CS-411: Digital Education & Learning Analytics

Chapter 10:

Eye-tracking

Kshitij Sharma, Pierre Dillenbourg and Patrick Jermann

Today

- Learn about eye-tracking
- Hands (eyes) on eye-tracker

Eye-tracker: then

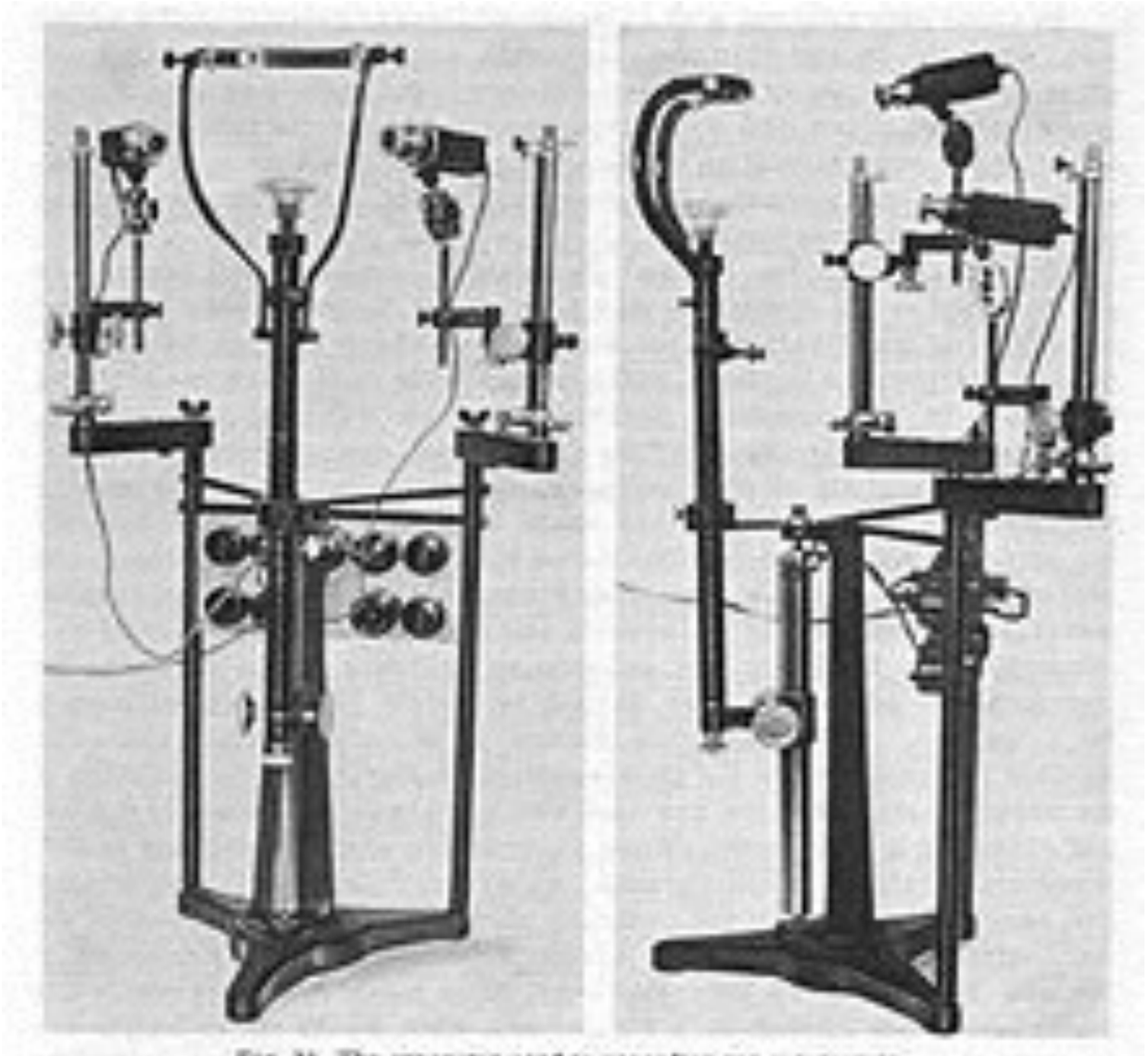


Fig. 21. The apparatus used in recording eye movements.

The first eye-tracking study

The first eye-tracking study

1

Free examination.

2

Estimate material circumstances of the family

3

Give the ages of the people.

4

Surmise what the family had been doing before the arrival of the unexpected visitor.

5

Remember the clothes worn by the people.

6

Remember positions of people and objects in the room.

7

Estimate how long the visitor had been away from the family.

3 min. recordings of the same subject

Eye-trackers: now



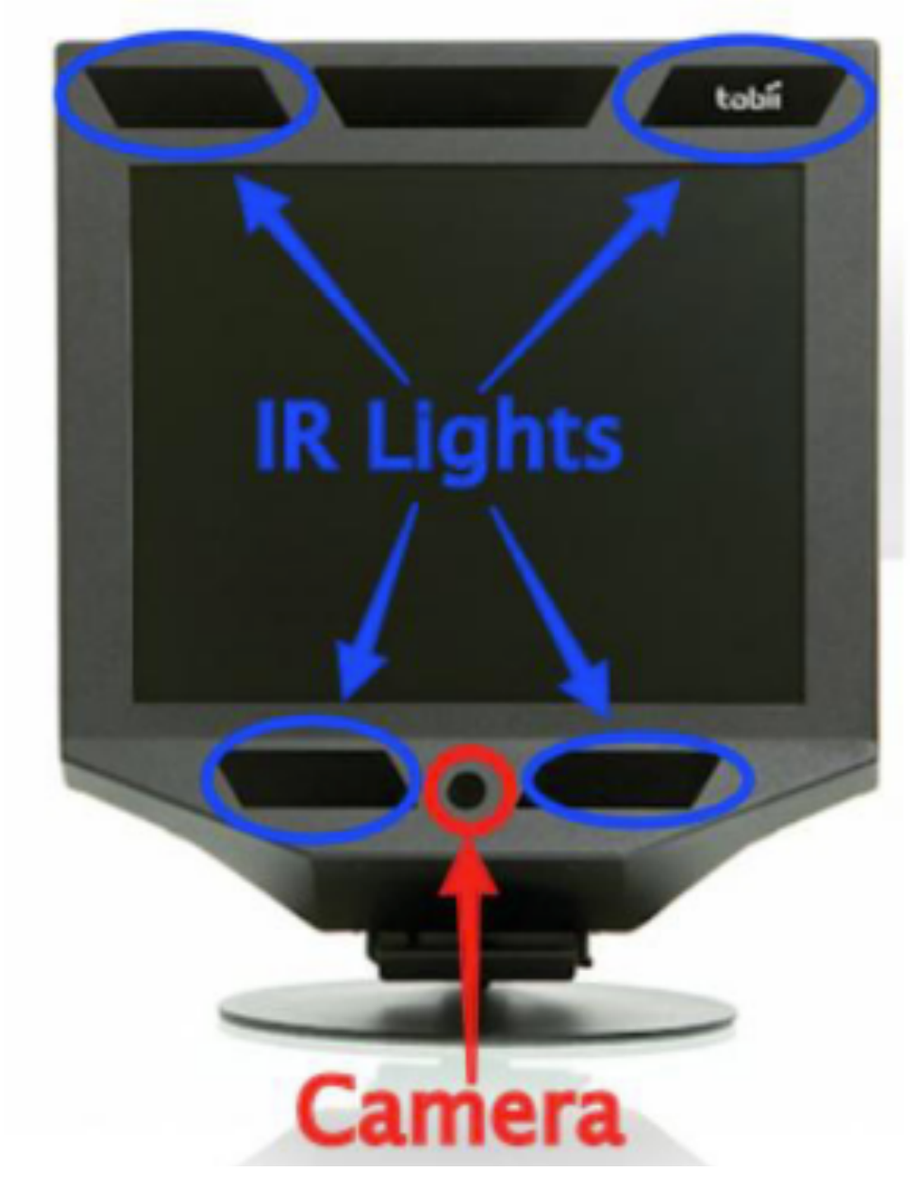








How does an eye-tracker work?

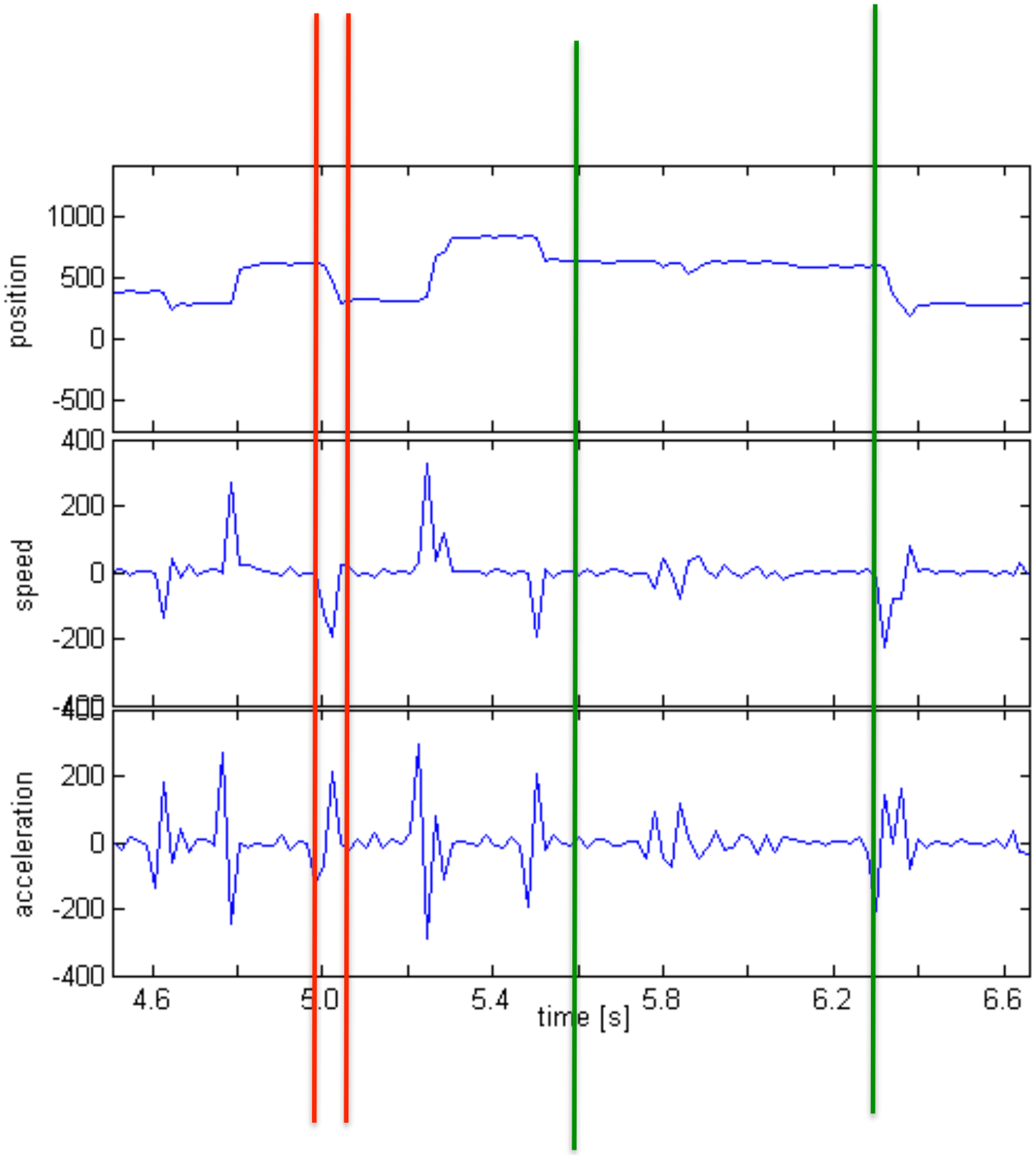


Tobii 1750

Raw Data

Timestamp [ms]	Category	Pupil size R [mm]	Pupil size L [mm]	Point of regard X	Point of regard Y	...
87542.5	Blink	3	2.9	936.3	691.7	
87575.7	Blink	3	2.8	908.6	639.5	
87609.2	Visual Intake	3	2.9	873.7	613.7	
87642.5	Visual Intake	3	2.9	851.3	608.9	
87675.8	Visual Intake	3	3	828.5	603.1	
87709.2	Visual Intake	3	3	809.1	613.9	
87742.3	Visual Intake	3.1	3	794.1	618.1	
87775.6	Visual Intake	3.1	3.1	783.7	627.1	
87808.8	Visual Intake	3.2	3.1	771.4	633.7	
87842.1	Saccade	3.1	3.2	769.3	651.5	
87875.3	Saccade	3.2	3.2	767.7	671.3	
87908.6	Saccade	3.2	3.2	764	679.8	
87941.8	Visual Intake	3.2	3.2	759	686.1	
87975.3	Visual Intake	3.2	3.2	758.9	690.9	
...	...	...	...	...	...	...

Fixations and Saccades



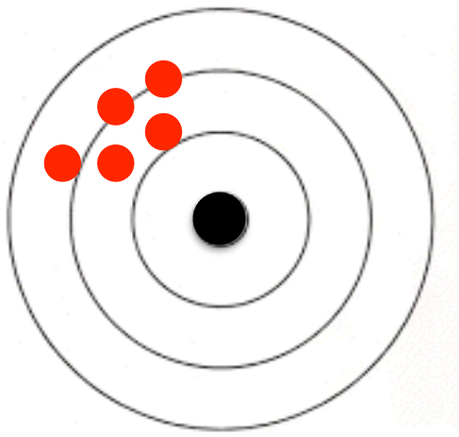
Fixations: when the eyes rest momentarily on a small part of screen, 120 - 1000 ms

Saccades: when eyes jump rapidly from one part of the screen to another, 40 - 120 ms

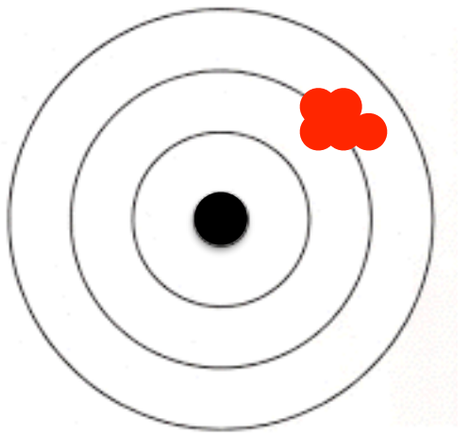
Accuracy and Precision

Accuracy: average difference between real position of the stimuli and the measured position of the gaze.

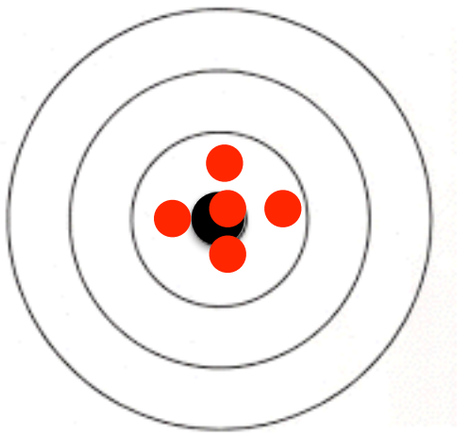
Precision: ability of the eye-tracker to reproduce the same gaze measurement (variance)



Poor accuracy
poor precision



Poor accuracy
good precision



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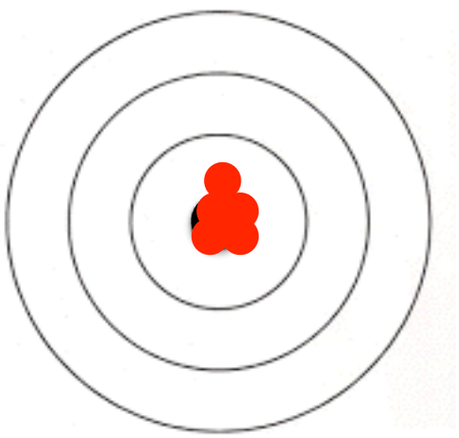
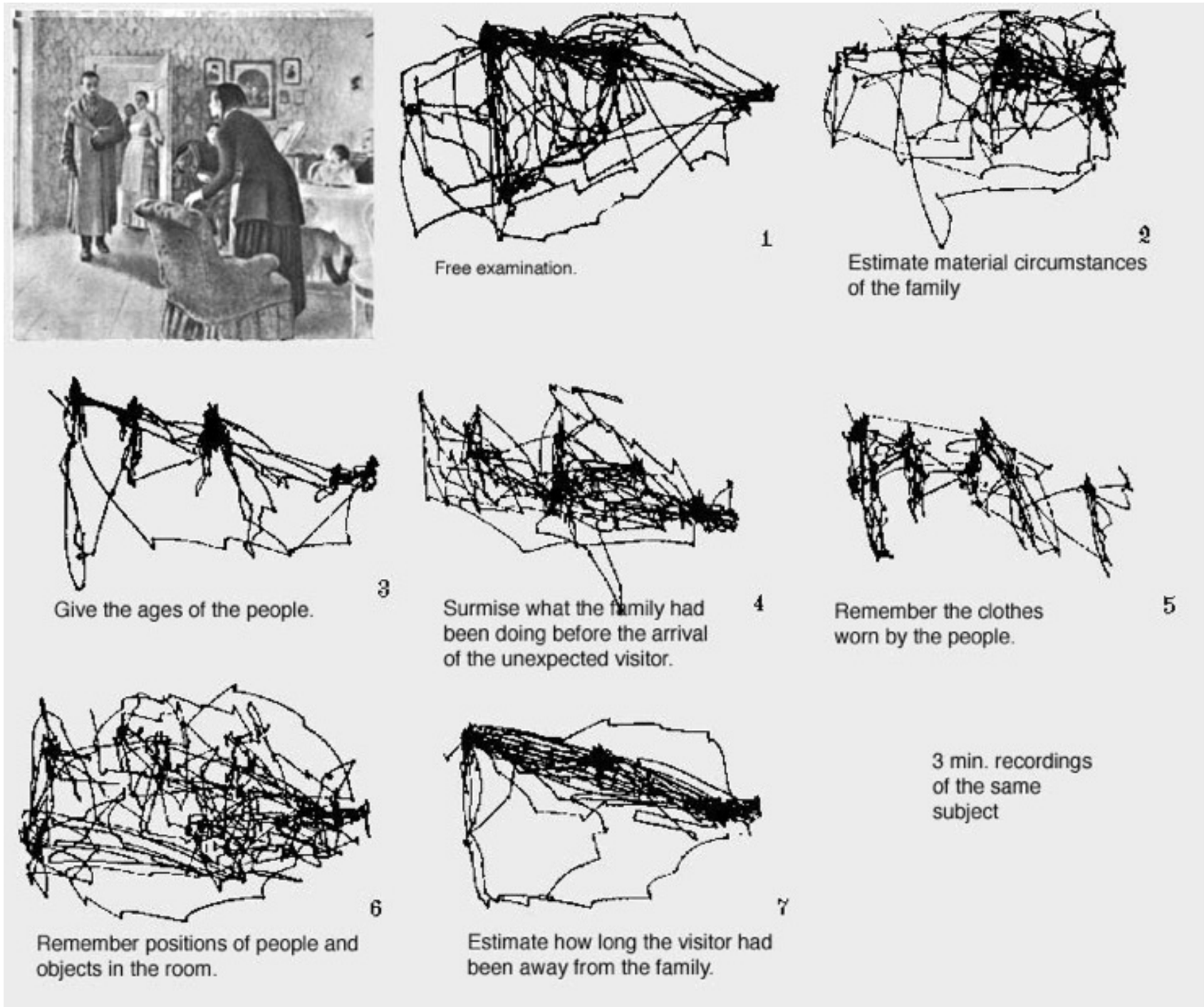


Good accuracy
Good precision

“Eye-mind” Hypothesis

What I see is what I process



Applications

1. Marketing: what attracts our attention?
2. Security: where are we paying attention?
3. Research: education, cognition, perception…
4. Groupware: quality of interaction.

1. Marketing

EYETRACKSHOP

Package

Pattern | Statistics | Order | Recall | Intention | Statement | Emotion | Method

Visual Attention Pattern

Heatmaps are used in eye tracking analysis to visualize the most popular areas for one or more persons in a simple and intuitive way. The most colorful areas indicates what is most interesting.

Least attention — More attention

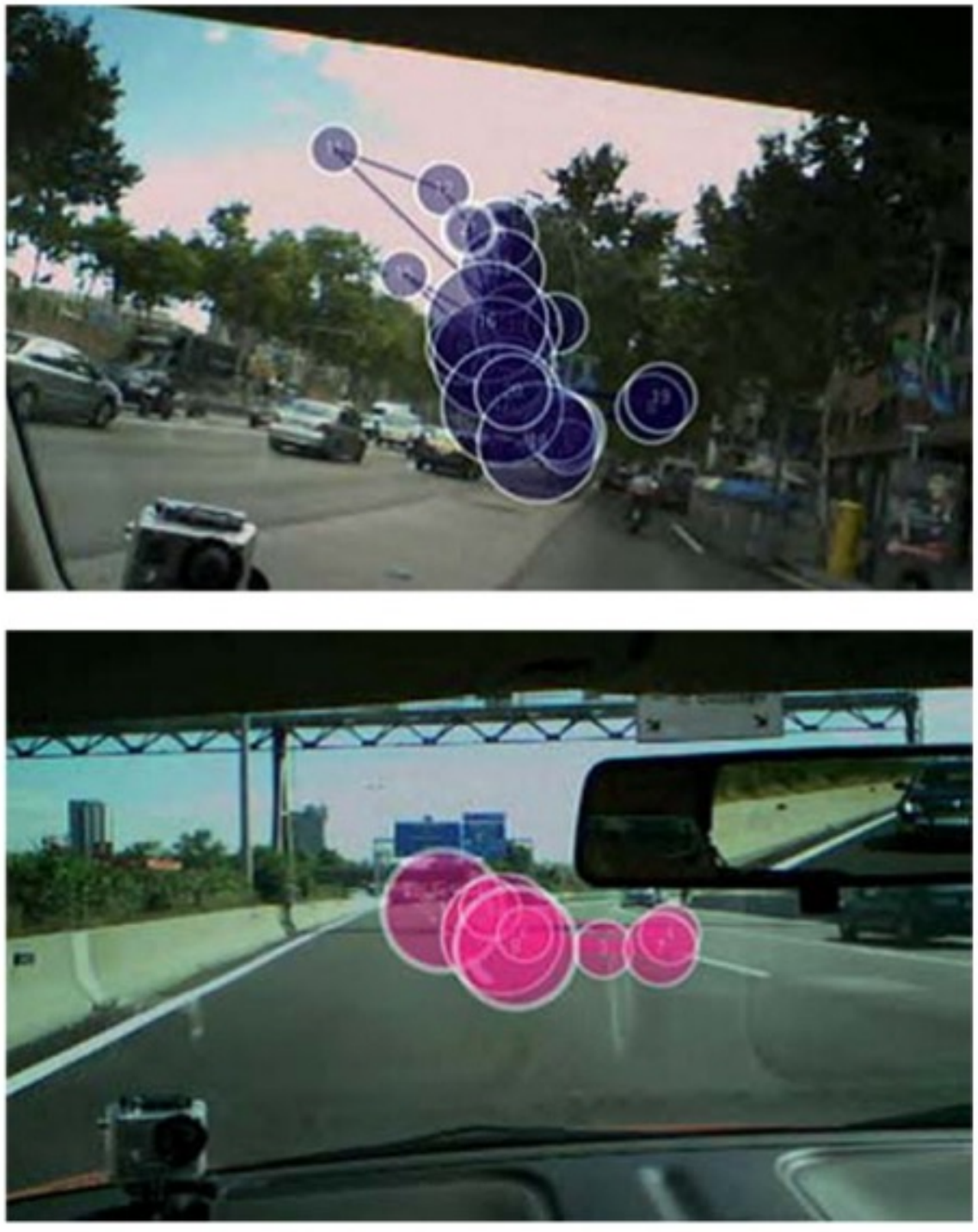
Users
- Current label
- New label

Non users
- Current label
- New label

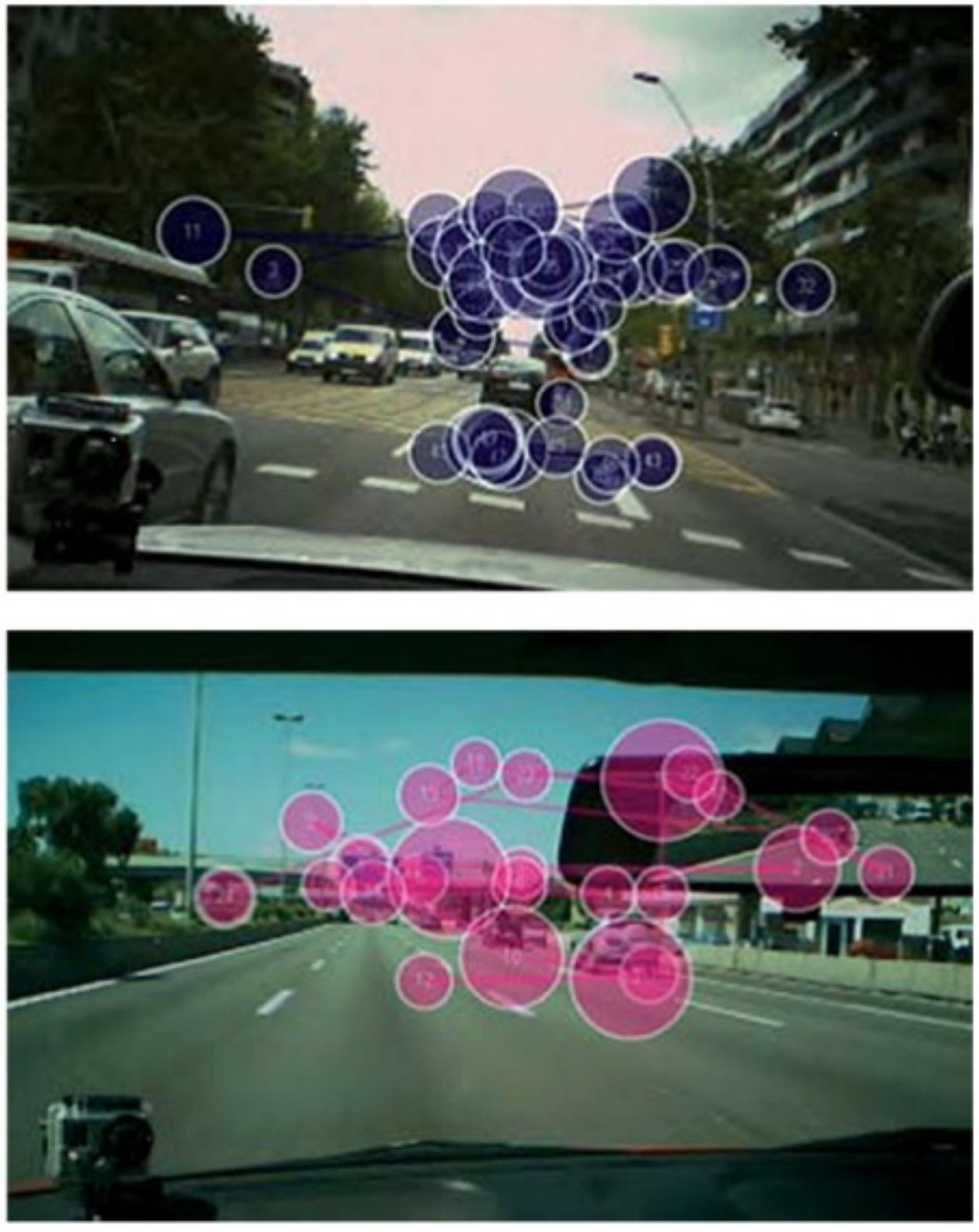
1. Marketing


Schampo och balsam
Schampo och balsam
Schampo och balsam
55:-

2. Security



Conscious driving P3



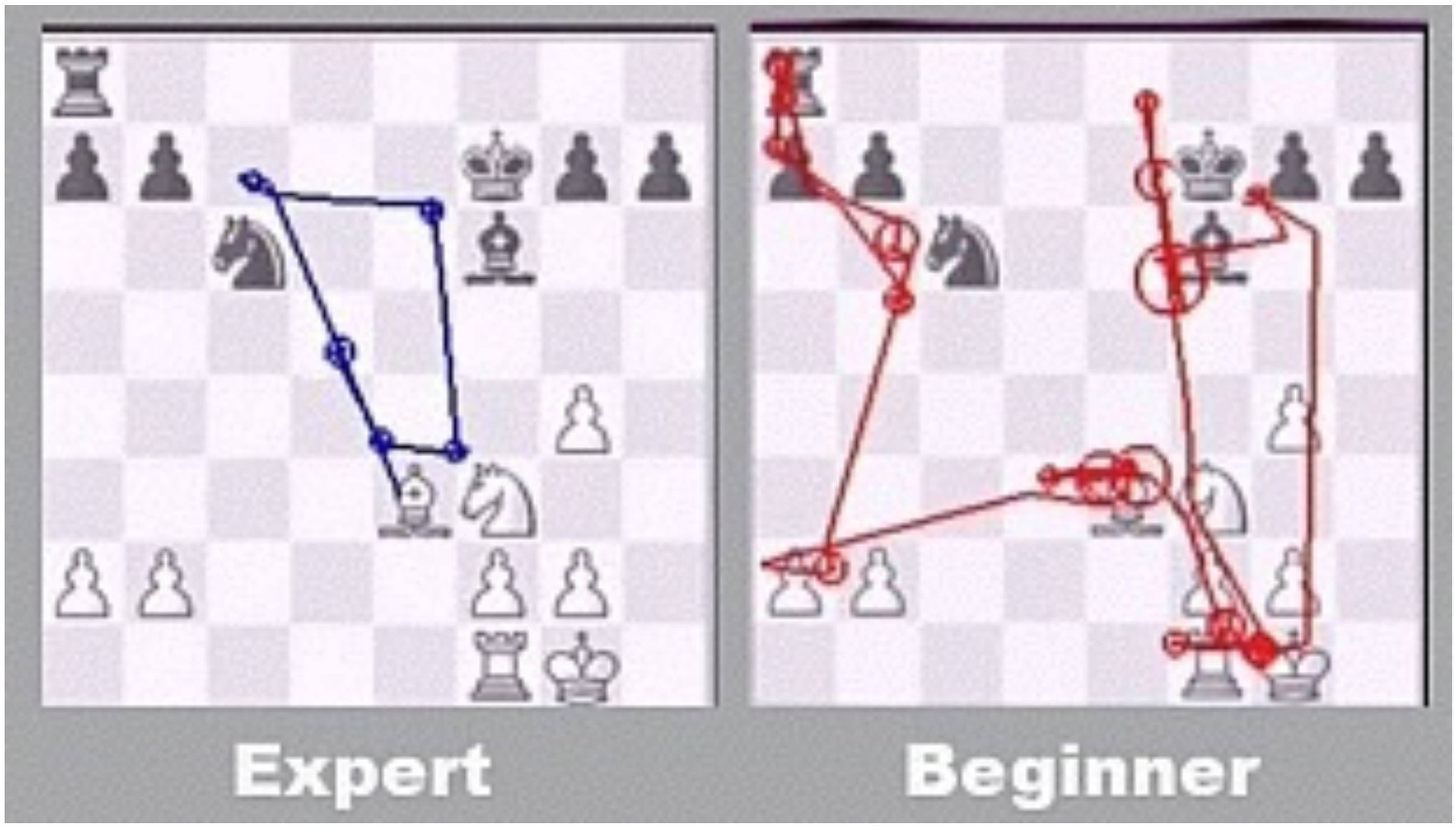
Driving subconscious P11

3. Research

1. Expert versus novice
2. Task based performance
3. Programming
4. Massive Open Online Courses (MOOCs)

3.1 Expert versus Novice

3.1 Expert versus Novice



3.2 Task based performance

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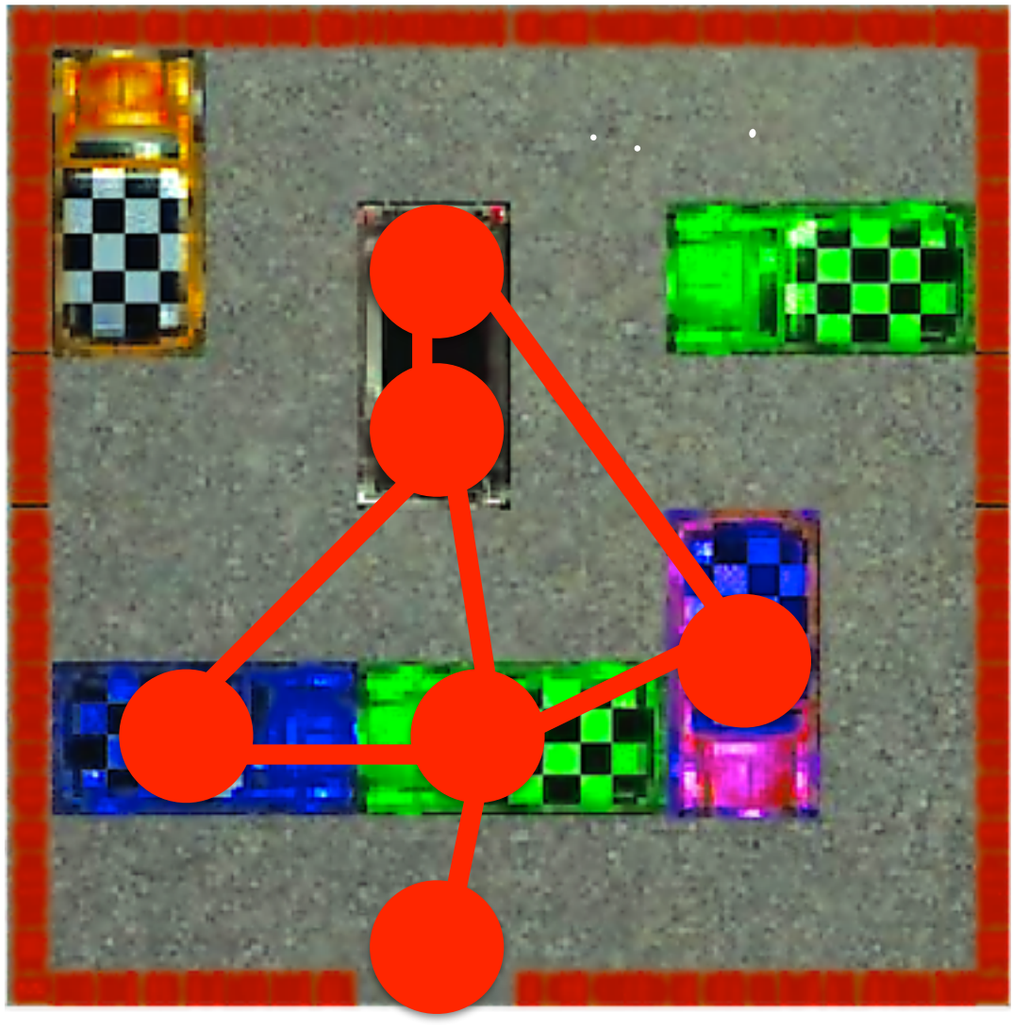

Solvers

Non-solvers

3.3 Programming

```
public static int goolbaka ( int vv )
{
        int c = 0 ;
        while ( vv >= 0 )
        {
                vv /= 10;
                c ++ ;
        }
        return c ;
}
```

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Good student

Poor student

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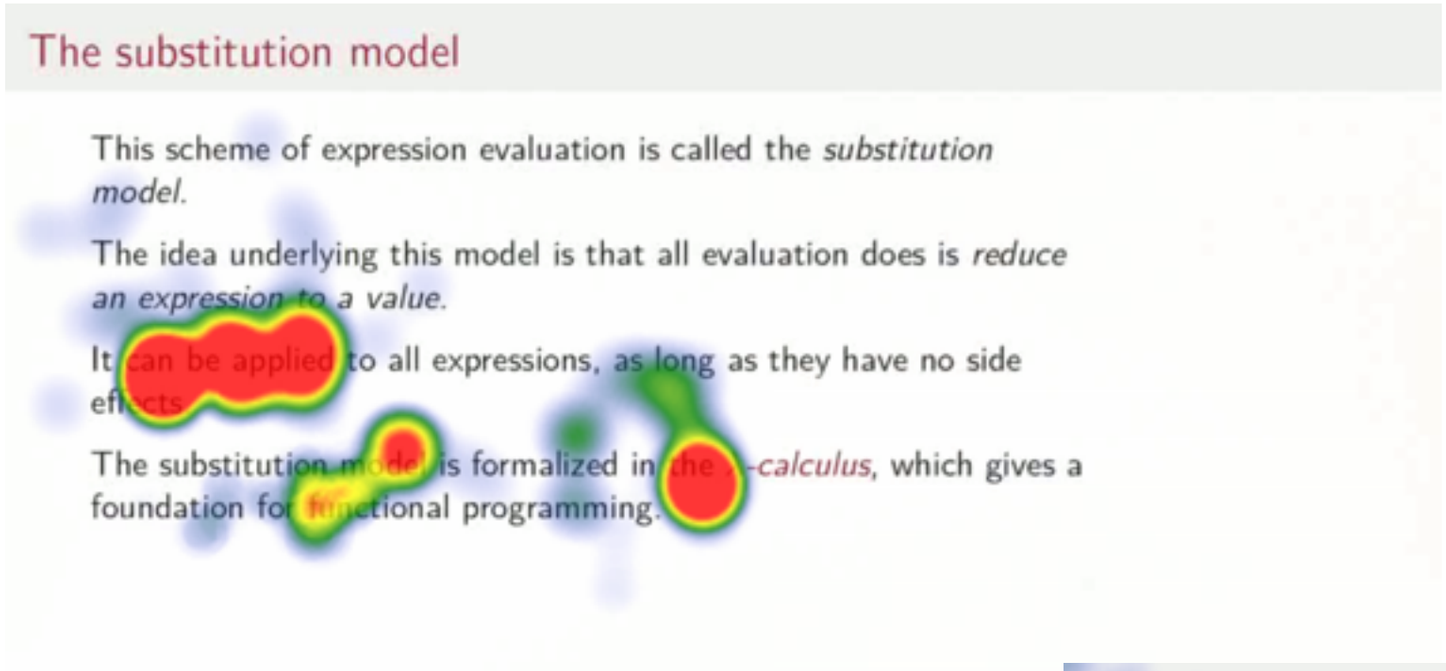
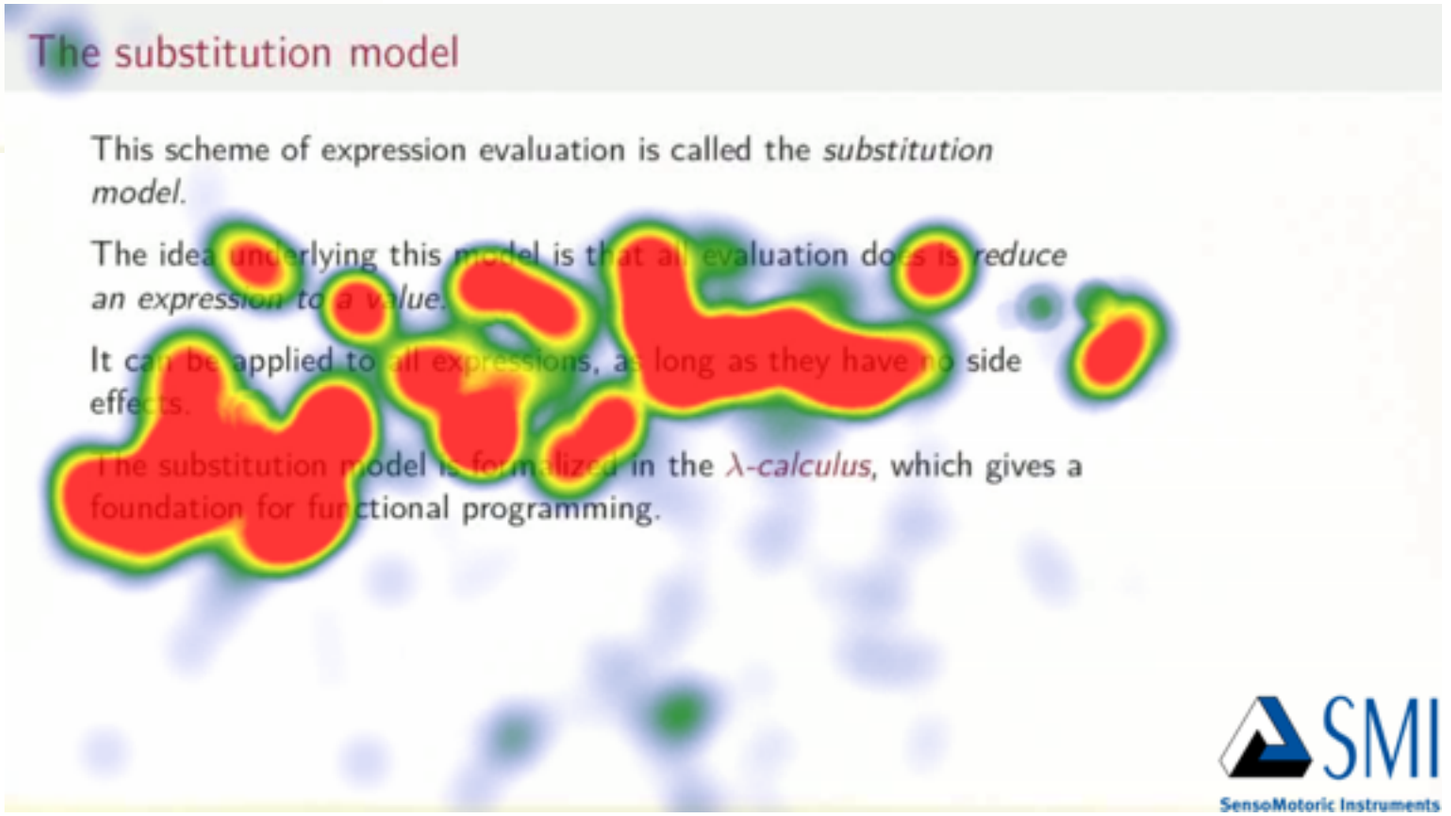
SMI
SensoMotoric Instruments

3.4 MOOCs



Poor student

Good student



4. Groupware

1. Gaze-dialogue coupling
2. Dual eye-tracking

4.1 Gaze-dialogue Coupling

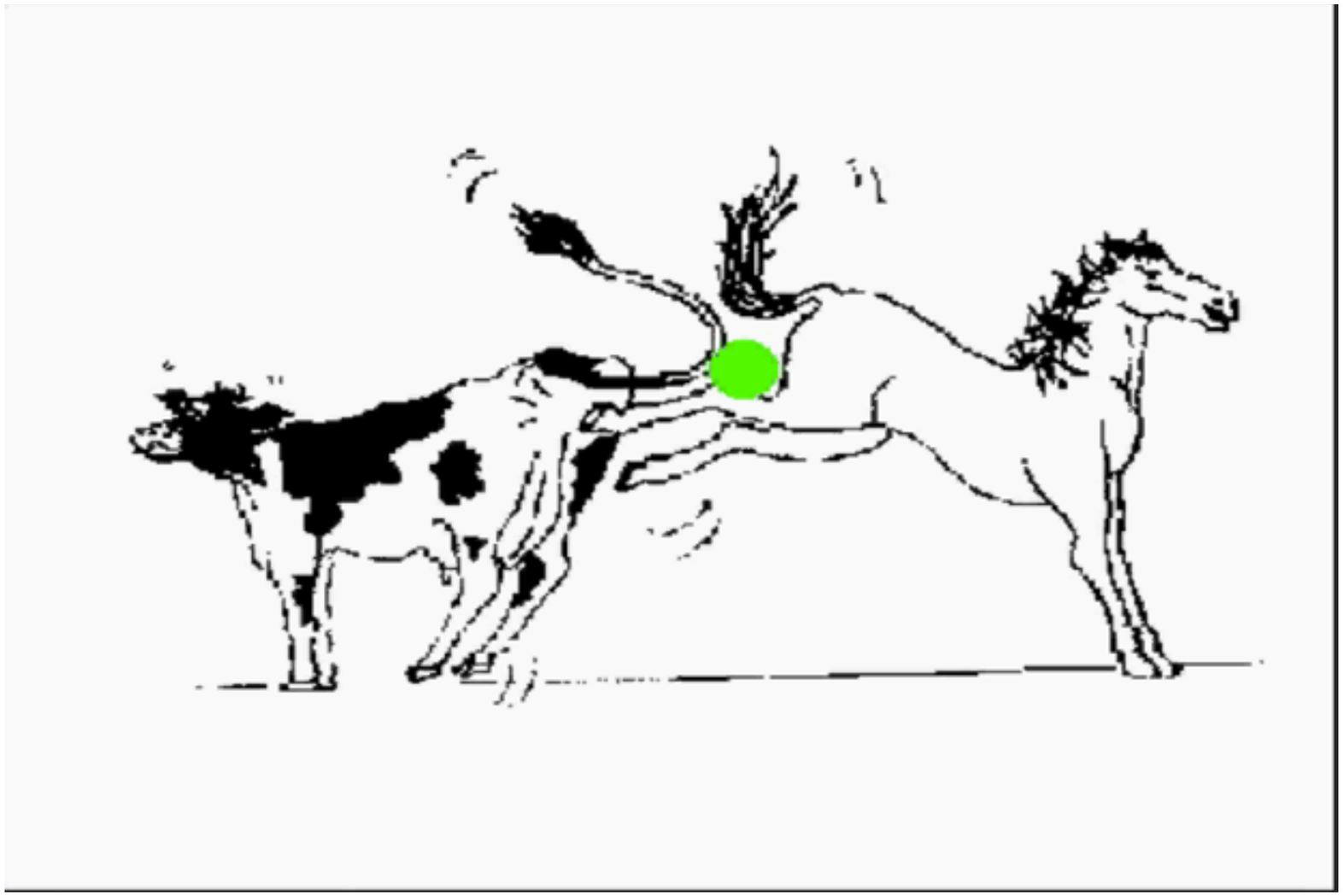
- Eye-voice span: time difference between what I see and what I say

- Voice-eye span: time difference between what you say and what I see

- Eye-eye span: time difference between what you see and what I see

4.1 Gaze-dialogue Coupling

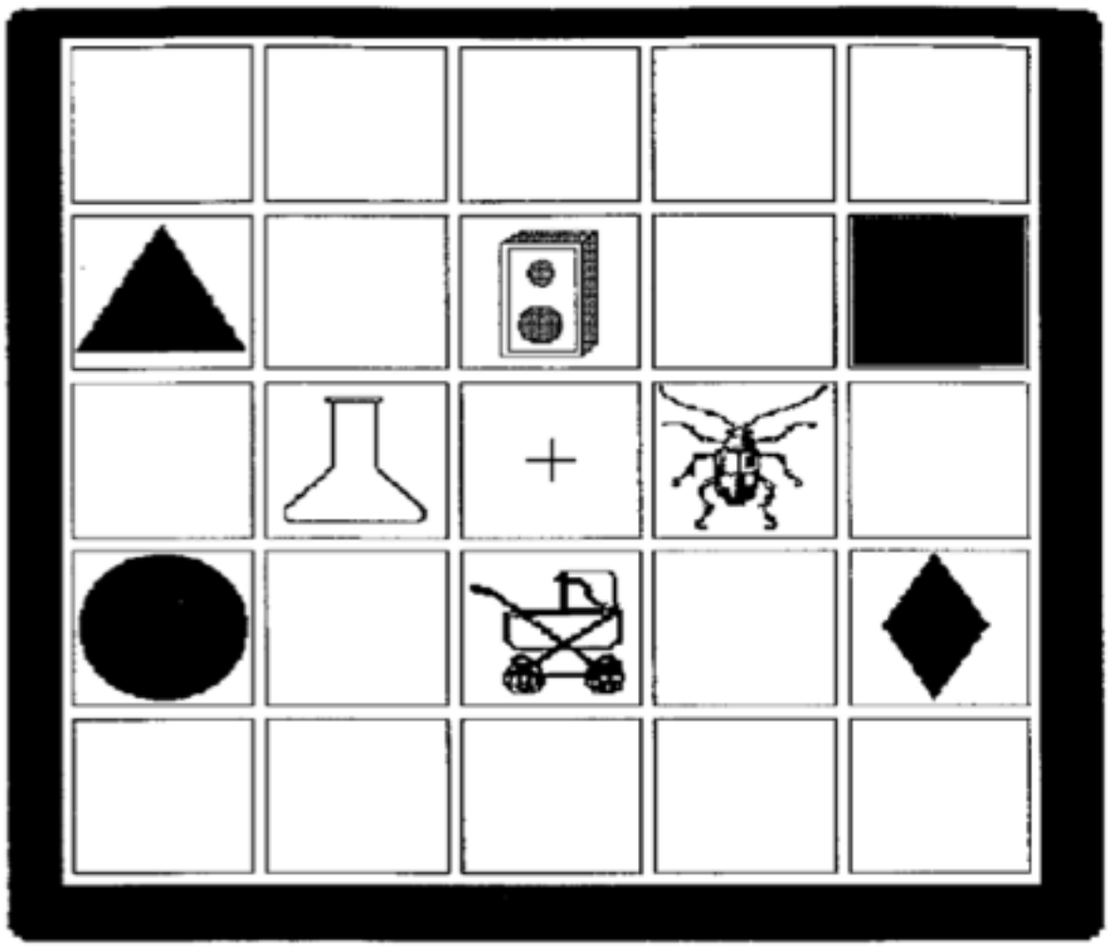
Eye-voice span

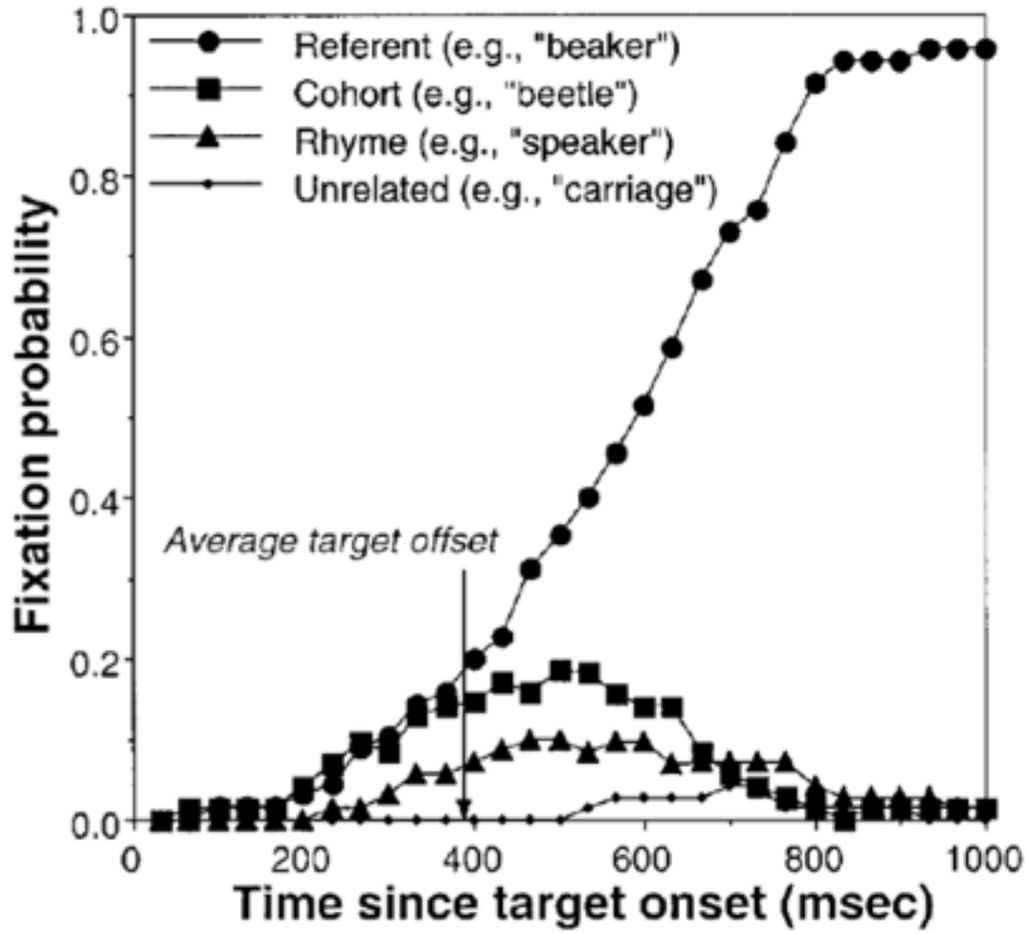


Griffin, Z. M., and Bock, K. (2000). “What the eyes say about speaking.”

4.1 Gaze-dialogue Coupling

Voice-eye span

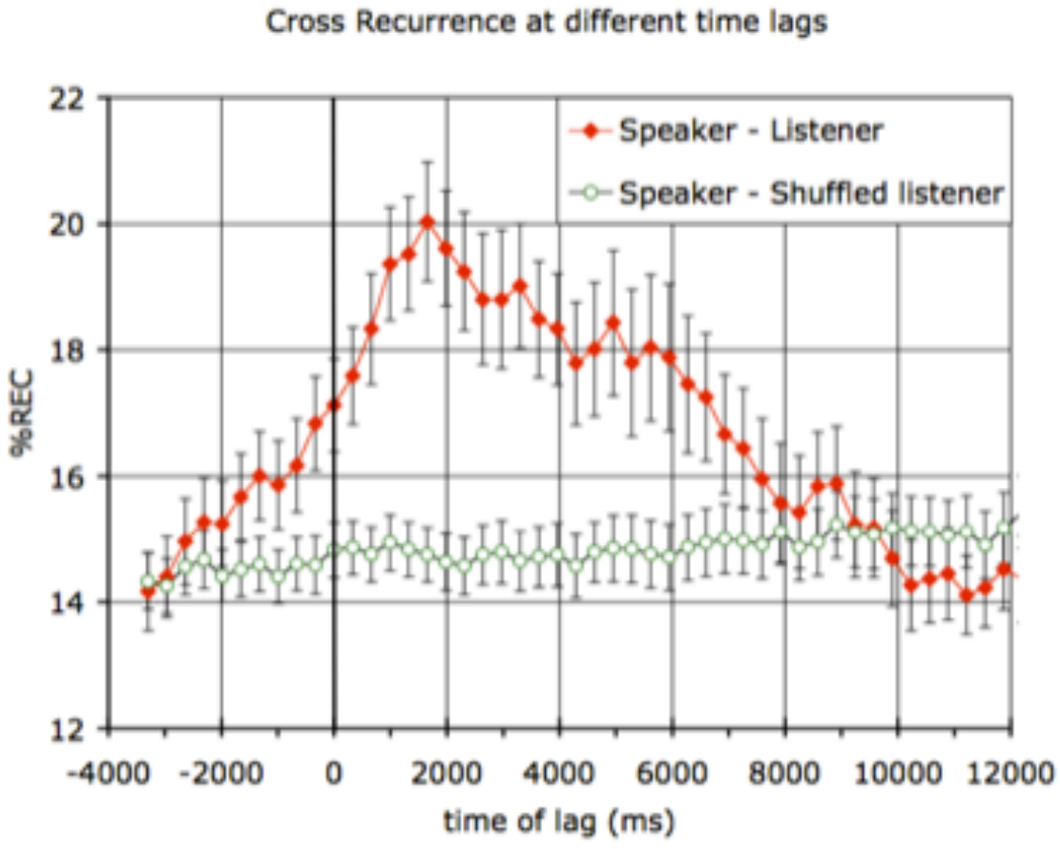




Allopenna, P. D., et. al., (1998). “Tracking the Time Course of Spoken Word Recognition Using Eye Movements: Evidence for Continuous Mapping Models”

4.1 Gaze-dialogue Coupling

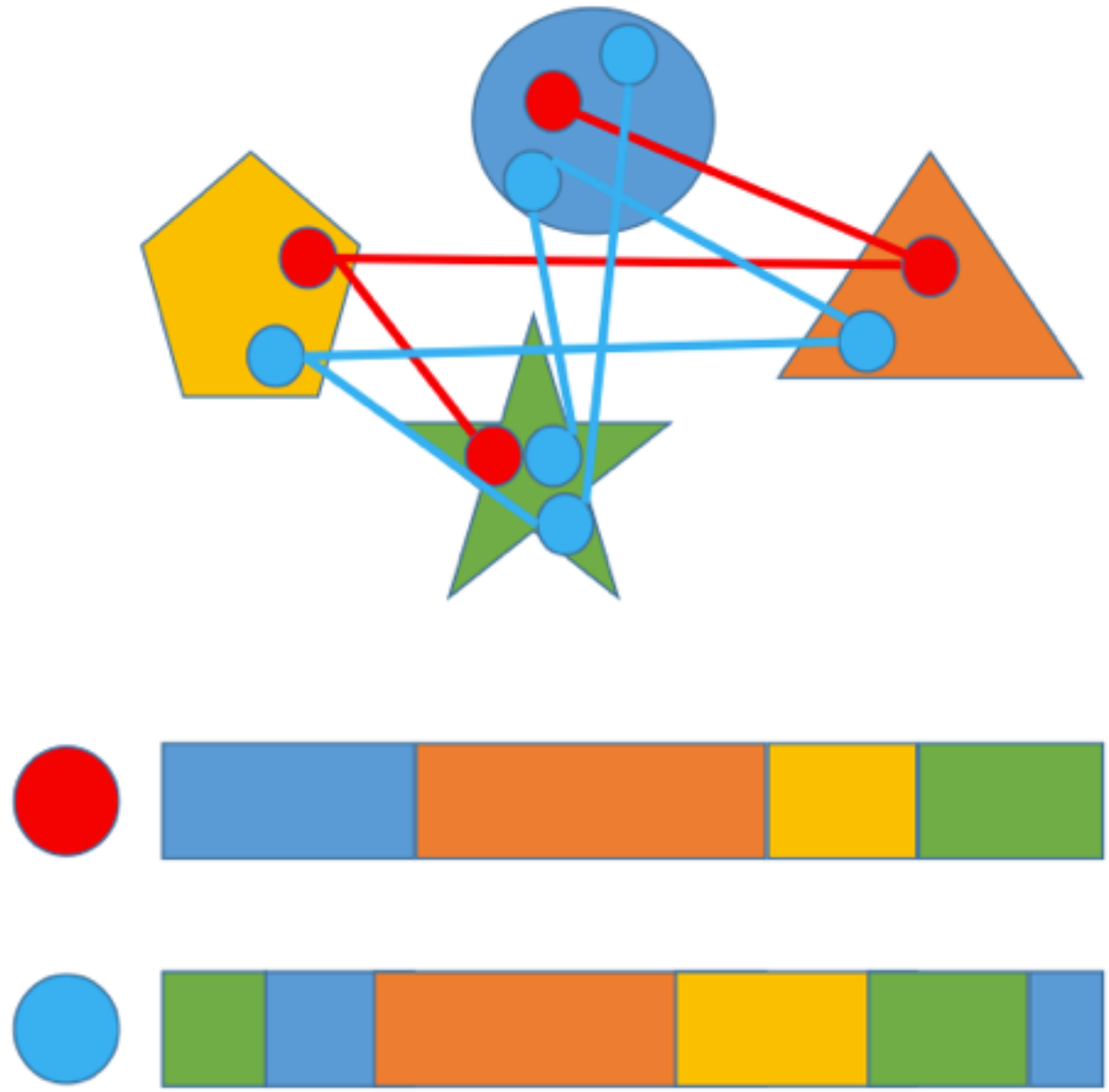
Eye-eye span



Dale, R. et. al., (2007), “Art of conversation is coordination”

4.1 Gaze-dialogue Coupling

Gaze cross-recurrence



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Gaze cross-recurrence

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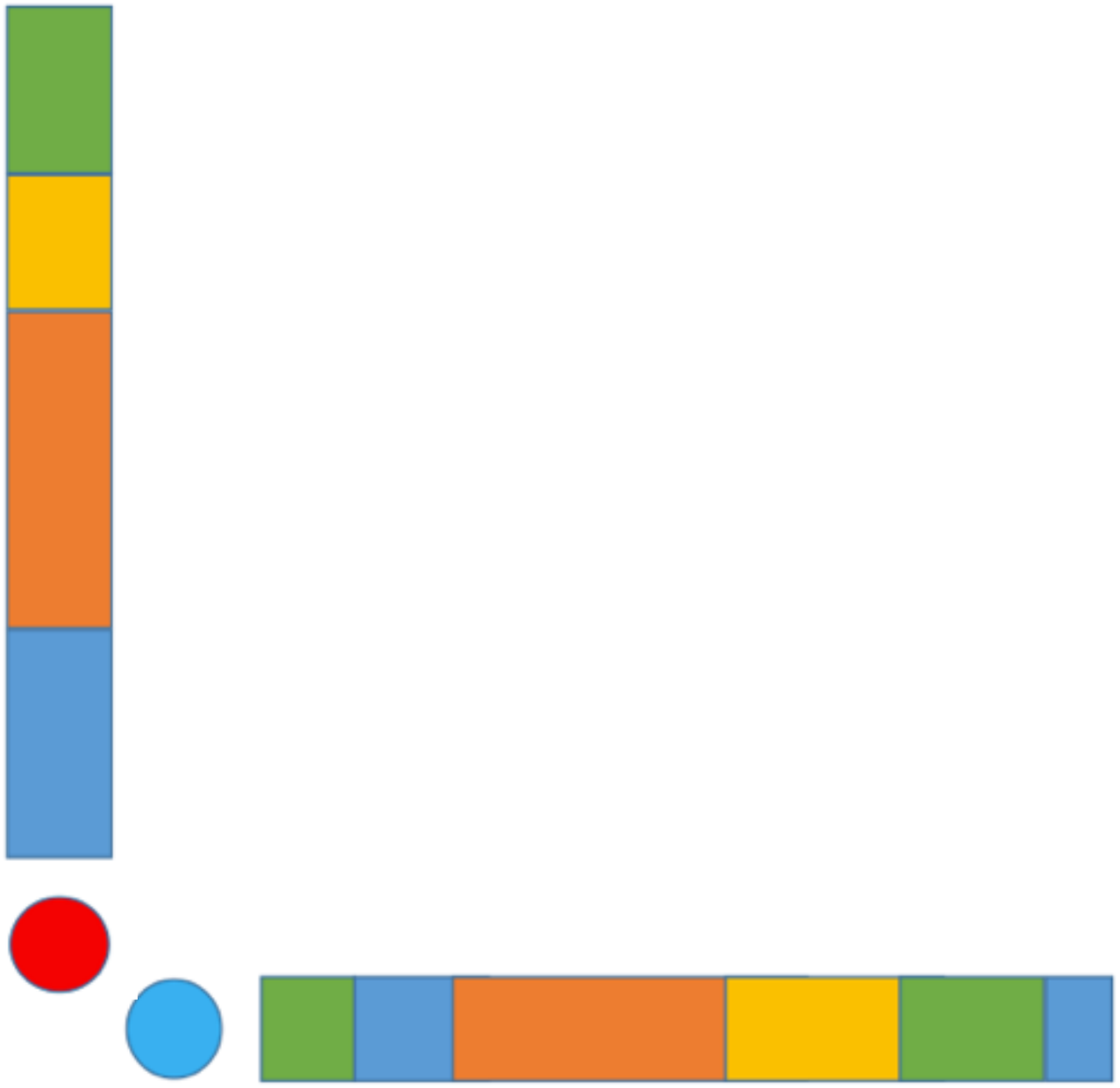

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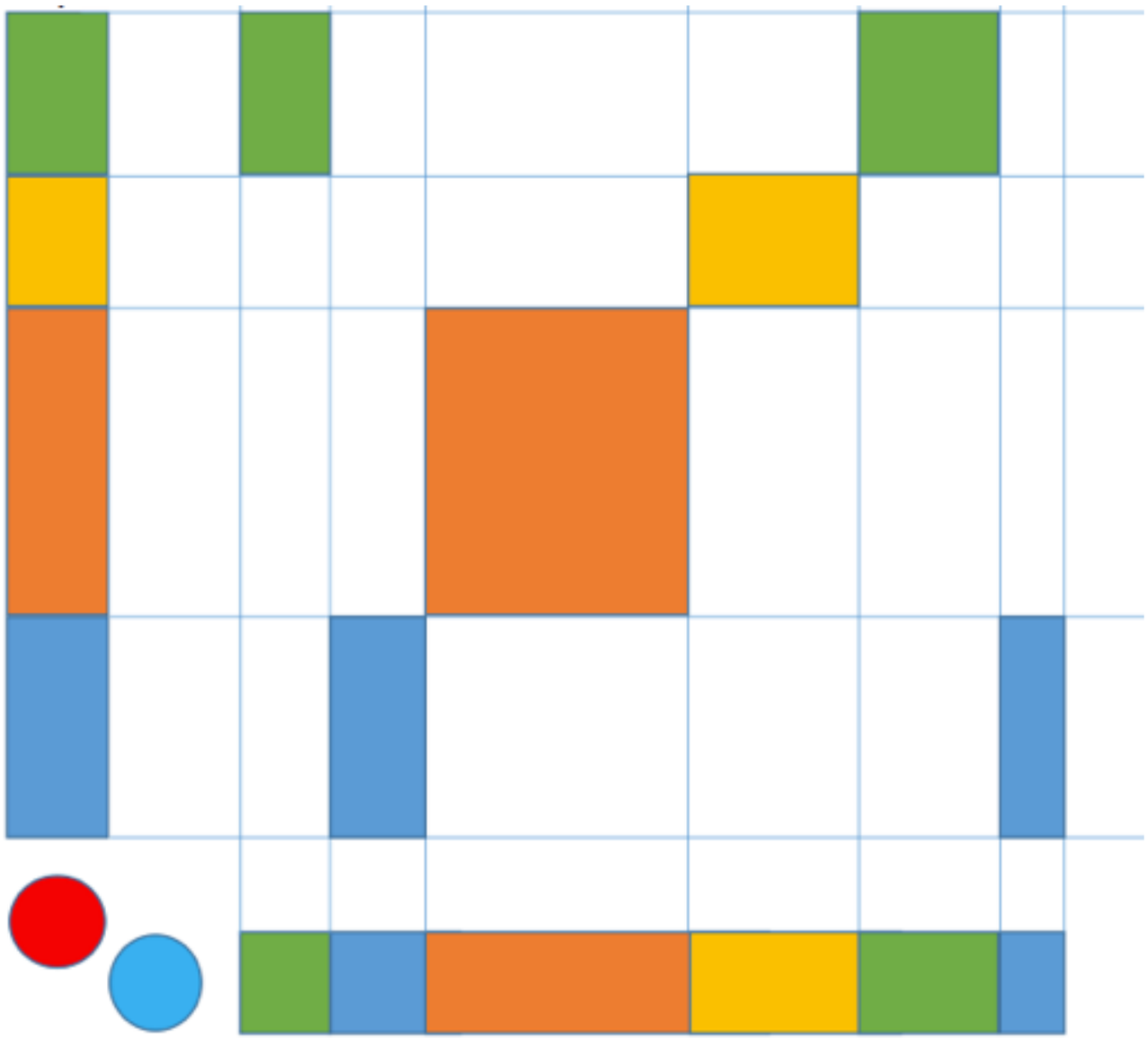

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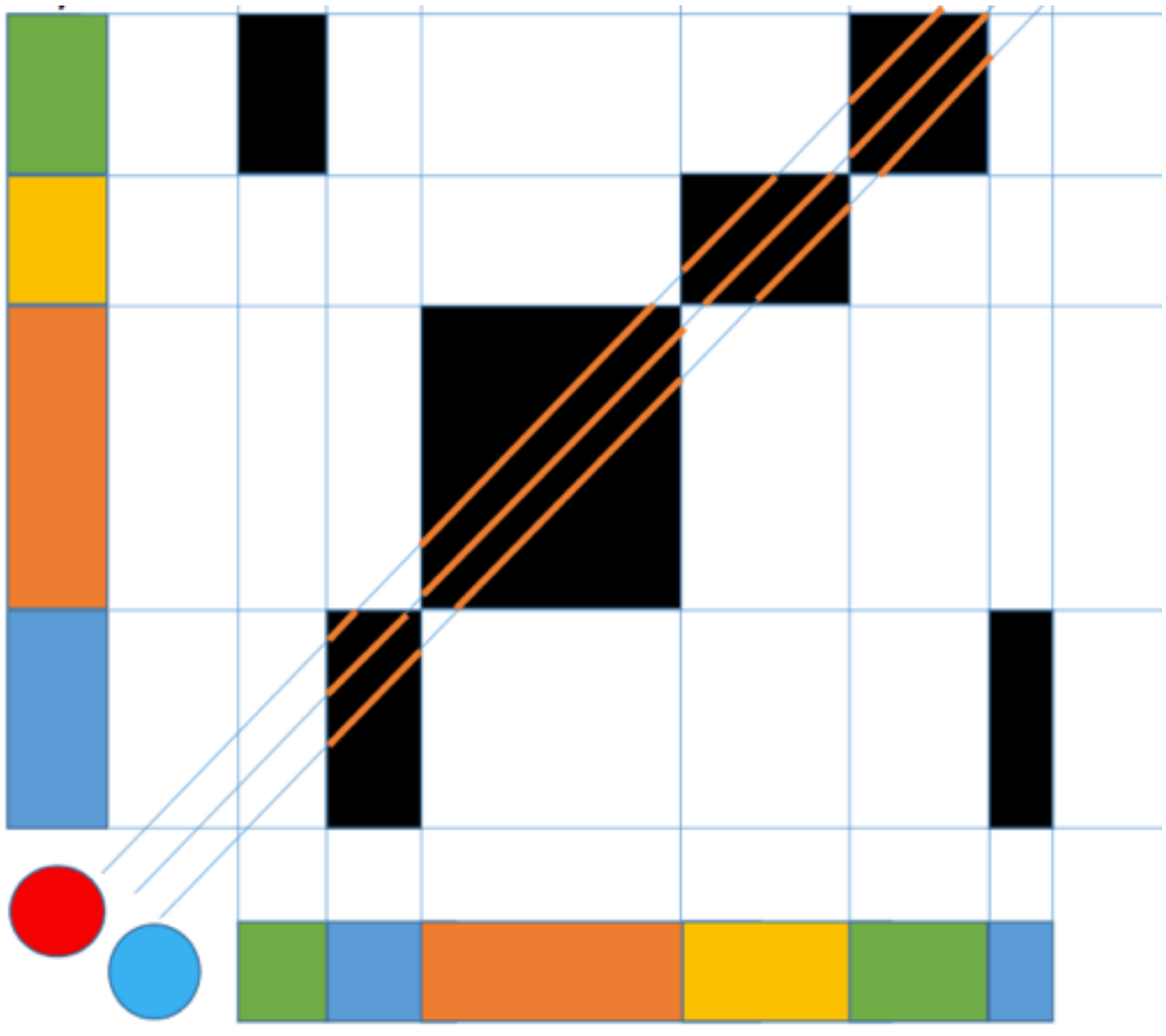


4.2 Dual eye-tracking

One task to complete.

Two synchronised eye-trackers.

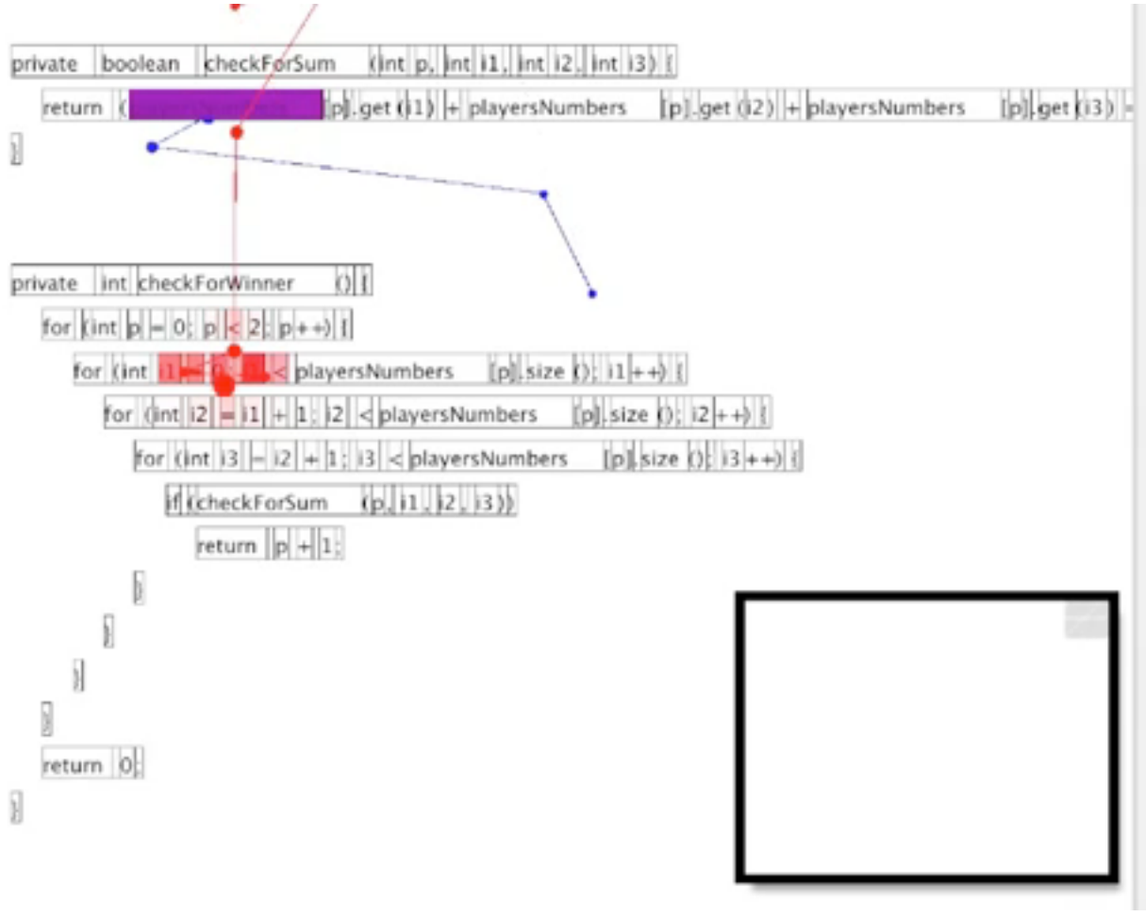
Synchronised screen: actions, viewports…

Peers can not see each other but can talk.

4.2 Dual eye-tracking

Example: pair-programming

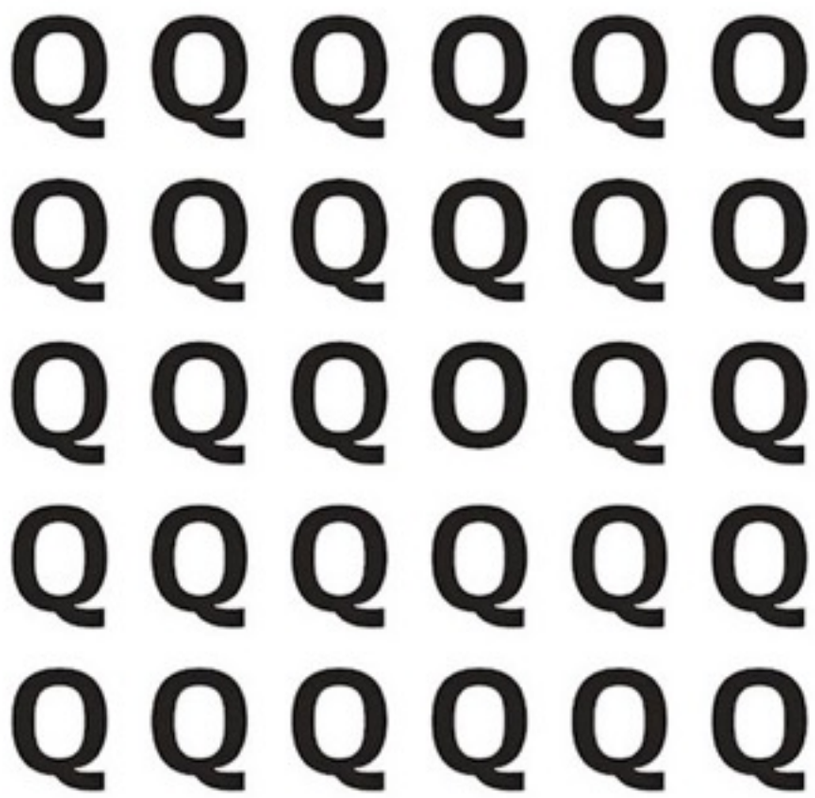
Good collaboration quality



Poor collaboration quality

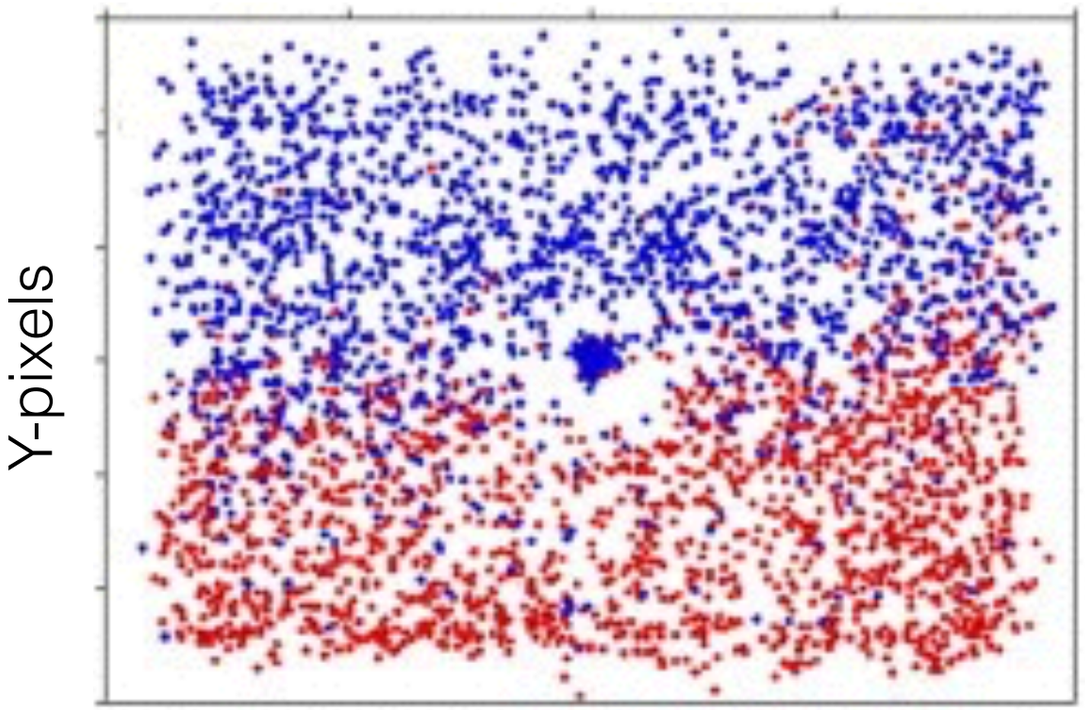
4.2 Dual eye-tracking

Example: collaborative visual search

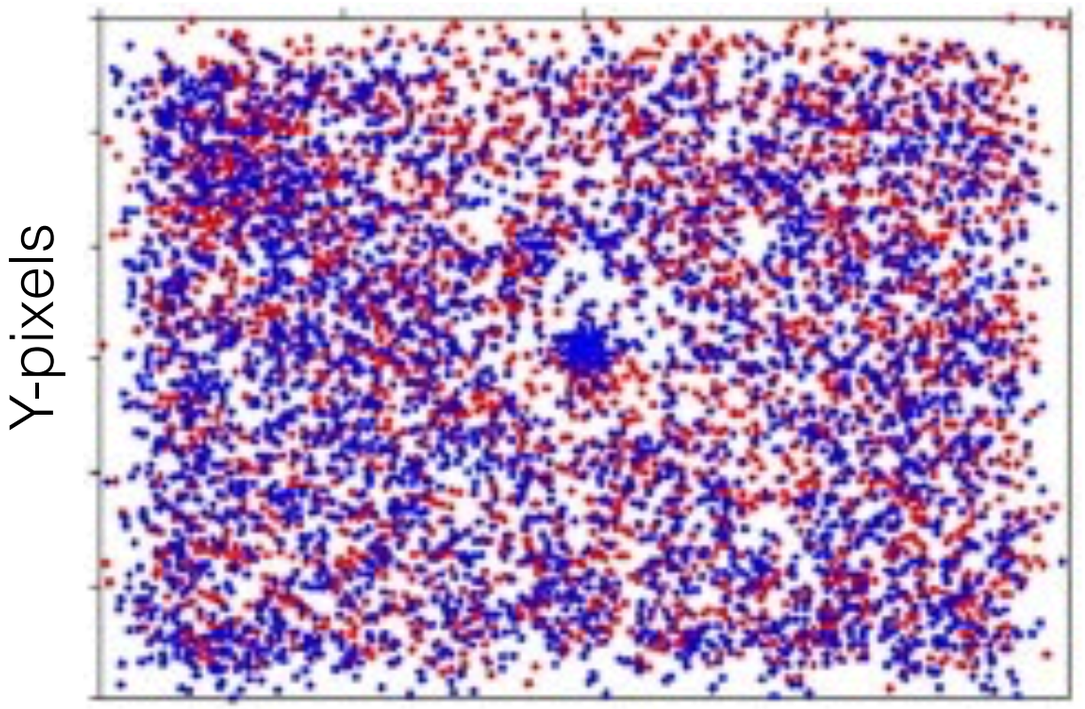


4.2 Dual eye-tracking

Example: collaborative visual search



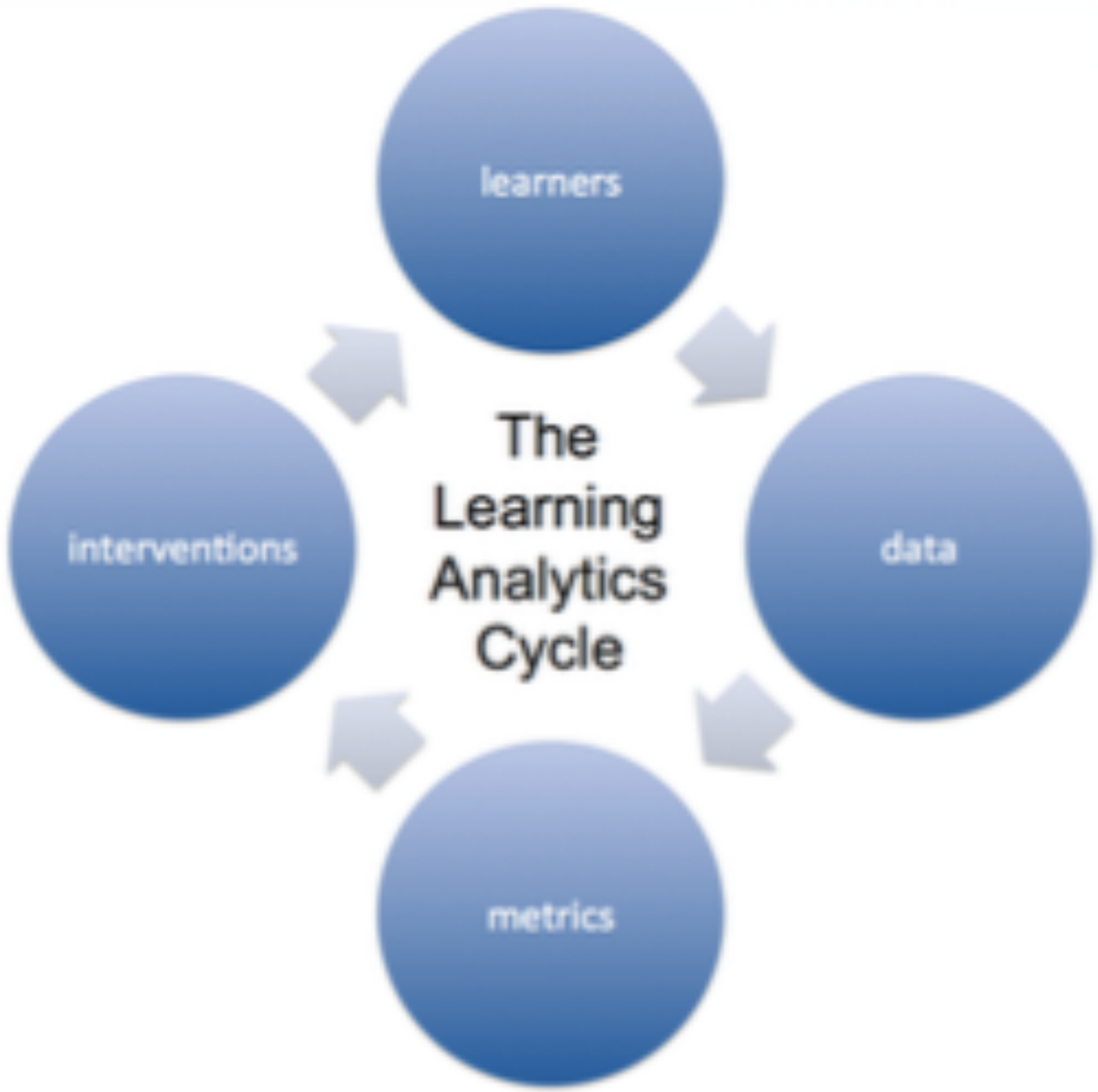
Good collaboration quality
Low cross-recurrence



Poor collaboration quality
High cross-recurrence

Eye-tracking and Learning Analytics

Learning Analytics: capture, compare, evaluate, intervene



Eye-tracking and Learning Analytics

Eye-tracking and Learning Analytics

1. Gaze-awareness: where am I looking?
2. Gaze-contingency: where is the speaker looking?

1. Gaze Awareness

With-me-ness

1. Perceptual with-me-ness: how much do you follow the teacher's explicit gestures?

2. Conceptual with-me-ness: how much do you follow the teacher's dialogues?

1. Gaze Awareness

Perceptual With-me-ness

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`

1. Gaze Awareness

Perceptual With-me-ness

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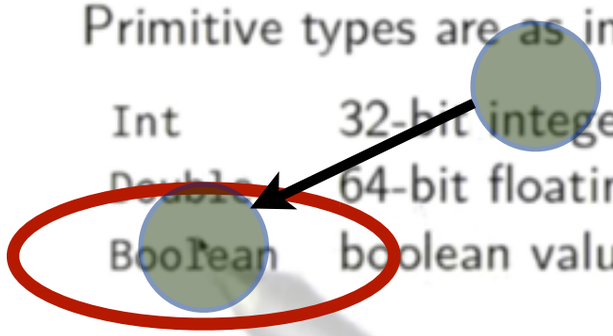

Entry time

1. Gaze Awareness

Perceptual With-me-ness

Parameter and Return Types

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First Fixation Duration

1. Gaze Awareness

Perceptual With-me-ness

Parameter and Return Types

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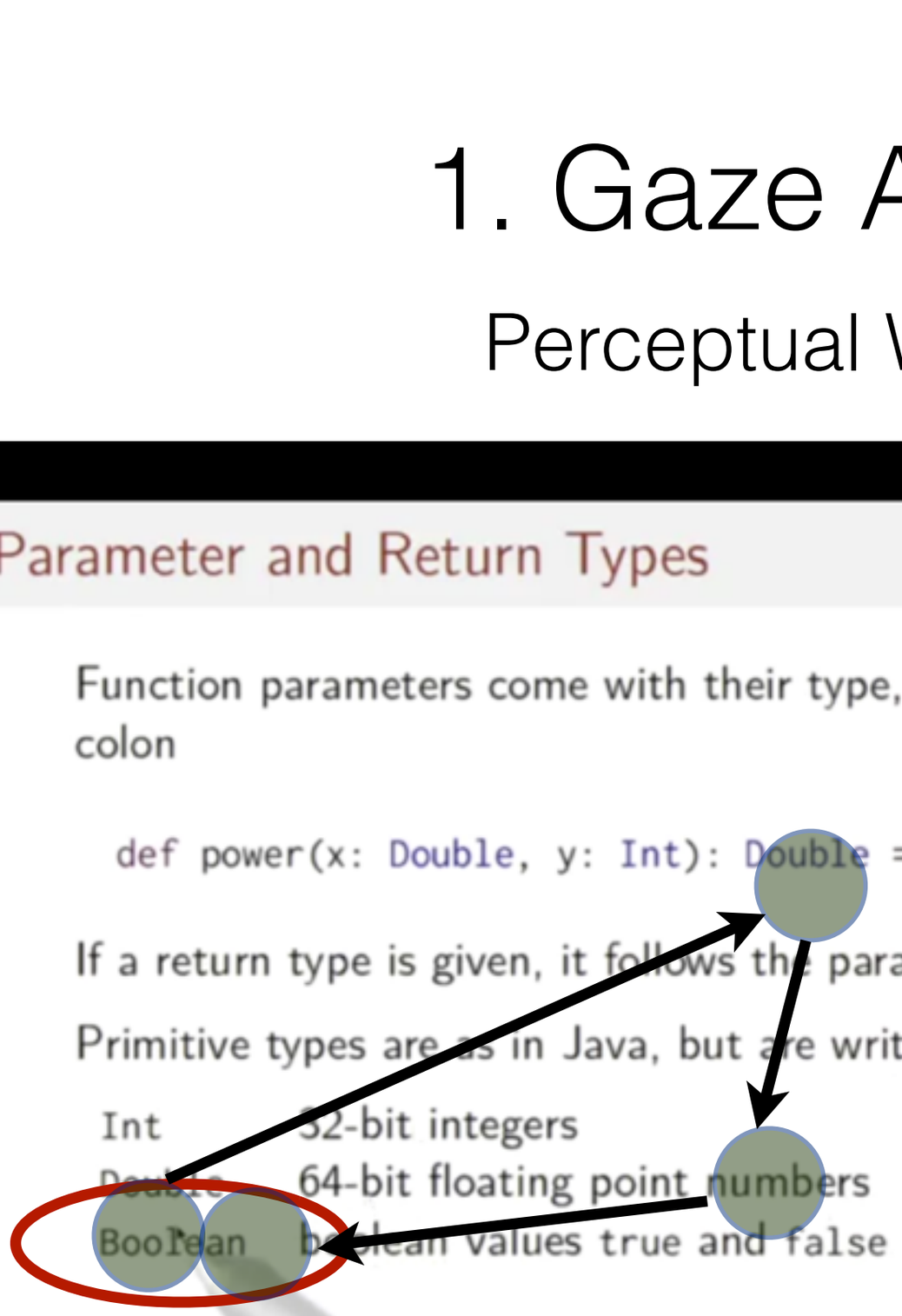


Revisits

1. Gaze Awareness

Conceptual With-me-ness

Time t = 0

```
for ( int i = 0 ; i < n ; i++)
{
        sum += array [i];
}
```

Teacher: the iterator loops

Time t = 1

```
for ( int i = 0 ; i < n ; i++)
{
        sum += array [i];
}
```

Teacher: over the array

Time t = 2

```
for ( int i = 0 ; i < n ; i++)
{
        sum += array [i];
}
```

Teacher: updating the sum

1. Gaze Awareness

With-me-ness

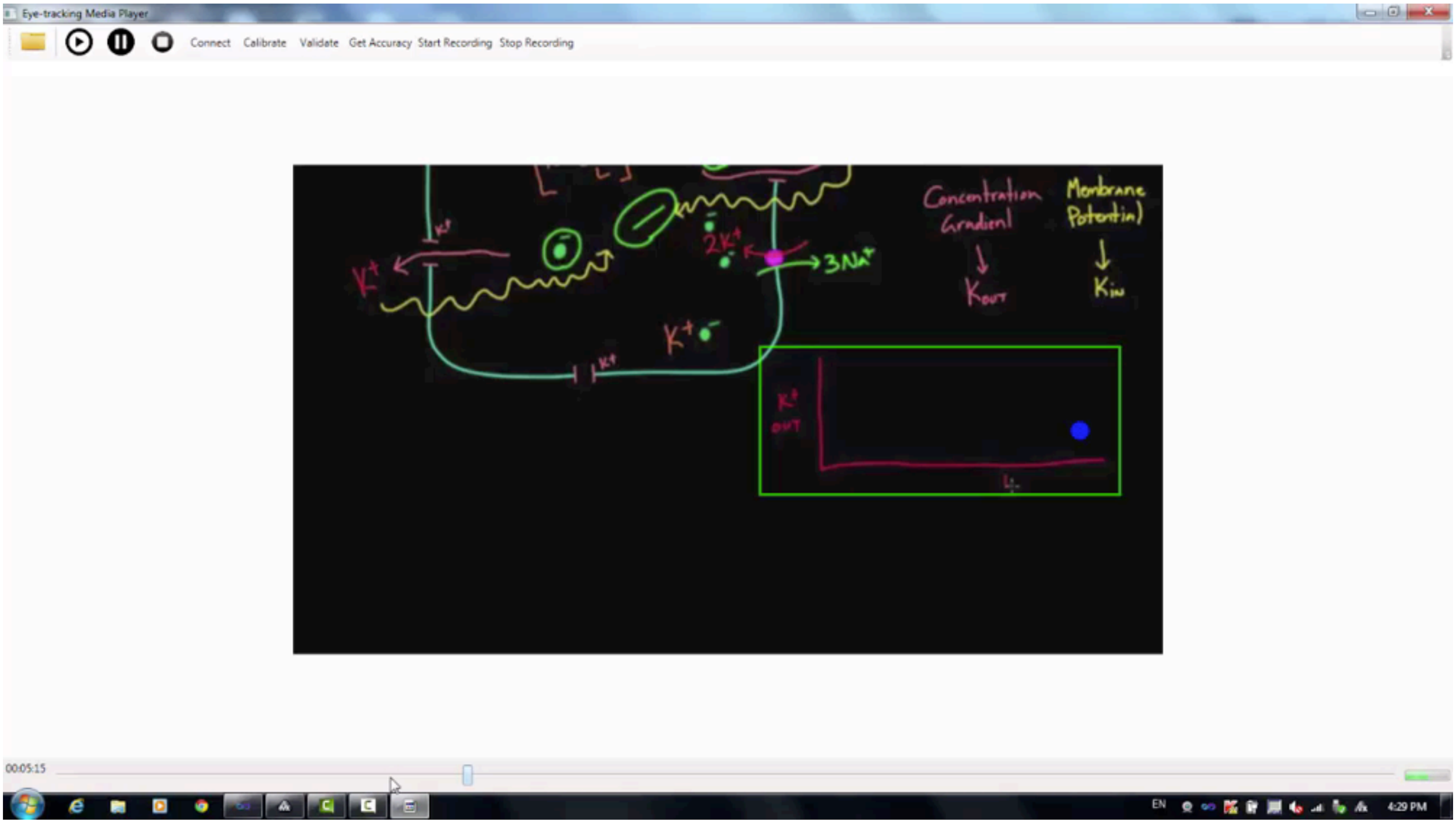
- Perceptual with-me-ness is correlated to learning gain.

- Conceptual with-me-ness is correlated to learning gain.

- What happens when we give students the feedback about their with-me-ness?

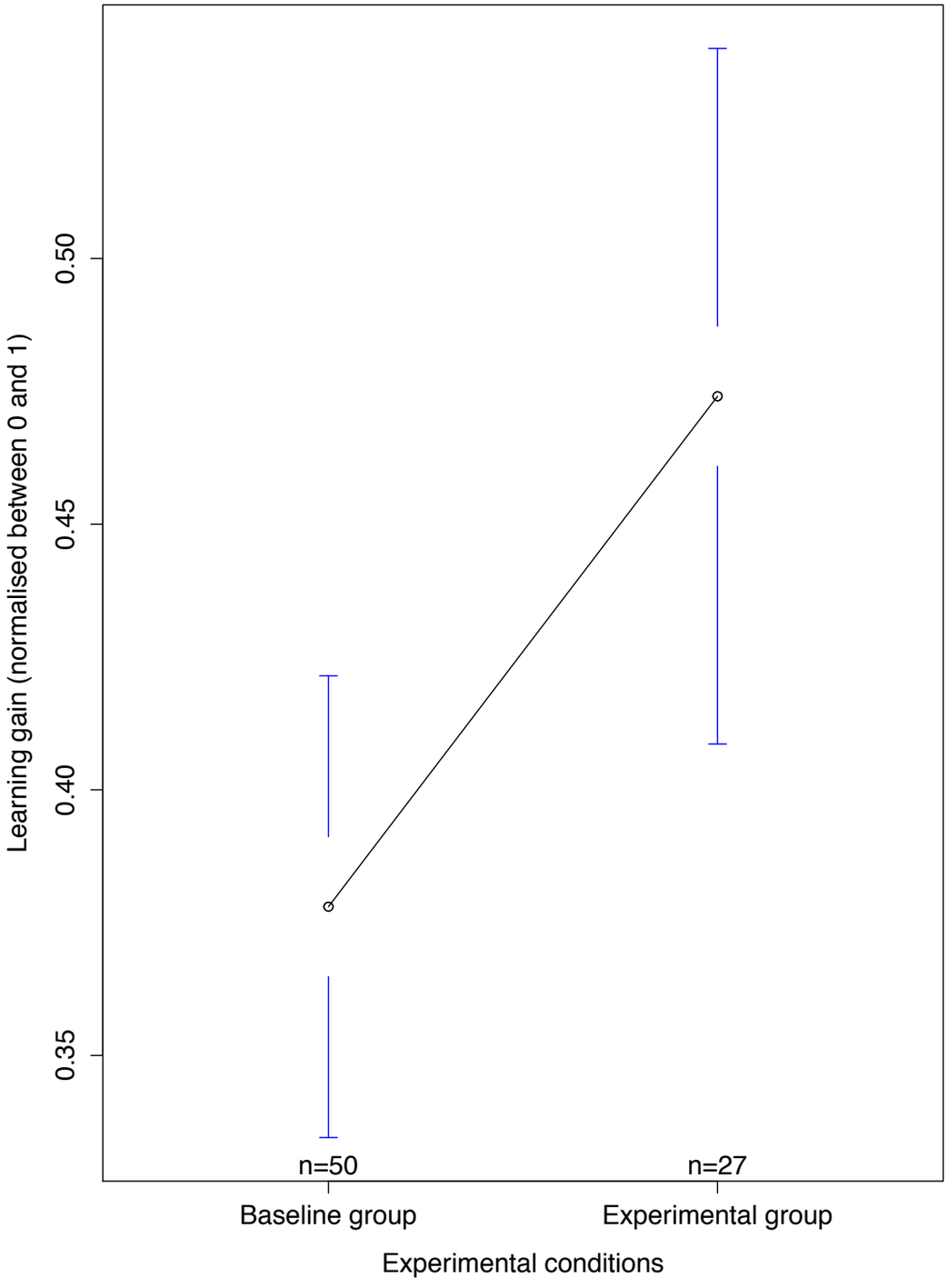
1. Gaze Awareness

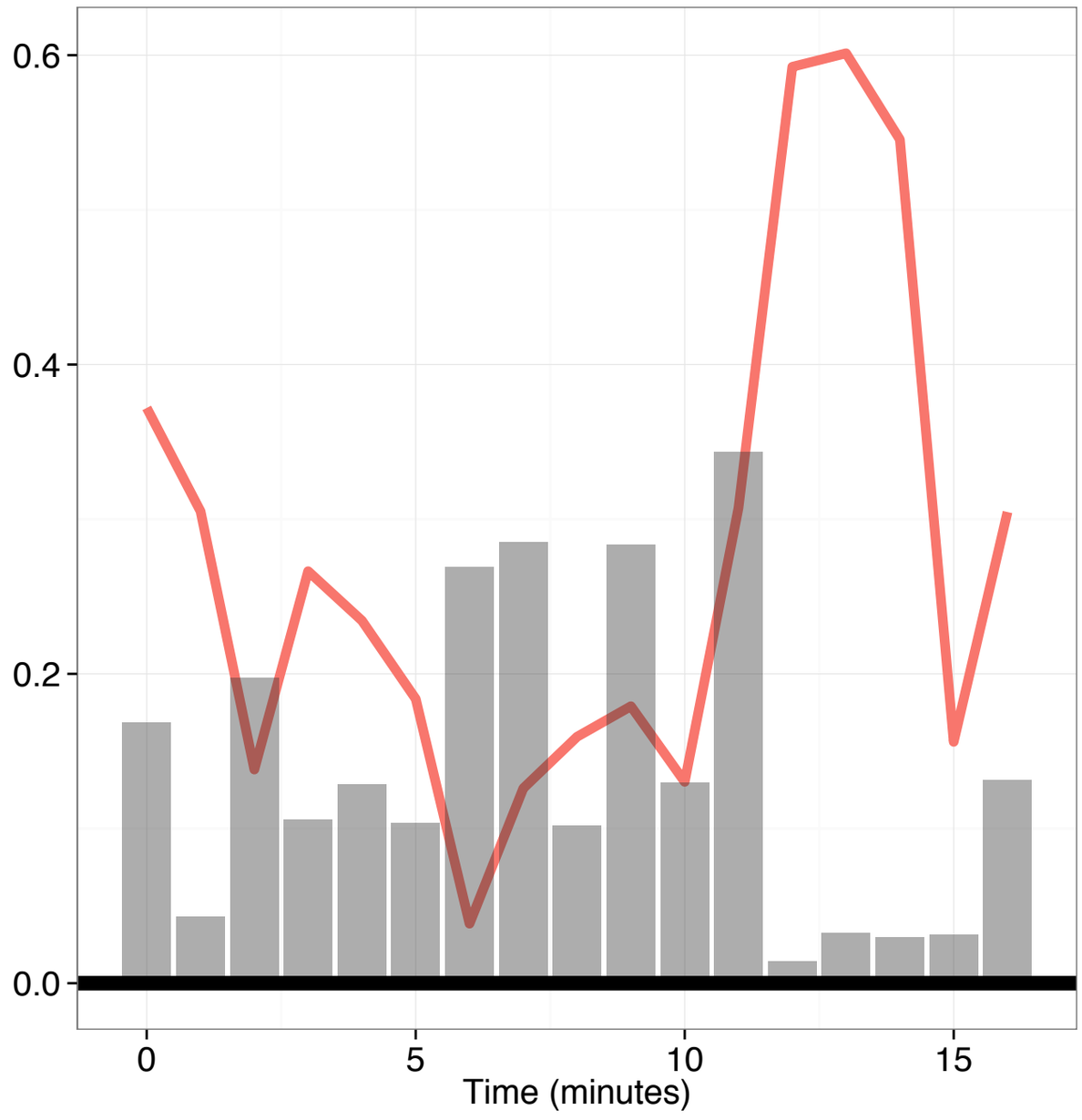
With-me-ness



1. Gaze Awareness

With-me-ness





2. Gaze Contingency

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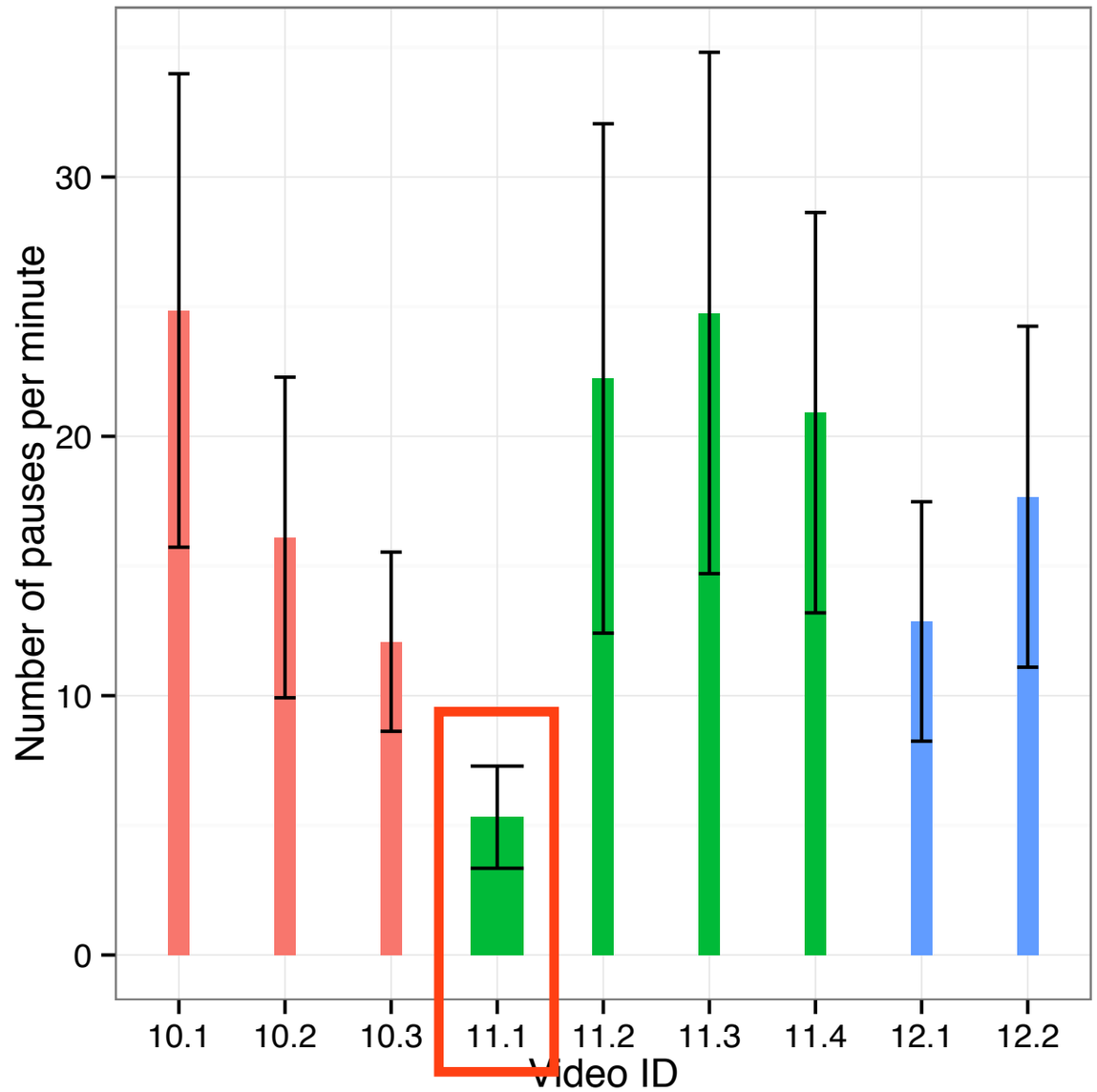
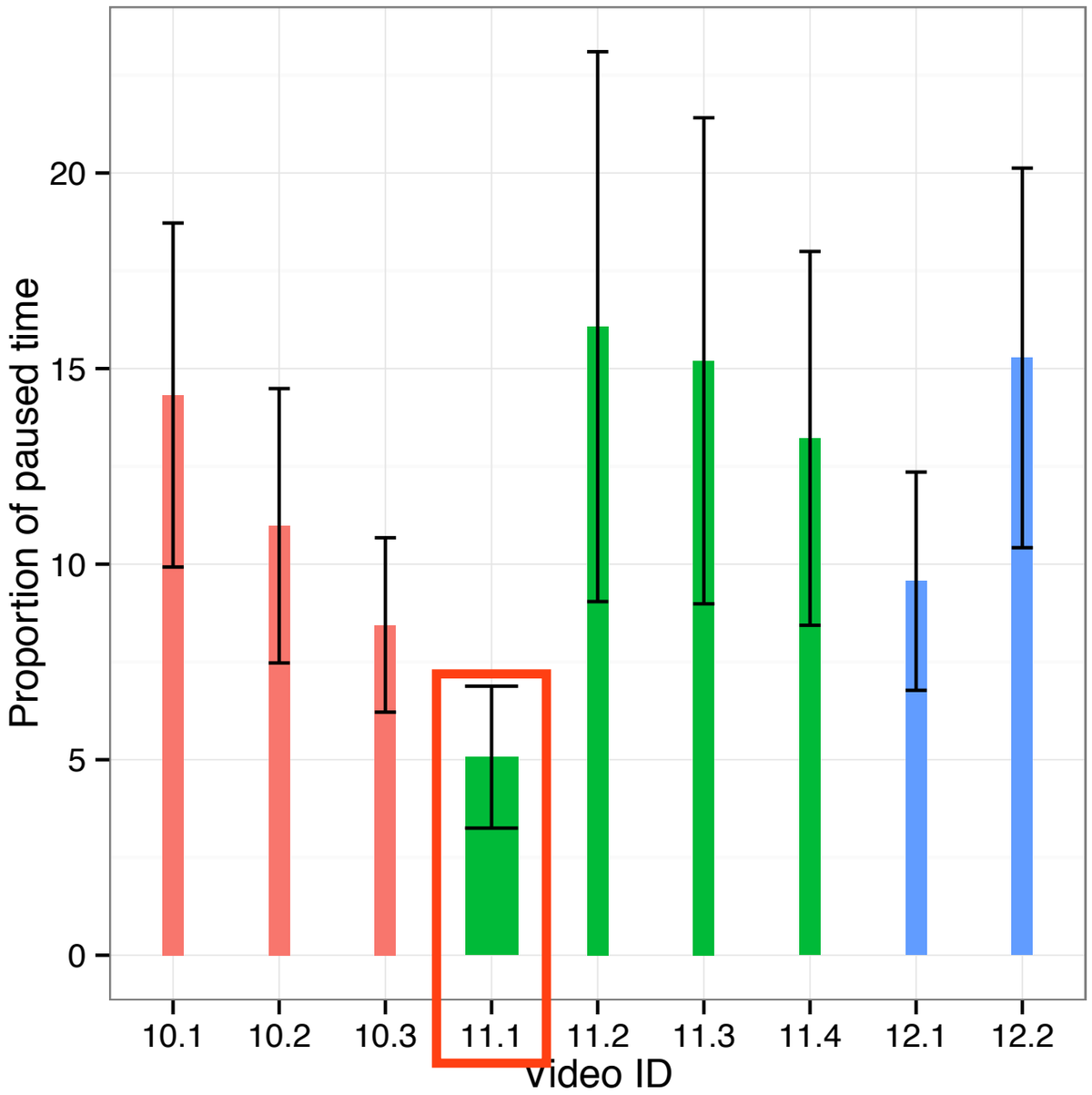


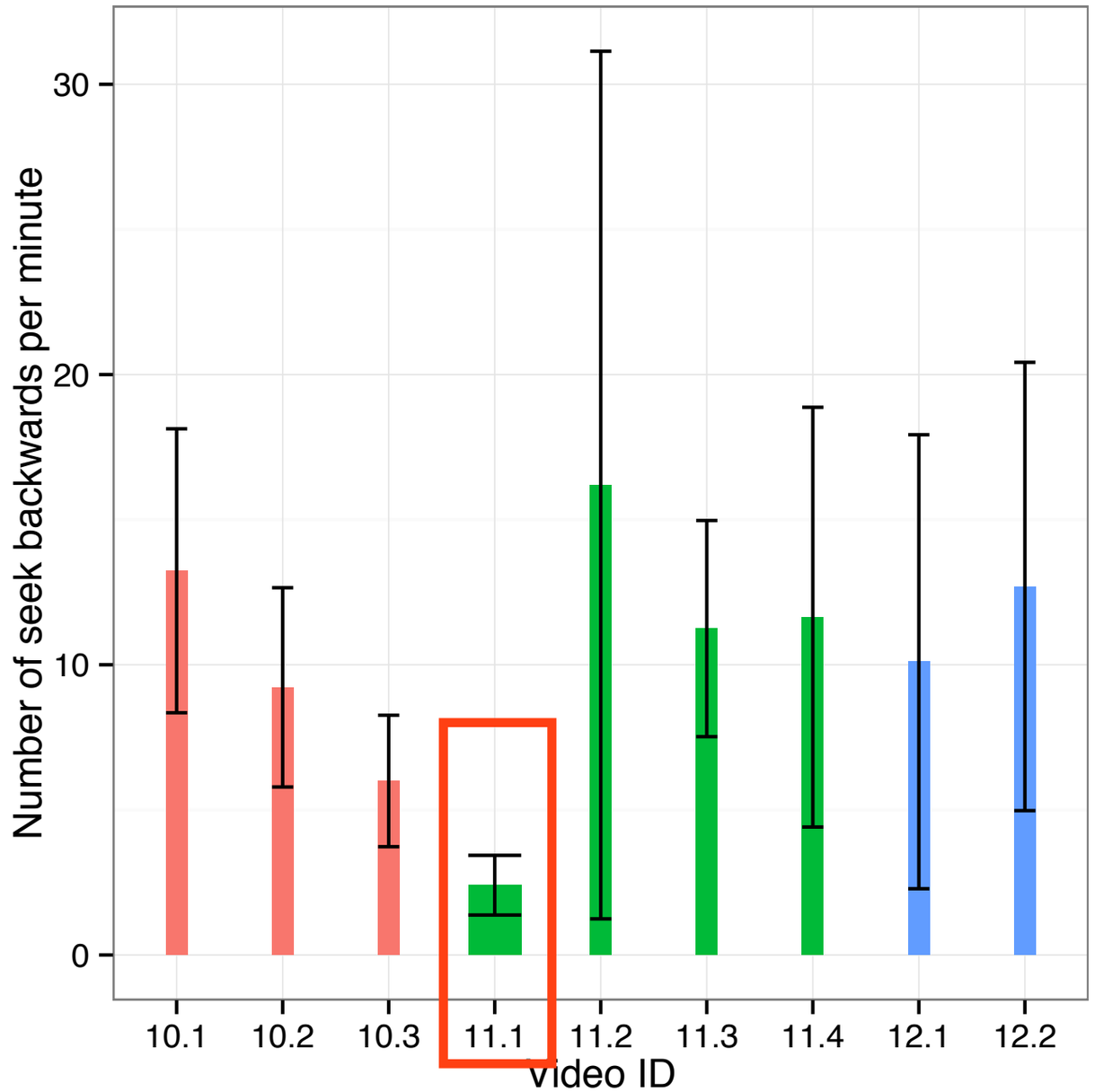
Number of pauses per minute

2. Gaze Contingency



Proportion of paused time

2. Gaze Contingency



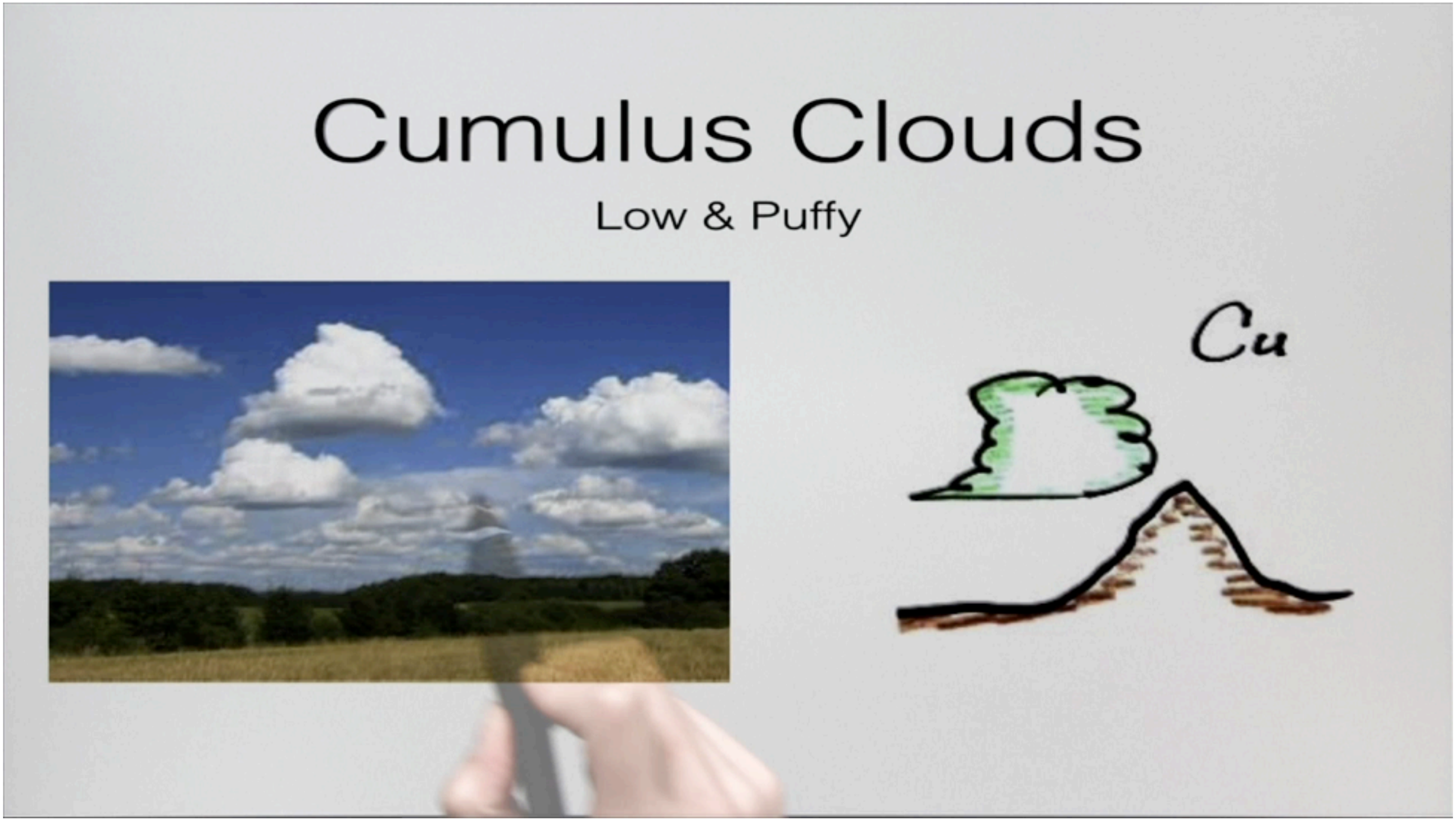
Number of seek-backs per minute

2. Gaze Contingency

- When the teacher's gaze is displayed the video-watching behaviour reflects low perceived difficulty.

- Is gaze better than a pen pointer?

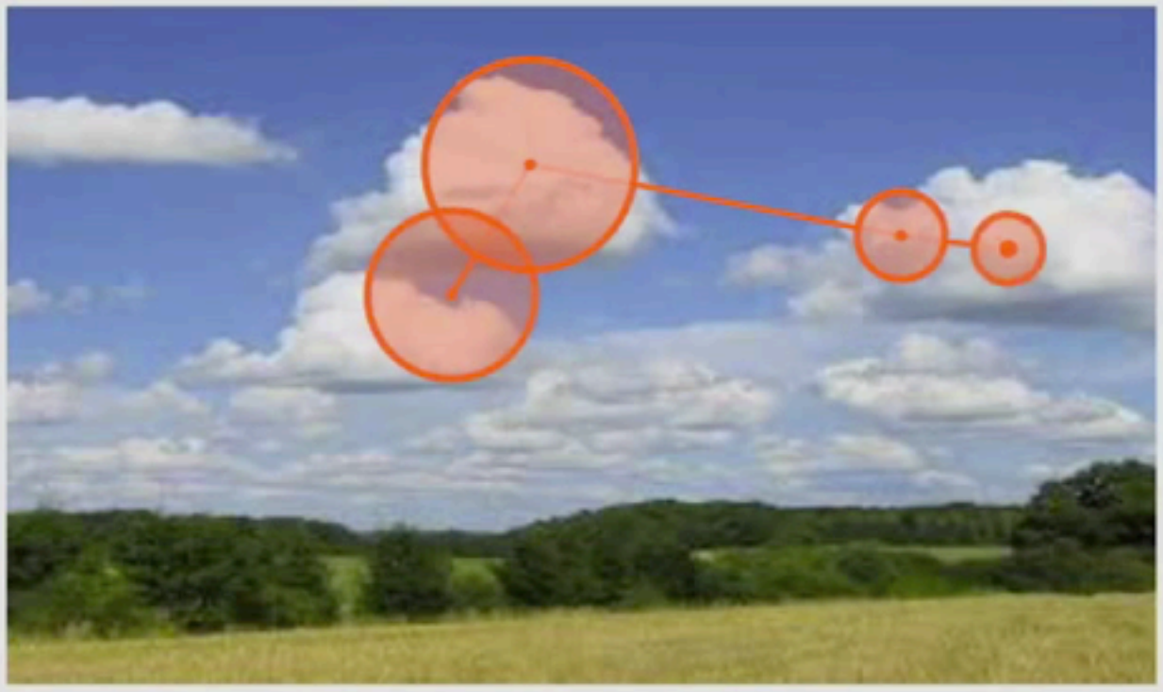
2. Gaze Contingency

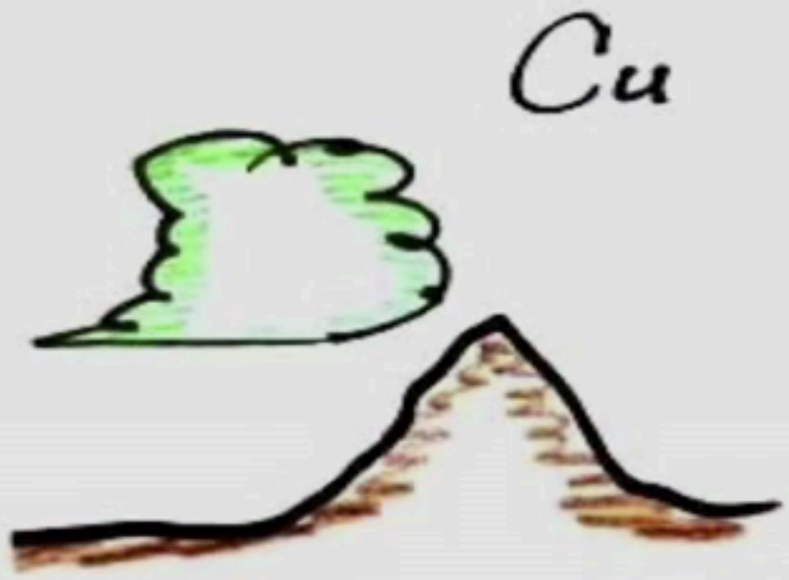


2. Gaze Contingency

Cumulus Clouds

Low & Puffy





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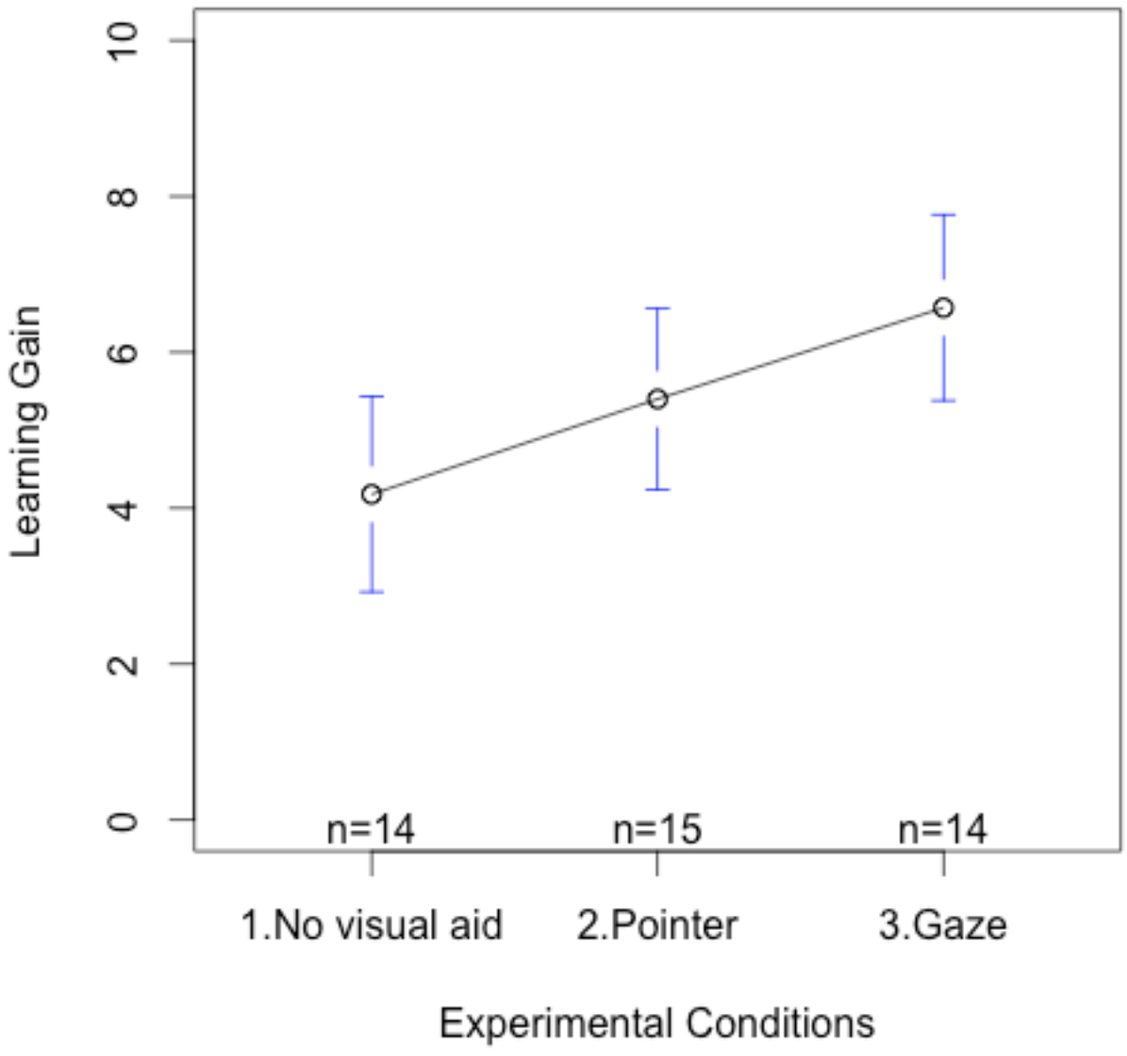

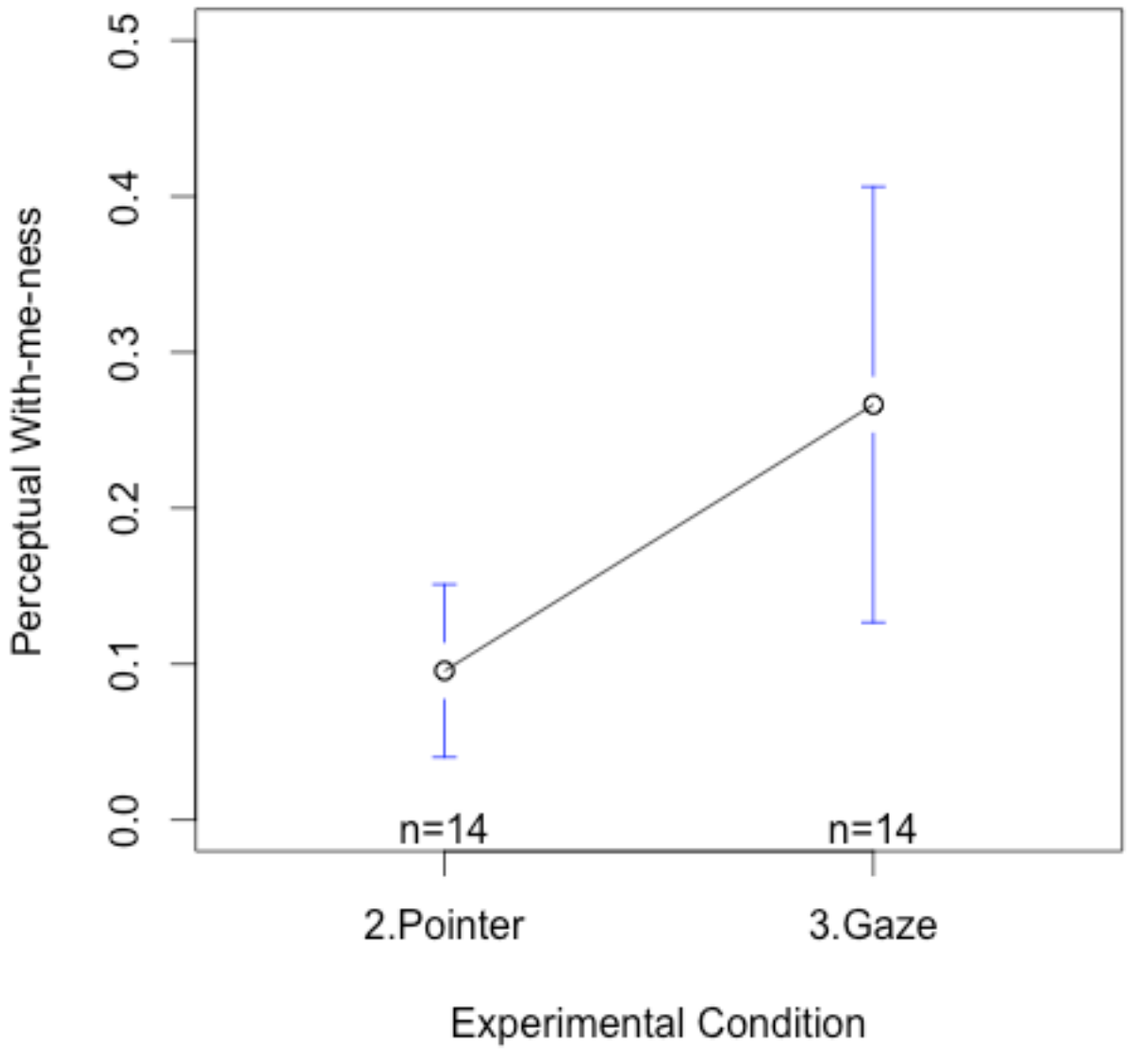

Next?

- Take any of the contexts mentioned in the slides and design an eye-tracking experiment.
- Eyes on eye-tracker.
- Work on your project (recommended).