

## Econ 311: Behavioral and Experimental Economics

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## Borrowing from Psychology

1 / 195

17 / 195

## Psychology and Economics

- ▶ Behavioral and experimental economics owe much to the psychology literature
- ▶ Many of the foundation papers we will read in each section are from major branches of psychology:
  - ▶ social psychology
  - ▶ cognitive psychology
  - ▶ judgement and decision-making
- ▶ Many groundbreaking researchers in behavioral economics were trained as psychologists:
  - ▶ Amos Tversky, PhD in Cognitive Psychology
  - ▶ Daniel Kahneman, PhD in Psychology
  - ▶ Dan Ariely, PhD in Cognitive Psychology

18 / 195

## Discussion Questions

- ▶ What ideas and concepts are shared between psychology and economics? Do they have the same names or different?
- ▶ What methods to the two areas share? What methods are distinct?
- ▶ How is theory in economics different than theory in psychology?

19 / 195

## Two Systems Model

- ▶ System 1: fast, associative
  - ▶ Make connections from similarity
  - ▶ Processing occurs automatically
  - ▶ Good at: pattern completion, emotional reactions, repetitive tasks
- ▶ System 2: slow, deliberative
  - ▶ Uses symbols and rules
  - ▶ Processing occurs with conscious awareness
  - ▶ Good at one-shot learning, formal logic, educational knowledge, abstract theories
- ▶ May interact alternatively or simultaneously
- ▶ Moderated by mood, energy level, difficulty of problem, type of judgement

20 / 195

## Probability

21 / 195

## Why Do We Need Probability?

1. Social scientists are interested in making predictions about future behavior
  - ▶ Sometimes the best prediction we can give is a likelihood of a certain event of interest happening
2. We need a benchmark to talk about rationality of behavior
  - ▶ Probability judgement: Process of assigning a number to an event that represents one's strength of belief that that event will occur
  - ▶ The rules of probability come from very general assumptions but still give powerful restrictions on how probability judgement should behave

22 / 195

## Probability Basics

- ▶ Let  $\Omega$  be the space of all possible outcomes
  - ▶ Eg if we are rolling a single die,  $\Omega = \{1, 2, 3, 4, 5, 6\}$
- ▶ A collection of one or more outcomes is an *event*, eg  $E \in \Omega$ 
  - ▶ The event "roll a 3 or greater" is  $E = \{3, 4, 5, 6\}$
- ▶ A probability function is a function  $P$  that assigns numbers between 0 and 1 (inclusive) to every possible event in  $\Omega$ 
  - ▶  $P(\{1\}) =$
  - ▶  $P(\{3, 4, 5, 6\}) =$

23 / 195

## Axioms of Probability

- ▶ An axiom is a mathematical rule that is assumed to be true
- ▶ We have just two axioms in probability theory:
  1.  $P(\Omega) = 1$ 
    - ▶ You can think of this as “something is guaranteed to happen”
    - ▶ Eg  $P(\{1, 2, 3, 4, 5, 6\}) = 1$  in dice example
  2.  $P(A \text{ or } B) = P(A) + P(B)$  for any two mutually exclusive events  $A$  and  $B$ 
    - ▶ Called the *addition axiom*
    - ▶ Eg  $P(\{1\}) + P(\{3, 4, 5, 6\}) = \frac{1}{6} + \frac{2}{3} = \frac{5}{6}$
- ▶ These rules may not uniquely determine the probability function for a given context
- ▶ But they do still allow us to make testable predictions about what a (possibly subjective) probability function should look like

24 / 195

## Where Do These Probabilities Come From?

- ▶ Frequentist perspective
  - ▶ Probabilities represent *long run* averages
  - ▶ Eg, dice:  $P(4) = \frac{1}{6}$  because if I roll a die a very large number of times,  $\frac{1}{6}$  of the time I will roll a 4
- ▶ Counting perspective
  - ▶ Break event space into small enough pieces that they are be equally likely to happen
  - ▶ Probabilities of more complex events can then be built by addition rule, since pieces are mut
  - ▶ Example: what is the probability of flipping two heads in a row?
    - ▶ Break down into 4 equally likely events:  $HH, HT, TH, TT$
    - ▶ Only 1 of these has two heads, so  $P(HH) = \frac{1}{4}$

25 / 195

## Conditional Probabilities

- ▶ We can define *conditional probability*  $P(A|B) = \frac{P(A \text{ and } B)}{P(B)}$ 
  - ▶ This is the probability of  $A$  occurring given that we know  $B$  has occurred.
  - ▶ Example:  $P(\text{winter}) = \frac{1}{4}$  but  $P(\text{winter} \mid \text{snowed last weekend}) > \frac{1}{4}$
- ▶ We say two events  $A$  and  $B$  are *independent* if  $P(A|B) = P(A)$ 
  - ▶ Dice example: Probability of rolling a six is independent of what you rolled previously
- ▶ Multiplication rule: For any two events  $A$  and  $B$  then  $P(A \text{ and } B) = P(A|B)P(B)$ 
  - ▶ Comes from rearranging definition of conditional probability
  - ▶ Note that if  $A$  and  $B$  are independent,  $P(A \text{ and } B) = P(A)P(B)$

26 / 195

## Bayes' Rule: Intuition

- ▶ Suppose you have the following information:
  - ▶ The baseline breast cancer rate in women is 10%
  - ▶ If a patient has breast cancer, a mammogram will return positive with 90% probability
  - ▶ If a patient **does not** have breast cancer, a mammogram will return positive with 20% probability
- ▶ Question: What is the probability that a patient has cancer given that you see a positive mammogram result?

27 / 195

## Bayes' Rule: Formalization

- ▶ Suppose we are considering two events  $A_1$  and  $B$
- ▶ From the definition of conditional probability, we have
  - ▶  $P(A_1|B) = \frac{P(A_1 \text{ and } B)}{P(B)}$
  - ▶  $P(B|A_1) = \frac{P(B \text{ and } A_1)}{P(A_1)} = \frac{P(A_1 \text{ and } B)}{P(A_1)}$
- ▶ Substituting one into the other:

$$P(A_1|B) = \frac{P(B|A_1)P(A_1)}{P(B)}$$

- ▶ This is the most basic statement of Bayes' rule

28 / 195

## Bayes' Rule: Alternate Formulations

- ▶ That  $P(B)$  on the bottom is not very useful
- ▶ Suppose  $A_2$  is the even that  $A_1$  does not happen, ie  $A_1 + A_2 = \Omega$
- ▶ Then

$$\begin{aligned} P(B) &= P(B \text{ and } A_1) + P(B \text{ and } A_2) \\ &= P(B|A_1)P(A_1) + P(B|A_2)P(A_2) \end{aligned}$$

- ▶ This give us a more useful version of Bayes' rule:

$$P(A_1|B) = \frac{P(B|A_1)P(A_1)}{P(B|A_1)P(A_1) + P(B|A_2)P(A_2)}$$

- ▶ Or more generally:

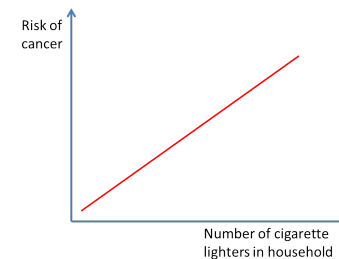
$$P(A_1|B) = \frac{P(B|A_1)P(A_1)}{\sum_i P(B|A_i)P(A_i)}$$

29 / 195

## Experimental Design

## Why Do We Need Experiments?

- ▶ Suppose we observe the following pattern in observational data:



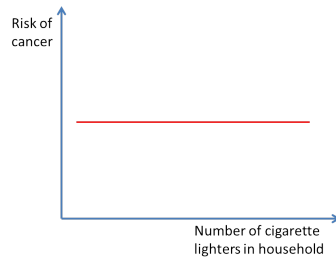
- ▶ Can we conclude that cigarette lighters cause cancer?
  - ▶ No, correlation is not causation
  - ▶ More likely that there is a third variable (smoking) that causes the other two

30 / 195

31 / 195

## Experiments Give Us Control

- ▶ Experiments allow the researcher to *control* all the variables (or at least control them more than in observational data)
- ▶ Experiments also the researcher to determine causality using *random assignment*
  - ▶ For example, if we randomly gave some people more cigarette lighters to have around the house, we would probably see that they have no *causal* relationship with cancer risk



32 / 195

## Building Blocks

- ▶ Every experiment needs some *participants*, also know as *subjects* or *decision-makers*
- ▶ The most basic unit in an experiment is a *task* or *choice*
  - ▶ For example, deciding whether or not to buy a food item
- ▶ A *treatment* is a series of one or more similar tasks
  - ▶ For example, choosing whether or not to buy many food items, one at a time
- ▶ An *experiment* consists of one or more treatments
  - ▶ For example, could have one treatment where all food items are 25 cents, and another where all food items are at 75 cents

33 / 195

## Treatment Variables

- ▶ Many experiment consist on only one treatment
- ▶ But many others have more than one treatment
  - ▶ The parts that differ between the treatments are called *treatment variables*
- ▶ A common experimental design is to have two treatment variables that can each take on two levels
  - ▶ This is called a *2-by-2* design
  - ▶ Example:
    - ▶ We are interested in responses to requests for donations to the local animal shelter
    - ▶ Vary whether picture of a dog is included, and vary whether a specific amount of money is asked for

	Amount Specified	Amount Not Specified
Photo	Treatment A	Treatment B
No Photo	Treatment C	Treatment D

34 / 195

## Within- vs Between-Subjects Design

- ▶ In a *between-subjects* design, each subject completes only one treatment
- ▶ In a *within-subjects* design, each subject completes multiple treatments
- ▶ Is one of these designs better than the other?
  - ▶ A within-subjects design can suffer from *order effects*: the order the subjects do the treatments in can matter
  - ▶ However, a within-subjects design needs less subjects and gives more control of subject characteristics

35 / 195

## Incentives

- ▶ Choices in experiments are typically incentivized with some kind of material *incentive* or *payoff*
  - ▶ Incentives may be cash, consumption goods, social image
  - ▶ Important to calibrate the size of the *stakes* to the task
  - ▶ Eg, bad idea to only pay a few cents for correctly solving an entire crossword puzzle
- ▶ In some cases, hypothetical stakes may be appropriate

36 / 195

## Context

- ▶ Generally want to avoid contexts that include unnecessary complications or distractions for subjects
- ▶ For example, consider food choice experiment
  - ▶ Primarily interested in testing the law of demand
  - ▶ Avoid confounds such as making decisions publicly observable
  - ▶ Unless, of course, this is the treatment variable I'm interested in
  - ▶ Controlling context is easier in lab experiments than field experiments
- ▶ Related issue: experimenter demand effect
  - ▶ Subjects may be influenced by what they think the experimenter wants them to do
  - ▶ Avoid using language that implies a value judgement or normative choice

37 / 195

## Independence

- ▶ A famous (likely apocryphal) story:
  - ▶ Graduate student is studying how fast lacerations heal on the skin of mice, depending on whether or not mice have a certain genetic mutation
  - ▶ Advisor tells graduate student he should double his sample size for increased statistical power
  - ▶ Doubling the number of mice is very expensive and time-consuming
  - ▶ Graduate student is very clever: makes a second laceration on each mouse
- ▶ Has the number of observations doubled?

38 / 195

## Pitfalls of Experiment Design

- ▶ Changing two treatment variables at the same time
- ▶ Poor choice of context
- ▶ Order effects not considered
- ▶ Observations not fully independent
- ▶ Poor choice of incentives and stakes

39 / 195