Cognition Revealed by Eye Movements in Physics Problem-Solving
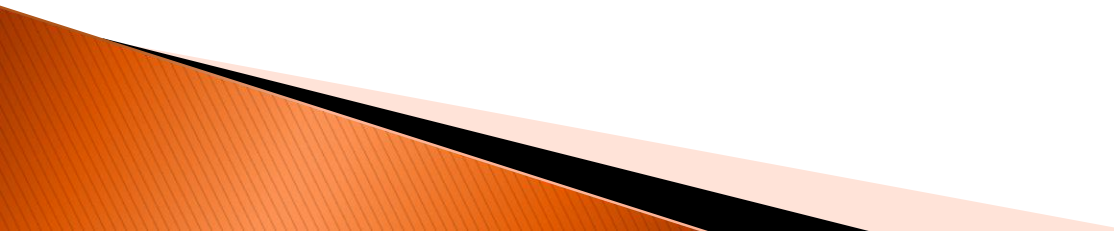
Betsy Olson

REU Final Presentation

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Outline

- Motivation
- Theory
- Experimental Setup
- Results / Work to Come
- Limitations
- Discussion
- Acknowledgments

Motivation

- PER:
  - Knowledge of student cognition
- Students:
  - Breadth of understanding
  - Problem-solving tools

Theory

- Johnson–Laird conceptual framework (1983)
  - Mental model
  - Mental image
  - Propositional representation
- Context:
  - Problem–solving
  - External representation: graph
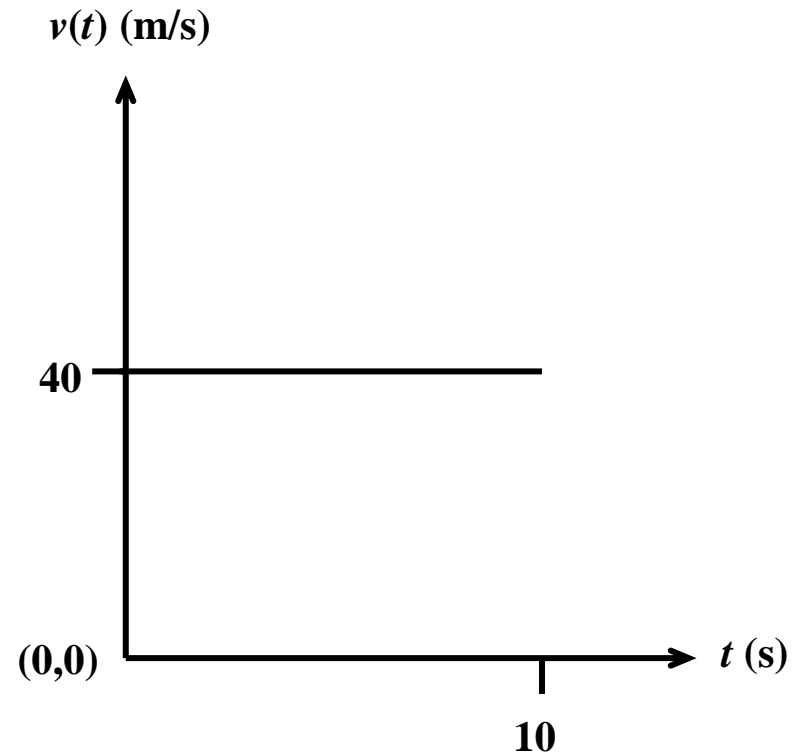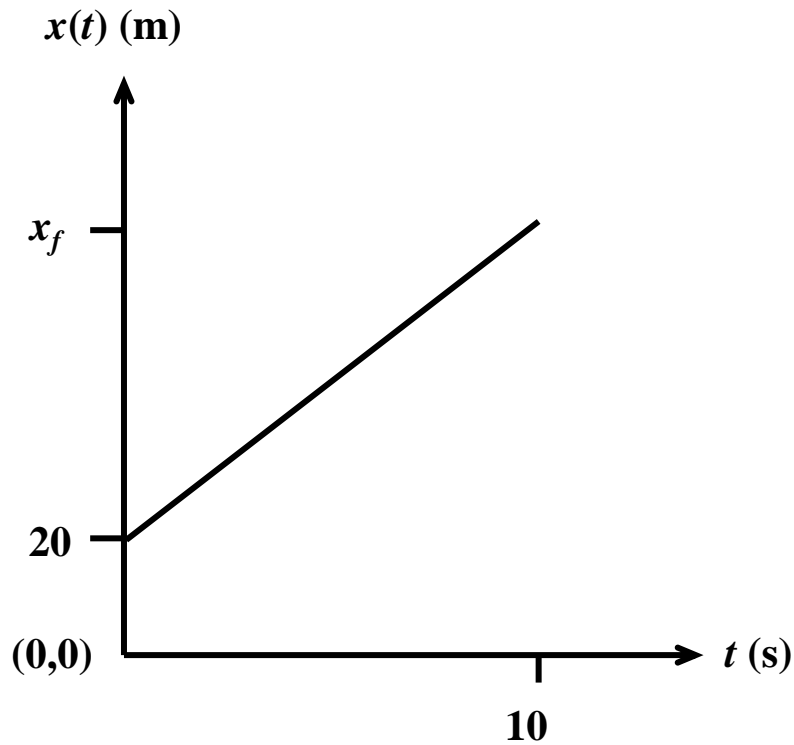- Eye tracking:
  - May give insight into cognition

Experimental Setup

- Mirametrix S2 Eye-tracker
- Cardwell 18-A

- Physics 1 and Physics 2 students
- Graduate students

- Same 10 problems – randomized order

The motion of a vehicle along a straight horizontal path is shown by the graphs below. Determine the position of the vehicle at 10 seconds.

x(t) (m)

x_f

20

(0,0)

10

t (s)

v(t) (m/s)

40

(0,0)

10

t (s)

Note:

- Very specific context – one task type
- Multiple <u>valid</u> strategies
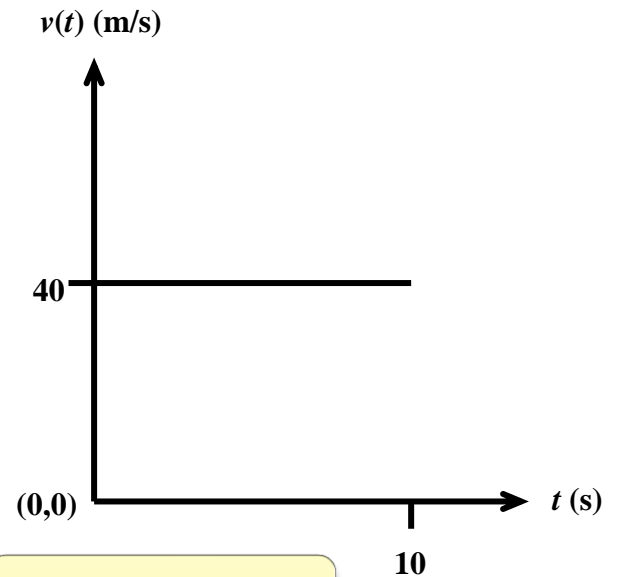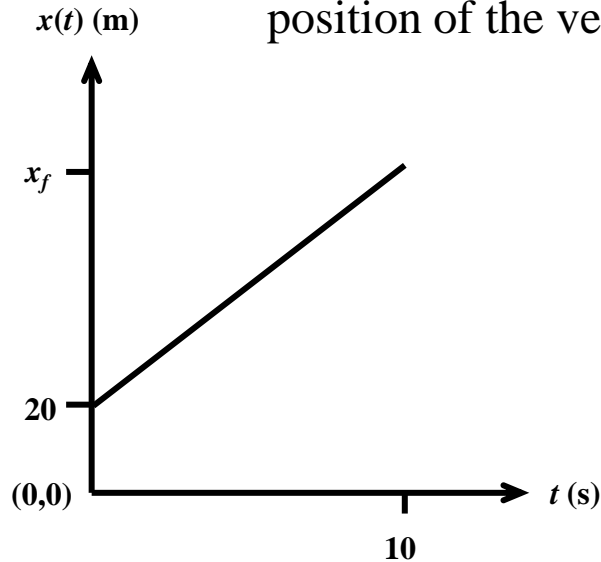- Students are thrifty when using cognition
  - A good thing

The motion of a vehicle along a straight horizontal path is shown by the graphs below. Determine the position of the vehicle at 10 seconds.

$x(t)$ (m)

x_f

20

(0,0) t (s)

10

$v(t)$ (m/s)

40

(0,0) t (s)

10

We hypothesize two major solution strategies:

Equation

use kinematics equations only

Equation + Graph

use kinematics equations

use slope, area, etc.

▶ From Bashirah's previous work:
  ◦ Each solution strategy corresponds to a type of cognition
    • Correspond to level of understanding? Not **necessarily.**

We hypothesize two major solution strategies:

Equation → use kinematics equations only → Use of **propositional representation**

Equation + Graph → use kinematics equations / use slope, area, etc. → Use (at some point) of **mental model**
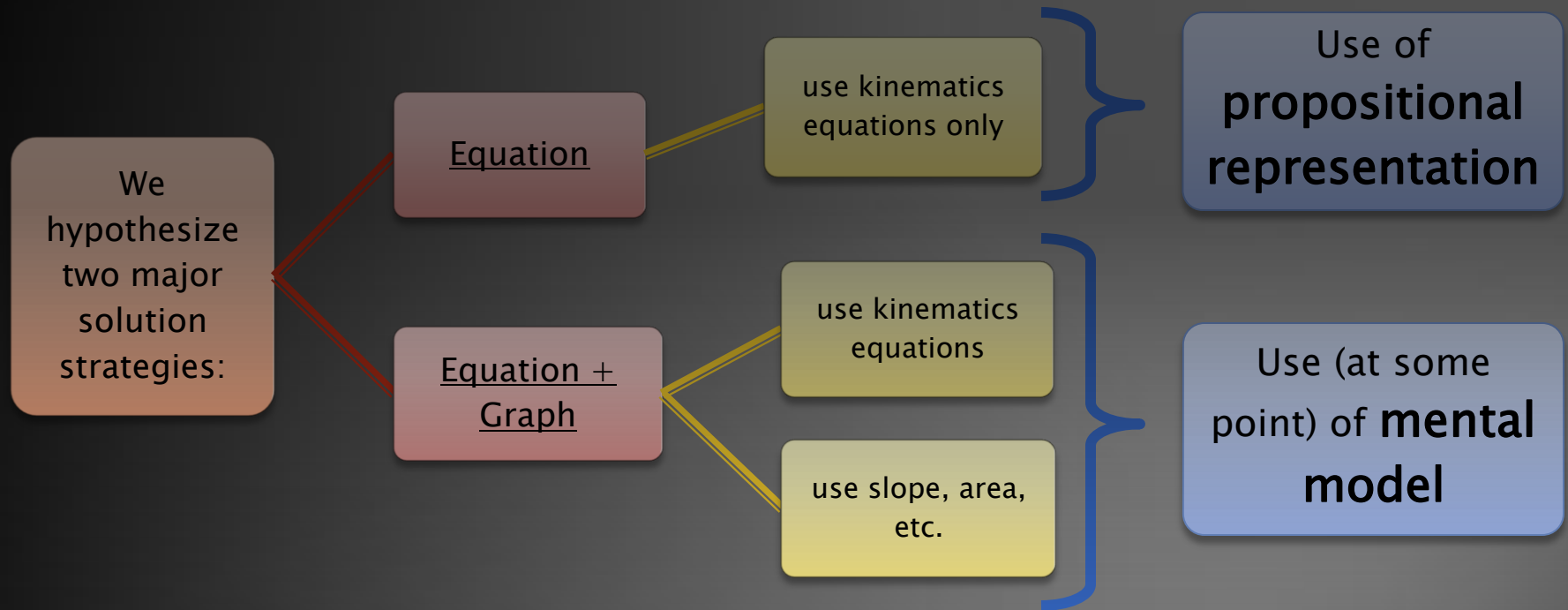
Can we tell a difference in students' eye movements when they solve problems using various types of cognition?

The motion of a vehicle along a straight horizontal path is shown by the graphs below. Determine the position of the vehicle at 10 seconds.

#2

#4

$x(t)$ (m)

#5

x_f

#10

#11

#6

20

#12

(0,0)

t (s)

#7

#9

10

#8

#1

#13

$v(t)$ (m/s)

#14

#19

40

#18

#20

(0,0)
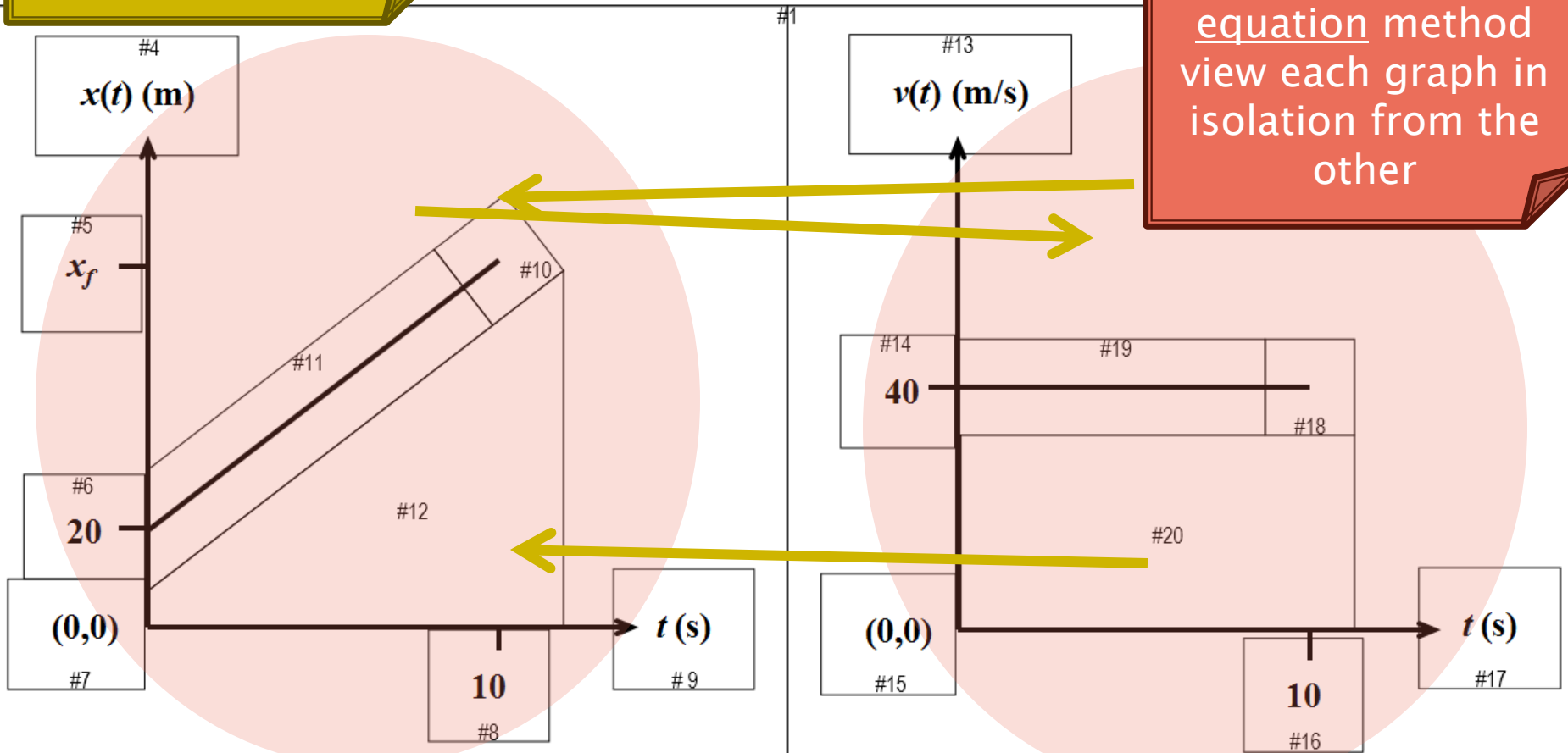
t (s)

#15

#17

10

#16

Hypothesis: solvers using equation method

Hypothesis: solvers using graph + equation method
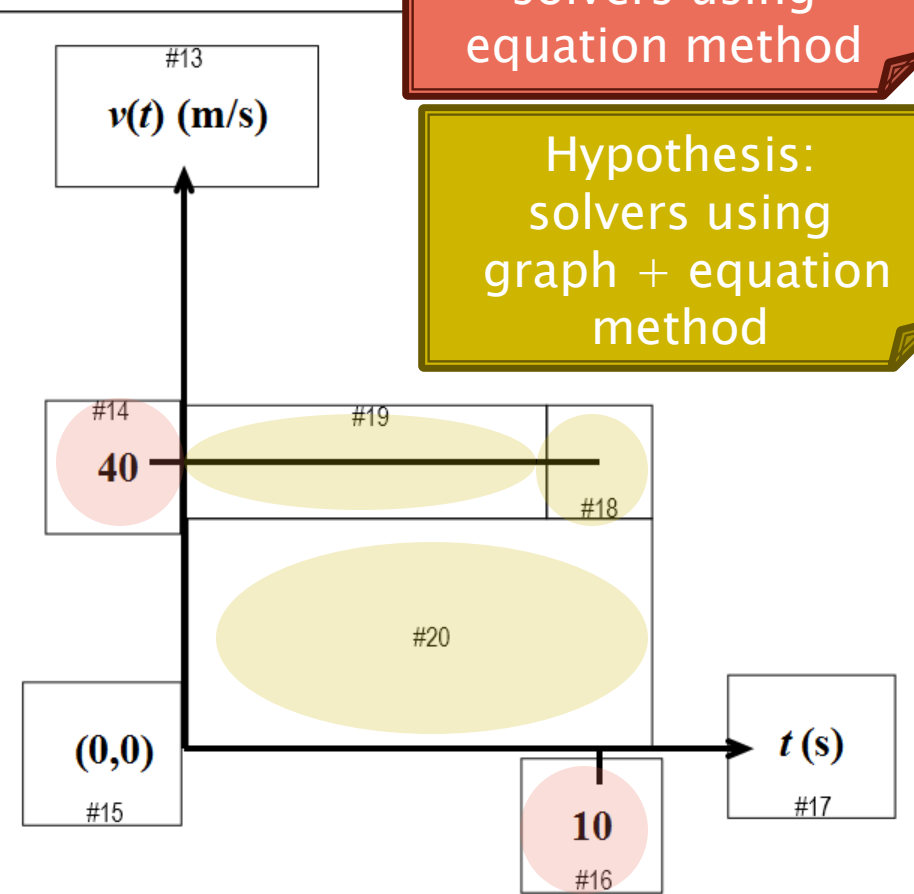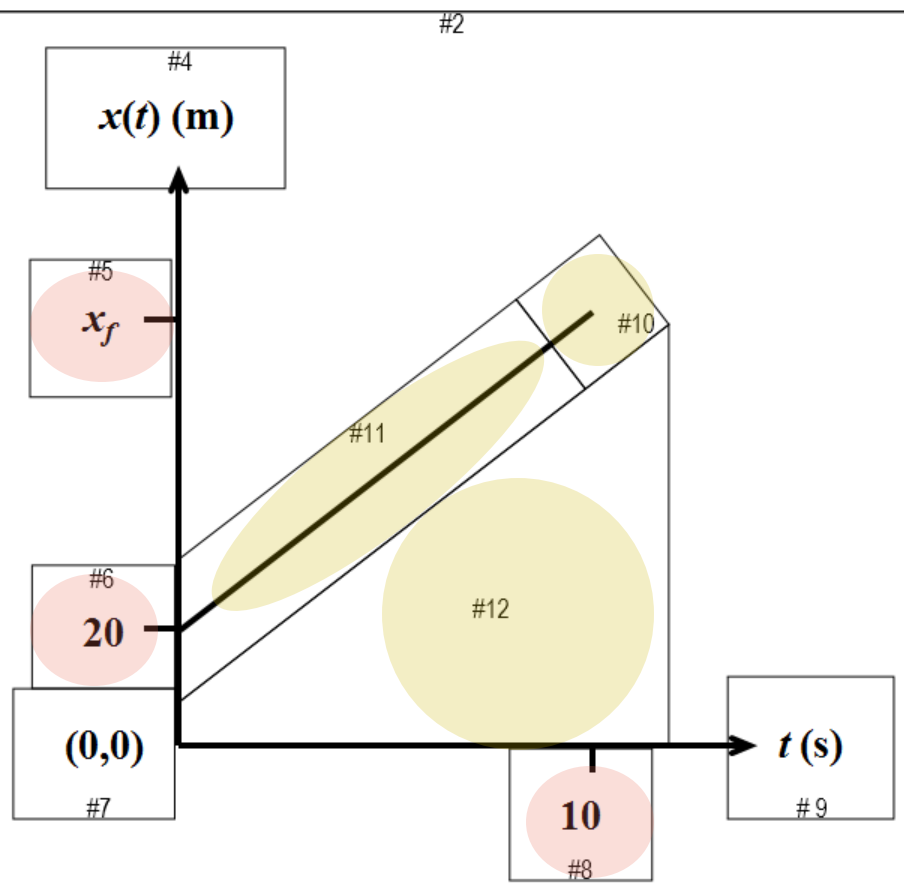
Hypothesis: solvers using **equation + graph** method often look from graph to graph

Hypothesis: solvers using **equation** method view each graph in isolation from the other

of a vehicle along a straight horizontal ... by the graphs below. Determine the ... the vehicle at 10 seconds.

#1

#4

$x(t)$ (m)

#5

x_f

#10

#11

#6

20

#12

(0,0)

#7

10

#8

t (s)

#9

#13

$v(t)$ (m/s)

#14

40

#19

#18

#20

(0,0)

#15

10

#16

t (s)

#17

Results / Work to Come
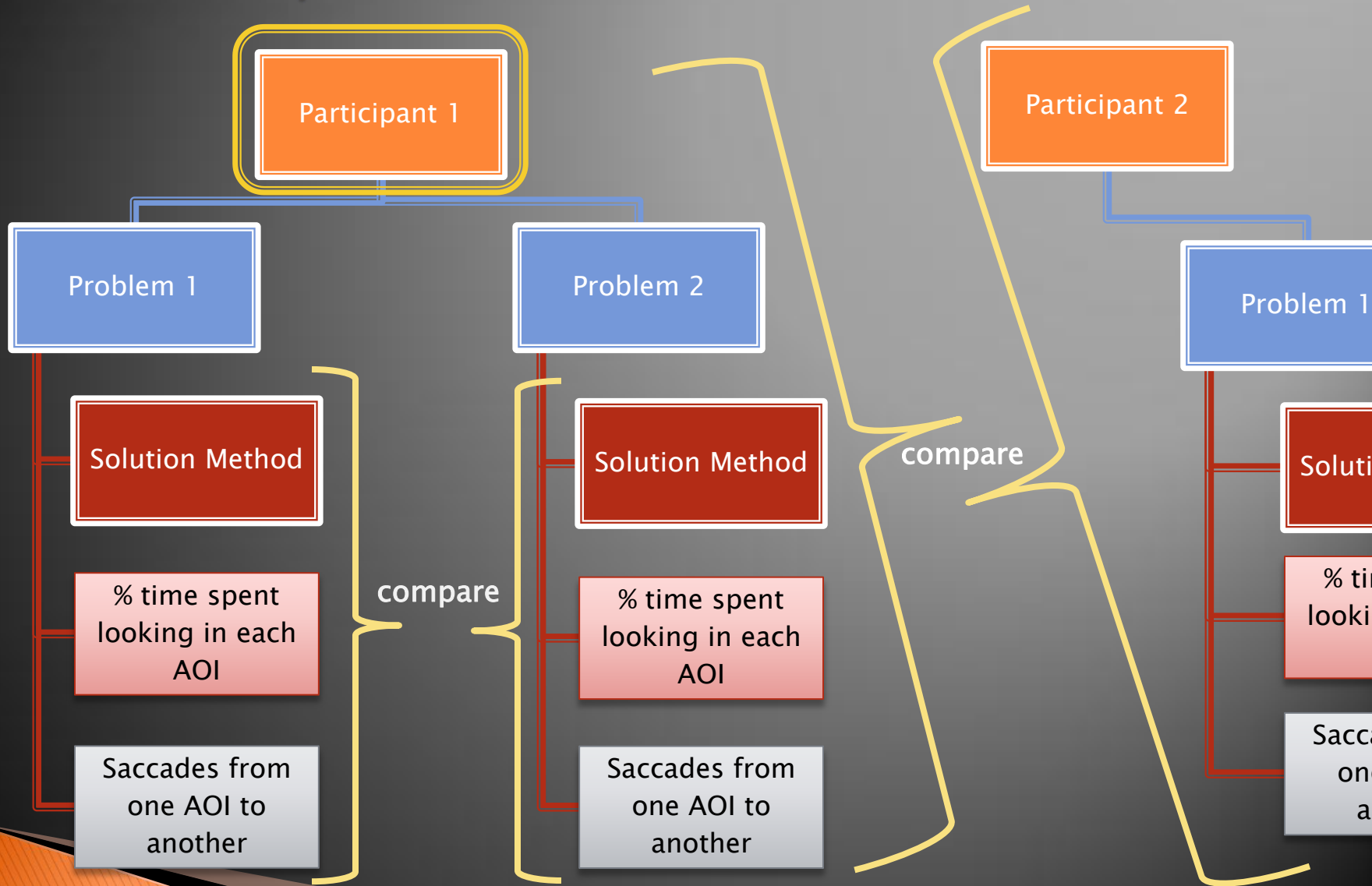
Limitations

- Eye tracker problems
- Graph scale incorrectly defined by origin (0,0)

Discussion

▸ Each solution is good
  ◦ Increase student's toolbox
  ◦ Increase student confidence
    ▪ Many students not confident, though capable
▸ Future questions:
  ◦ What else can we learn about student cognition?
  ◦ Possible graphical manipulations to help students?

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