Graph practice

Seeley, speed graphs. Problems first. Answers start on the last page.

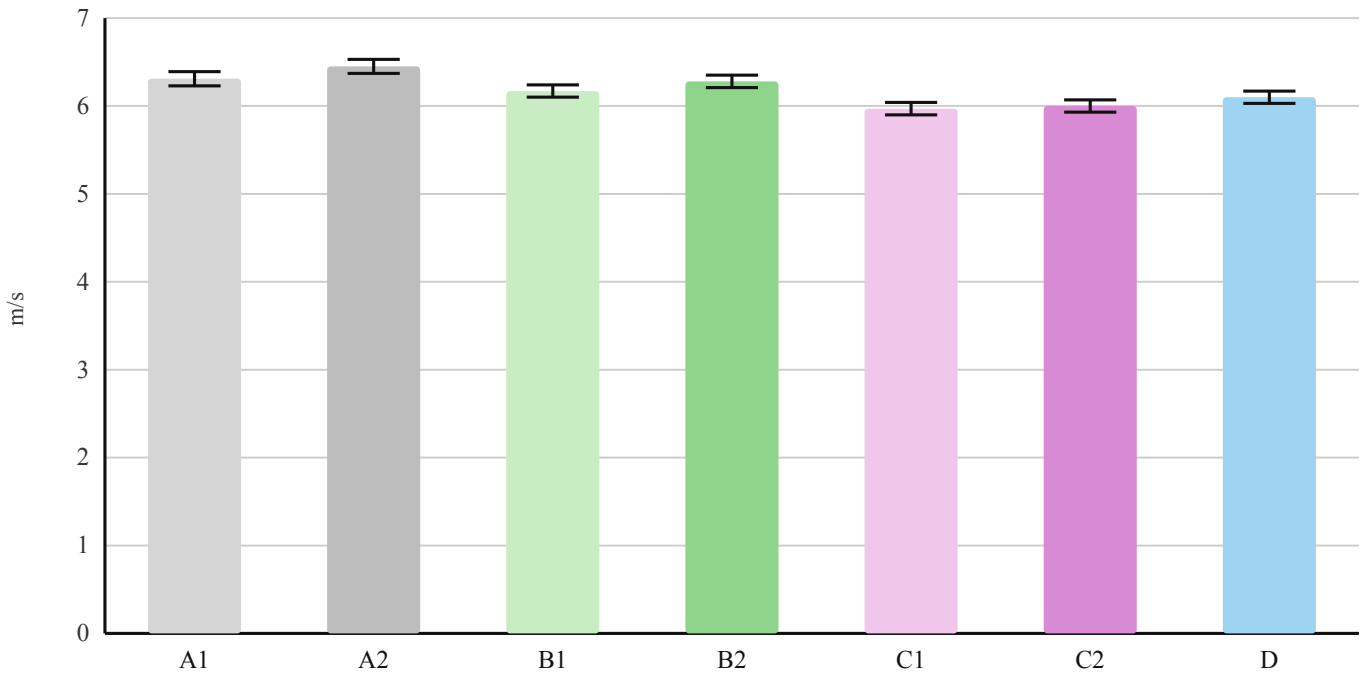
Several trials use (highest - lowest) / 2. If two ranges overlap, you cannot call a winner.

Pair 1. Same speeds, two scales

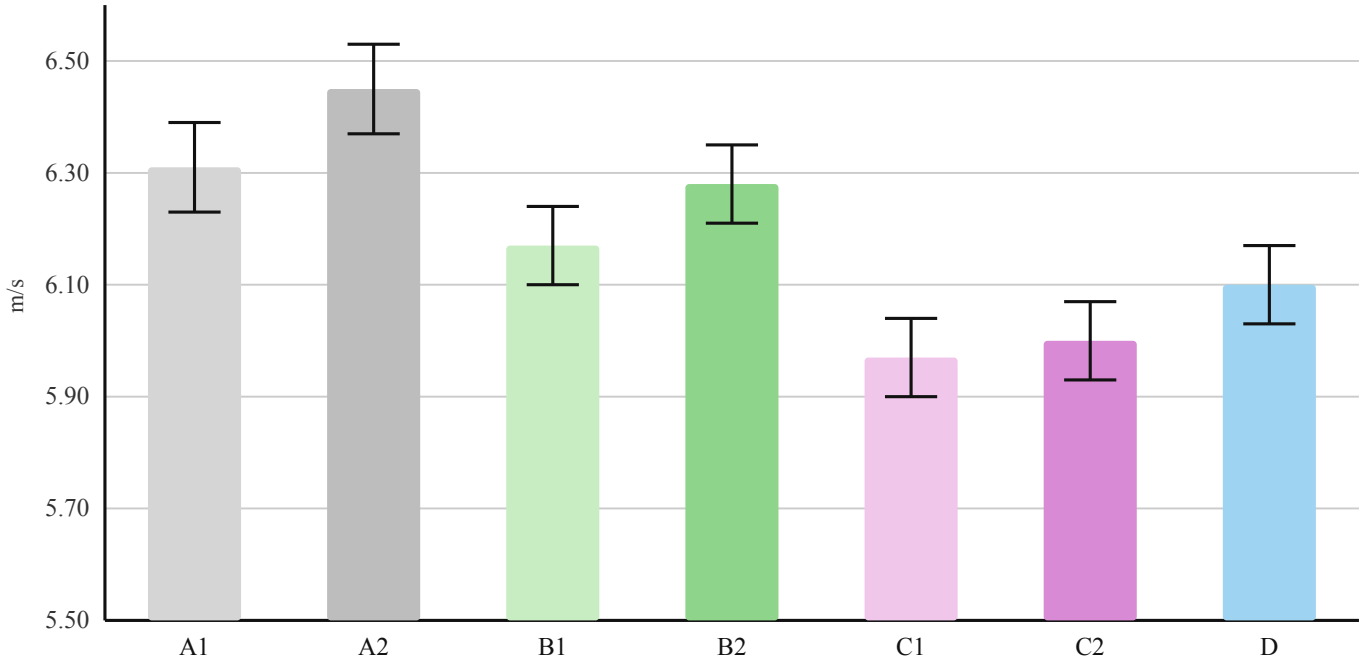
A is pickleball, B is wiffle, C is small wiffle, D is the golf ball. Both graphs plot this table.

Drop	v (m/s)	±
A1	6.31	0.08
A2	6.45	0.08
B1	6.17	0.07
B2	6.28	0.07
C1	5.97	0.07
C2	6.00	0.07
D	6.10	0.07

Graph 1. Axis from 0 to 7 m/s.



Graph 2. Axis from 5.50 to 6.60 m/s. Same drops.

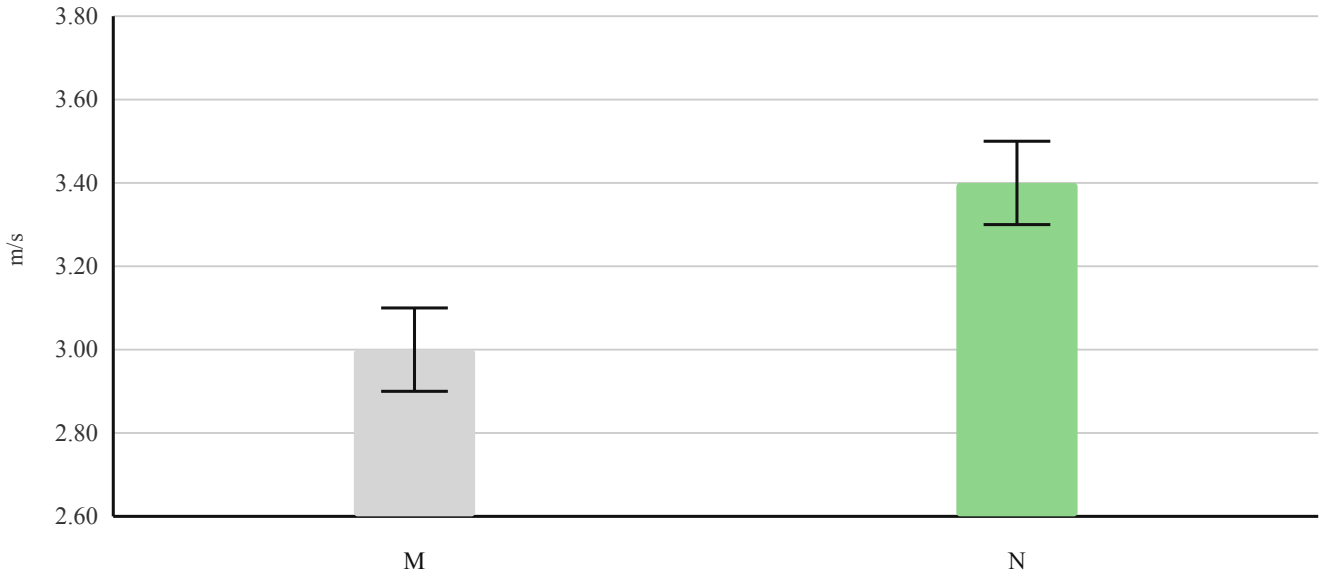


1. Which graph lets you see who is faster? Are the speeds on the other graph wrong, or is something else hiding the comparison?
2. What error does a whisker show? What does a short whisker mean?
3. Write the range for A1, A2, B2, and C1. Which overlap: A2 with B2, A1 with B2, A2 with C1?
4. Can you say ball A is faster than ball B? One sentence, from the ranges.
5. A kinked tape adds 0.20 m/s to every bar. The whiskers stay the same length. What error is that? Do more trials fix it? Are the bars precise, accurate, or both?

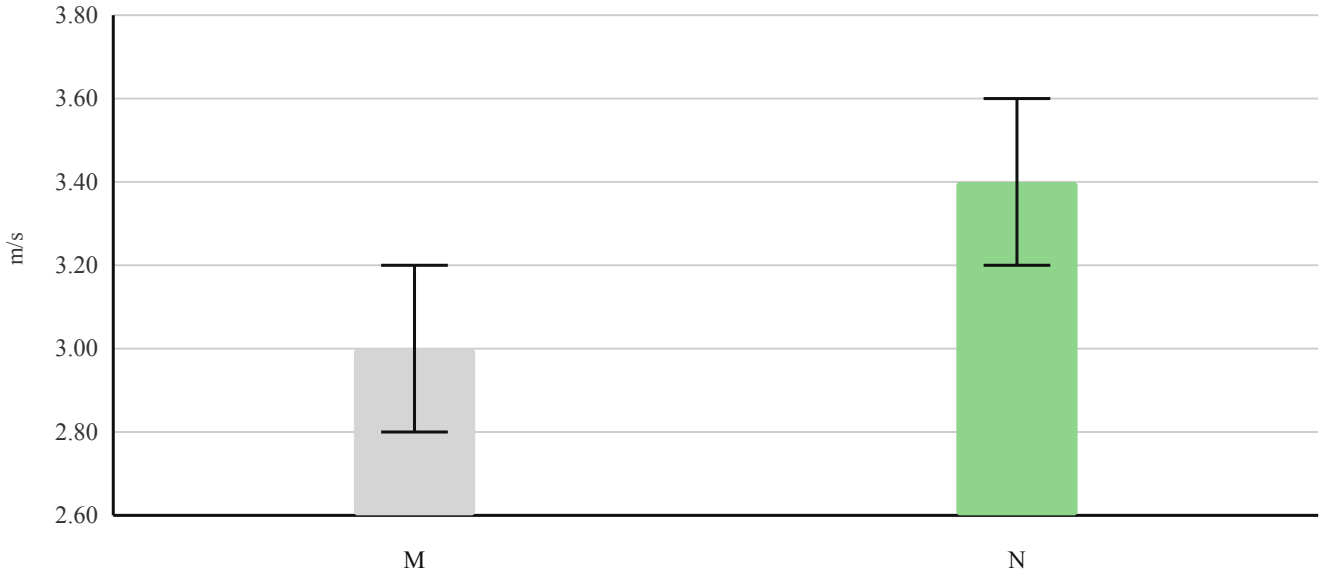
Pair 2. Which error bar matches the rule

M trials are 2.90, 3.00, and 3.10 m/s. N trials are 3.30, 3.40, and 3.50 m/s. Both graphs put the bar at the mean. The whiskers are not the same length.

Graph P.



Graph Q. Same means.

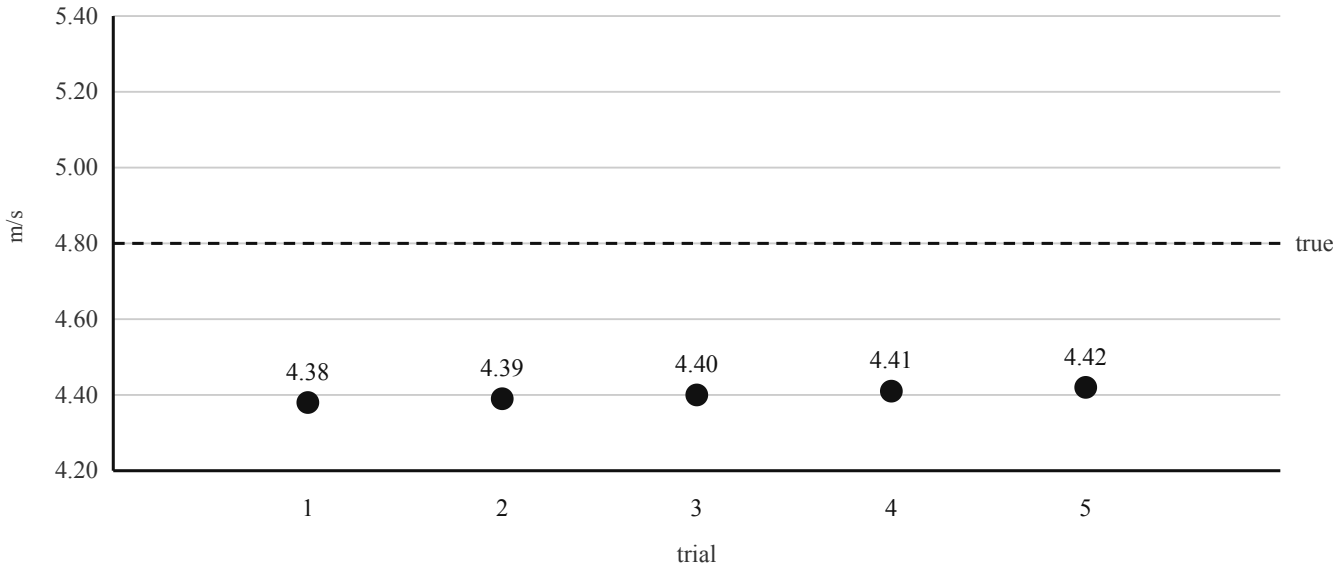


6. Which graph uses (highest - lowest) / 2?
7. What is wrong with the other whiskers? What does that mistake do when you ask whether N is faster?
8. On the correct graph, do the ranges overlap? Is N faster?

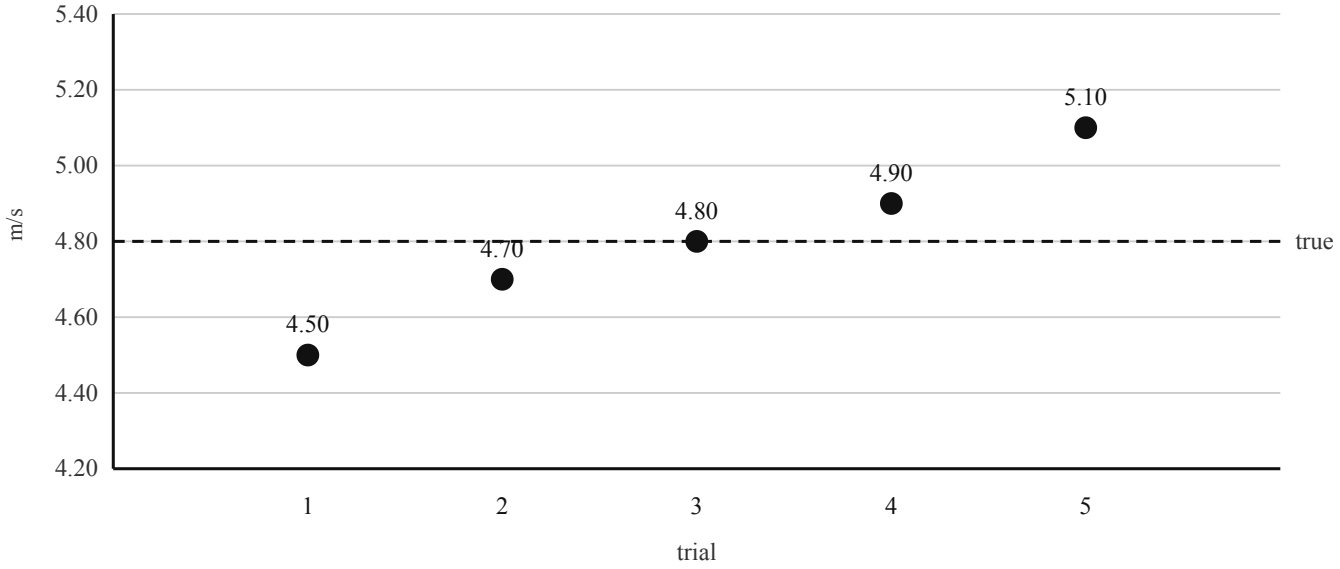
Pair 3. Which graph is accurate

The dashed line is the true speed, 4.80 m/s. Each dot is one trial.

Graph R.



Graph S.



9. Which graph is accurate? Which one is only precise?
10. What error is on the graph that sits off the dashed line? The dots are close together. What does that closeness mean, and what does it not mean?
11. What error is on the graph that scatters around 4.80? If you took 20 more trials the same way on each graph, what gets smaller, and what stays wrong?

Answers

1. Use graph 2. Graph 1 is the same speeds and the same ±. The axis starts at 0, so a 0.07 m/s whisker shrinks to a speck and every ball looks the same. That is a bad scale, not bad data.
2. The whisker is statistical error, the spread of that drop. A short whisker means the trials agreed. That is precision. It does not mean the average is the true speed.
3. A1 is 6.23 to 6.39. A2 is 6.37 to 6.53. B2 is 6.21 to 6.35. C1 is 5.90 to 6.04. A2 and B2 do not overlap (6.37 is above 6.35). A1 and B2 do overlap. A2 and C1 do not overlap.
4. No. A2 beats both wiffle drops, but A1 overlaps B2. One pickleball drop is clearly faster. The other is not. You cannot say ball A is faster than ball B.
5. A shift that hits every bar the same way is systematic error. More trials shrink the whisker. They do not slide the bars back down by 0.20 m/s. The bars stay precise and are not accurate.
6. Graph P. M is (3.10 - 2.90) / 2 = 0.10, so 2.90 to 3.10. N is (3.50 - 3.30) / 2 = 0.10, so 3.30 to 3.50. Graph Q draws ±0.20, which is the full spread with the divide-by-2 skipped.
7. Graph Q's whiskers are twice too long. They meet at 3.20, so the picture says you cannot tell M from N. The real ranges have a gap. A whisker that is too long makes a real difference look like a tie.
8. On graph P they do not overlap. N's low end is 3.30 and M's high end is 3.10. N is faster.
9. Graph S is accurate. The mean is (4.50 + 4.70 + 4.80 + 4.90 + 5.10) / 5 = 4.80, on the true speed. Graph R is only precise. Its mean is 4.40, and (4.42 - 4.38) / 2 = 0.02, so the trials agree with each other and miss the truth by 0.40 m/s.
10. Graph R has a systematic error. Something in that method shifted every trial. Close dots mean the measurements repeat. They do not mean the speed is right. Report it as 4.40 ± 0.02 m/s and it still sits 0.40 m/s low.
11. Graph S is statistical error. The average landed on 4.80, and the shots are spread out, so it is accurate and imprecise. Half the spread is (5.10 - 4.50) / 2 = 0.30 m/s. More trials shrink that scatter on both graphs. They do not move graph R up onto 4.80. You have to find the bias and remove it.