Can Visual Cues and Correctness Feedback Influence Students' Reasoning?

Amy Rouinfar[1], Elise Agra[1], Jeffrey Murray[1], Adam M. Larson[2], Lester C. Loschky[2], and N. Sanjay Rebello[1]

[1]*Department of Physics, Kansas State University, Manhattan, KS*

[2]*Department of Psychological Sciences, Kansas State University, Manhattan, KS*

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

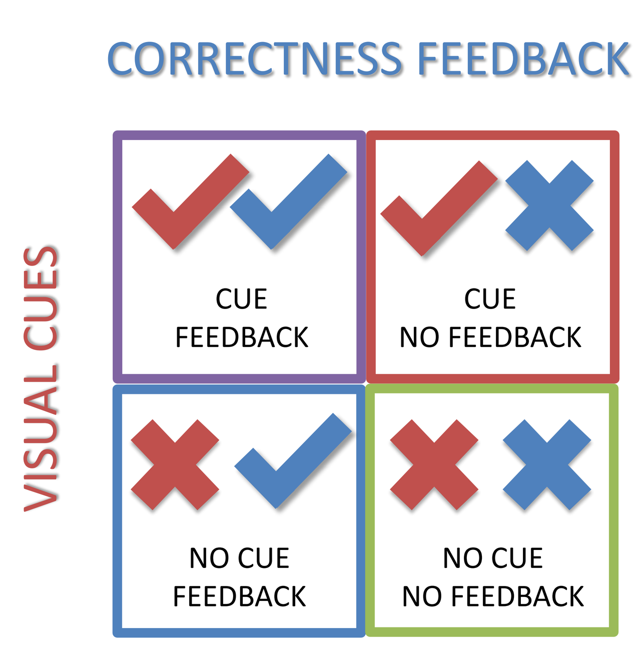
METHODS

Participants: Students enrolled in algebra-based, introductory mechanics course (N=90)

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.

INITIAL PROBLEM ⇨ TRAINING PROBLEM #1 ⇨ ○○○ ⇨ TRAINING PROBLEM #6 ⇨ TRANSFER PROBLEM

Procedure: Students participated in individual sessions lasting 50-60 minutes and were randomly assigned to one of four conditions. Answers were provided verbally.



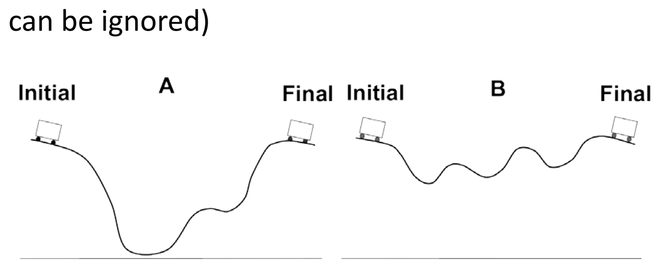
Those in CUED conditions saw colored shapes overlaid on the training problem diagrams for 8s at a time.

Those in FEEDBACK conditions were told if their responses (answer + explanation) were correct, but no further information was provided.

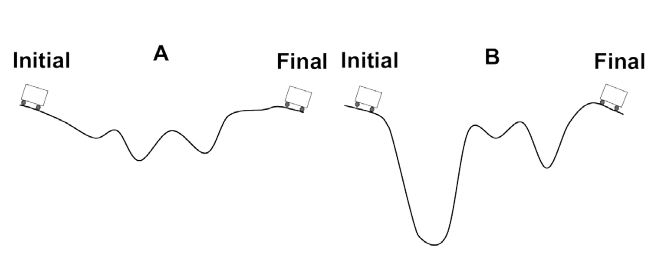
EXAMPLE PROBLEM SET

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)

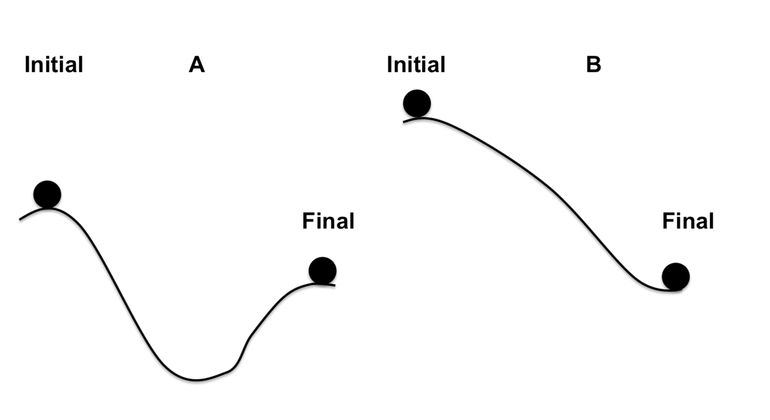


TRAINING PROBLEM



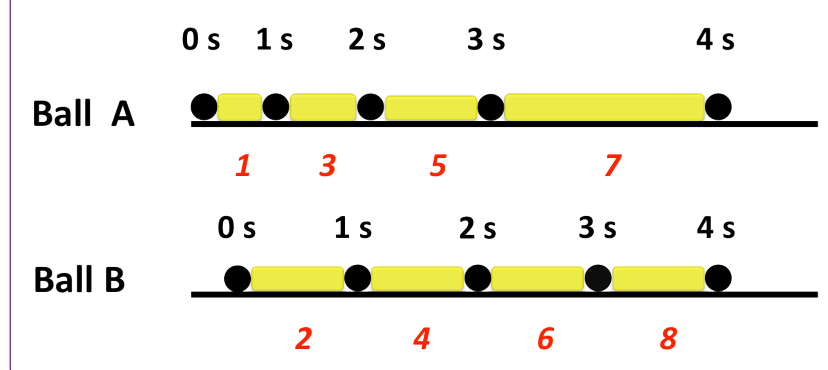
TRANSFER PROBLEM

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)

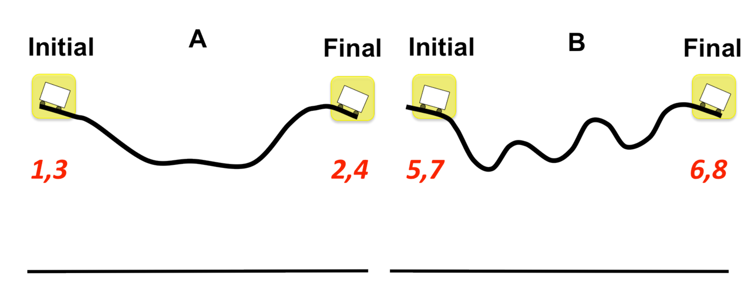


EXAMPLES OF CUES

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?

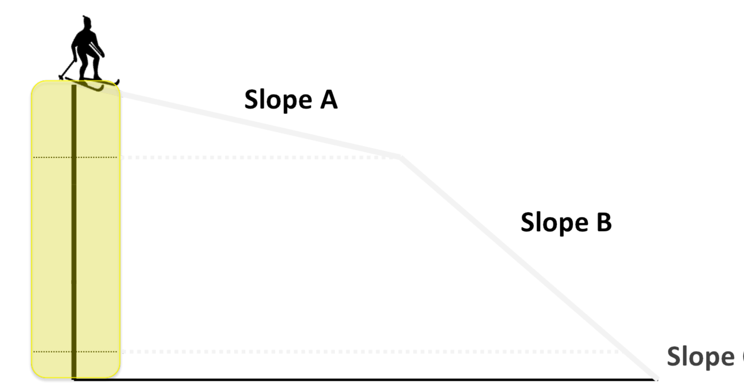


How does the final speed of cart A compare to the final speed of cart B, if the mass of the carts is the same and they both start at rest? (Frictional effects can be ignored)

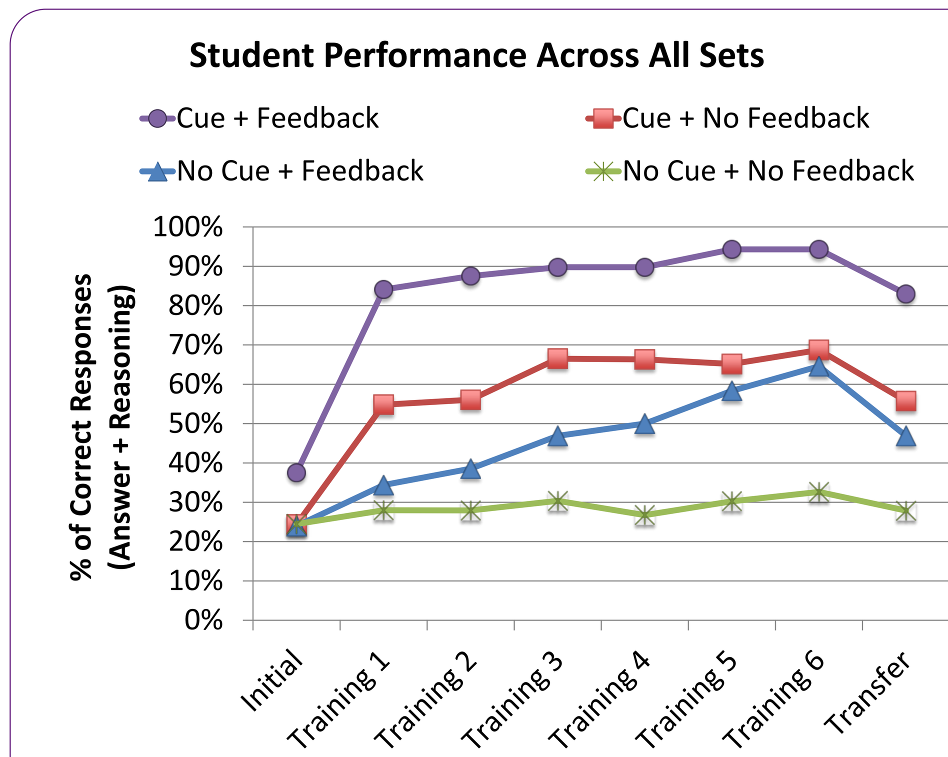


The motion of two objects is represented in the graph. When are the two objects moving with the same speed?

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



OMNIBUS TRAINING PROBLEM RESULTS

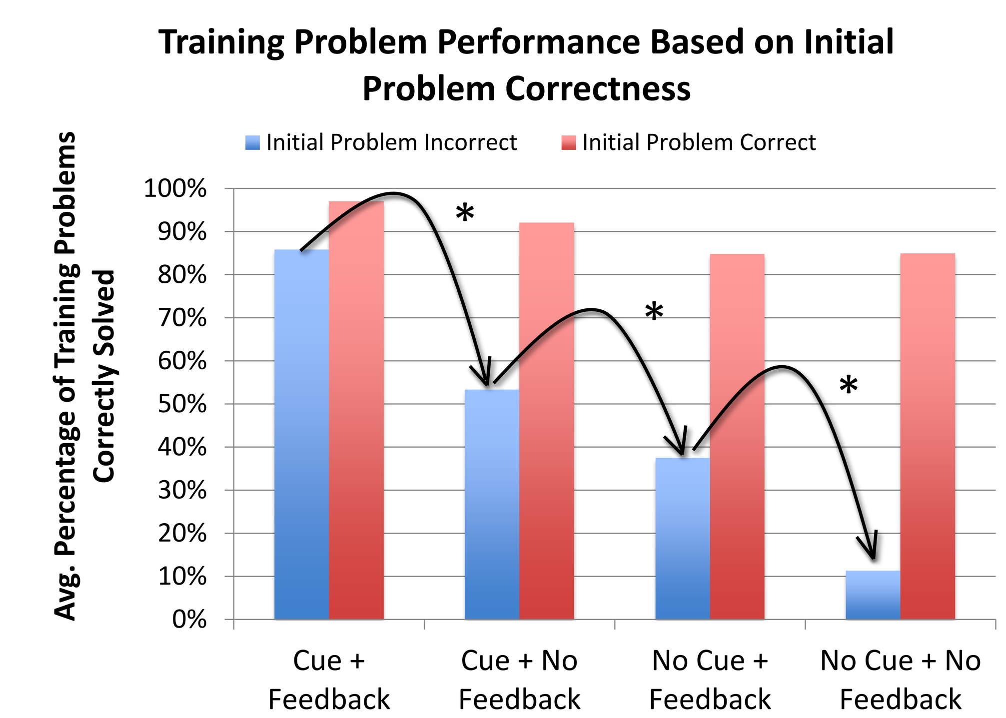


Among students who incorrectly solved the initial problem, there is a significant effect of condition. Those who saw cues and received feedback correctly answered the significantly highest percentage of the training problems followed, respectively, by those who only saw cues, those who only received feedback, and those who received neither.

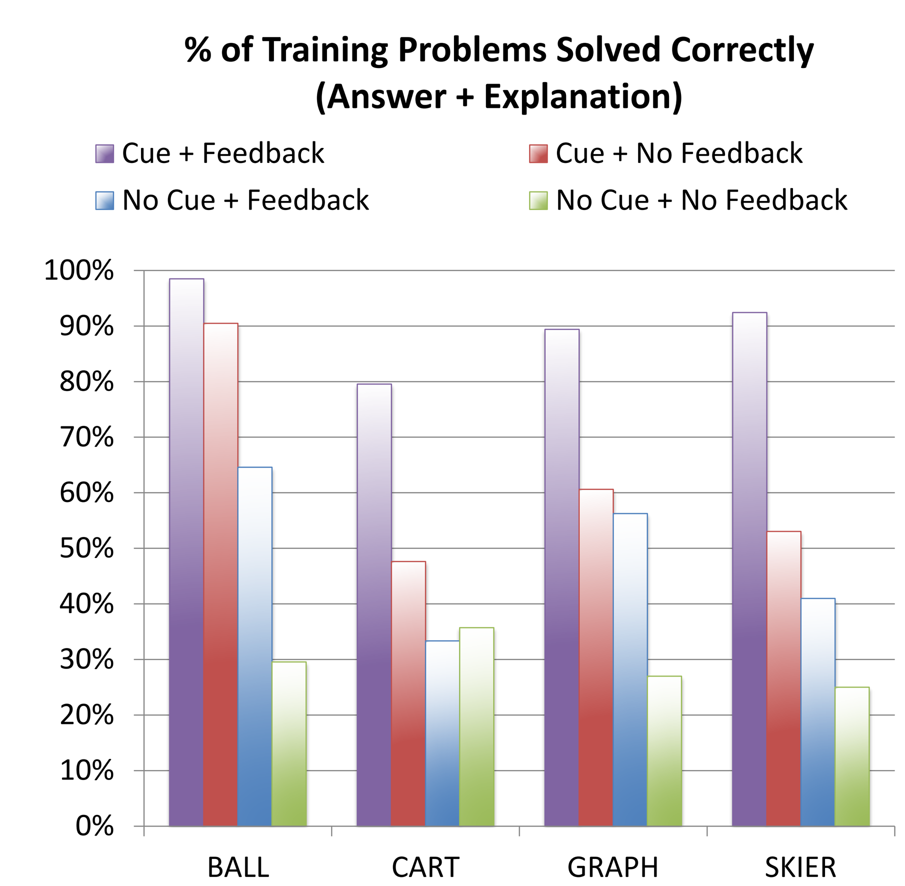
For students who are able to correctly solve the initial problem, all groups perform equally well on the training problems.

A 4 (condition) x 2 (initial problem correctness, IPC) ANOVA was conducted with average training problem performance as the dependent variable.

- Main Effect of Condition: $F(3,348)=27.40$, $p<.001$, $d=1.43$
- Main of IPC: $F(1,348)=139.95$, $p<.001$, $d=1.07$
- Interaction Condition*IPC: $F(3,343)=13.31$, $p<.001$
- Simple Effect of Condition (IPC = 0): $F(3,348)=64.20$, $p<.001$, $d=1.78$
- Simple Effect of Condition (IPC = 1): $F(3,348)=1.06$, $p=.366$



TRAINING RESULTS BY SET

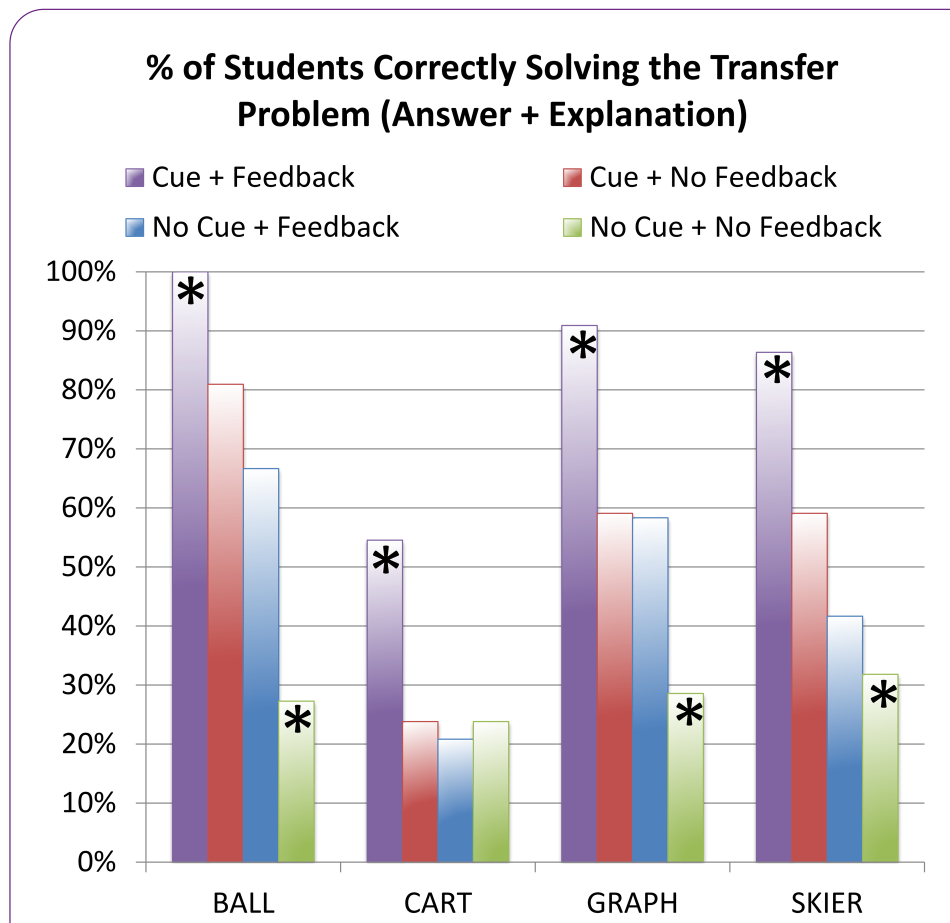


For all problem sets, the results of the 4x2 ANOVA follow the same trend as the omnibus results.

For the Cart and Graph problems, the CUE + FEEDBACK condition significantly outperforms all other conditions ***regardless of initial problem correctness.***

For the Ball and Skier problems, the CUE + FEEDBACK condition significantly outperforms all other conditions ***only among students who were unable to correctly solve the initial problem*** in the set.

TRANSFER PROBLEM



For all problem sets, students in the CUE + FEEDBACK condition were significantly MORE likely to provide a correct answer and explanation on the transfer problem.

Those in the NO CUE + NO FEEDBACK condition were significantly LESS likely to provide a correct response to the transfer problem in the Ball, Graph, and Skier sets.

Problem	Chi-Square Test
Ball	$\chi^2(3, 89)=29.01$, $p<.001$
Cart	$\chi^2(3, 88)=7.92$, $p=.048$
Graph	$\chi^2(3, 88)=16.32$, $p=.001$
Skier	$\chi^2(3, 90)=15.35$, $p=.002$

CONCLUSIONS

Among students who incorrectly solved the initial problem in a set, those who saw visual cues and received feedback 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 and received correctness feedback are significantly more likely to provide a correct answer and explanation.

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