Visual Cueing Influencing Eye Movements and Reasoning in Physics Problems

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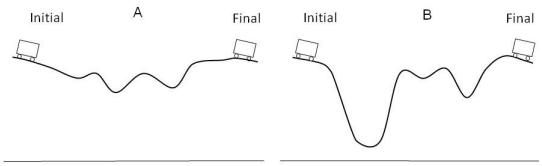
Research Question 1

Can a 6-second visual cue modeled after expert eye movements really help students answer physics questions?

If frictional effects can be ignored, how does the final speed of roller coaster cart A compare to the final speed of roller coaster cart B, if the mass of the carts is the same and they both start at rest?



(1) The cart A is moving faster at the final position
(2) The cart B is moving faster at the final position
(3) Carts A and B have the same speed at the final position
(4) There is not enough information to decide

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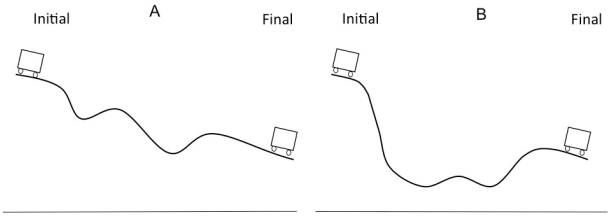
Research Question 2

Does students' ability to answer transfer problems improve after seeing visual cues?

Assume frictional effects can be ignored. How does the final speed of roller coaster cart A compare to the final speed of roller coaster cart B, if the mass of the carts is the same and they both start at rest?



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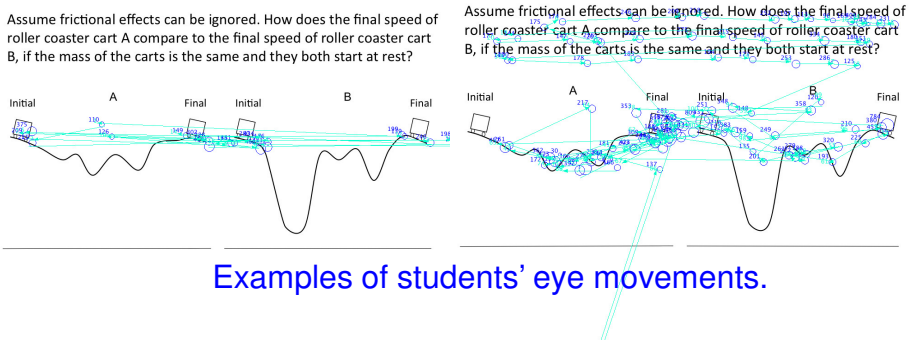
Research Question 3

Do cues influence students' eye movements on current and subsequent problems?



Examples of students' eye movements.

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Background

- Previous study found differences in the eye movements of experienced physicists and novices on physics problems [1].
- The eye is coupled with the mind in such a way that it fixates on an object as long as it is processing it [2].
- By directing attention to relevant portions of diagram, can help learners focus on important information [3].
- Cueing to relevant information has been successful in other contexts [4-5]

[1] Carmichael et. al, 2010 [2] Just and Carpenter, 1980 [3] de Koning et. al, 2009 [4] Grant & Spivey, 2003 [5] Thomas & Lleras, 2007

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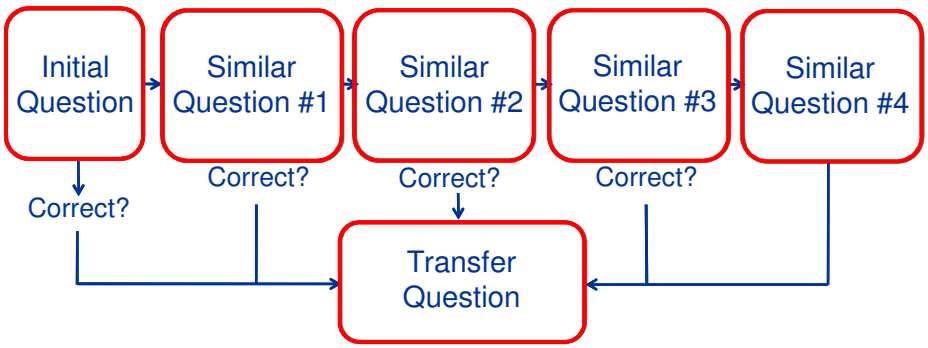
Method

- First & second semester introductory physics students.
- "Cued" group (N=22) and "No Cue" group (N=23)
- Online pre-test: 4 open-ended questions on kinematics & energy



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Overview of Results

1. Students' answers on similar and transfer problems (no eye movements).
2. Eye movements on roller coaster and ball problems.

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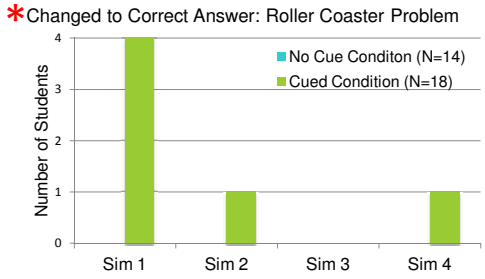
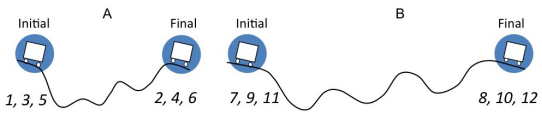
Results: Answers on Similar Problems



*Mann-Whitney U Test, p=.002

Assume frictional effects can be ignored. How does the final speed of roller coaster cart A compare to the final speed of roller coaster cart B, if the mass of the carts is the same and they both start at rest?



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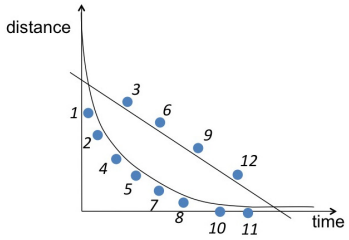
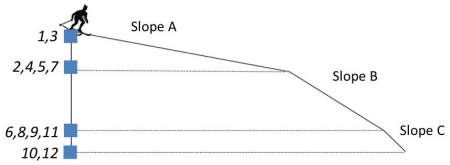
Results: Answers on Similar Problems

	Ball Problem		Skier Problem		Graph Problem	
Changed to Correct Answer	Cued (N=10)	No Cue (N=14)	Cued (N=11)	No Cue (N=7)	Cued (N=17)	No Cue (N=22)
	6	4	2	2	4	1

The motion of two objects is represented in the graph below. When are the two objects moving with the same speed?



Rank the changes in potential energy during the skier's descent down each slope from greatest to least.



No significant differences found.

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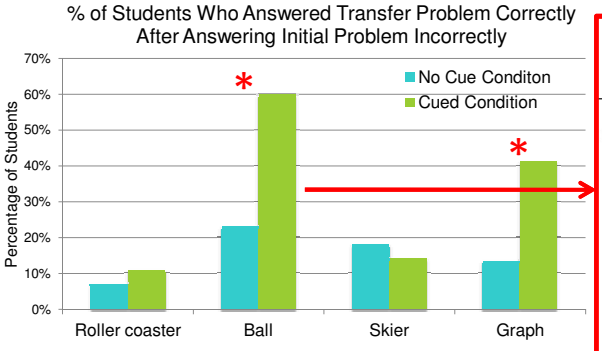
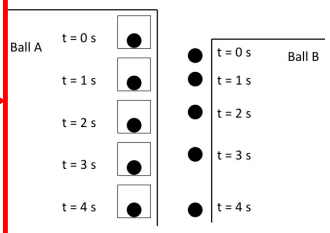
Results: Transfer Problem



*Mann-Whitney test, nearly significant
Ball (p=.06), Graph (p=.054)

When does Ball B have the same speed as Ball A?



Ball transfer problem.

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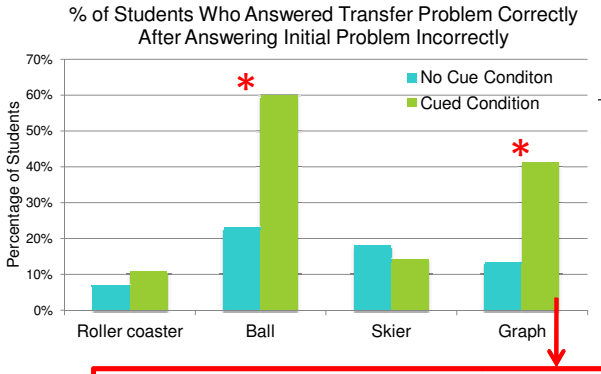
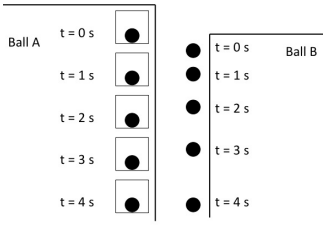
Results: Transfer Problem



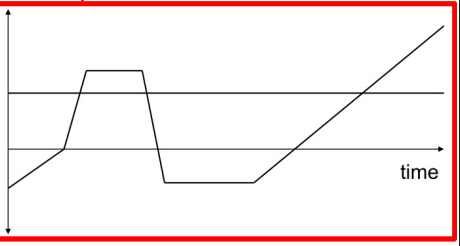
When does Ball B have the same speed as Ball A?



Ball transfer problem.

When are the two objects moving with the same speed?

Graph transfer problem.



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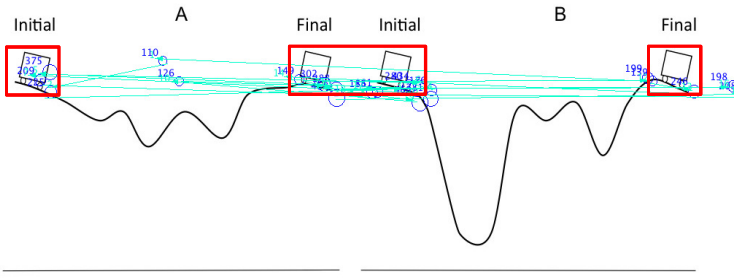
Eye Movements: Roller Coaster Problem

	Cued	No Cue	Cued Correct	Cued Incorrect
% of saccades in pattern similar to cues: *During Cues*	53%	1%*	86%	46%*



Eye movements during cues.

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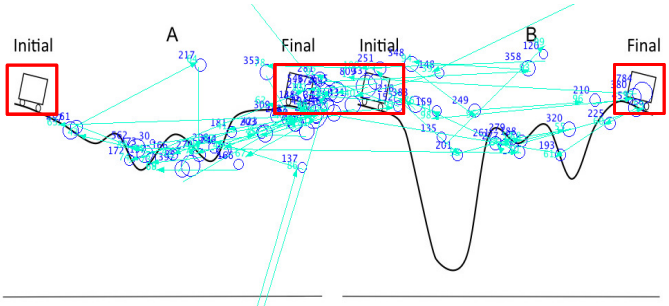
Eye Movements: Roller Coaster Problem

	Cued	No Cue
Percentage of saccades in pattern similar to cues: *After Cues Ended*	2%	1%



Eye movements after cues ended.

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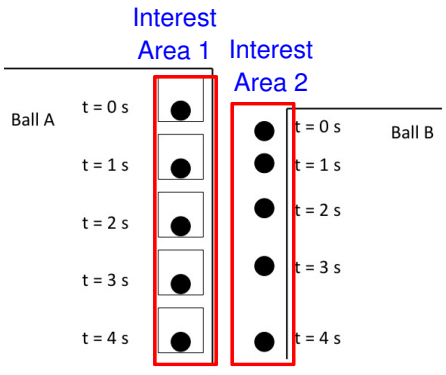
Eye Movements: Ball Transfer Problem

% of saccades within interest areas 1 and 2	
Cued	23%
No Cue	24%

	% of saccades within interest areas 1 and 2	
Correct	Cued	18%
	No cue	17%
Incorrect	Cued	26%
	No Cue	29%



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Conclusions

- In one case, short duration visual cues helped students answer conceptual physics questions they were previously unable to.
- Visual cues can influence transfer problem performance. Those who saw visual cues answered ball and graph transfer problems more correctly.
- Following cues closely with eyes is related to getting correct answer on roller coaster problem.
- Seeing visual cues doesn't seem to influence eye movements after cues cease (roller coaster) or on transfer problem (ball).

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Thank you.

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Poster on this study at PERC Contributed Poster Session on tonight (Wednesday) from 7:00-10:00 pm

Thomas and Lleras, 2007

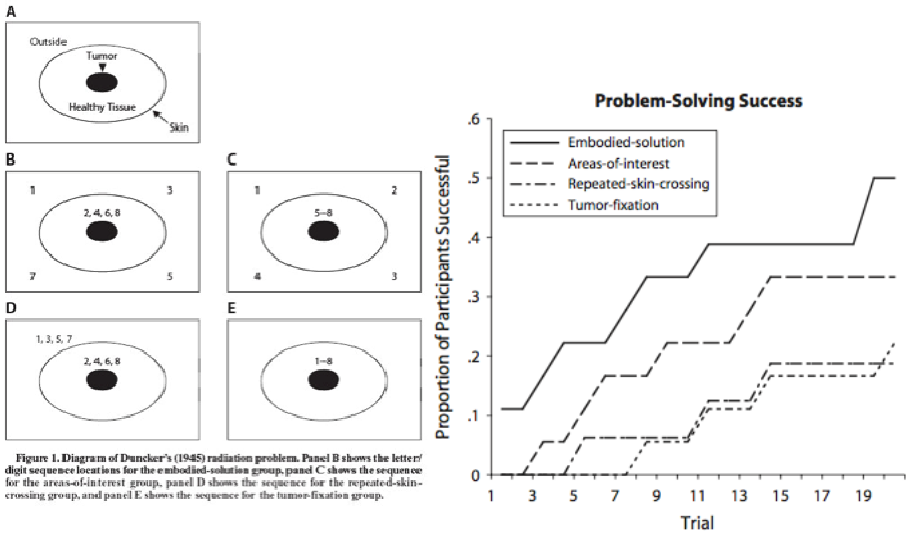

Figure 1. Diagram of Duncker's (1945) radiation problem. Panel B shows the letter/digit sequence locations for the embodied-solution group, panel C shows the sequence for the areas-of-interest group, panel D shows the sequence for the repeated-skin-crossing group, and panel E shows the sequence for the tumor-fixation group.

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Results: Answers on Similar Problems