Engaging reflective thinking during an exam

Slowing students down on multiple choice questions increases performance

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Motivation:

What (possibly extraneous) factors impact student performance on exams?

Background

- Dual processing theory[1]: Two modes of thinking

System 1	**System 2**
Unconscious, intuitive judgements	Deliberate, conscious mental effort

- The Cognitive Reflective Test (CRT)[2] measures tendency to engage system 2
- CRT scores correlate with Force Concept Inventory pre- and post-scores[3]
- Imposing a 3 s delay in responding increased student performance on simple science questions[4]

[1]Kahneman. *Thinking, fast and slow*. Macmillan, 2011. [2]Frederick. *J. Econ. Perspect.* 19.4 (2005): 25-42. [3]Wood et al. *Phys. Rev. Phys. Educ. Res.* 12.2 (2016): 023101. [4]Heckler and Scaife. *Cog. Sci.* 39.3 (2015): 496-537.

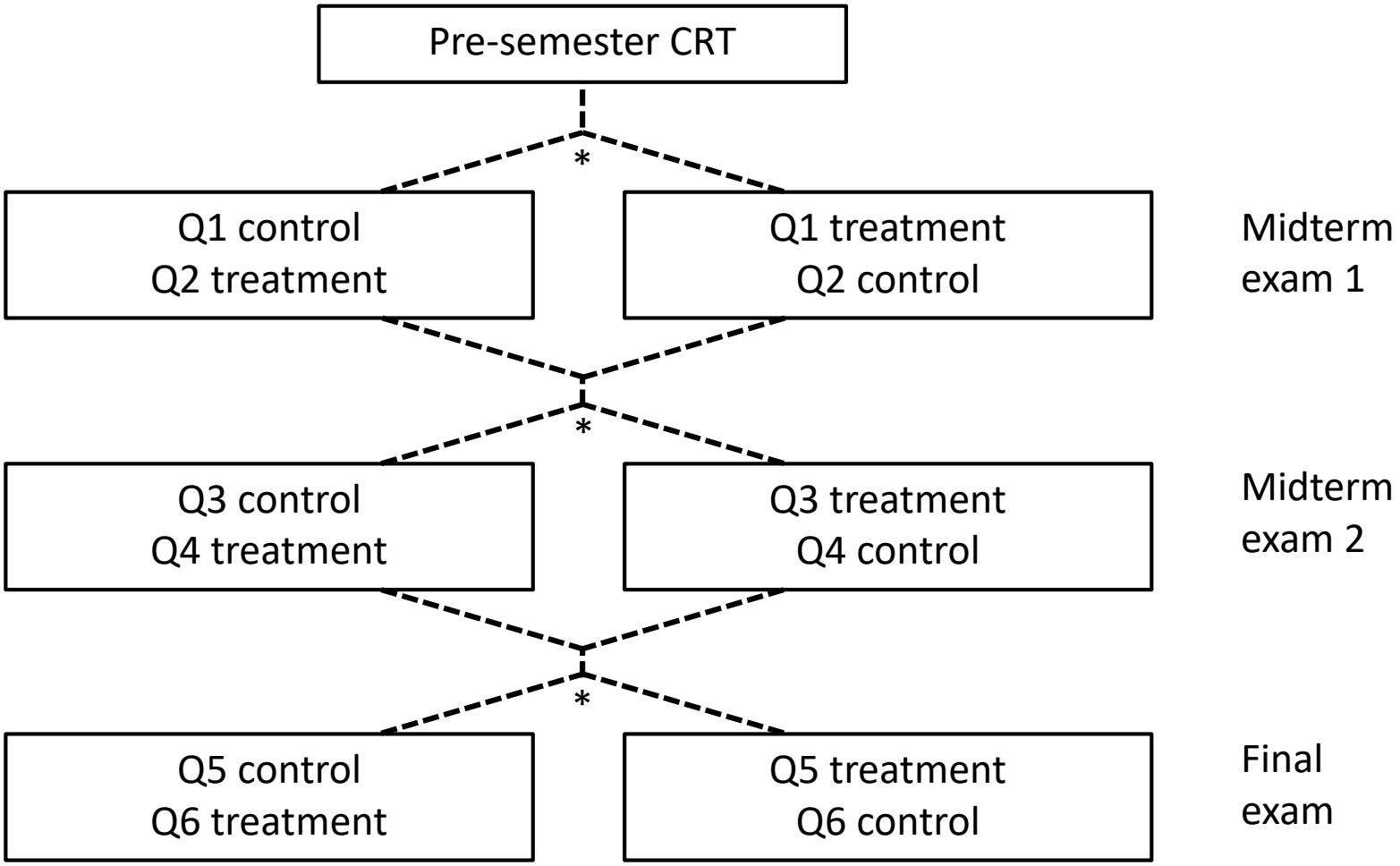
Method

- Idea: Slow students down by including an “Explain your answer” box with multiple choice questions (“treatment”):

[0.5 points] Explain your reasoning in 1-2 sentences:

- Trialled two questions on each of three exams
- First-year physics, N = 650 students

Experimental design



*Random assignment to each group

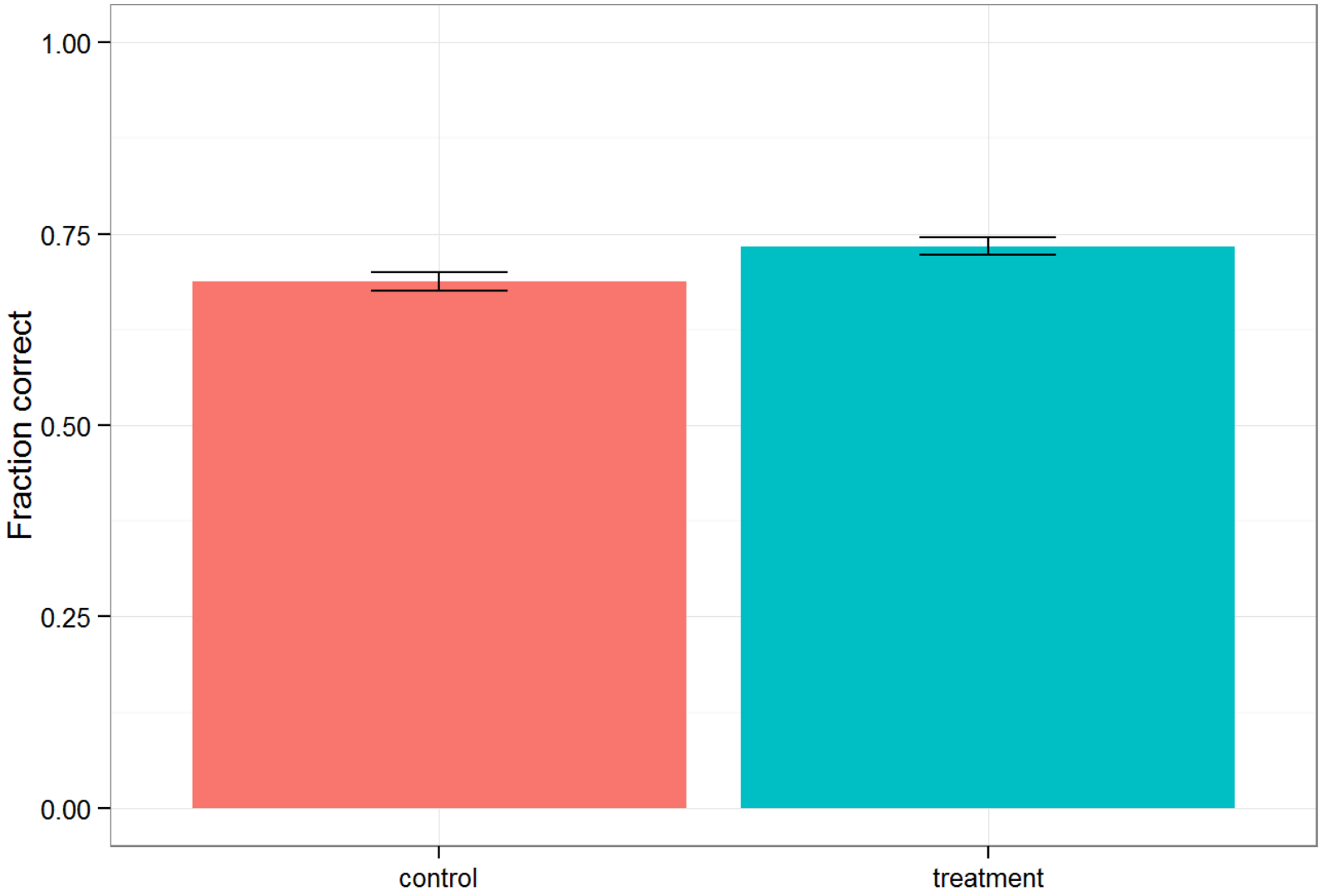
Take the CRT

(1) A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? ____ cents

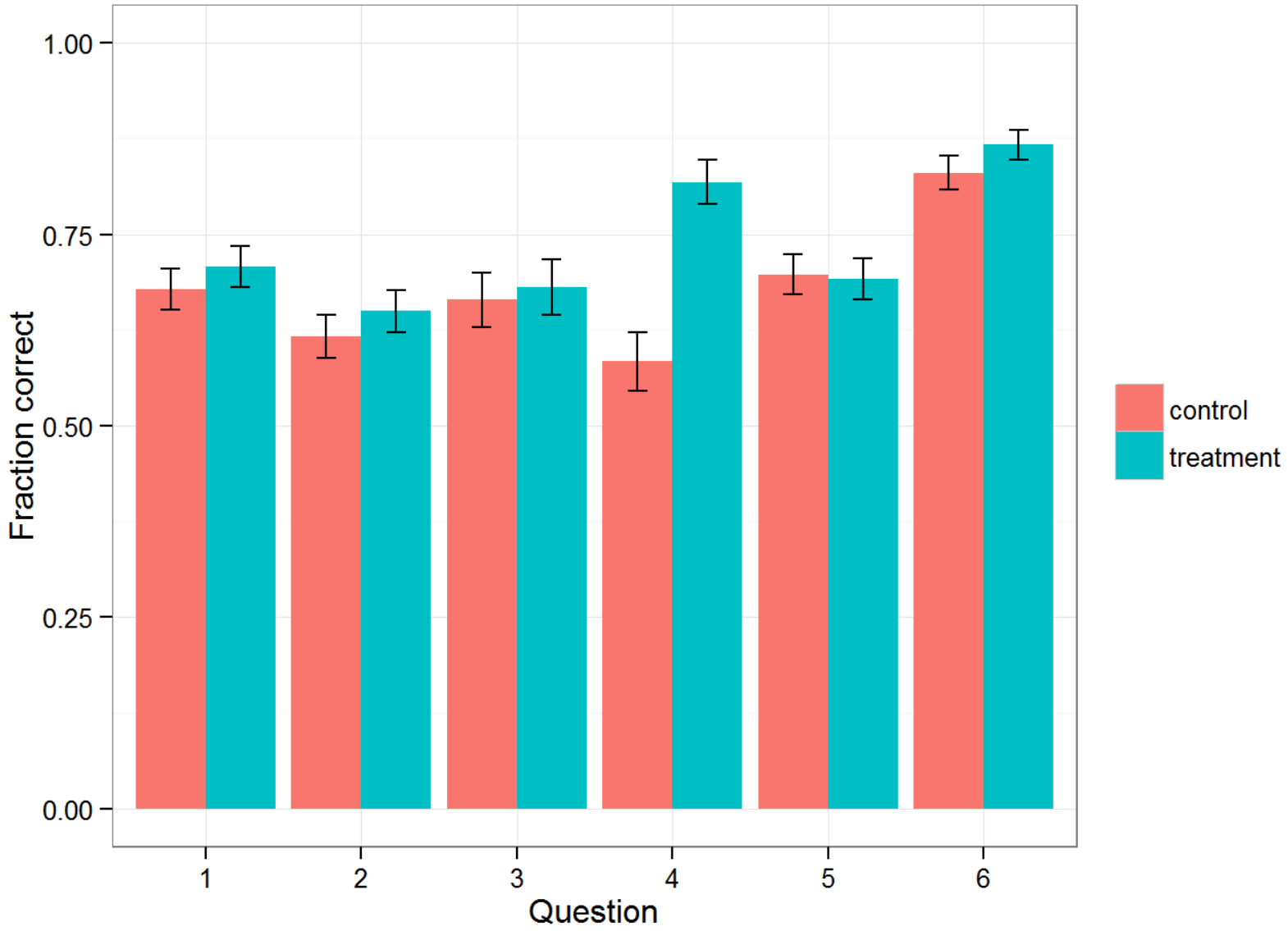
(2) If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? ____ minutes

(3) In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? ____ days

Results



“Explain your answer” (treatment) statistically significantly increased odds of getting the question correct. $p<0.01$, odds ratio of 1.28, with 95% CI of (1.09, 1.51).



Range of “Explain your answer” (treatment) effect, from raw change in performance of -0.6% (Q5) to +23% (Q4).

Q3

A2 [2 points] Two identical horizontal mass-spring systems are oscillating. System A has a total energy of 6J, system B has a total energy of 12 J.

$\frac{1}{2}kA^2$ ↑ larger

[1.5 points] Which one has the longest oscillation period:

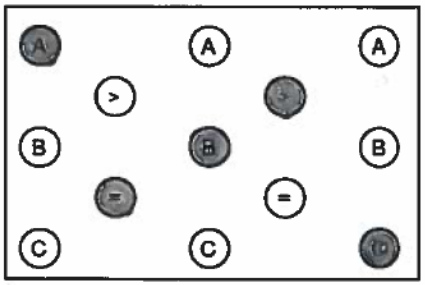
- Ⓐ A
- Ⓑ B
- ● They are the same

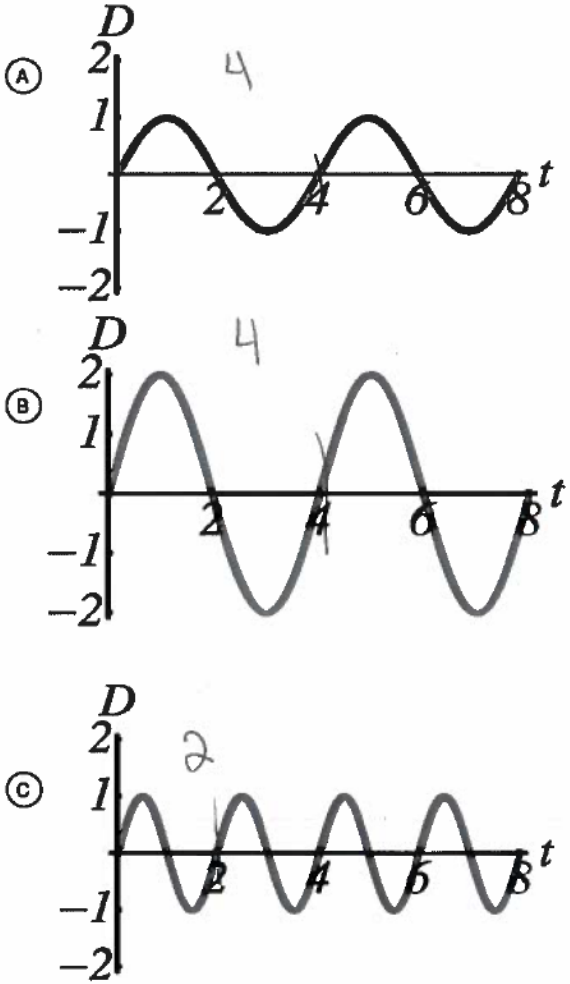
[0.5 points] Explain your reasoning in 1-2 sentences: Assume all energy is in potential energy! The total energy determines the maxium amplitude of the syster. However, period does not depend on amplitude. ($T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{K}}$), it only depends on the mass attacked and the spring constant, which are both identical in this case.

Q4

A3 [2 points] The displacement vs time graphs for three mass-spring systems are shown on the right. They all use the same spring.

[1.5 points] Rank the systems based on their mass.



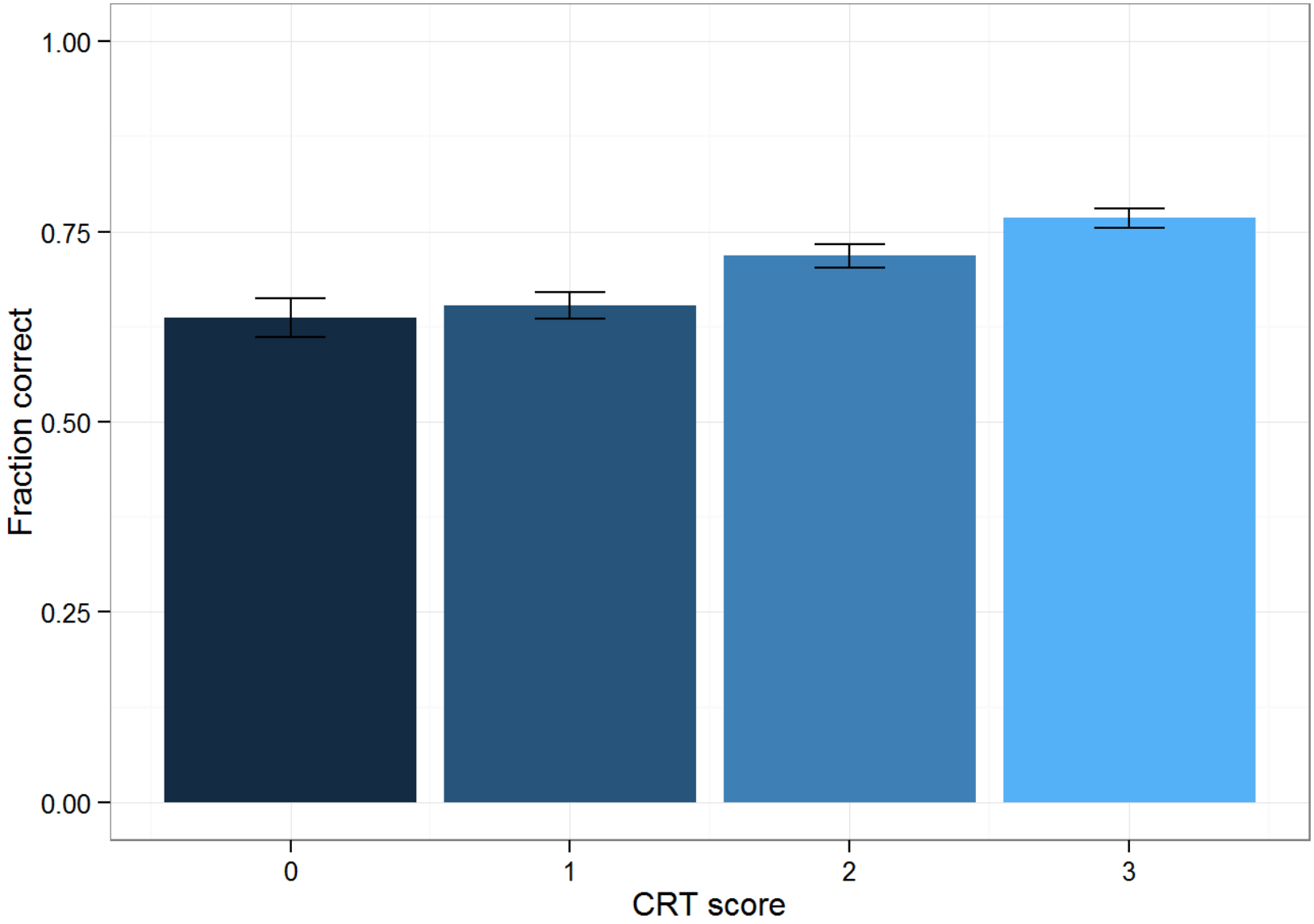


$c < a = b$

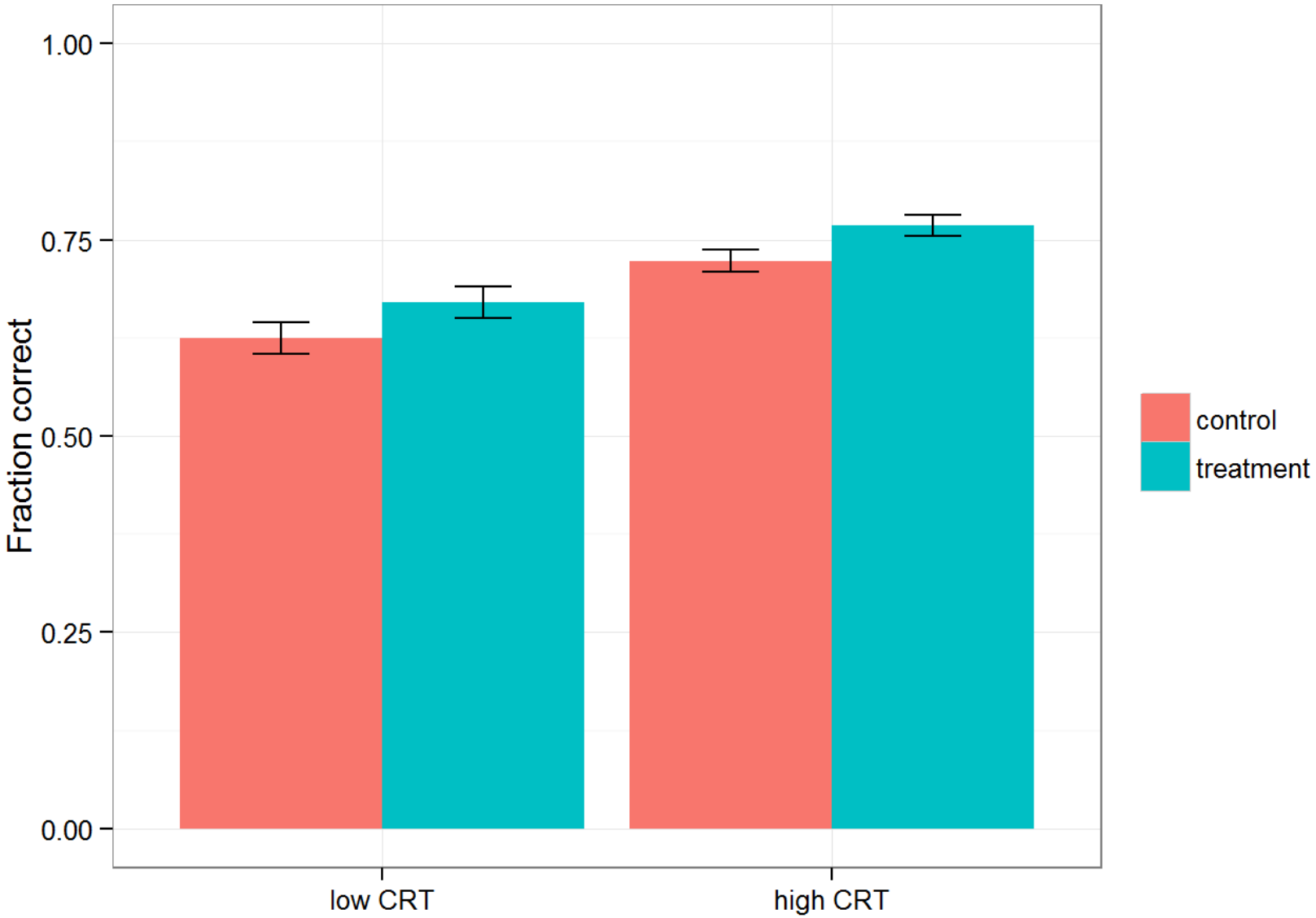
$T = 2\pi\sqrt{\frac{m}{k}}$

[0.5 points] Explain your reasoning in 1-2 sentences:

Because $T = 2\pi\sqrt{\frac{m}{k}}$, as the mass increases, the time increases as a factor of $\sqrt{m}$. Therefore time and mass have a $T \propto \sqrt{m}$ therefore, C has $\downarrow T = \downarrow\sqrt{m}$ however a and b have = time so their masses will be the same. Mand time are independant of amplitude.



The CRT is a good predictor of performance overall.



"Explain your answer" (treatment) does not appear to impact students with different CRT scores differently.

Feedback

1. What do these results say about your multiple choice exams?
2. What other data would be interesting?
3. What other questions do you have?