Effect of Visual Cueing on Students' Eye Movements and Reasoning

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INTRODUCTION

- There are several visual environments in physics used for learning and/or assessment which contain both relevant and irrelevant features.
- Visual attention may be redirected through the usage of cues.
- In a variety of contexts, cueing has been shown to increase learning in animations and static problems [1-5].
- We have found that incorrect solvers spend more time than correct solvers attending to the irrelevant features of a problem diagram [6].

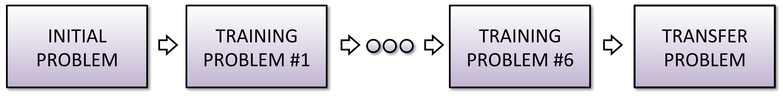
Can visual cueing help students correctly solve and reason about conceptual physics problems they previously were unable to? Furthermore, can cueing and feedback promote transfer?

For those students whose performance improved on the transfer problem relative to the initial problem, how do the eye movements of the cued students compare with those of the non-cued students on both the initial and transfer problem?

METHODS

Participants: Students enrolled in algebra-based, introductory mechanics course randomly assigned to a cued (N=38) or non-cued (N=42) condition.

Materials: Four sets of conceptual physics problems related to energy and speed. The order of the sets was randomized, as were the order of the training problems within a set.



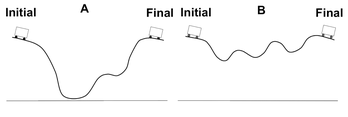
Those in *CUED* condition saw colored shapes overlaid on the training problem diagrams for 8s at a time.

Procedure: Students participated in individual sessions lasting 50-60 minutes and were randomly assigned a condition. Problems were presented on a computer screen. Students solved the problems while their eye movements were recorded and provided verbal answers.

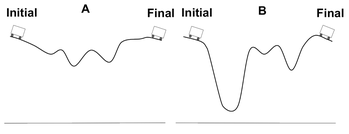
EXAMPLE PROBLEM SET

INITIAL PROBLEM

How does the final speed of cart A compare to the final speed of cart B, if the mass of the carts is the same and they both start at rest? (Frictional effects can be ignored)

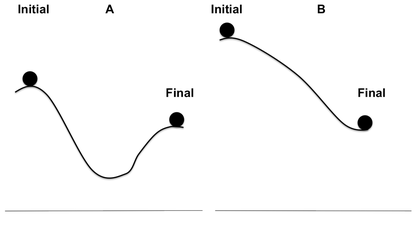


TRAINING PROBLEM



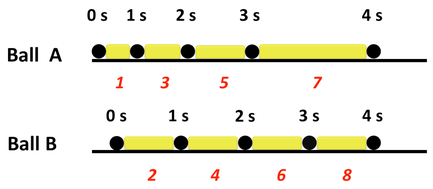
TRANSFER PROBLEM

Two identical balls roll down a hill. How does the final speed of ball A compare to the final speed of ball B if the masses are the same and they both start at rest? (Frictional effects can be ignored)

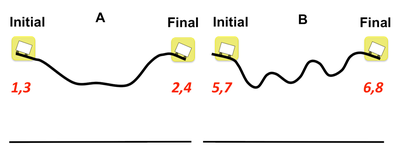


EXAMPLES OF CUES

Two balls roll along the paths shown. A snapshot of the position of the balls is taken every second. At what point in time does Ball B have the same speed as Ball A?



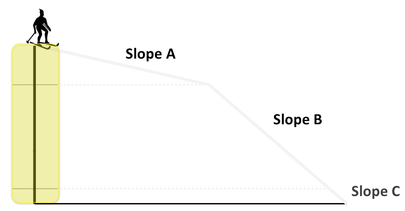
How does the final speed of cart A compare to the final speed of cart B, if the mass of the carts is the same and they both start at rest? (Frictional effects can be ignored)



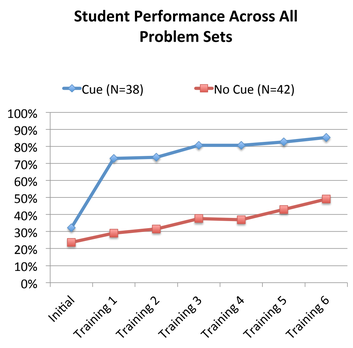
Red numbers indicate the order in which the shapes appeared. Each appeared on screen for 1s at a time.

The motion of two objects is represented in the graph. 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.

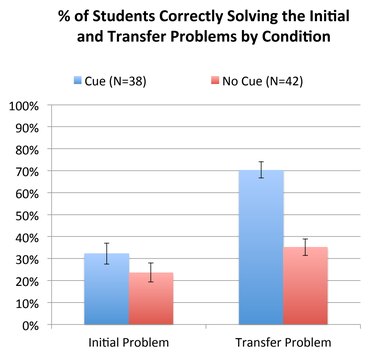


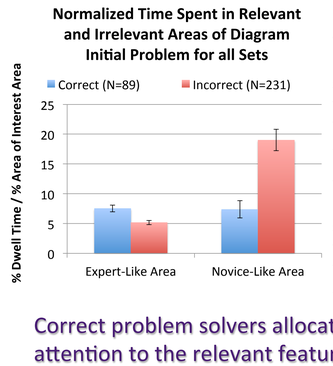
CORRECTNESS OF RESPONSES



There was no significant difference in the proportion of students in each group who were able to solve the initial problem.
$\chi^2(1, N=320) = 2.72$, $p=.106$

A significantly larger proportion of students who received cues on the training problems were able to correctly solve the transfer problem.
$\chi^2(1, N=320) = 38.15$, $p<.001$, $V=.345$





Those who solved the initial problem *correctly* spent a significantly higher proportion of time attending to the *relevant* features of the diagram.
$F(1, 318) = 13.20$, $p<.001$, $d=.445$

Those who solved the initial problem *incorrectly* spent a significantly higher proportion of time attending to the *irrelevant* features of the diagram.
$F(1, 318) = 14.85$, $p<.001$, $d=.791$

Correct problem solvers allocate significantly more attention to the relevant features in the diagram.

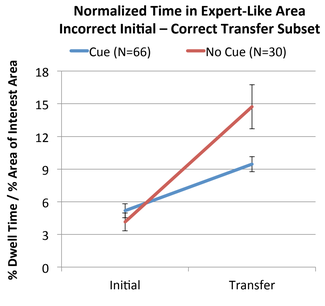
EFFICIENCY OF EXTRACTING RELEVANT INFORMATION FROM DIAGRAM

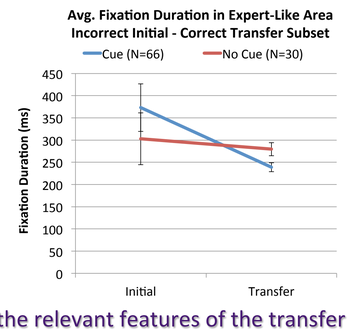
Both groups have significant shifts towards the relevant features of the diagram.

No Cue: $F(1,94) = 41.63$, $p<.001$, $d=1.59$
Cue: $F(1, 94) = 14.94$, $p<.001$, $d=.79$

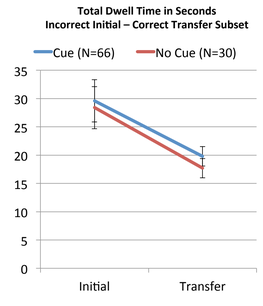
Comparing the proportion of time spent attending to the relevant information, there is no significant difference on the initial problem, $F(1, 94) < 1$.

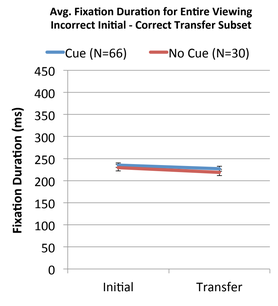
On the transfer problem, the non-cued group spends a larger proportion of time attending to the relevant features, $F(1, 94) = 14.25$, $p<.001$, $d=.652$





The cued group spent a *SMALLER* proportion of time attending to the relevant features of the transfer problem and had *SHORTER* fixation durations in the expert-like area than the non-cued group, indicating that cues help students process the relevant information more efficiently.





Overall both groups spend, on average, the same amount of time solving the problems and have similar fixation durations.

CONCLUSIONS

Among students who incorrectly solved the initial problem in a set, those who saw visual cues correctly solved and reasoned about a significantly greater proportion of training problems.

When asked to solve a transfer problem (without cues), those who saw cues on the training problems are significantly more likely to provide a correct answer and explanation.

Among students who provided an incorrect response on the initial problem, but were able to solve the transfer problem correctly, those who saw cues on the training problems were able to more efficiently extract the relevant information from the diagram on the transfer problem.

REFERENCES

1. E.R. Grant and M. Spivey, *Psychol. Sci.* **14**, (2003).
2. L.E. Thomas and A. Lleras, *Psychon. B. Rev.* **14**, (2007).
3. L.E. Thomas and A. Lleras, *Psychon. B. Rev.* **16**, (2009).
4. S. Kriz and M. Hegarty, *Int. J. Hum.-Comput. St.* **65**, (2007).
5. B.B. de Koning, H.K. Tabbers, R.M.J.P. Rikers, F. Paas, *Appl. Cognitive Psych.*, **21**, (2007).
6. A.M. Madsen, A.M. Larson, L.C. Loschky, and N.S. Rebello, *Phys. Rev. ST Phys. Educ. Res.* **8**, (2012).

This work is supported by NSF grants 1138697 and 0841414.