Advice for young investigators

Sam Gershman Harvard University

Picking a puzzle

- Many students struggle to find an appropriate research project when they start grad school.
- I think this stems from the fact that science is taught as a body of knowledge rather than as a body of epistemic activities. So undergrads leave college "interested" in certain topics, but with little idea about what one does with those interests.
- <u>Science is a puzzle-solving activity</u>. A puzzle is a gap in the scholarly literature. This means that you need to start by identifying phenomena that are not well-explained by existing theories, or posit unobserved phenomena that would challenge existing theories.
- Good puzzles are gaps that (a) people care about closing, and (b) can be closed in the course of a Ph.D.

Strong puzzles

- In an influential paper, Platt (1964) asked why some fields have made faster progress than others. His answer was that the successful fields made use of strong inference: the design of experiments to discriminate alternative hypotheses.
- This seems intuitive and obvious, but a lot of science is done without theories that make clear and distinctive predictions.
- Many scientists seem to have the attitude of "let's measure stuff, and then from these measurements we can construct a theory." In my view this random walk in the space of experiments is hopeless (see also "Can a biologist fix a radio?").
- Strong puzzles complement strong inference: <u>pick puzzles that</u> <u>can be solved through strong inference</u>. This means finding unexplained phenomena that discriminate between theories.

Platt, J. R. (1964). Strong inference: certain systematic methods of scientific thinking may produce much more rapid progress than others. *Science*, *146*, 347-353.

Little puzzles and big puzzles

- Naturally, most of us want to solve big puzzles. But this can be hazardous for your health. It's not good to toil for years on big puzzles with uncertain prospects. It's a recipe for demoralization.
- I encourage my students to work on two timescales at the same time: at short timescales (months), work on small puzzles, while making progress on a large puzzle at longer timescales (years).
- The psychological impact of having produced intellectual output, no matter how small, is not to be underestimated.
- Multiple timescales also help alleviate boredom and frustration.

Things aren't obvious

- Science is prone to premature canonization of ideas. Certain ideas are "obvious" or "established" until you start scratching the surface.
- A big issue is that <u>we sometimes neglect the impact of the</u> <u>measurement process on our theoretical ideas</u>.



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- 1. Maps are a basic organizational motif in the brain. Can be motivated computationally by wiring economy.
- 2. We find maps because that's what we know how to find.

The drunkard's search



Another example: Wald's contribution to World War II



Planes that returned to base were the ones that survived attack, so you should reinforce parts of the plane that had no bullet holes.

Don't be cool

- Everyone wants to work on topics that are cool using methods that are cool. This means those topics and methods are going to be crowded. You'll worry about getting scooped. People are less generous with one another when they're competing.
- It's hard to find puzzles that people care about but nonetheless aren't working on. One heuristic is to look at areas where people aren't using strong inference because their theoretical ideas aren't well formulated. <u>A well-formulated</u> theory is worth a million experiments.
- Being uncool requires courage and creativity. Read outside your specialty. Read poetry, novels, philosophy, history. Take long walks and talk to madmen wherever you can find them.

Interesting but wrong

- Sometimes theories are criticized for being wrong.
- Being right (i.e., making correct predictions) is not the only goal of theorizing. Remember that <u>science is a puzzle-solving</u> <u>activity</u>: it is an epistemic practice, not a fixed body of knowledge. An important role of theorizing is in formalizing points of view that bring clarity to puzzles. Wrong theories can help define puzzles by "carving nature at its joints."
- Particularly when you first present a theory, you should present it in its simplest and clearest form, even if it's wrong. The goal is not to be right, but to endow your audience with a certain way of seeing the phenomenon. <u>Theories are tools for thinking</u>.