

# **Experimental economics**

## **Introduction**

2016-2017

# What is an experiment?

- Example : Pasteur (1882) : public proof of the immunity property of a new vaccine (Anthrax) :
- Prococol: random assignment of the vaccine in a herd of 50 sick sheep
- Results:
  - 25 sheep vaccinated → all alive after 2 days
  - 25 sheep not vaccinated → all dead after 2 days

# What is an « economic » experiment?

- Example 1 : Incentive to exercise

Charness & Gneezy (2009). Incentive to exercise.  
*Econometrica*, 77(3), 909–931.

- Example 2: are women more generous than men?

Eckel & Grossman (1998). Are women less selfish than men ?:  
evidence from dictator experiments. *Economic Journal*, 108, 726-735.

# Example 1 : Incentive to exercise

(Charness & Gneezy, Econometrica, 2009)

- Two experiments on monetary incentives to exercise.
- **Experiment 1:** 120 students (U. Chicago)
  - Payment promise for 2 attendencies to the lab (at a given date and a week later)
    - All students hold a membership to the athletic facility (included in the univ. fees)
    - Participants sign consent to access their records of entries to the gym
    - 40 subjects assigned to a control treatment
    - 80 subjects assigned to the gym treatment

80 subjects assigned to the gym treatment

- Get 25\$ if they **go to the gym in the coming week** and return to the lab at the end to answer questions
- After returning to the lab one week later, participants randomly assigned to :
  - a) end of the experiment
  - b) promise 100\$ additional for **going to the gym at least eight times during the 4 coming weeks** (and come back to the lab after)

- **Experiment 2:** N = 168 undergrad. Students (U. California, San Diego)
  - All participants paid \$175 (first visit = \$75, two later visits \$50 each) people to show up 3 times (January, one month later, and five months later) for biometric tests.
  - Group 1 (control): keep an exercise log for five weeks and complete a questionnaire.
  - Group 2 : required to **go to the gym at least once in the next month**
  - Group 3 : required to **go to the gym at least eight times in the next month.**

Measurement (all groups): height, weight, body fat percentage, waist, pulse, and blood pressure.

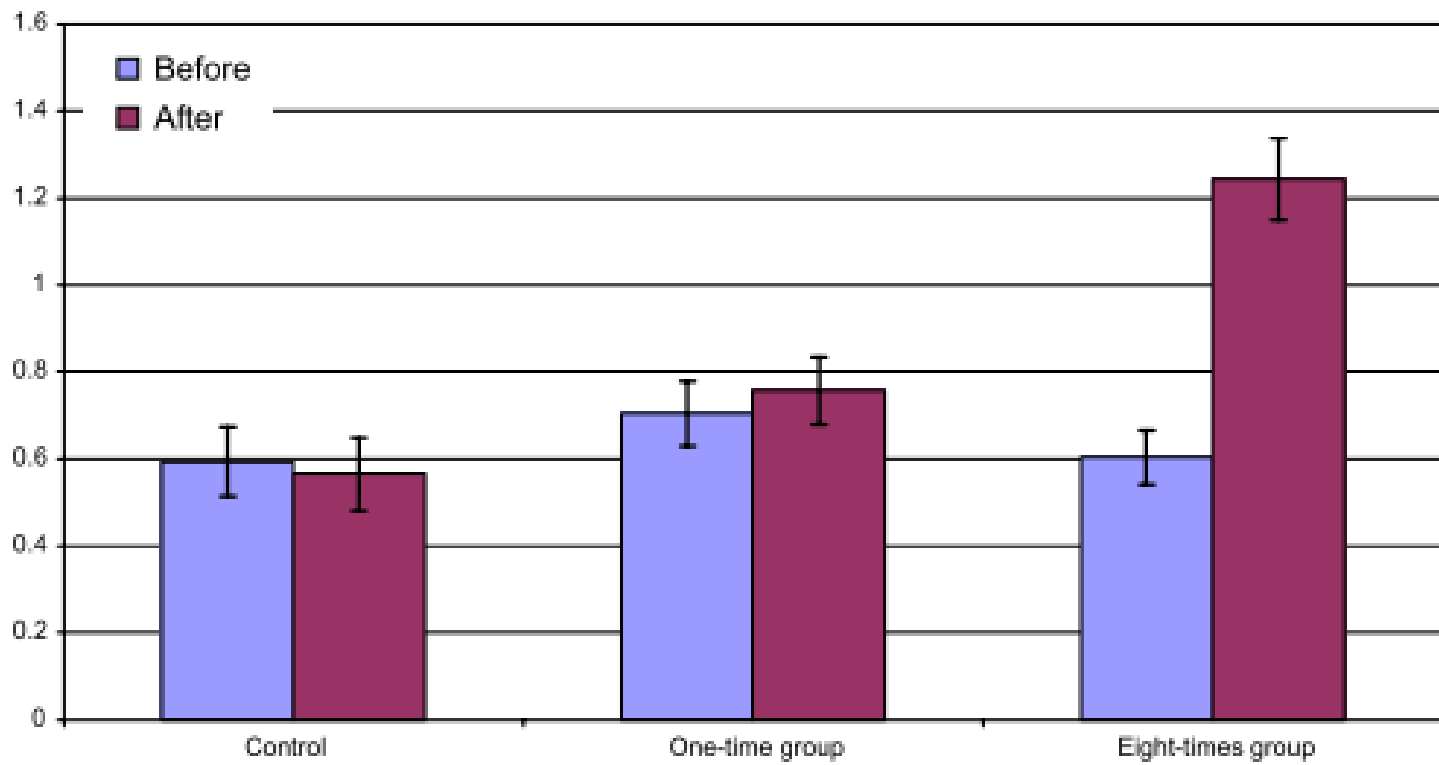
- HYPOTHESIS 0:
- *Participants will visit the gym with the same frequency after the incentives are removed as before the incentives were introduced.*
- HYPOTHESIS 1: (intrinsic) motivation crowding out

*Participants will visit the gym less frequently after the incentives are removed as compared to before the incentives were introduced.*

- HYPOTHESIS 2: Habit formation

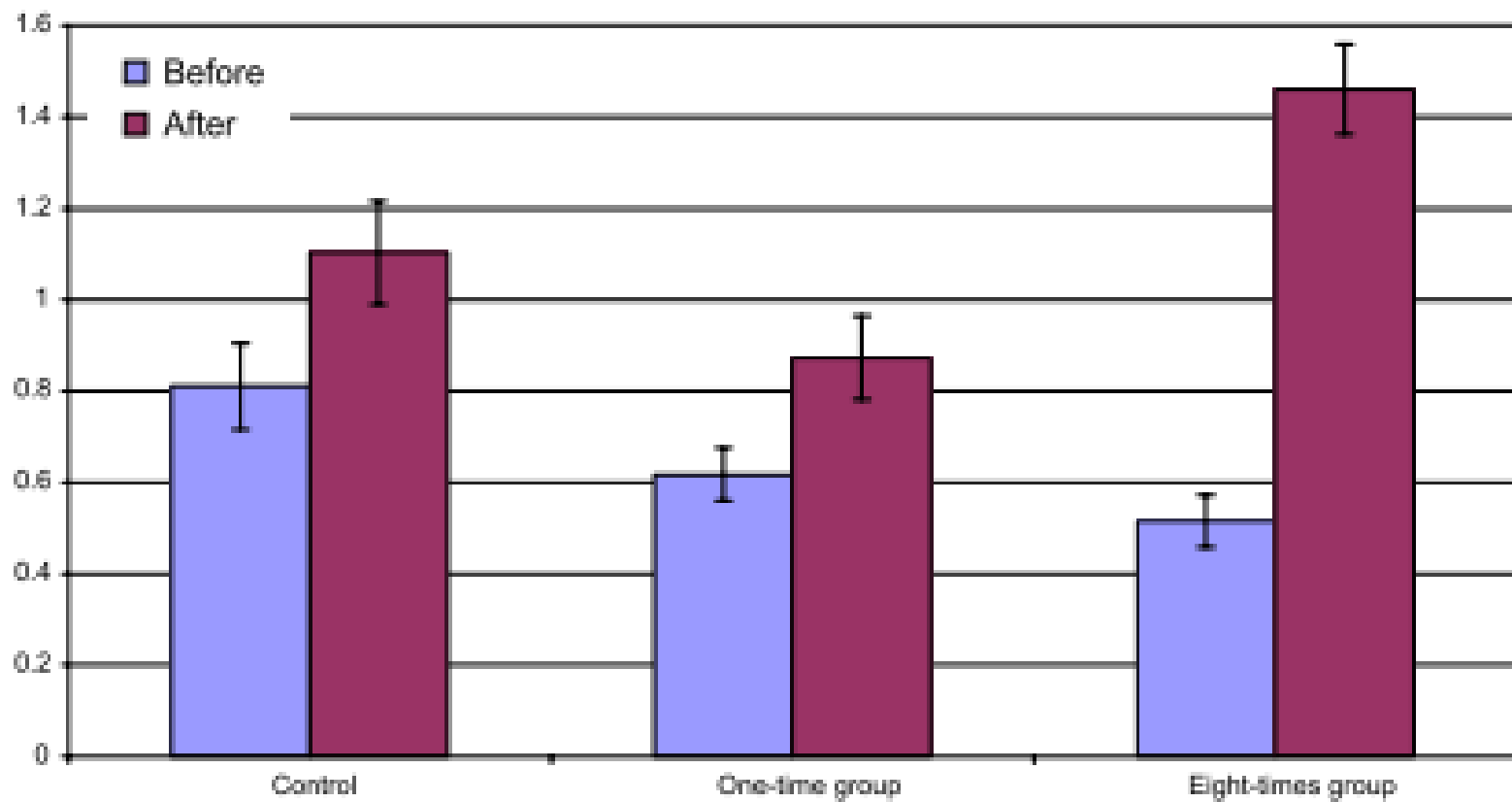
*Participants will visit the gym more frequently after the incentives are removed as compared to before the incentives were introduced.*

# Results



(a) Study 1



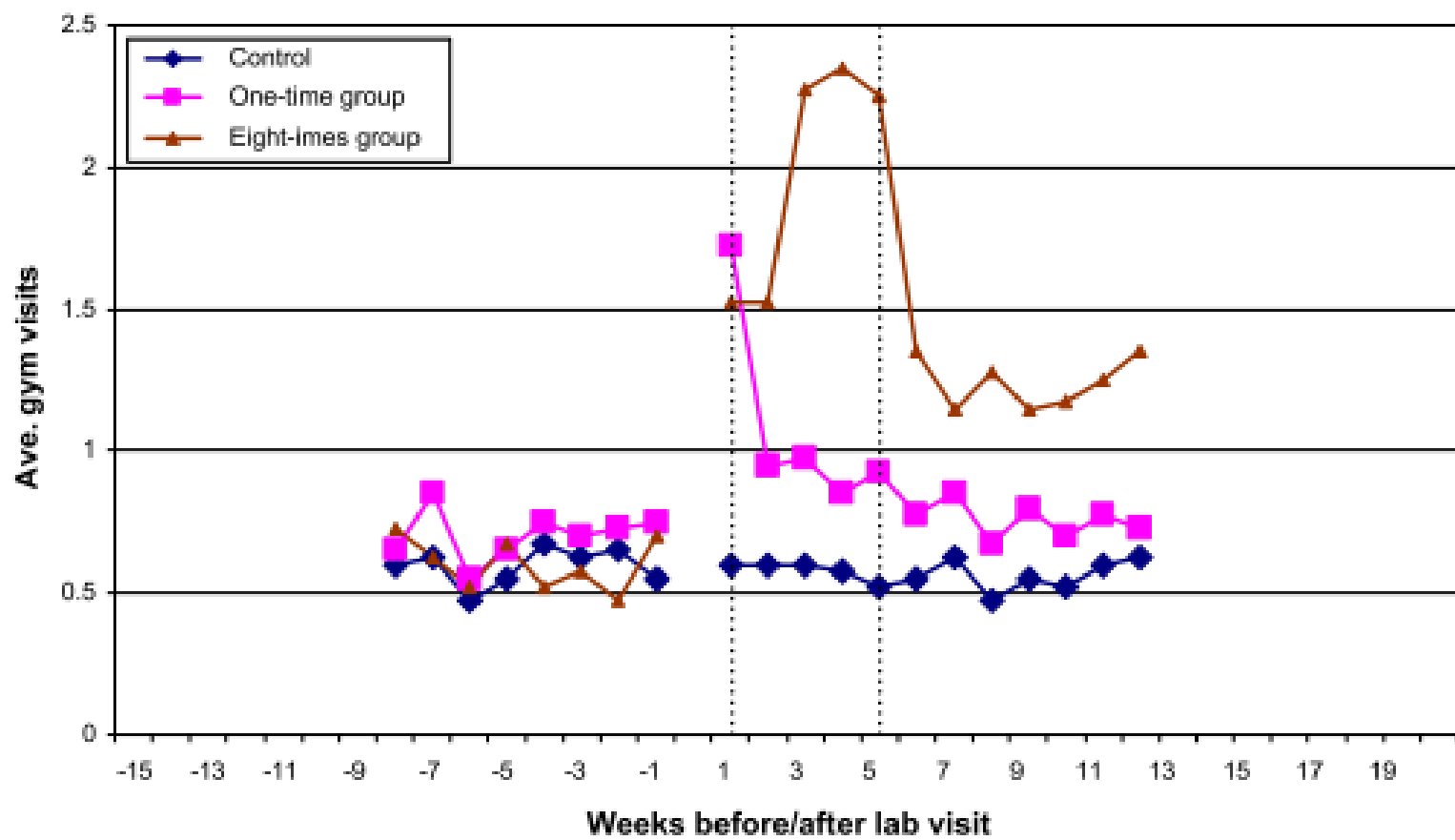


(b) Study 2

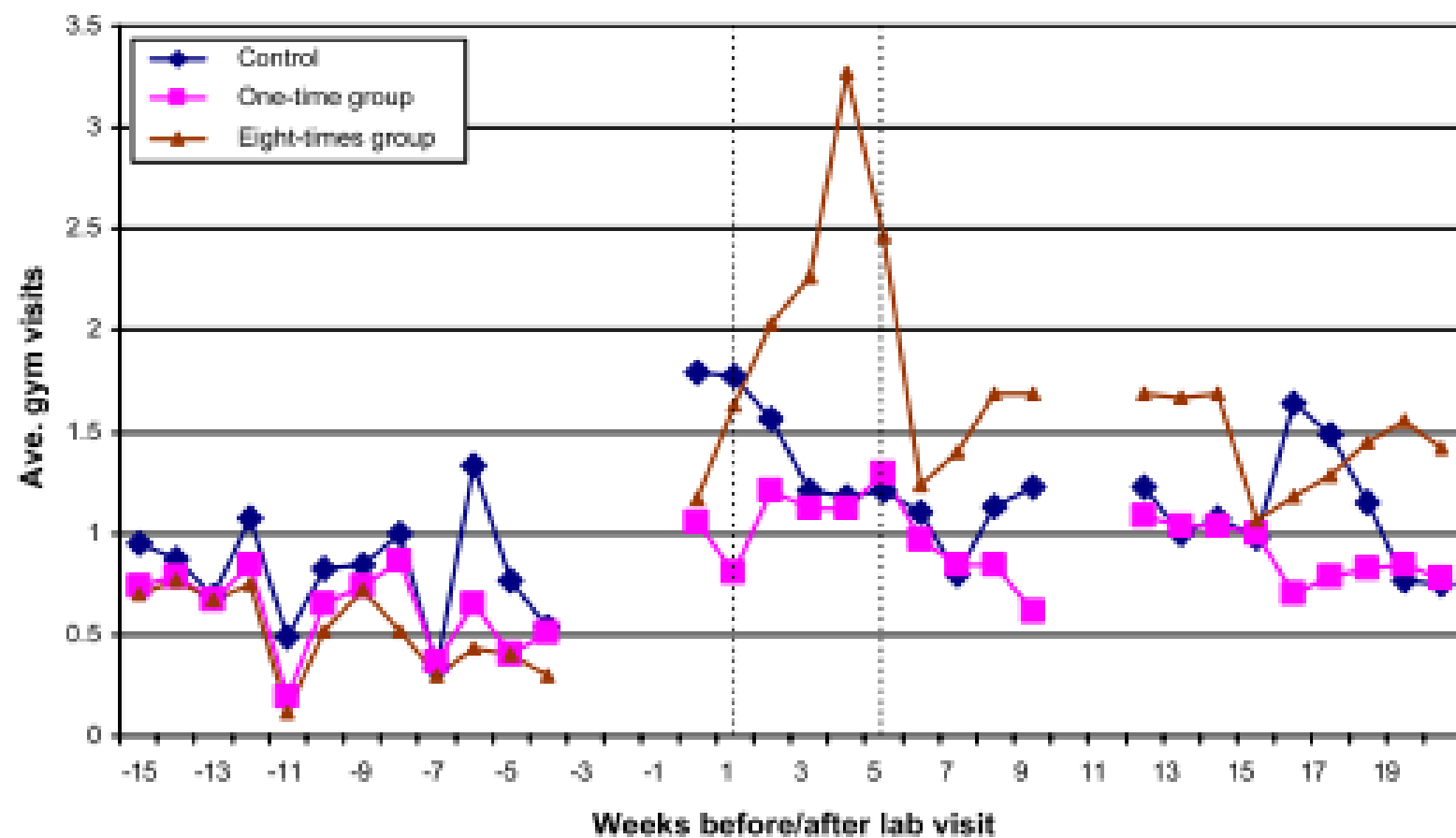
TABLE I  
MEAN WEEKLY GYM ATTENDANCE RATES<sup>a</sup>

		Ex ante Regular Attendees			Ex ante Nonregular Attendees		
		Before	After	Change	Before	After	Change
Study 1	Control	1.844 (0.296)	1.774 (0.376)	-0.070 (0.206)	0.058 (0.036)	0.046 (0.023)	-0.012 (0.020)
	One required visit	1.866 (0.165)	1.827 (0.211)	-0.040 (0.204)	0.077 (0.040)	0.181 (0.094)	0.104 (0.106)
	Eight required visits	1.644 (0.127)	1.571 (0.304)	-0.073 (0.264)	0.102 (0.044)	1.085 (0.234)	0.983 (0.231)
Study 2	Control group	2.433 (0.419)	2.677 (0.465)	0.244 (0.417)	0.250 (0.047)	0.560 (0.168)	0.310 (0.160)
	One required visit	2.051 (0.191)	2.491 (0.583)	0.440 (0.537)	0.193 (0.039)	0.395 (0.079)	0.202 (0.080)
	Eight required visits	1.901 (0.402)	1.706 (0.786)	-0.195 (0.411)	0.204 (0.038)	1.405 (0.170)	1.201 (0.171)

<sup>a</sup>Standard errors are in parentheses.



(a) Study 1



(b) Study 2

TABLE II  
TOBIT REGRESSIONS FOR GYM ATTENDANCE RATE AFTER INTERVENTION<sup>a</sup>

Independent Variables	Study 1		Study 2	
	Spec. 1	Spec. 2	Spec. 1	Spec. 2
Attendance before	1.262*** [0.154]	1.434*** [0.205]	1.045*** [0.112]	1.195*** [0.140]
One-time group	0.292 [0.358]	0.184 [0.450]	-0.022 [0.289]	-0.043 [0.307]
Eight-times group	1.320*** [0.350]	1.874*** [0.404]	0.884*** [0.284]	1.234*** [0.294]
Male	0.135 [0.280]	0.153 [0.268]	-0.031 [0.249]	-0.114 [0.240]
One-time*regular		0.198 [0.589]		0.230 [0.480]
Eight-times*regular		-1.527*** [0.533]		-1.664*** [0.480]
Constant	-1.243** [0.366]	-1.362*** [0.386]	-0.020 [0.250]	-0.114 [0.252]
# Observations	120	120	156	156
Pseudo $R^2$	0.211	0.241	0.140	0.164

<sup>a</sup>The control-group attendee is the omitted variable in these regressions. Standard errors are in parentheses.

\*\* indicates significance at the 5 percent level.

\*\*\* indicates significance at the 1 percent level, two-tailed test.

# Health improvement

TABLE III  
BIOMETRIC DATA AVERAGES AND CHANGES OVER TIME—STUDY 2<sup>a</sup>

	Control (G1)		One-Time (G2)		Eight-Times (G3)		Difference-in-Difference (Wilcoxon–Mann–Whitney Test)		
	First	Δ	First	Δ	First	Δ	G1–G2	G2–G3	G1–G3
Body fat %	25.7 (1.54)	1.41 (0.42)	21.6 (1.07)	0.29 (0.33)	26.9 (1.09)	−0.78 (0.21)	1.12* [0.088]	−1.07*** [0.000]	−2.19*** [0.000]
Pulse rate	78.0 (1.86)	3.90 (2.08)	81.8 (1.56)	−1.75 (1.45)	80.2 (1.47)	−1.25 (1.78)	5.65** [0.030]	−0.50 [0.974]	5.15** [0.040]
Weight (kg)	61.8 (2.03)	0.57 (0.55)	59.8 (1.60)	0.59 (0.21)	64.0 (1.54)	−0.34 (0.25)	−0.02 [0.560]	0.93*** [0.005]	0.91*** [0.006]
BMI	22.7 (0.64)	0.23 (0.19)	21.7 (0.45)	0.22 (0.07)	23.2 (0.40)	−0.12 (0.09)	0.01 [0.560]	0.34*** [0.005]	0.35*** [0.006]
Waist (in.)	34.3 (0.63)	0.07 (0.36)	33.0 (0.47)	−0.10 (0.27)	35.0 (0.42)	−0.72 (0.23)	0.17* [0.790]	0.62** [0.045]	0.79* [0.068]
Systolic BP	122 (1.82)	5.23 (1.71)	121 (2.01)	2.32 (1.88)	122 (1.90)	1.78 (1.99)	2.91* [0.084]	0.54 [0.897]	3.45* [0.090]
Diastolic BP	74.0 (1.22)	2.87 (1.22)	75.8 (1.44)	1.07 (1.23)	74.7 (1.07)	2.58 (1.33)	1.80 [0.160]	−1.51 [0.654]	0.29 [0.535]

<sup>a</sup>Standard errors are in parentheses, Two-tailed *p*-values are in brackets. Body mass index (BMI) is calculated using the formula: BMI = (weight in kilograms)/(height in meters)<sup>2</sup>. “First” refers to the first measurement, which was taken in the initial week, and “Δ” indicates the change from the initial level as determined using the final measurement, taken 20 weeks later.

## Example 2: are women more generous than men?

(Eckel & Grossman, Economic Journal, 1998).

- Protocol: dictator game. Participants randomly assigned to the role of « sender » (**S**) or « receiver » (**R**). **S** receives 10 monetary units from the experimenter. **R** receives nothing. **S** can send any amount between 0 and 10 to **R**.
- 140 student-subjects in the role of dictator (**S**) (50% women): introductory classes in economics, finance, sociology, accounting, psychology from university of Arizona and Virginia Polytech.

- Material: dictators receive an envelope containing 10 1\$ bills.
- All dictators are in the same room and receivers are in another room.
- All subjects received 5\$ show-up fee (common knowledge).
- Task = dictators take as many dollar bills they want from their envelope, seal the envelope and drop it in a box.



Results:  
*Women are  
more generous  
than men*

<i>Percent of Decisions for Each Amount Donated</i>		
Amount donated	Women	Men
\$ 0	46.67	60.00
\$ 1	10.00	26.67
\$ 2	13.33	3.33
\$ 3	11.67	5.00
\$ 4	3.33	0.00
\$ 5	15.00	3.33
\$ 6	0.00	0.00
\$ 7	0.00	0.00
\$ 8	0.00	0.00
\$ 9	0.00	0.00
\$10	0.00	1.67
Average donation	\$1.60	\$0.82
Observations	60	60

## Statistical Test Results

Test description:	Statistic	p-value
z-test of equal average donations*	2.44	< 0.01
$\chi^2$ test of equal medians**	4.29	< 0.05
$\chi^2$ contingency table test that donations are independent of sex ***	15.32	< 0.01
$\chi^2$ contingency table test that donations, conditional on giving, are independent of sex ****	12.71	0.01
Kolmogorov-Smirnov test of donations distributions <sup>+</sup>	0.30	0.01
Kolmogorov-Smirnov test of donations, conditional on giving, distributions <sup>++</sup>	0.48	0.01
Epps-Singleton test of donations distributions <sup>+++</sup>	15.18	0.004
Epps-Singleton test of donations, conditional on giving, distributions <sup>+++</sup>	16.53	0.002
Logit Analysis		
Probability of Donating ( <i>DONATE</i> ) <sup>†</sup>	0.54 <sup>‡</sup> (1.46)	< 0.10 <sup>c</sup>
Amount Donated ( <i>AMOUNT</i> ) <sup>  </sup>	1.60 <sup>‡</sup> (3.48)	< 0.01 <sup>§</sup>
Amount Donated Conditional on Donating ( <i>AMOUNT*</i> ) <sup>††</sup>	1.35 <sup>‡</sup> (2.29)	< 0.025 <sup>§</sup>

\* Critical value for significance of 0.99 = 2.36, one-tailed test.

\*\* Distributed  $\chi^2(1)$ , critical value for significance of 0.95 = 3.84.

\*\*\* Distributed  $\chi^2(4)$ , critical value for significance of 0.99 = 13.28.

\*\*\*\* Distributed  $\chi^2(3)$ , critical value for significance of 0.99 = 11.34.

<sup>+</sup> Critical value for significance of 0.99 = 0.297.

<sup>++</sup> Critical value for significance of 0.99 = 0.440.

<sup>+++</sup> Distributed  $\chi^2(4)$ , critical value for significance of 0.95 = 9.49.

<sup>†</sup> *DONATE* = 1 if donation > 0

<sup>‡</sup> Coefficient on *SEX* (= 1 if female), t-statistic in parentheses.

<sup>§</sup> One-tailed test.

<sup>||</sup> *AMOUNT* = 1 if donation ≥ 2.

<sup>††</sup> *AMOUNT\** = 1 if donation ≥ 3.

Do the distributions differ according to the sample (university of Arizona vs Virginia Tech) ?

<sup>11</sup> The Kolmogorov-Smirnov, Epps-Singleton, and  $\chi^2$  contingency table statistics for women are 0.17 (p-value > 0.20), 2.46 (p-value = 0.65), and 3.52 (p-value = 0.62). For men the respective statistics are 0.11 (p-value > 0.20), 2.46 (p-value = 0.65), and 1.23 (p-value = 0.75).

- Example 1: field experiment
- Example 2 : lab experiment

## Some specific « ingredients » of economic experiments

- Participants are real individuals (e.g. students, doctors, farmers, children, retired...)
- Participants get real incentives (e.g. money prizes, candy,...)
- Participants usually know that they are involved in an experiment (not for field exp)

# Menu of the introduction

1. Why is economics becoming an experimental science?
2. Two Main types of experiments
3. Reasons for running experiments
4. Types of experiments
5. Control and external validity
6. Historical marks
7. Methodological issues
8. Some experimental findings about human behaviour

# 1. Why is economics becoming an experimental science?

- Traditional opinion:

*In contrast to chemists or biologists we cannot perform controlled experiments, but like astronomers, we are bound essentially to « observe »* Paul Samuelson (Nobel Prize winner 1970), *Economics* (1985).

- Modern opinion:
- Will Economics Become an Experimental Science? Charles R. Plott (*Southern Economic Journal*, 1991)



«for having integrated insights from psychological research into economic science, especially concerning human judgment and decision-making under uncertainty »



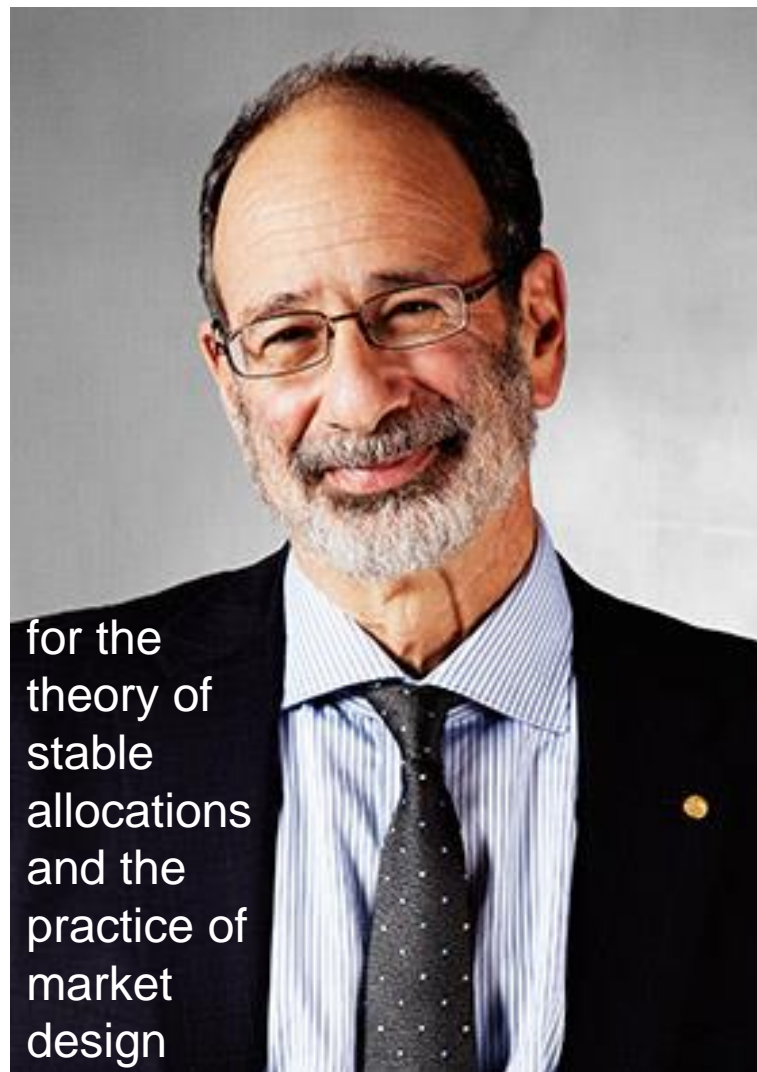
« for having established laboratory experiments as a tool in empirical economic analysis, especially in the study of alternative market mechanisms »

**Nobel Prize in Economics, 2002**





Elinor Ostrom (2009)

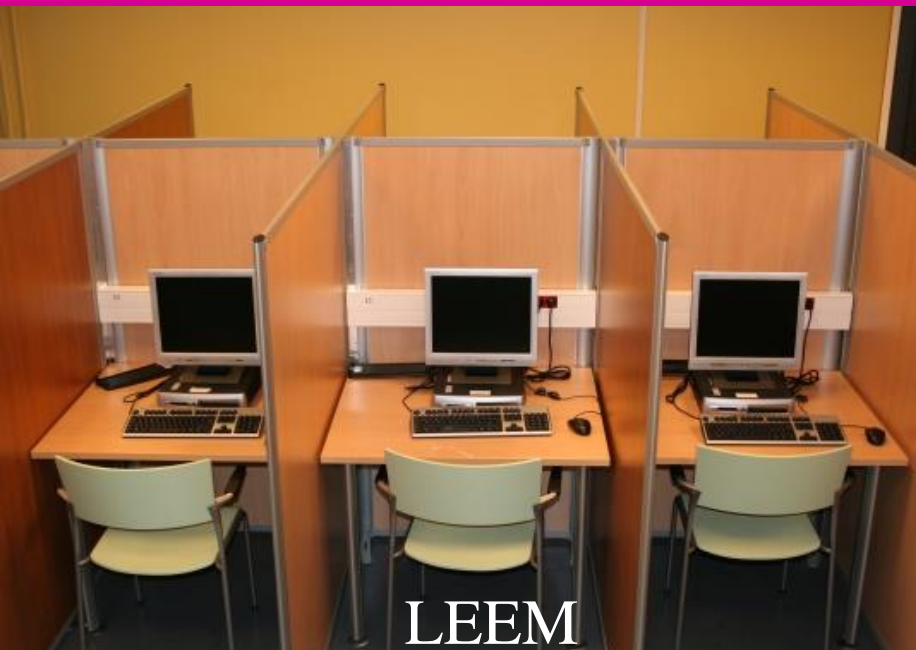


Alvin Roth (2012)

- Most economic theories and models provide testable predictions
- Natural occurring data usually do not correspond to the data required for testing theories
- Experiments are useful for testing new instruments and policies
- Economics is partly a behavioral science (like psychology)

**2.**

## **TWO MAIN TYPES OF EXPERIMENTS**



- Recruitment of subjects from a subject pool
- Subjects randomly allocated to roles
- Subjects read instructions and solve control questions
- Anonymous interaction; no deception
- Payment according to performance + show up fee





(Lab in the) field  
experiments



# A field experiment on provision of a club good with farmers of the region of Kairouan (Tu)





# A field experiment on risk-taking and cooperation in Arequipa (Peru)





# A field experiment on risk-perception and risk-taking in the region of Yogyakarta (Indonesia)



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### 3. Reasons for running experiments

(A. Roth, 1988)

1. Testing theory
2. Exploring new hypotheses (producing facts)
3. « Whispering to the ears of the Princes »

➔ Teaching economics

# A more detailed list of reasons

Nine reasons for doing economics experiments (from Vernon Smith.)

1. Test or select between theories.
2. Explore the cause(s) of a theory's apparent failure.
3. When a theory succeeds, explore extreme portions of the parameter space to “stress” test the model and identify the edges of its validity.
4. Compare institutions.
5. Compare environments.
6. Establish empirical regularities as a basis for a new theory.
7. Evaluate policy proposals.
8. Use the lab as a testbed for institutional design.
9. Use the lab to evaluate new products.

## 4. Types of economic experiments

Taxonomy by Carpenter, Harrison & List (2005) :  
*ingredients* of an experiment

- the nature of the subject pool,
- the nature of the information and experience that the subjects bring to the task,
- the nature of the commodity,
- the nature of the task or institutional rules applied,
- the nature of the environment that the subject operates in.

# (I) Conventional laboratory experiment

- Standard subject pool : randomly selected,  
...
- Inexperienced with the good or task
- artefact
- Abstract rule or task
- Laboratory environment : (ex : interactions through a computer network)

Objective : experimental control, usually theory testing

- (II) artefactual field experiment

Identical to conventional lab-experiment but with a non-standard subject-pool (e.g. farmers, traders, CEO, children ...)

- (III) framed field experiment

Same as a artefactual field experiment but with field context in either the commodity, task, or information set that the subjects can use.

- (IV) Natural field experiment

Same as a framed field experiment but where the environment is one where the subjects naturally undertake these tasks and where the subjects do not know that they are in an experiment

# Natural (or randomized) field experiment vs field study

**Field study** : the researcher collects data that already exists (naturally produced).

**Natural field experiment** : the researcher participates in the production of data that does not yet exist (ex: conditional cash transfer programs)

- Objective of the field experiment: answering a **counterfactual** question :
  - What would have happened to those involved in the *treatment* without the *treatment*
  - What would have happened to those not involved in the *treatment* if they had been involved ?
- Not possible to answer directly, but we can construct a method to answer indirectly
- Ex ante vs ex post comparison: not satisfactory
- **Randomization (Fisher, 1919)**

# Randomization (Fisher, 1919)

Ex: yield improvement with new fertilizer

Treatment effect:  $\tau = y_{i1} - y_{i0}$  (individual  $i$ )

$y_{i1}$  : value of indicator with new fertilizer (treatment 1)

$y_{i0}$  : value of indicator with conventional fertilizer (treatment 0)

Problem: Missing counterfactual.  $i$  can be observed only in one condition (1 or 0).

Solution: comparing different plots with randomized treatments



# Natural (or randomized) field experiments

- **Randomized field experiments (RFE)** : “the Gold Standard” of evaluation (OECD)
- Example : Pasteur (1882) : public proof of the immunity property of a new vaccine (Anthrax) :
- Key : **random assignment** to control group (no vaccine) or to test group (vaccine)

**Design** : two (or more) sub-groups within the studied population : Control and Test

- **Control group** : behaves as the group exposed to the test would have behaved without the test
- **Test group** : reacts (or not) to the test

**Impact** : Difference between the test and the control group

## 5. Control and validity

Control: Extend to which the researcher can manipulate the environment and choose the treatments variables

- Laboratory experiments : high control
- (Lab in the field) experiments : lower control, but control over treatments
- RFE : no control over the environment, but control over treatments
- Natural occurring data : no control

# Validity

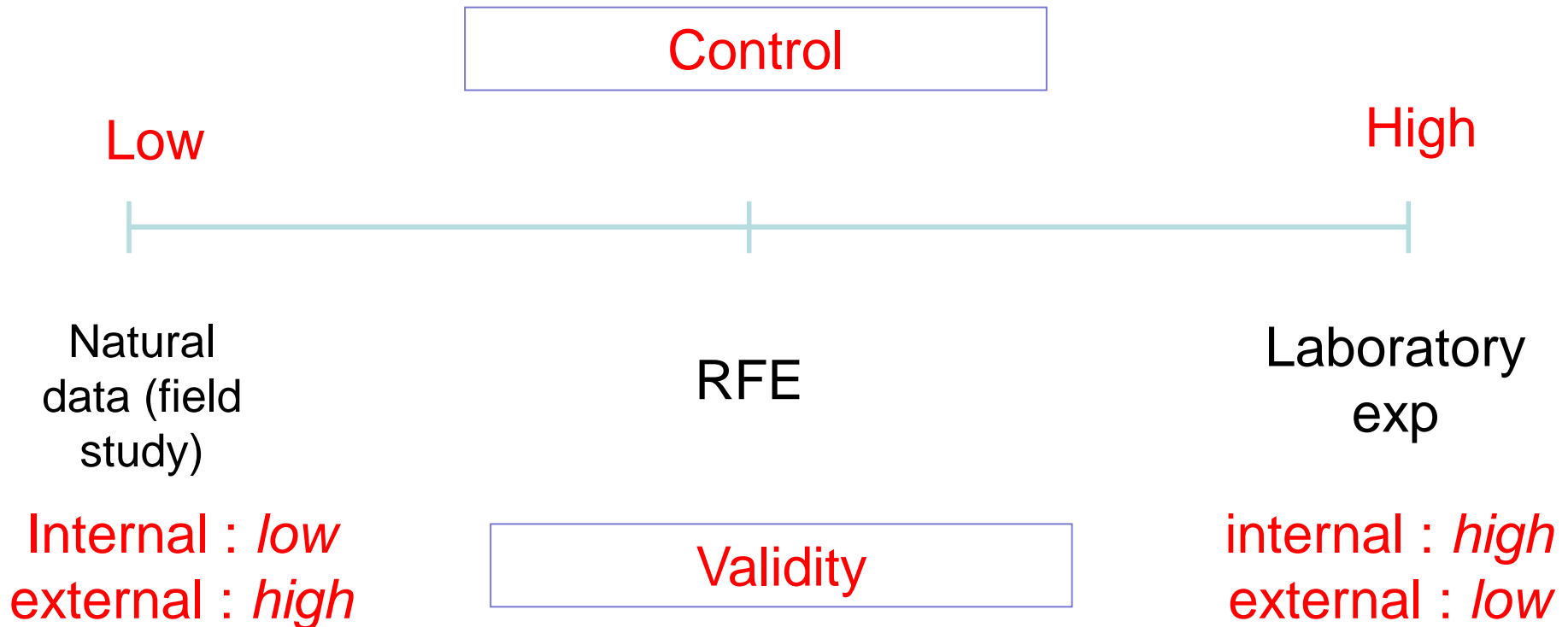
## Internal validity

ability to establish causality based on observed correlation between facts.

## External validity

ability to generalize the relationships found in an experiment outside the lab (e.g., other persons, times and settings).

# Is there a tradeoff ?

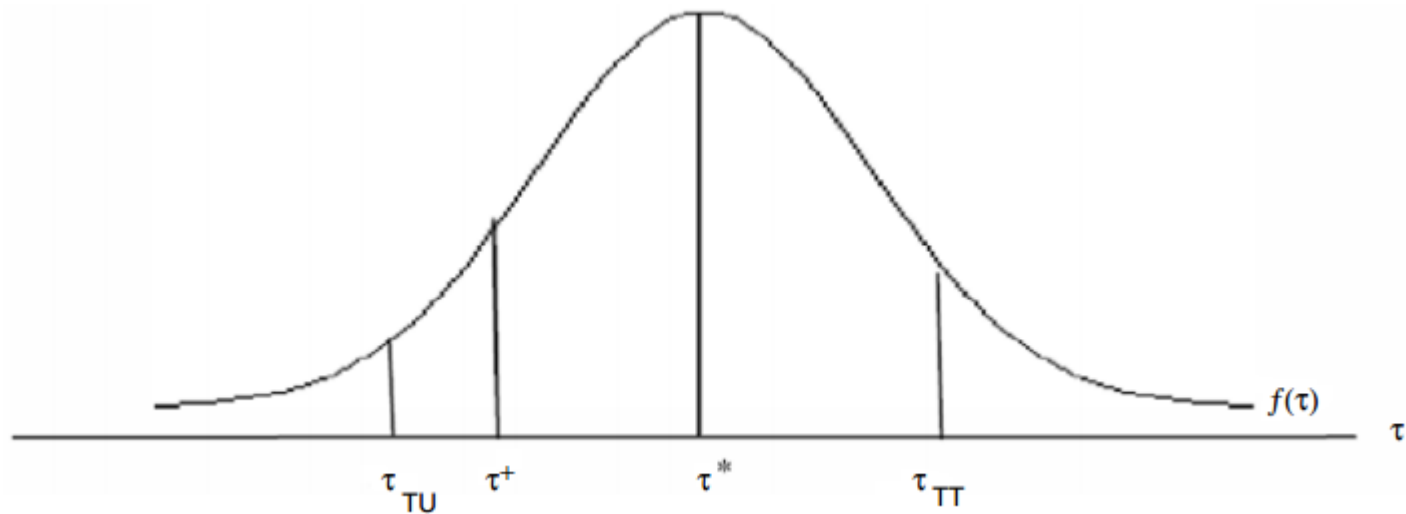


# Selection bias

- *“Plots of ground do not respond to anticipated treatments of fertilizer, nor can they excuse themselves from being treated.”* (Heckman, 1992)
- Social experiments  $\neq$  agricultural experiments
- Subjects react to anticipated (perceived) treatments
- Subjects select themselves into experiments or treatments

Example: eliciting patience in a student population (the impatient are the most likely to skip the test)

# Illustration of the selection bias



Treatment effect for  $i$ :  $\tau = y_{i1} - y_{i0}$

The true density of the population is  $f(\tau)$  with mean  $\tau^*$  (average treatment effect)

Selection bias occurs when the selection into the exp is non-random but varies with

$\tau$

Subjects with  $\tau$  above  $\tau^+$  participate but not those with  $\tau$  below

Consequence: biased estimate  $E(\tau / \tau > \tau^+) = \tau_{TT}$

## 6. Historical marks

- *Game theory* : Dresher & Flood (1952), Nash (??), Schelling (1957)
- *Industrial Organization* : Chamberlin (1948)
- *Lottery choice* : Allais (1953)



# Legacy of agronomy

- 19<sup>th</sup> century agronomists' question: how are agricultural yields influenced by field conditions?
- 1843: Sir J. Bennet Lawes, founded the agricultural research station Rothamsted Experimental Station, an **agricultural research station** (with a young chemist, J. Henry Gilbert)
- Test of fertilizers (inorganic and organic) and test of how different cereals affected yields
- 1919: Ronald Fisher was hired at Rothamsted Manor to bring modern statistical methods to the experimental data collected by Lawes and Gilbert.
- Fisher realized weakness of the experimental approach at Rothamsted (lack of replications and control)
- Introduced the triad: replication, randomization and local control



*Figure 1. Vue aérienne de l'expérience de Broadbalk (Rothamsted Experimental Station, Harpenden, Grande-Bretagne).*

# 7. Methodological issues

- Ceteris Paribus (all things equal) : experimental control
- Comparative vs absolute experiment
- Experimental methods
  - *Hot* : observing actions
  - *Cold* : « observing » strategies (*strategy-method*, *Selten*)
- Robustness / reproductibility
- Monetary incentives vs other incentives
- Artefact / natural selection argument

## 8. Some experimental findings about human behaviour

- Other-regarding preferences : Altruism, equity, fairness, social norms
- Reciprocity and giving
- Incentives and crowding out
- Cooperation in social dilemma
- Trusting behaviour
- Errors and learning
- Emotions

# Topics related to experiments

- Neuro-economics
- Behavioural economics

# 9. Steps towards designing your own experiment

## 1) Formulate a precise research question

Outline  
Ex : does random auditing reduce tax evasion ?

Possible design :  
1. Introduction

- N subjects in a group. Each subject  $i$  receives a randomly selected income  $y_{it}$  in period  $t$ , from a known distribution (iid)  
2. Incentive compatible mechanism
- Task = declare her income  $y_{it}^\circ \leq y_{it}$   
3. Trust and economic performance
- Income after tax is equal to  $y_{it}^\theta = y_{it} - \theta y_{it}^\circ$  ( $0 < \theta < 1$ : taxation rate)  
4. Public good experiments
- After declaration  $k < n$  agents are randomly chosen to be inspected  
5. Market experiments
- if  $y_{it}^\circ > y_{it}$ , agent has to pay taxes on undeclared income + a fine  $F$  ( $F$  might be fixed or a function of undeclared income)  
6. Cognitive slant and depth of pay design  
7. Elicitation of preferences and beliefs
- Payoffs
  - Non inspected subjects :  $y_{it}^\theta = y_{it} - \theta y_{it}^\circ$
  - Inspected subjects :  $y_{it}^\theta = y_{it} - \theta y_{it}^\circ - \theta(y_{it} - y_{it}^\circ) - F$

# Outline

1. Introduction
2. Ultimatum and negotiation
3. Trust and economic performance
4. Public good experiments
5. Market experiments
6. Cognitive skills and depth of reasoning
7. Elicitation of preferences and beliefs

## 2) Derive clear predictions

Ex : prediction from EU theory, Prospect-Theory (loss aversion), and other theories...

N.B. sometimes predictions are qualitative

## 3) Choose treatment variables

Which treatments should be included in the design ? How many treatments ? How many categories in each treatment ?

Possible treatments : audit probability ( $k$ ), tax rate ( $\theta$ ), fine ( $T$ ), population size ( $n$ ), income range ( $y_{\min}$  and  $y^{\max}$ ), time (number of periods).

Categories : ex : « high fine ( $T^h$ ) vs low fine ( $T^l$ ) », or « high, medium, low »

## 4) Choose an experimental procedure

Partner/stranger : subjects stay in the same group or are rematched during the experiment

Hot/cold : you want to elicit strategies or observe decisions

Within/Across : the same subjects play the sequence  $T^h \rightarrow T^l$  or the sequence  $T^l \rightarrow T^h$ . Each subject group plays only one treatment.

## 5) Define the statistical methods that will be used to analyse the data

Income declaration : does compliance increase with experience ? With  $T$ , with  $k$  etc...

Panel-data regression, or comparing group averages using non-parametric tests, ..



# Some advice....before you start !

- Conceive your experiment by providing precise answers for each step together. Eventually fold back to earlier steps if some answers are unclear or if the data analysis becomes too complex.
- Simulate your data analysis before running the experiment
- Run pilots to get some insights about the treatment effect you want to isolate
- Write simple, clear and concise instructions. They must be understandable by any randomly drawn individual from the general population (above 18, except if you want to run experiments with children). Test the understanding before running the experiment
- Always check understanding by adding a questionnaire
- Collect individual data at the end of the session (gender, age, study, etc...)

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