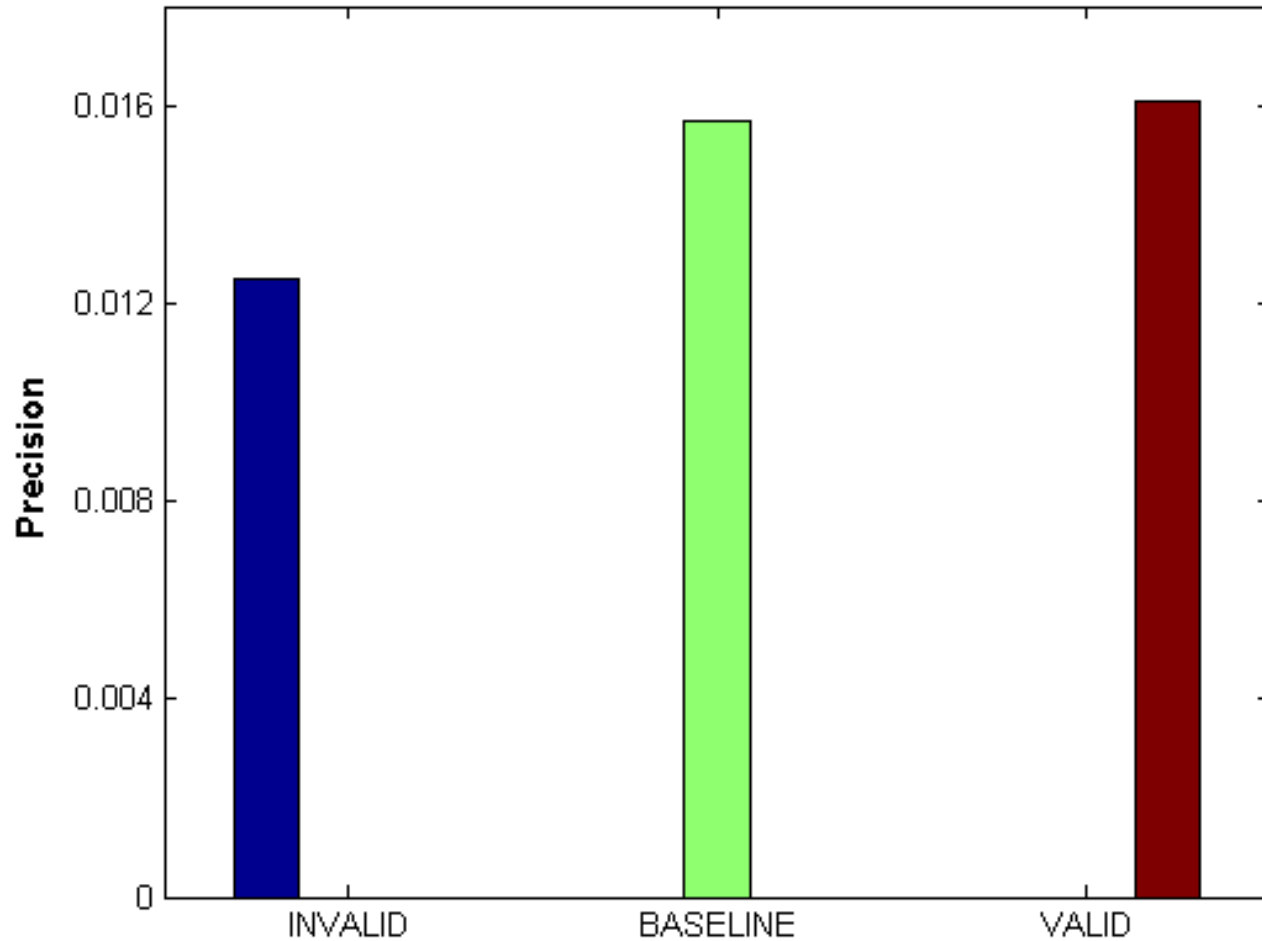
- Main effect of WM load (adj. for jitter): $p < 0.05$ (n=9)

Linear fit



Experiment 4: 'CUED'

Precision vs. Attentional cues



• n=5 (in progress)

Summary

Memory for time not studied for intervals in the context of sequences with more than one interval and with different temporal structures

We developed a new paradigm and measure of temporal memory

We characterized of memory for time intervals for sequences with different

- temporal structure**
- inter-onset intervals**
- working memory loads**
- attentional conditions**

A good behavioural index of memory for time, that can be applied to different patient groups

Imaging paradigm to investigate bases of memory for time in progress

(cf Teki et al., 2011; 2012)

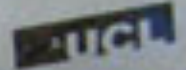
Acknowledgments

Sukhbinder Kumar

Tim Griffiths

wellcometrust

wellcome^{trust}



Wellcome Trust Centre
for Neuroimaging

Leopold Muller
Functional Imaging
Laboratory