

Physiological measures in Learning Sciences Research

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<http://www.dualeyetracking.org>

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ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Outline

General Framework
Referencing
Recurrence
Moving up the scale



Why physiological measures ?

Technology

Augmented reality

Cheap sensors

Society

Self-disclosure of information

No more privacy

Individualisation

“Big Data”

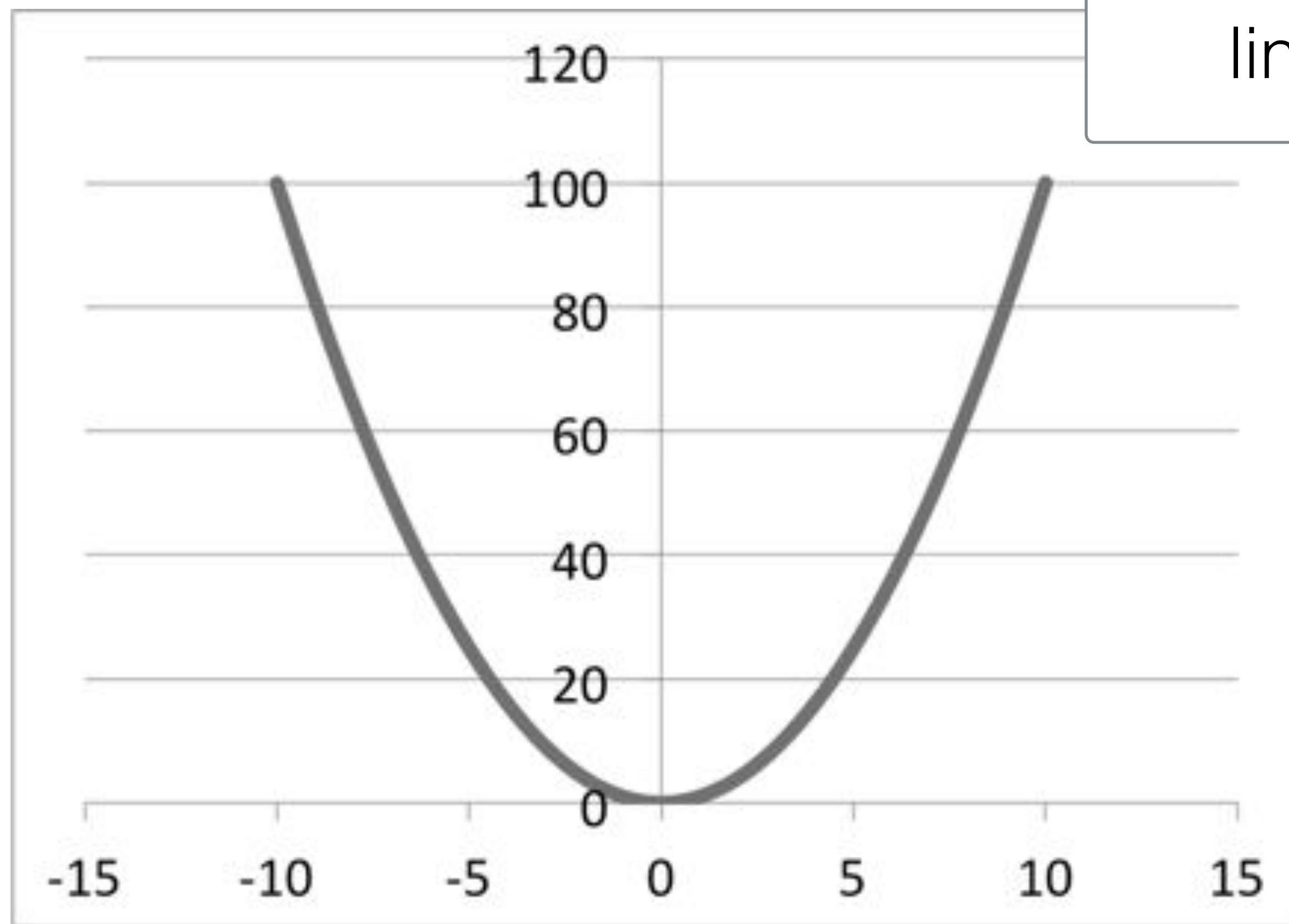
Services



<http://www.emotiv.com/>

Activity 1: Do what is written in the bubbles

How long does each activity take ?



Is this function linear ?

Show where this function take its zero ?

Read this formula ...

$$y = x^2$$

Where is y on the graph ?

Explain why the curve is symmetrical ?

TABLE 1
Time Scale of Human Action

<i>Scale (sec)</i>	<i>Time Units</i>	<i>System</i>	<i>World (theory)</i>
10^7	months		SOCIAL BAND
10^6	weeks		
10^5	days		
10^4	hours	Task	RATIONAL BAND
10^3	10min	Task	
10^2	minutes	Task	
10^1	10sec	Unit task	COGNITIVE BAND
10^0	1sec	Operations	
10^{-1}	100ms	Deliberate act	
10^{-2}	10ms	Neural circuit	BIOLOGICAL BAND
10^{-3}	1ms	Neuron	
10^{-4}	100 μ s	Organelle	

From *Unified Theories of Cognition* by A.N. Newell, 1990, Ch. 3, p.122.

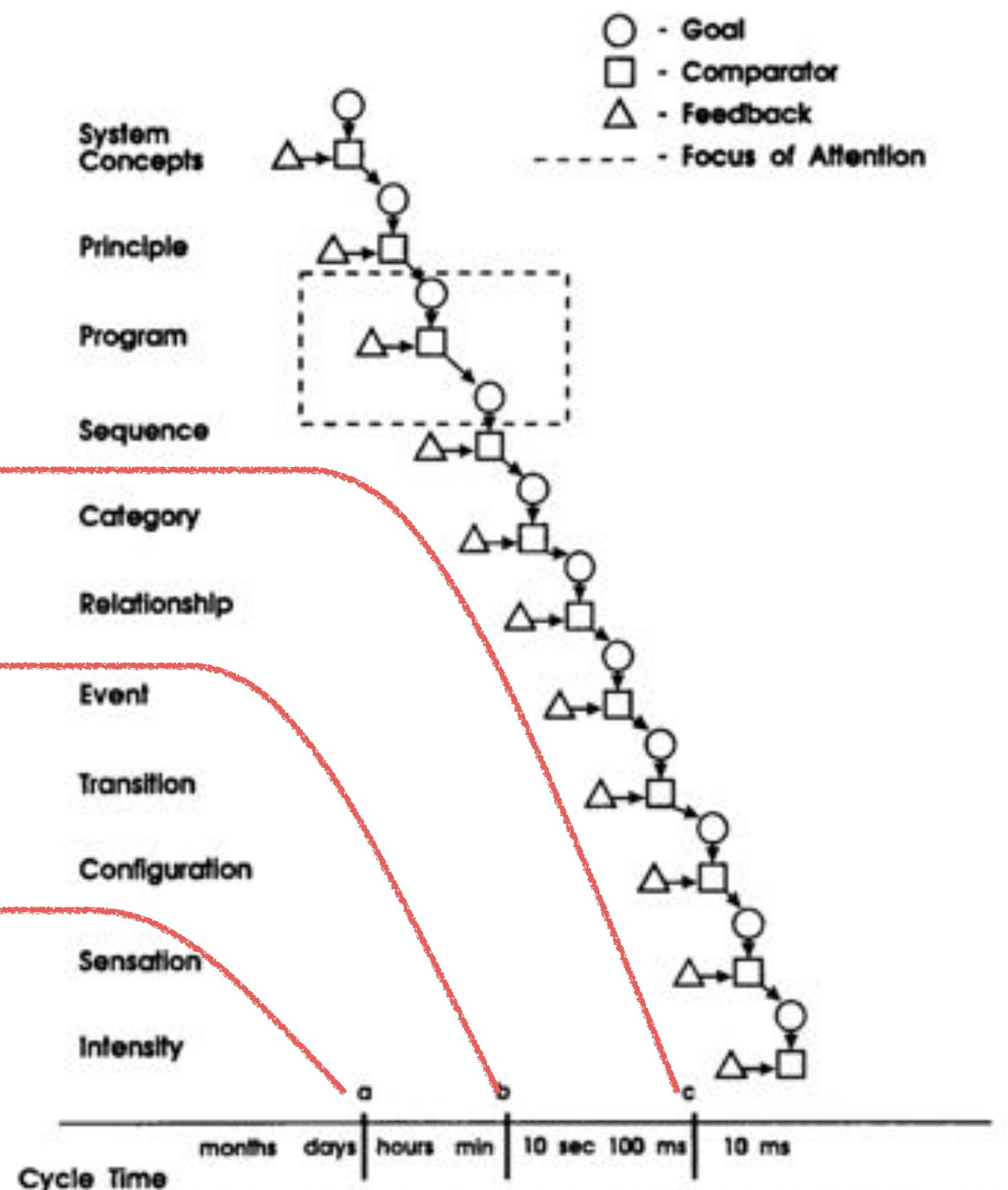


FIG. 2. Hierarchical organisation of control systems with shifting band signifying focus of attention. Note: The hash marks labelled a, b, and c correspond to the boundaries between social, rational, cognitive, and biological levels respectively.

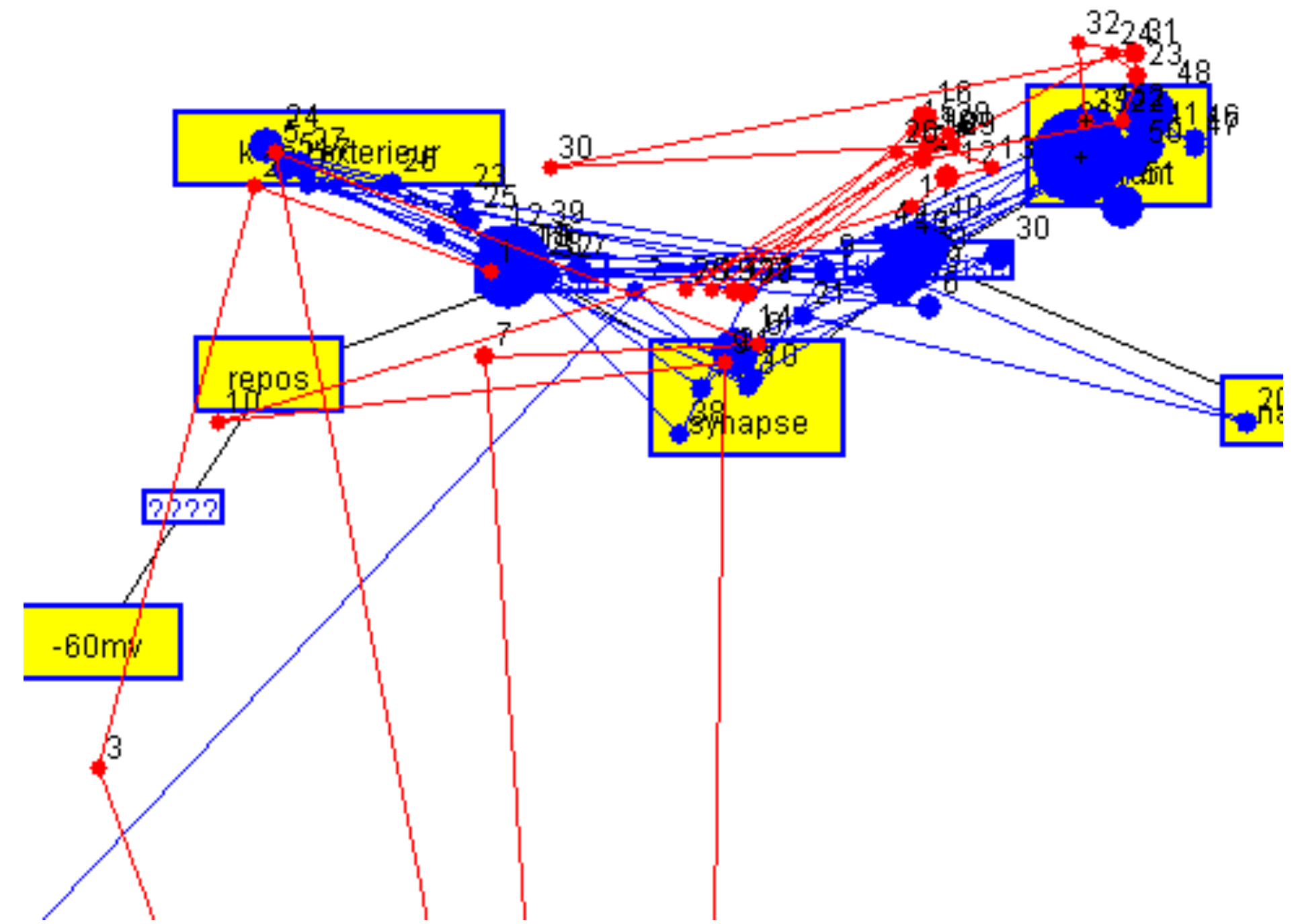
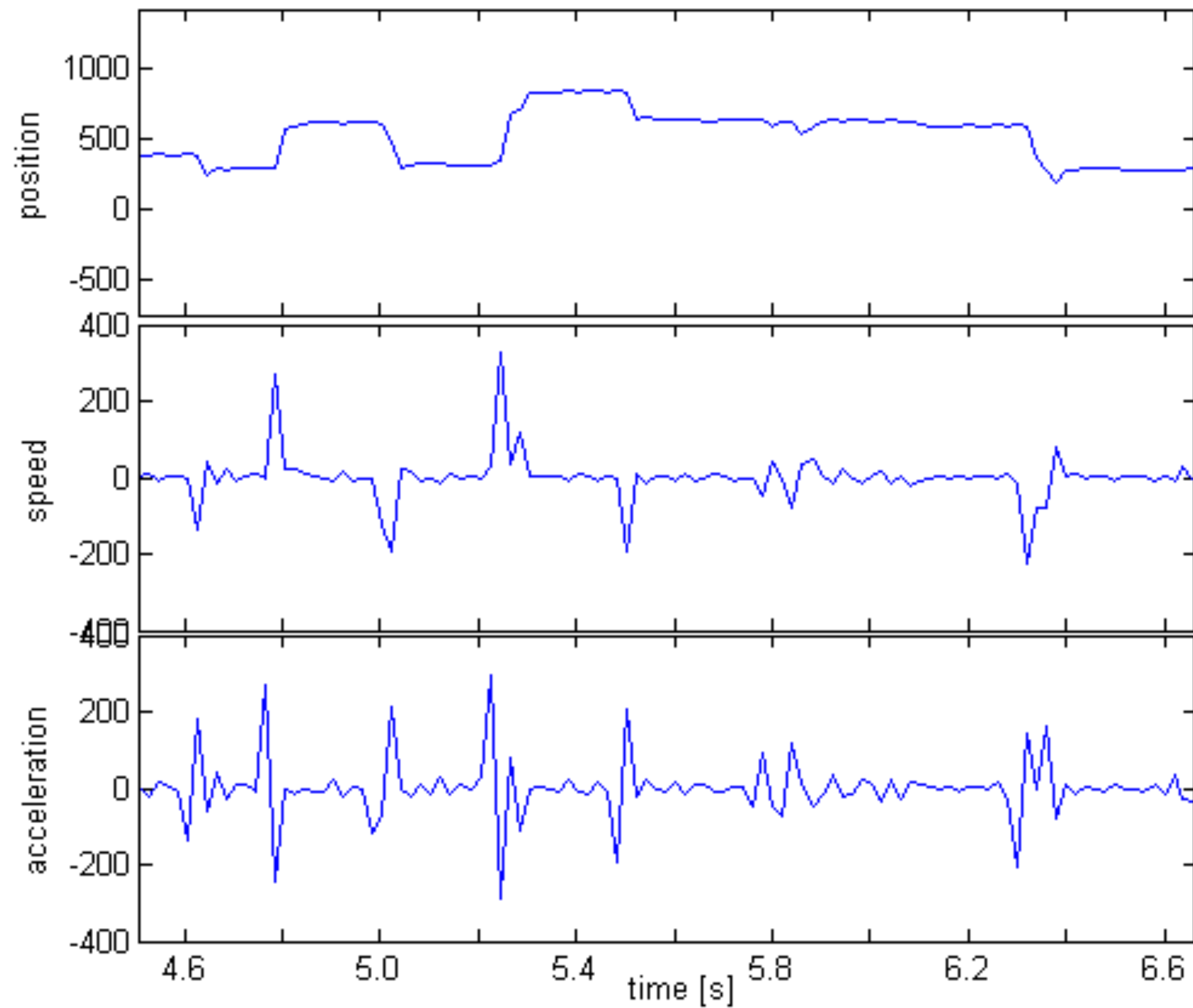
Time scales

Time	Gaze	Cognitive Science	Learning Sciences
100 sec [1000 fixations]	recurrence		understanding interaction quality
10 sec [100 fixations]	episodes		dialogue
1sec [10 fixations]	eye-voice span voice-eye span	grounding referring	
100 ms [250 samples]	fixation	perception	
4ms [1 sample]	raw data		

Time scales

Time	Gaze	Learning Sciences
100 sec [1000 fixations]	recurrence	understanding interaction quality
10 sec [100 fixations]	episodes	dialogue
1sec [10 fixations]	eye-voice span voice-eye span	grounding referring
100 ms [250 samples]	fixation & saccades	
4ms [1 sample]	raw data	

Fixations and Saccades



Activity 2 : Watch MOOC video

http://www.youtube.com/watch?v=lpzw_aFQOkg

What is the timing between:

- 1) The gaze
- 2) The pointer
- 3) The voice

Parameter and Return Types

Function parameters come with their type which is given after a colon

```
def power(x: Double, y: Int): Double = ...
```

If a return type is given, it follows the parameter list.

Primitive types are as in Java, but are written capitalized, e.g:

Int	32-bit integers
Double	64-bit floating point numbers
Boolean	boolean values true and false

Time scales

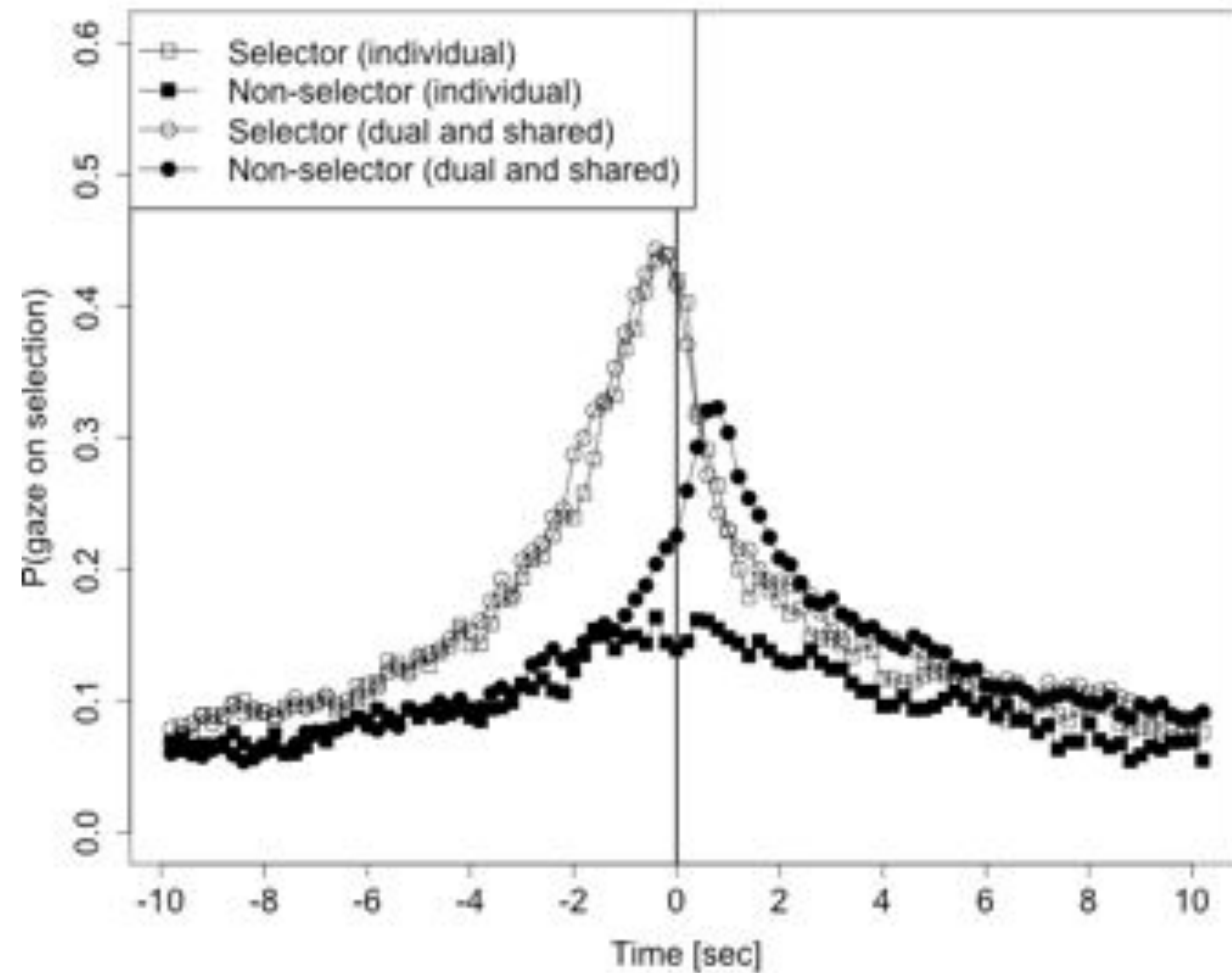
Time	Gaze	Learning Sciences
100 sec [1000 fixations]	recurrence	understanding interaction quality
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1sec [10 fixations]	eye-voice span voice-eye span	grounding referring
100 ms [250 samples]	fixation	
4ms [1 sample]	raw data	

1sec

[10 fixations]

eye-voice span
voice-eye span

grounding
referring



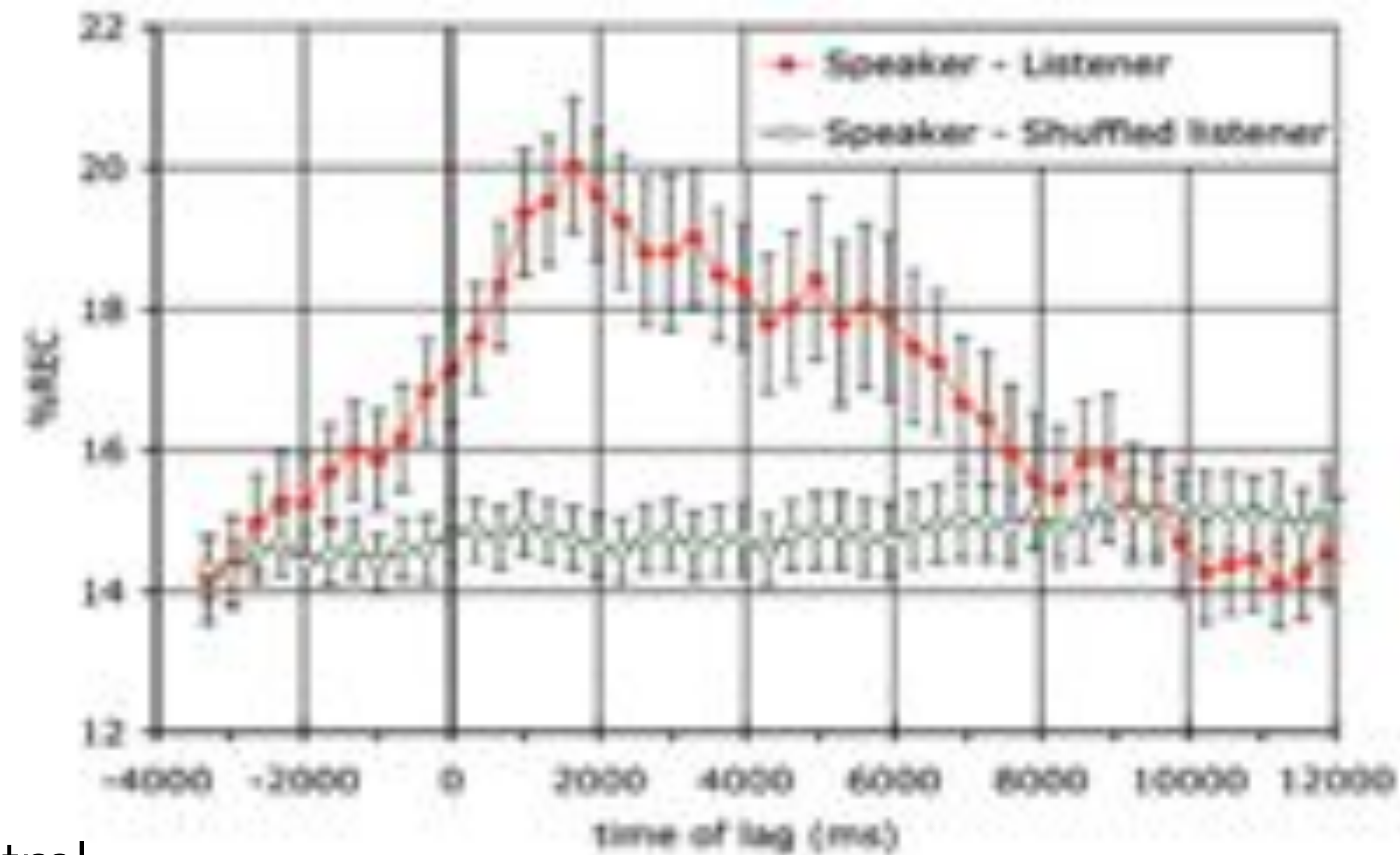
Griffin and Bock (2000); Allopenna et al., 2000; **Jermann & Nüssli (2012)**

Time scales

Time	Gaze	Learning Sciences
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4ms [1 sample]	raw data	

Gaze Coupling

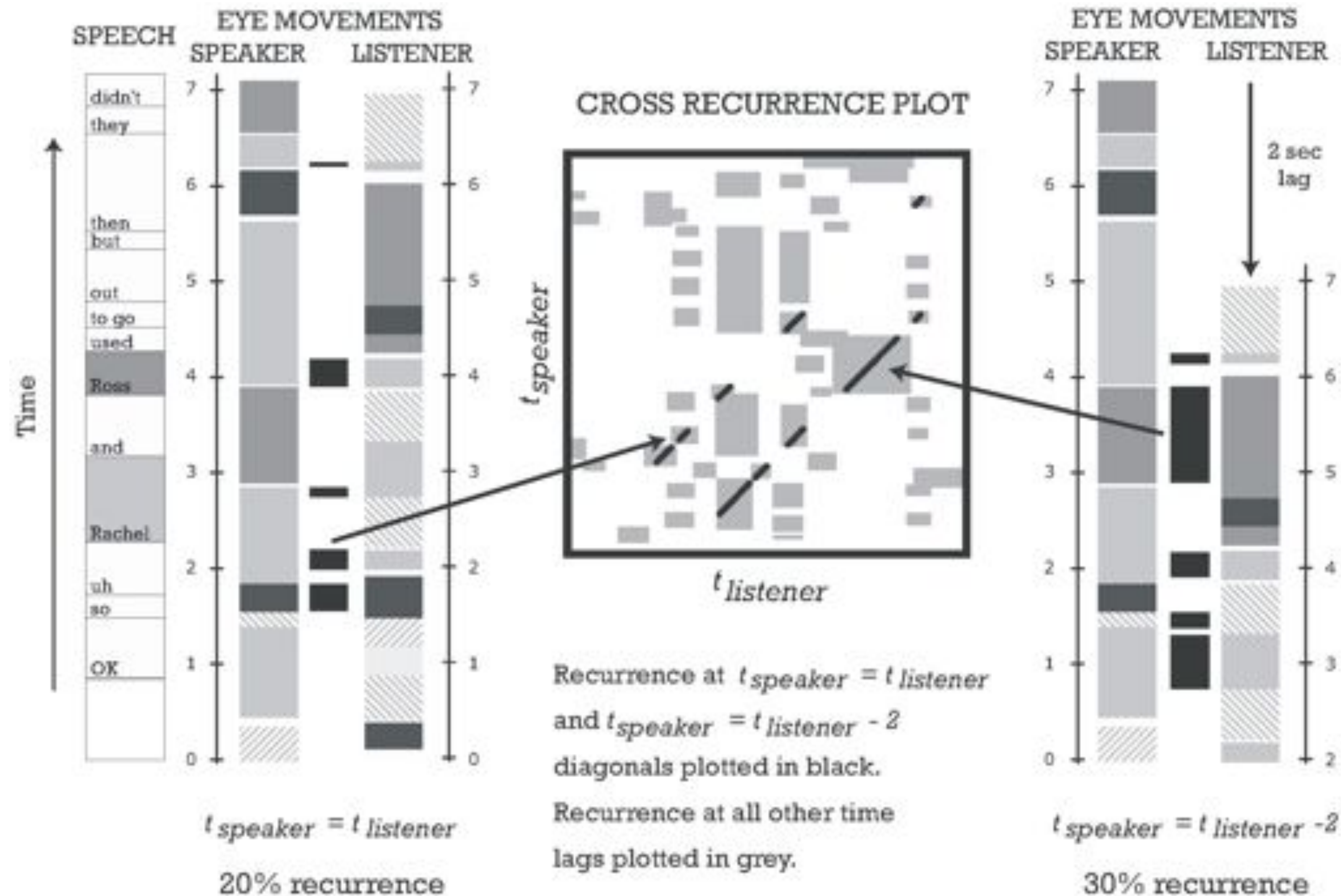
Daniel Richardson and Rick Dale (2005)



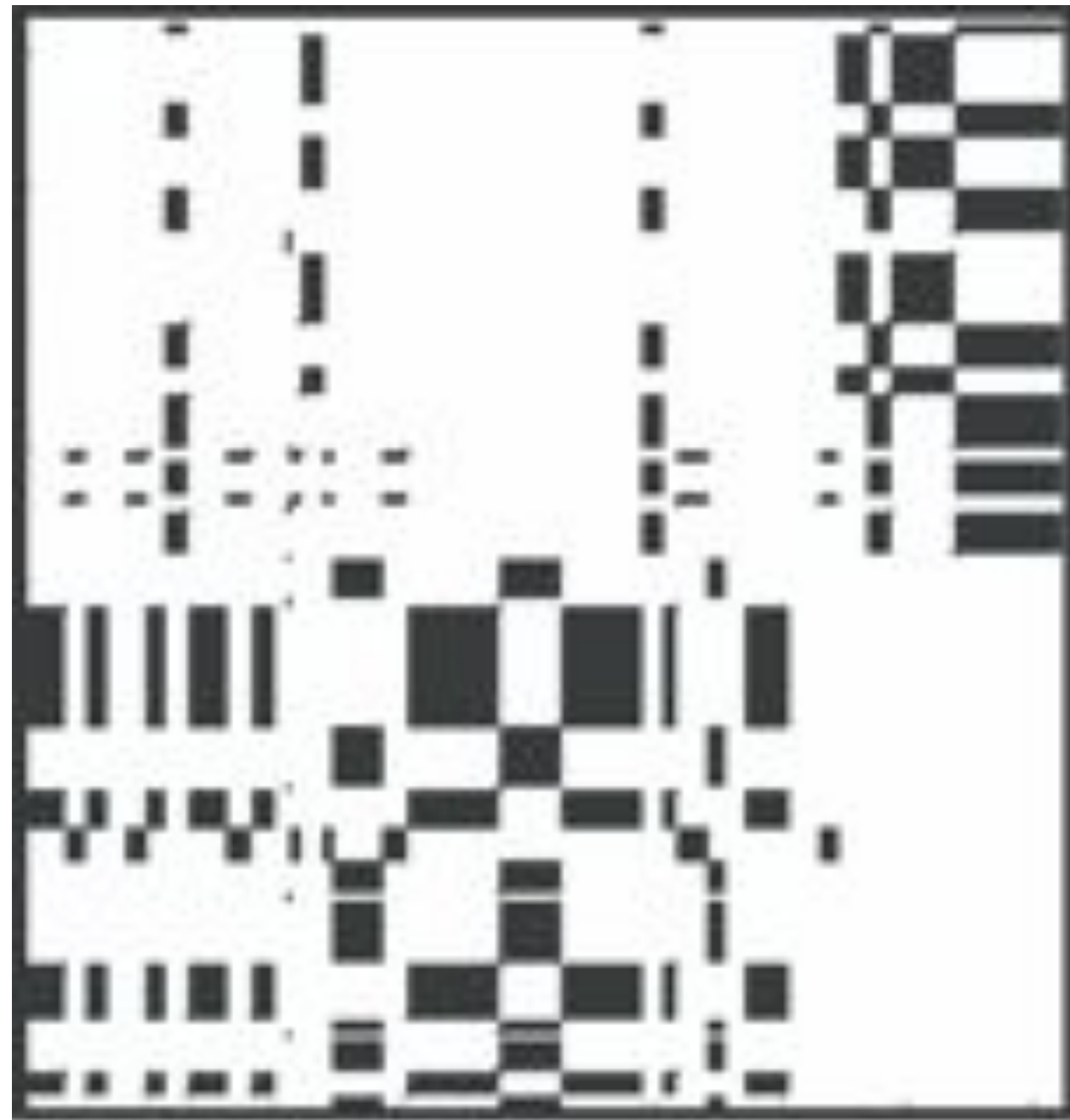
<http://www.eyethink.org/eye-chat.html>

http://www.eyethink.org/resources/movies/coordination/friends_example.mp4

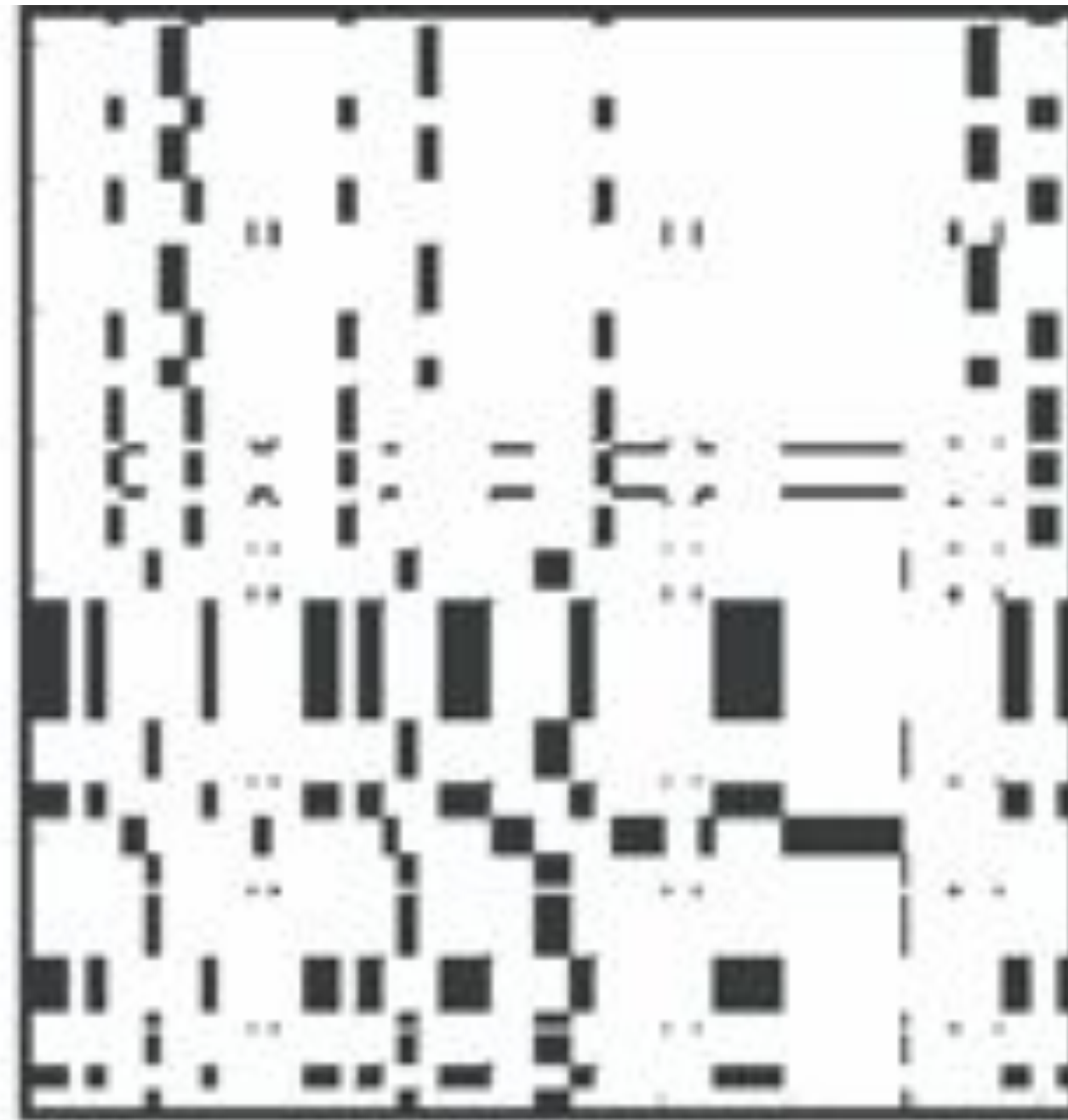
Cross-recurrence



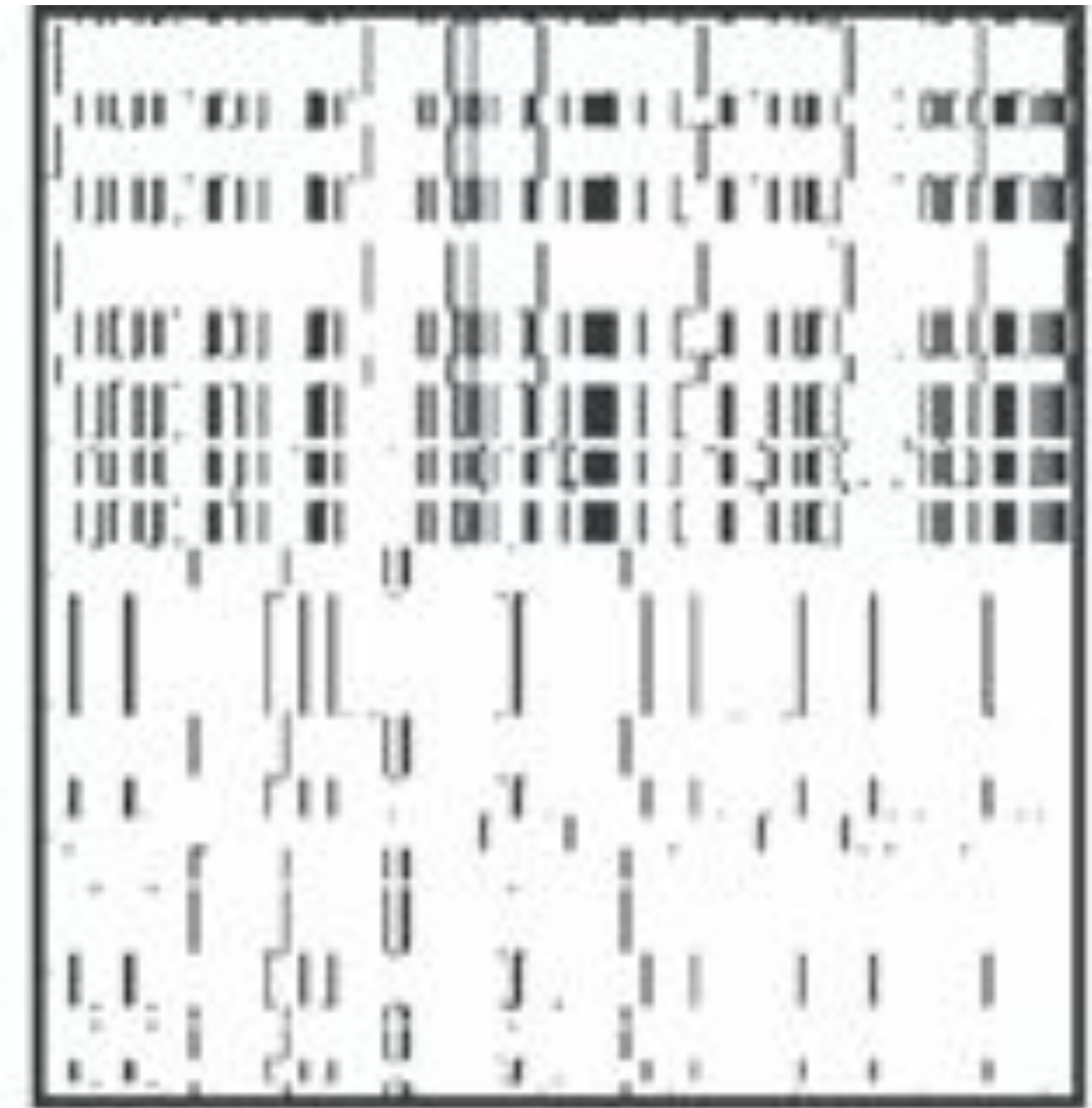
Cross-recurrence



Good Listener



Bad Listener



Randomized Listener

Recurrence in pair programming

Task: count the number of references

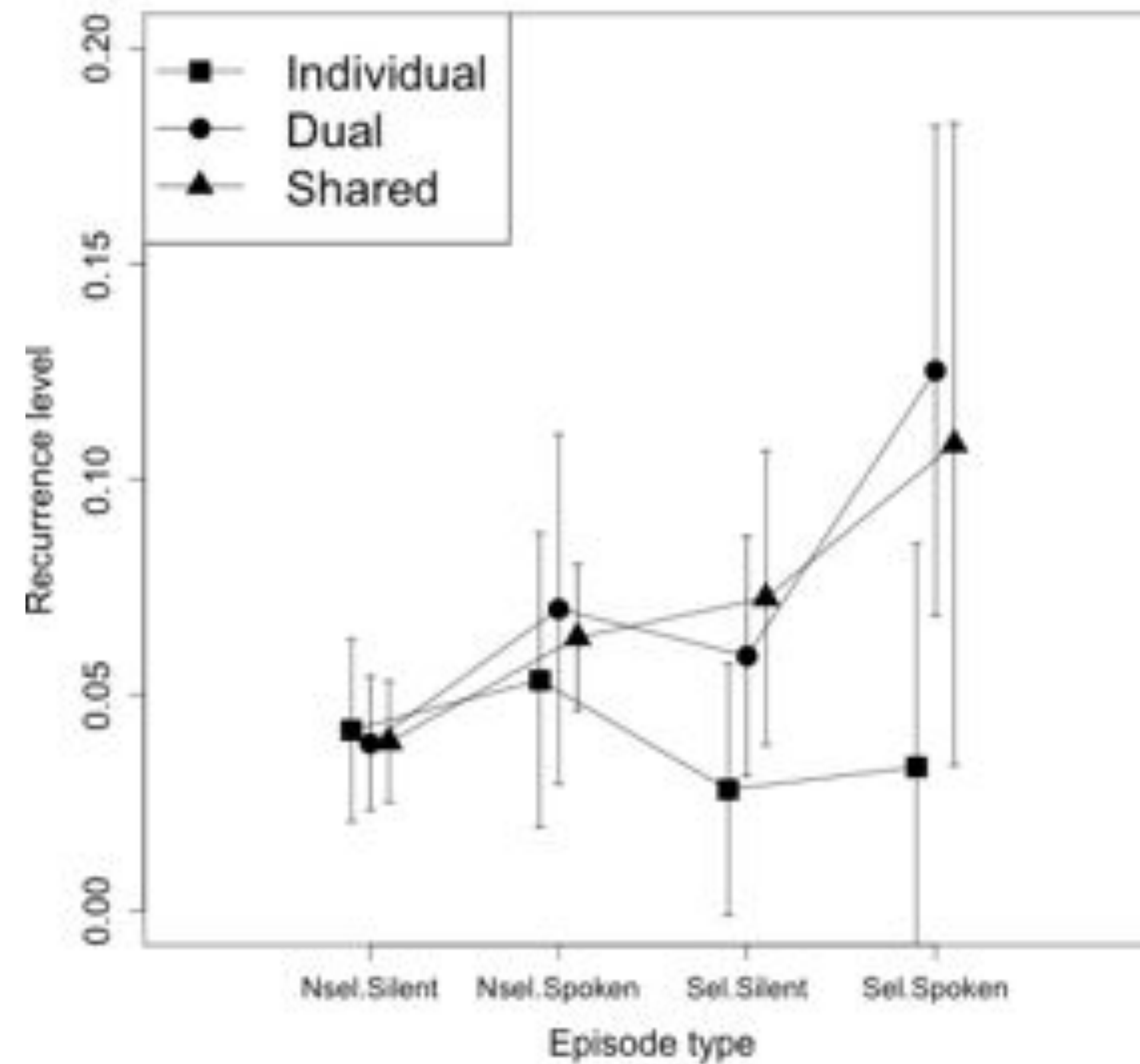
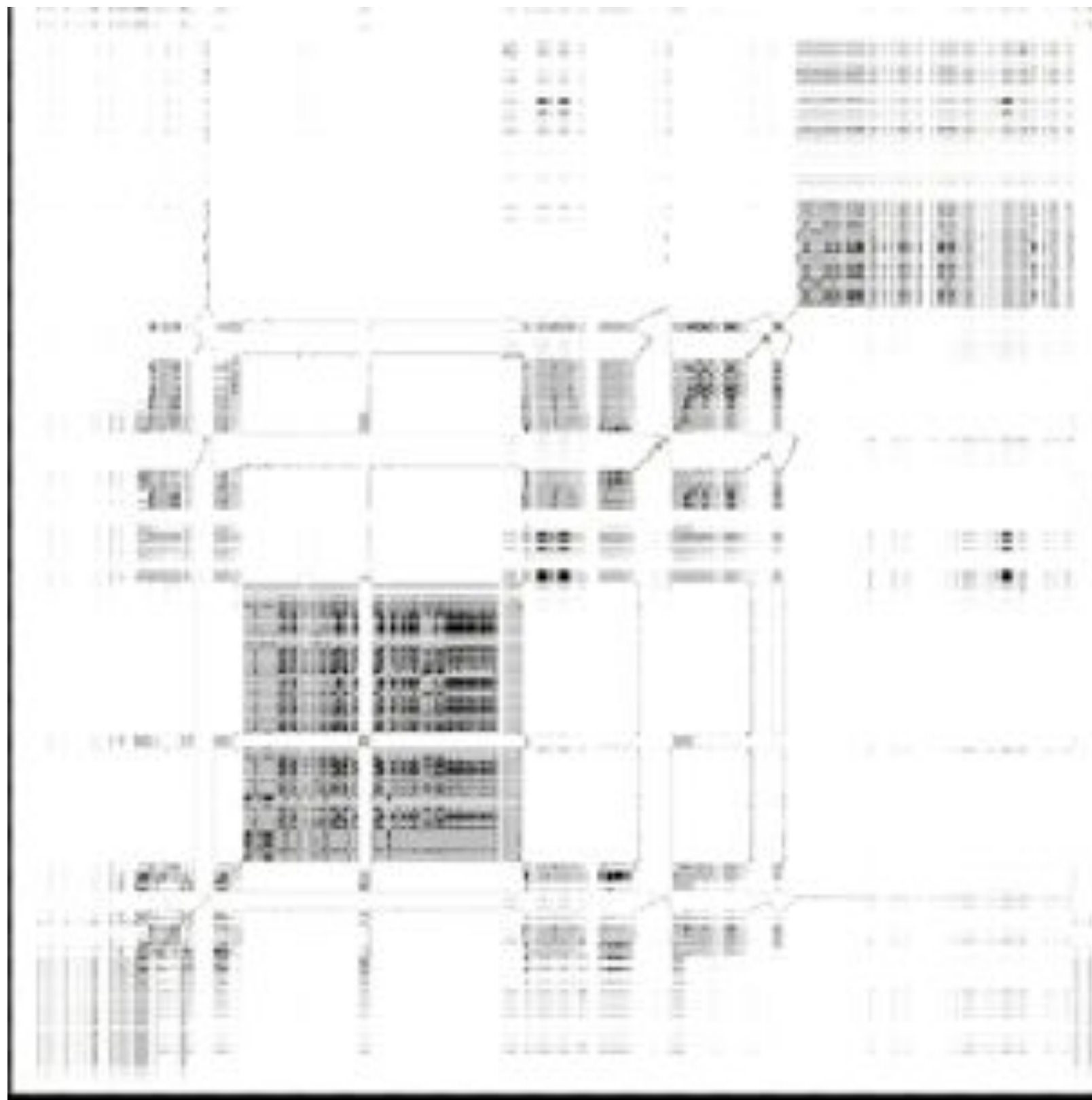
- High recurrence
<http://www.youtube.com/watch?v=dumgo3gPM78>
- Low recurrence
<http://www.youtube.com/watch?v=38qxsyNoAsI>



100 sec
[1000 fixations]

recurrence

understanding
interaction quality

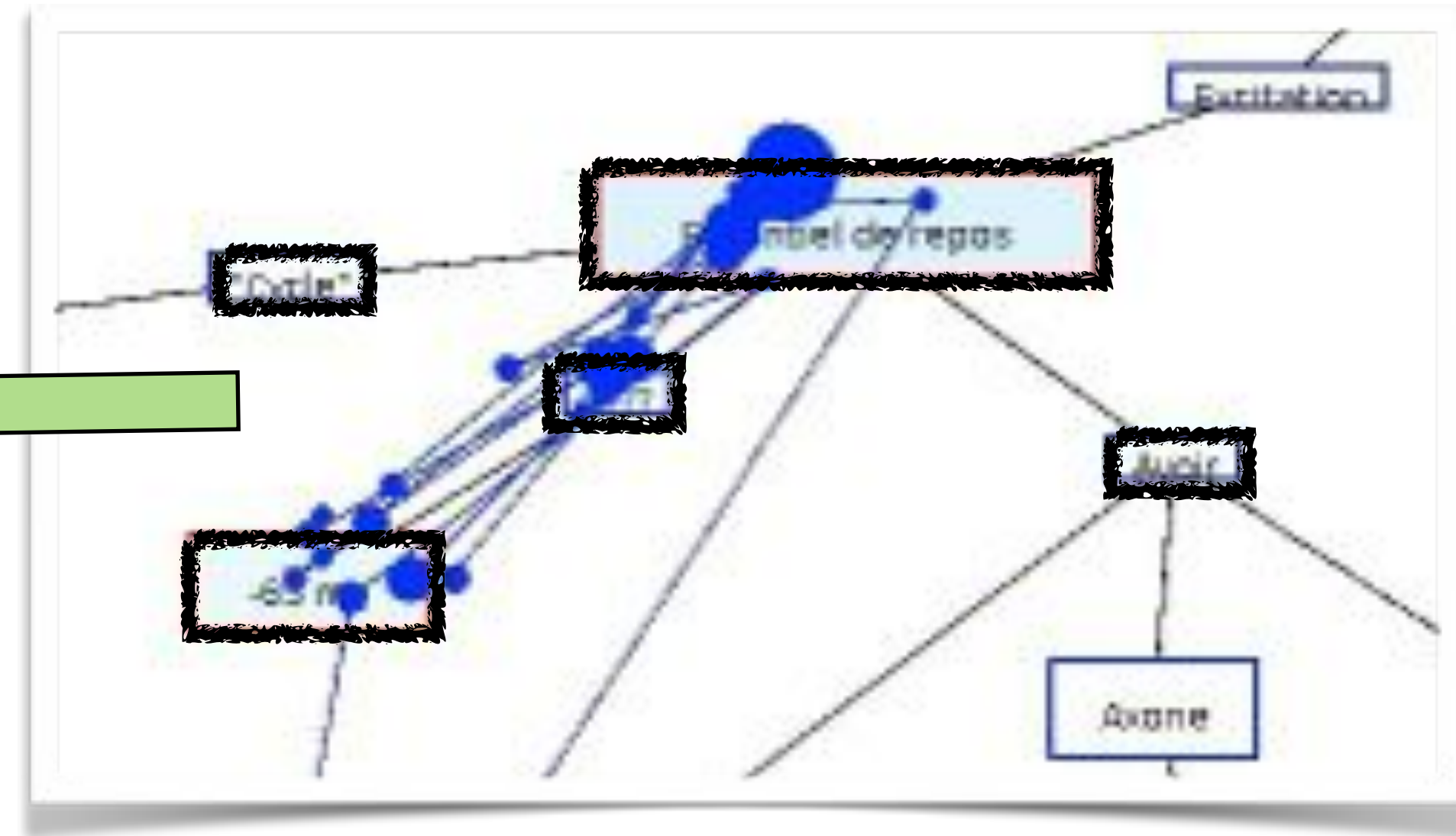
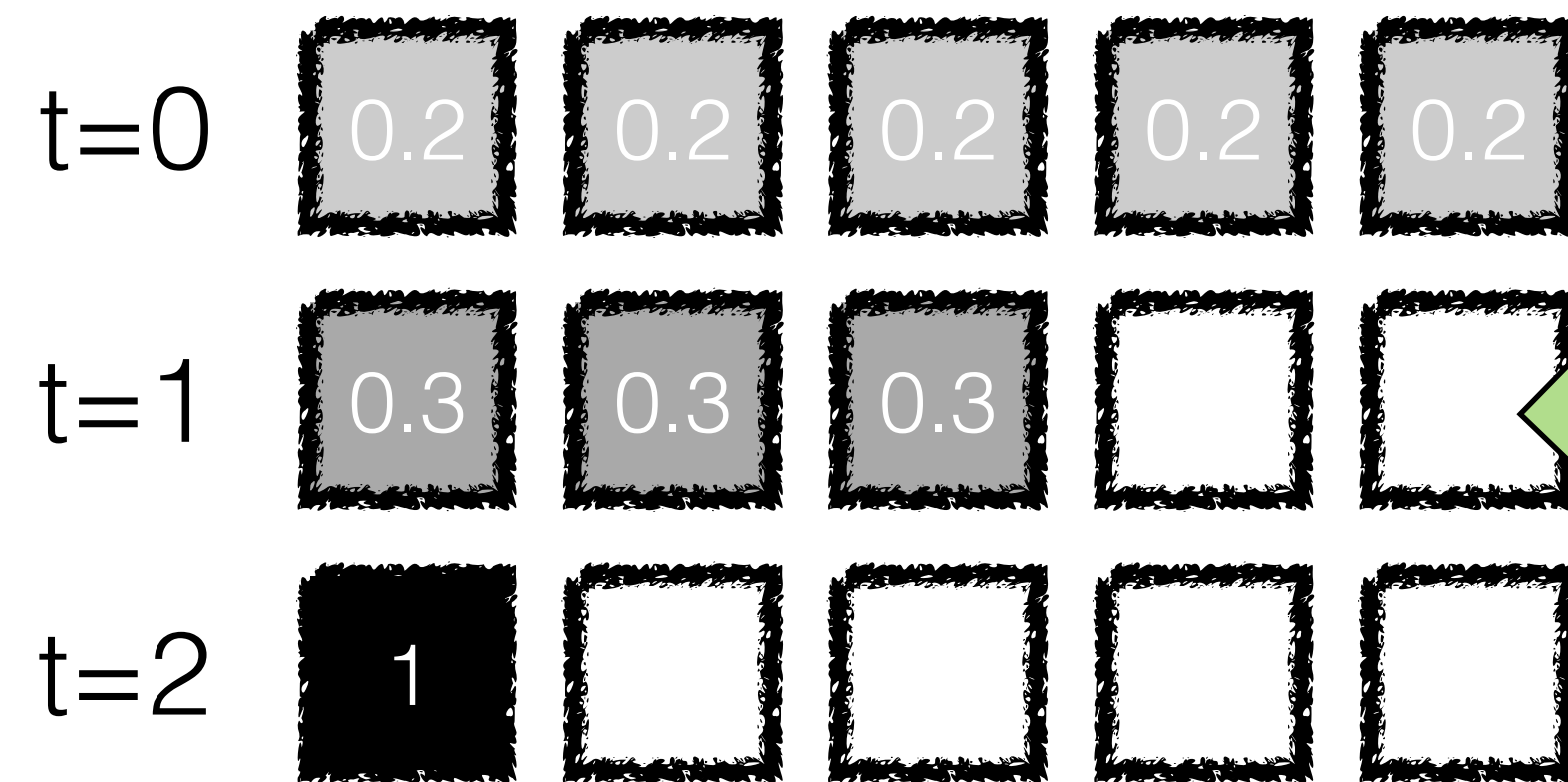


Time scales

Time	Gaze	CSCL
100 sec [1000 fixations]	recurrence	understanding interaction quality
10 sec [100 fixations]	episodes ?	dialogue
1sec [10 fixations]	eye-voice span voice-eye span	grounding referring
100 ms [250 samples]	fixation	
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Attentional map

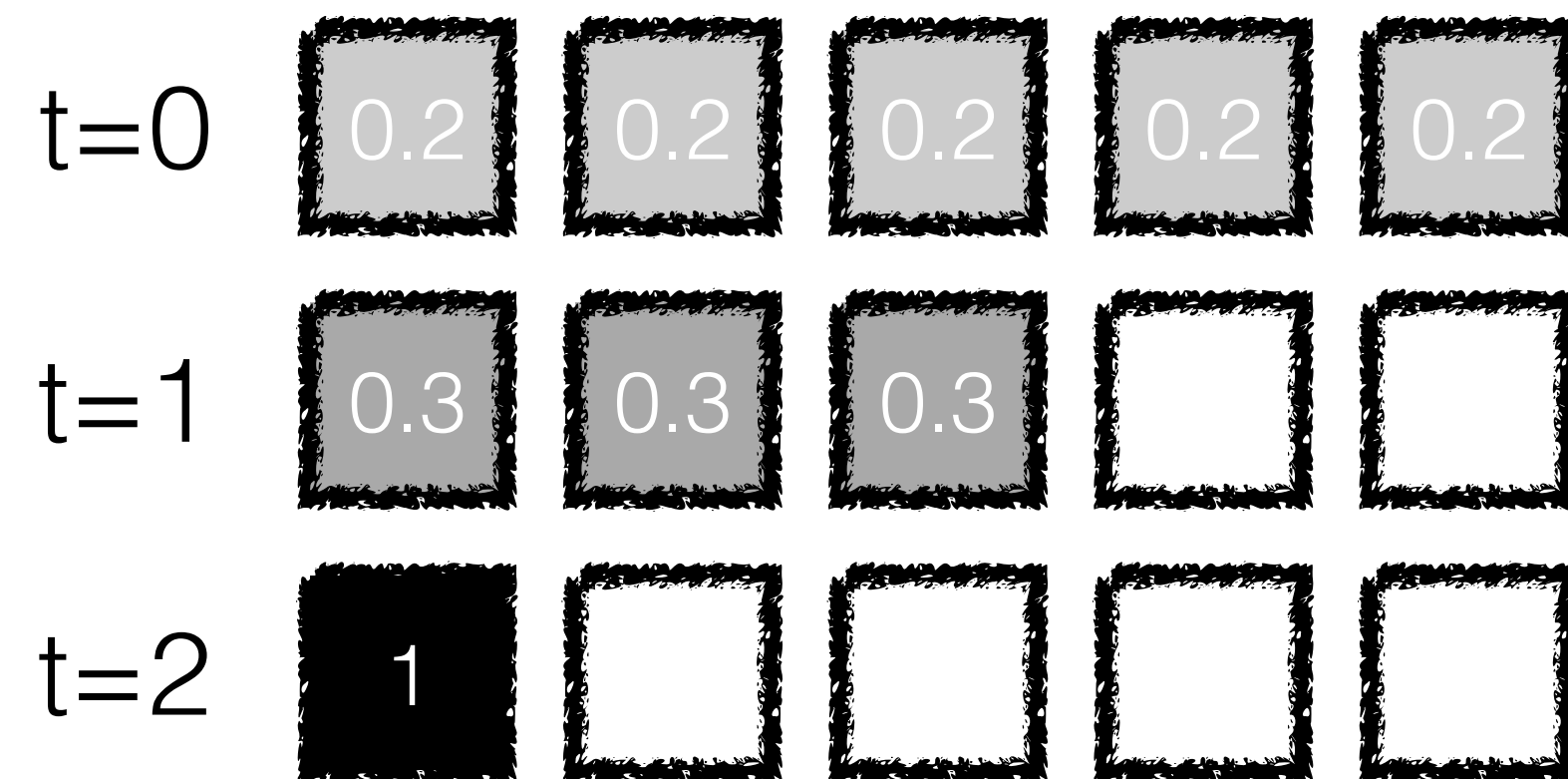
Subject A



Attentional focus

$$\text{entropy} = \sum p \log(p)$$

Subject A



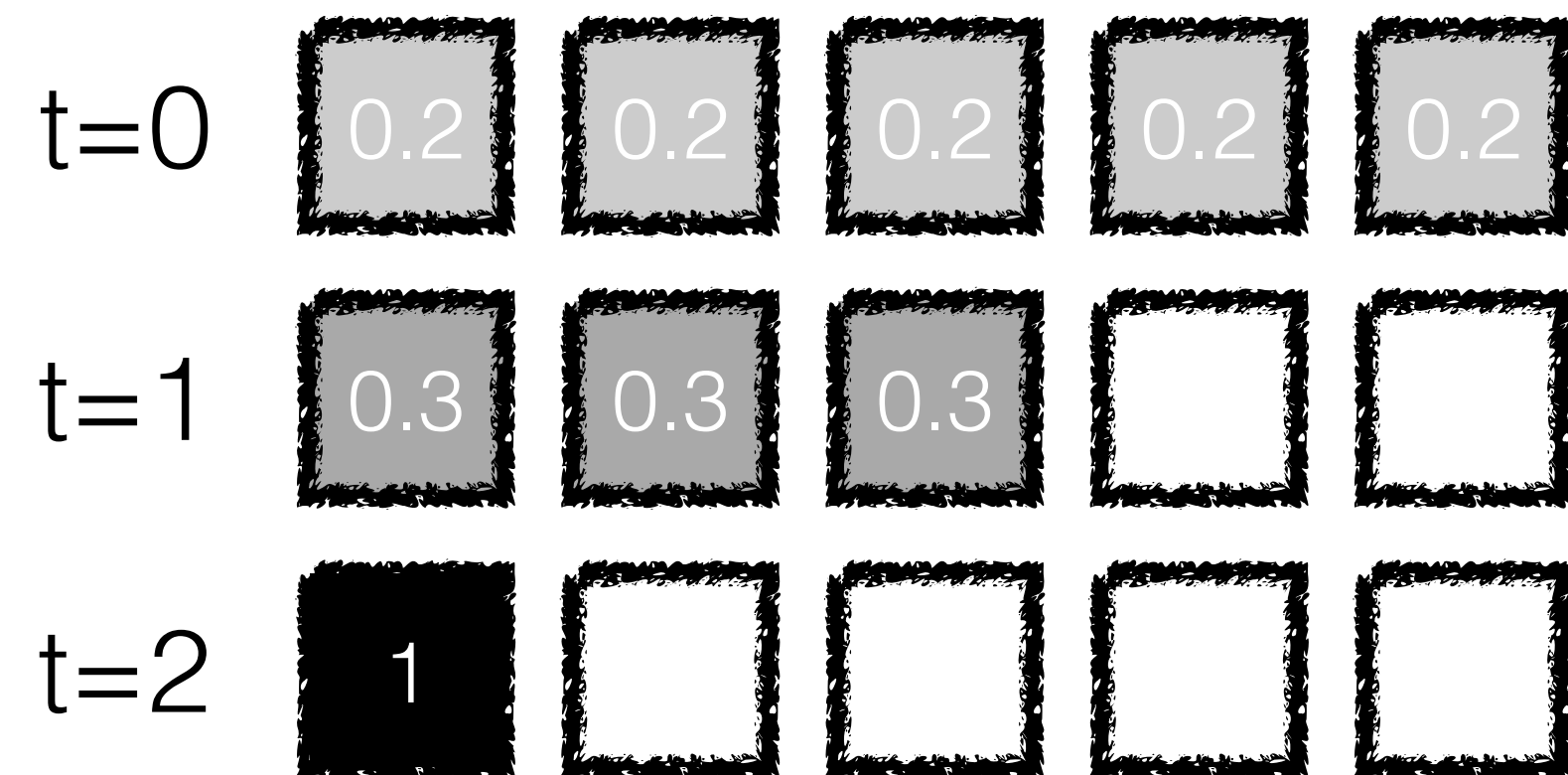
Low focus = high entropy

High focus = low entropy

Attentional similarity

$$\text{similarity} = \cos \theta = \frac{\langle \mathbf{a}, \mathbf{b} \rangle}{\|\mathbf{a}\| \|\mathbf{b}\|}.$$

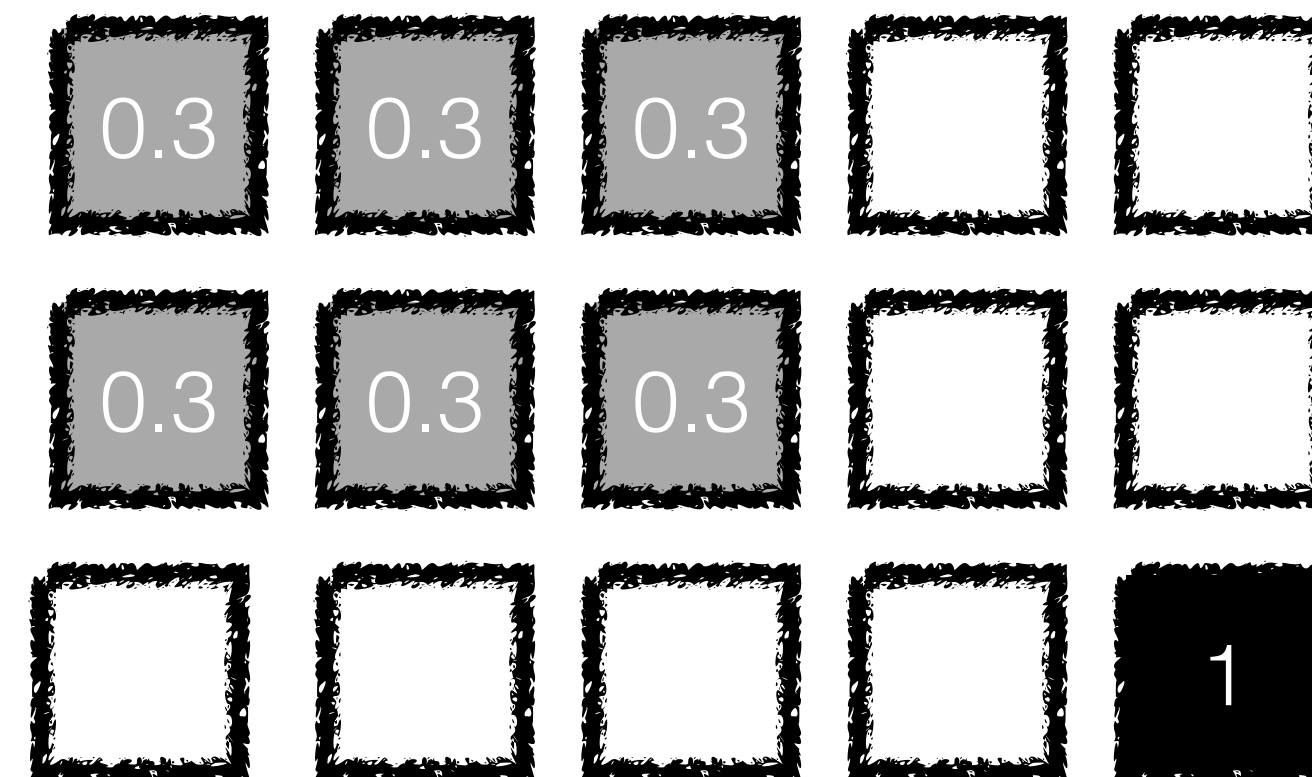
Subject A



similarity = 1

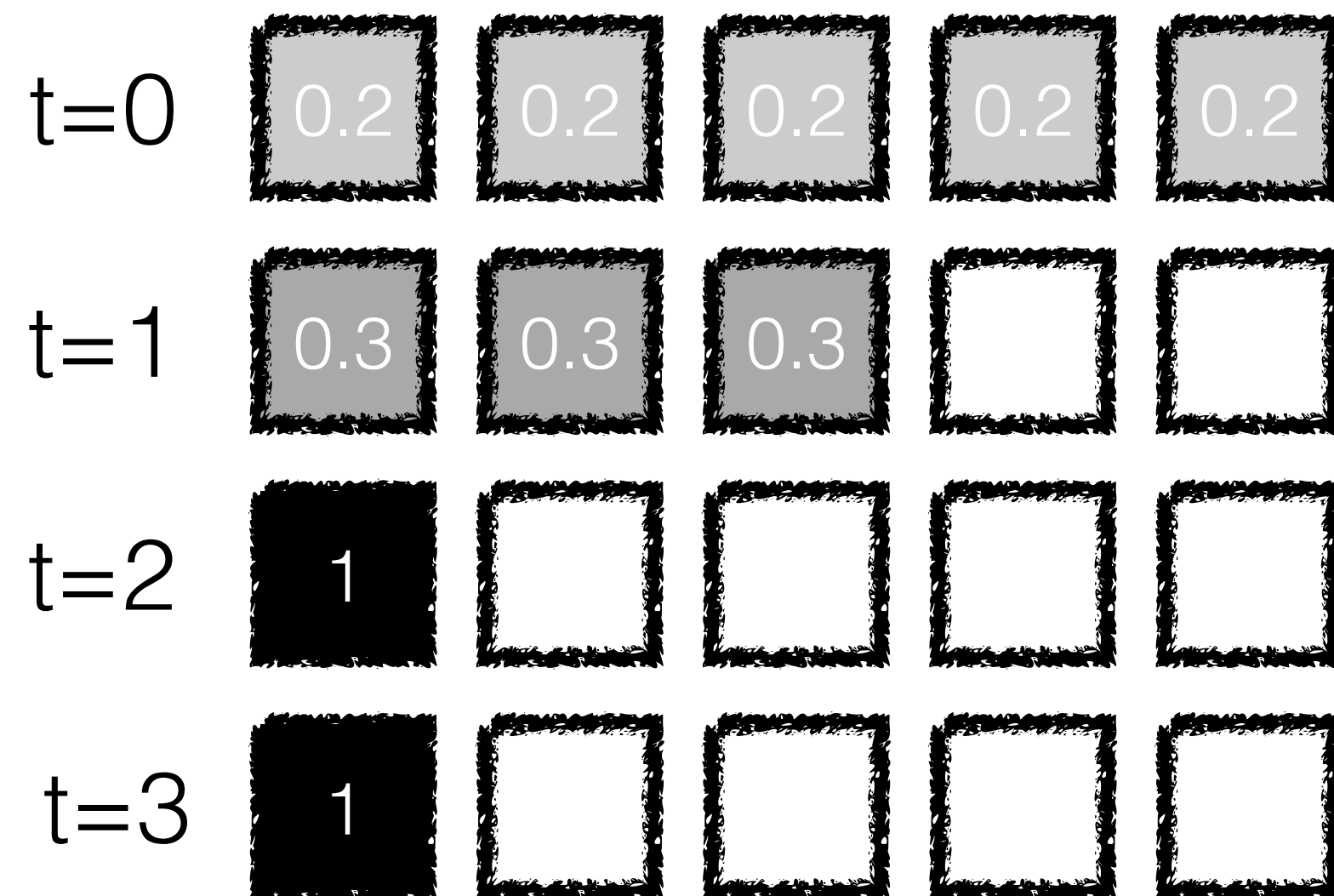
similarity = 0

Subject B



Attentional stability

Subject A



$$\text{stability} = \cos \theta = \frac{\langle \mathbf{a}, \mathbf{b} \rangle}{\|\mathbf{a}\| \|\mathbf{b}\|}.$$

$$\text{stability} = 0.6$$

$$\text{stability} = 0.2$$

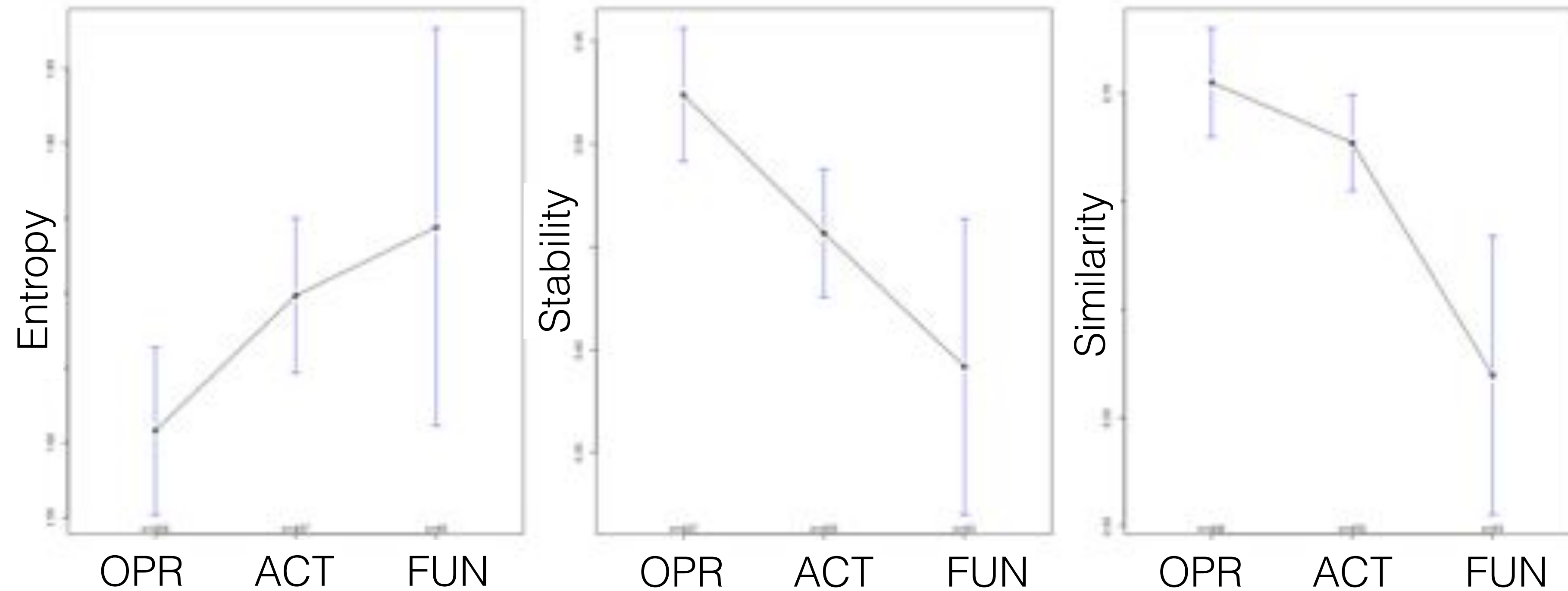
$$\text{stability} = 1$$

Dialogue coding

[Program understanding]

		Level of abstraction		
		Syntactic level (OPR)	Abstract code (ACT)	World model (FUN)
Scope of reference	> 10 lines PROG	PROG_OPR (rare)	PROG_ACT	PROG_FUN
	2-10 lines METH	METH_OPR	METH_ACT	METH_FUN
	1 line LINE	LINE_OPR	LINE_ACT	LINE_FUN (rare)

Level of abstraction



Do people speak about concrete operations (OPR) or general functionalities (FUN) ?

Dialogue Coding

[Concept Mapping]

CMAP	Tool functionality
COOP	Organization
EXPLAN-C	Giving explanations [C=ref to concept map]
EXPLAN-K	
NEGO-C	Negociate knowledge [C=ref to concept map]
NEGO-K	
METACOG	Evaluate process

M. Sangin. Peer Knowledge Modeling in Computer Supported Collaborative Learning. PhD thesis, Ecole Polytechnique Federale de Lausanne, 2009.

Sangin, M., Dillenbourg, P., NüssliMarc-Antoine, & MolinariGaëlle. (2008). How learners use awareness cues about their peer's knowledge?: insights from synchronized eye-tracking data. In Proceedings of the 8th international conference on International conference for the learning sciences-Volume 2 (287–294).

Focus

