Comparing Expert and Novice Eye Movements While Solving Physics Problems

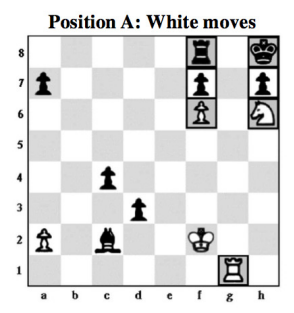
Adrian Carmichael
Adam Larson, Elizabeth Gire, Lester Loschky, N. Sanjay Rebello
Kansas State University

1

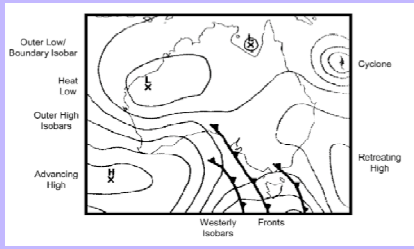
Previous Research

- Research has shown attention can be driven by salient (most noticeable) features in the environment or driven by knowledge. [1]

Expert chess players exhibit more fixations on relevant pieces. [2]



Novice students primarily attended to salient features on weather maps. [3]



1. T. van Gog et. al. (2009) 2. N. Charness et. al. (2001) 3. R.K. Lowe (2003)

2

Attention

- In several domains experts and novices allocate visual attention differently.
- May be helpful to give novices more insight into how experts allocate visual attention.
  - Manipulate novices' visual attention to match that of experts using attentional cueing.

3

Research Question

- How does the amount of time experts and novices spend looking at relevant versus noticeable portions of a physics diagram compare?
- Terminology
  - *Perceptually salient*: most noticeable portions of a diagram or picture.
  - *Thematically relevant*: portions of a diagram which contain necessary information.
  - *Dwell time:* total time spent looking at an area while viewing the diagram
- How does expertise affect the dwell time in perceptually salient versus thematically relevant areas in a figure?

4

Method

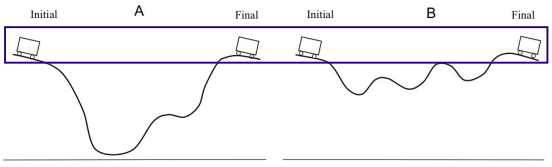
- Participants
  - 9 PhD student in physics who had taught a lab or recitation
  - 13 introductory psychology students who had taken high school physics
- Materials
  - 10 multiple choice conceptual questions about energy, kinematics graphs and circuits.

5

Problems

- Each problem contained a diagram with a thematically relevant visual component that participants needed to attend to in order to correctly answer the question.

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

6

Equipment

- EyeLink 1000 Remote Eye Tracker

7

Procedure

1. Instructions and calibration of eye tracker
2. Answer 10 multiple choice conceptual questions while eye movements recorded
3. Explain reasoning for answers to questions while watching playback of eye movements

8

Analysis

- Area's of interest defined (AOI)
  - Perceptually salient
  - Thematically relevant
- AOI's defined by 3 independent raters
- Choose 5 problems with strongest agreement among raters
- Dwell time (total time spent) in AOI determined for each participant
- Percentage of total viewing time in diagram calculated for each AOI
- One-way ANOVA
  - Independent variable: correctness of answer.
  - Dependent variable: percentage of time in AOI

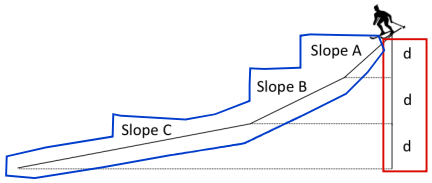
9

Areas of interest

Perceptually salient interest area along slope.

Thematically relevant interest area along height of hill.

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



(1) $\Delta PE_A > \Delta PE_B > \Delta PE_C$

(2) $\Delta PE_C > \Delta PE_B > \Delta PE_A$

(3) $\Delta PE_A = \Delta PE_B = \Delta PE_C$

(4) $\Delta PE_A = \Delta PE_B > \Delta PE_C$

(5) $\Delta PE_B > \Delta PE_C = \Delta PE_A$

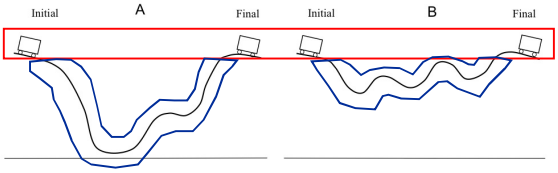
10

Results 1

Thematically Relevant
Correct: 26.6%(± 16.1)
Incorrect: 21.4% (± 12.2)

Perceptually Salient
Correct: 10.5% (± 8.2)
Incorrect: 31.5% (± 18.3)*
*p=.002

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

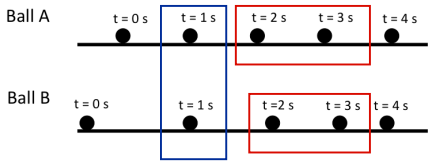
11

Results 2

Thematically Relevant
Correct: 46.6% (± 10.7)
Incorrect: 25.8% (± 11.5)*
*p<.001

Perceptually Salient
Correct: 19.2% (± 8.2)
Incorrect: 29.0% (± 6.9)*
*p=.009

Two balls roll along the paths shown above. The position of the balls is shown at equal time intervals of one second each. When does Ball B have the same speed as Ball A.



(1) t = 1.0 sec (2) t = 1.5 sec (3) t = 2.0 sec
(4) t = 2.5 sec (5) t = 3.0 sec

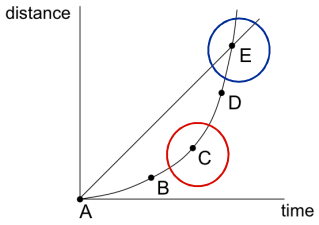
12

Results 3

Thematically Relevant
Correct: 29.9% (± 14.2)
Incorrect: 18.0% (± 10.8)*
*p=.047

Perceptually Salient
Correct: 12.8% (±9.0)
Incorrect: 25.3% (±15.8)*
*p=.028

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



(1) Point A (2) Point B (3) Point C (4) Point D
(5) Point E (6) At all points

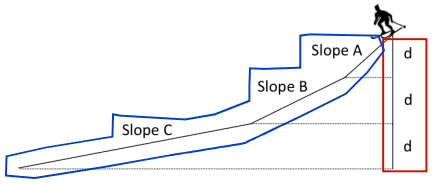
13

Results 4

Thematically Relevant
Correct: 26.0% (± 13.9)
Incorrect: 14.3% (± 11.0)*
*p=.041

Perceptually Salient
Correct: 46.4% (± 17.1)
Incorrect: 52.9% (± 19.3)

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



(1) $\Delta PE_A > \Delta PE_B > \Delta PE_C$
(2) $\Delta PE_C > \Delta PE_B > \Delta PE_A$
(3) $\Delta PE_A = \Delta PE_B = \Delta PE_C$
(4) $\Delta PE_A = \Delta PE_B > \Delta PE_C$
(5) $\Delta PE_B > \Delta PE_C = \Delta PE_A$

14

Conclusions

- Found significant differences in the way those who answered correctly versus incorrectly allocated visual attention on problems about energy and speed.
- Provides some evidence to support previous findings:
  - Those who answer correctly spend more time looking at thematically relevant elements of a diagram
  - Those who answer incorrectly spend more time looking at perceptually salient portions.
- Lays the foundation for future work in guiding novices' attention using various visual cueing techniques.

15

CONTACT INFORMATION

adrianc@phys.ksu.edu

For more information see my PERC poster tonight

Kansas State University
Physics Education Research

16