Research questions

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Empirical research

- **Empirical research** is any research that uses structured observations from the real world to attempt to answer questions.
- **Quantitative empirical** research is just empirical research that uses quantitative measurements (numbers, usually). More data sets, fewer interviews.
- One problem with quantitative empirical research is that the numbers that are observed often don't tell exactly what we want to know.
- It turns out that, by doing right kind of research, we can get the *right kind of numbers*. By carefully designing the right kind of analysis, we can get the answer to our research question from the numbers.

Why research needs a design

- A lack of solid research design can be seen in the results, as well.
- Different studies seem to give different answers to research questions because they are not actually answering that question in the first place.
- For example:
  - Scientists may claim $2 + 2$ only has one answer
  - If you're actually calculating something entirely different from $2 + 2$, you might come back with an answer of 6, or 1, or -52
  - Then you wake up to a news headline reading that scientists have determined that $2 + 2 = -52$
- There may not be a straightforward answer to our research question, but we must continue to try!

What is a research question anyway?

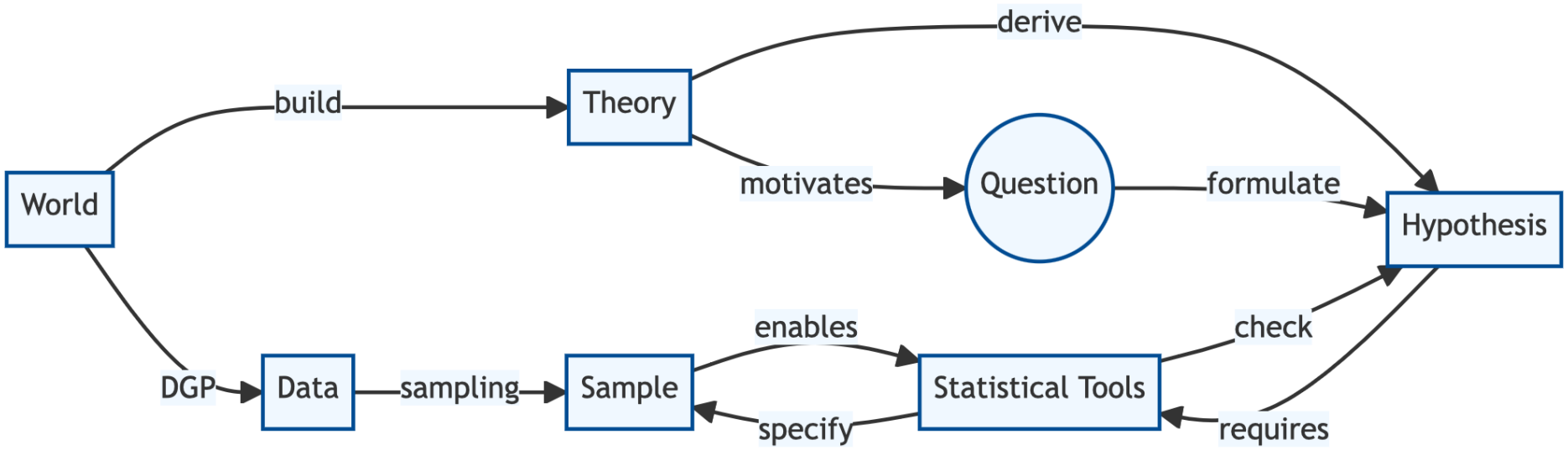
Key Koncept: Research question

A **research question** is a question

1. ... that *can be answered* and
2. ... for which having that answer will *improve our understanding of how the world works*.

A research questions takes us from a **theory** to an **hypothesis** that we can check using real world data. The data may provide **evidence** in favor or against our hypothesis.

What is a research question anyway? — ctd.



Research questions

Example: The influence of smartphone usage on children

- Does heavy smartphone usage damage children's eyesight?
- Does smartphone usage stimulate creative or intellectual activity?
- Does smartphone usage reduce children's ability to concentrate?

Why not simply look for patterns in the data?

- We are living in an information economy, surrounding us by an increasing amount of readily available data
- Why not skip hassling with theories and research questions and simply look for *patterns* in the data?
- A lot of people do — this commonly referred to as **data mining**

Definition: Data Mining

Data mining is the systematic application of computer-aided methods to discover patterns, trends or correlations in (often large and connected) data sets. Algorithms based on statistical methods are frequently used for this purpose.

Data mining

... is a useful toolkit if we care more about the *what* rather than the *why* :

- Data mining is often good at
  - ... making *predictions under stability*.
  - ... finding patterns in the data. These may foster research questions that we can examine further in other data sources.
- Data mining is less good at
  - ... helping to come up with a good theory or to improve an existing one.
  - ... producing valid inference. It has a tendency to find **false positives**.[1]

[1] A false positive is a result that incorrectly indicates the presence of a condition under examination.

Data mining — predictions under stability

Example: Predicting die roll outcomes

- By a stable mechanism we mean that the process giving us the data does not change
- If the process is "rolling a six-sided die" data mining would based on a thousand rolls would be great at predicting that the probability of observing a 1 is 1/6
- If the process switches to "rolling a twenty-sided die", that data mining prediction will be bad: it will still predict a 1/6 chance of a 1 until it gets a lot more data.
- Probability theory will properly predict the switch to a 1/20 chance immediately

Data mining — looking for patterns

Example: Viagra

To find a pattern can make you rich

- Pfizer scientists originally developed Viagra scientists to mitigate high blood pressure and angina.
- Famous side effects have been found using data mining: instead of coming to the data with a theory, the scientists noticed an interesting pattern in the data.

Data mining is bad as a final step

- Taking a pattern found as given would be problematic
- Pfizer did clinical studies to *see if the pattern replicated*: they verified an hypothesis derived from their research question using experimental data.

So what makes a research question a *good* one?

Simplicity

- Do not bundle a bunch of research questions into one.
- Consider potential answers — research question and theory probably do not align very well if we cannot place potential answers within the framework of our theory.

Feasibility / scalability

- A good research question can be answered using the right data.
- Data acquisition is often subject to constraints. Think time, money, data protection laws.

Suitable research design

- The research design must be suitable to investigate the derived hypothesis.
- Thoughtful consideration must be given as to which statistical method is appropriate. We will deal with this aspect in particular in this course.