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LECTURE 3 EXPERIMENTAL DESIGN

Aim: To learn how to design an experiment by discussing weaknesses and strengths of some papers and to introduce the concepts of cognitive bias and dual system.

Outline: Context effects in confirmation bias. Eye-tracking and overconfidence.

Readings:

Jones, M. and R. Sugden (2001) "Positive confirmation bias in the acquisition of information", *Theory and Decision*, 50, 59-99.

Innocenti, A., A. Rufa, and J. Semmoloni (2010) "Overconfident behavior in informational cascades: An eye-tracking study", *Journal of Neuroscience, Psychology, and Economics*, 3, 74-82.

Blogs, Videos and Websites:

Behavioral Design Lab, Warwick Business School

http://www.behaviouraldesignlab.org/

EXP 1. CONTEXT EFFECTS IN CONFIRMATION BIAS

CONFIRMATION BIAS

Once individuals devise a strong hypothesis they will tend to misinterpret or even misread new information unfavorable to this hypothesis

Also production of treatment effects: when a researcher believes an hypothesis is true, he often produces a biased sample of evidence that reinforces his or her belief (unconsciously?)

Consequence is obvious: confirmation bias inhibit learning whether one's underlying belief is false

But fresh thinkers may be better at seeing solutions to problems than people who have meditated at length on the problems, because the fresh thinkers are not overwhelmed by the "interference" of old hypotheses.

Correlated phenomena

False consensus

People use their own tastes and beliefs as information in guessing what others like and believe

Application: to put in other people's shoes is not useful to find focal points

Hindsight bias

Current recollections of past judgments tend to be biased by what actually happened since then

Wysiati Rule

what you see is all there is

We often fail to allow for the possibility that evidence that should be critical to our judgment is missing (what you see is all there is)

Applications

- Jumping to conclusions on the basis of limited evidence
- The halo effect judgments of a person's character can be influenced by one's overall impression of him or her (attractiveness)
- Overconfidence. The WYSIATI rule implies that neither the quantity or the quality of the evidence counts for much in subjective confidence

Martin Jones and Robert Sugden "Positive confirmation bias in the acquisition of information",*Theory and Decision*, 50, 2001, 59-99

Positive confirmation bias: tendency, when testing an existing belief, to search for evidence which could confirm that belief, rather than for evidence which could disconfirm it

Wason's (1968) *selection task*

Four double-sided cards. Subjects are told that each card has a letter on one side and a number on the other, but they can see only the upper faces of the four cards

Four cards uncovered show 'A', 'D', '4' and '7'

Each subject is asked to consider the following *rule*, as applied to the four cards: 'If a card has a vowel on one side, then it has an even number on the other side'

Instruction: 'Your task is to say which of the cards you need to turn over to find out whether the rule is true or false'

Two most common responses

- ‘A’ card alone
- ‘A’ and ‘4’ cards in combination

The correct answer to the question posed is, of course, the combination of ‘A’ and ‘7’.

The frequently-chosen ‘4’ card can provide no information which is relevant to the issue of whether the rule is true or false

The ‘A’ and ‘4’ cards are the ones that are capable of providing evidence which *confirms* the rule: by turning over either of these cards, the subject may find a card with a vowel on one side and an even number on the other

In contrast, the ‘7’ card can only *disconfirm* the rule (i.e. by revealing a card which has a vowel on one side but not an even number on the other)

In this sense, the evidence from the selection task can be interpreted as consistent with positive confirmation bias

Criticism

The original selection task was formulated in highly abstract terms

Counterargument

Correct response might be facilitated by adding *thematic* content to the task, i.e. by providing a *cover story* which accounts for the statement and gives some point to the selection task

Jones and Sudgen's design

- Subjects have to pay a fixed *cost* per card turned over
- After they have made this choice, the chosen cards are turned over
- Then they make the *judgment* that the statement is 'true' or 'false'
- Finally the remaining cards are turned over and they receive a fixed *reward* if and only if their judgment was in fact correct

Experiment carried out at the University of East Anglia in Norwich

- 120 students recruited on the campus (wide range of courses)
- Computerized experiment
- No communication between subjects

Each task is presented by means of a sequence of six screens

The screen presents first the cover story, then the statement and finally four cards to choose

Each object has two characteristics, each of which can take one of two values that correspond with p, ¬p, q, and ¬q (as before vowel and consonant, even and odd)

Each subject perform seven different tasks

<p, ¬q> or < ¬q, p>, if turned over, is a *disconfirmation* of the experimental HP

<p> <p, q> and <q, p> are *confirmations*

Exemplificative Tasks

1. *Relatives .* A survey is taken of 100 people in Los Angeles, Seattle, London and Norwich who have relatives living in other cities. Each person in the survey living in Britain has relatives in Los Angeles or Seattle and each person living in America has relatives in Norwich or London. No one has relatives in more than one city. The details of the survey are written down on report cards by putting the city each person lives in on one side of the card and the city their relatives live in on the other side. A sample of four report cards is selected. Look at whichever cards you wish to test the statement:

[Standard statement] Every person in the sample who lives in London also has a relative who lives in Los Angeles.

[Contraposed statement] Every person in the sample who lives in Seattle also has a relative who lives in Norwich.

2. *Drinkers .* Only people over the age of eighteen are allowed to drink alcohol in a pub in Britain. A survey is carried out of 100 people in a large public house which identifies their age and whether they are drinking alcohol or a soft drink. Each person's details are put down on a report card with the person's age on one side and their drinking behaviour on the other. A sample of four report cards is selected. To find out if the four people in the sample are obeying the law, look at whichever cards you wish to test the statement:

[Standard statement] Every person in the sample who is drinking alcohol is also over eighteen.

[Contraposed statement] Every person in the sample who is under eighteen is also drinking a soft drink.

Results

In favour of the confirming bias hypothesis: 62% of the choices (445/720)

<No cards> 18%

<p> 14%

<p, q> 18%

Conclusions

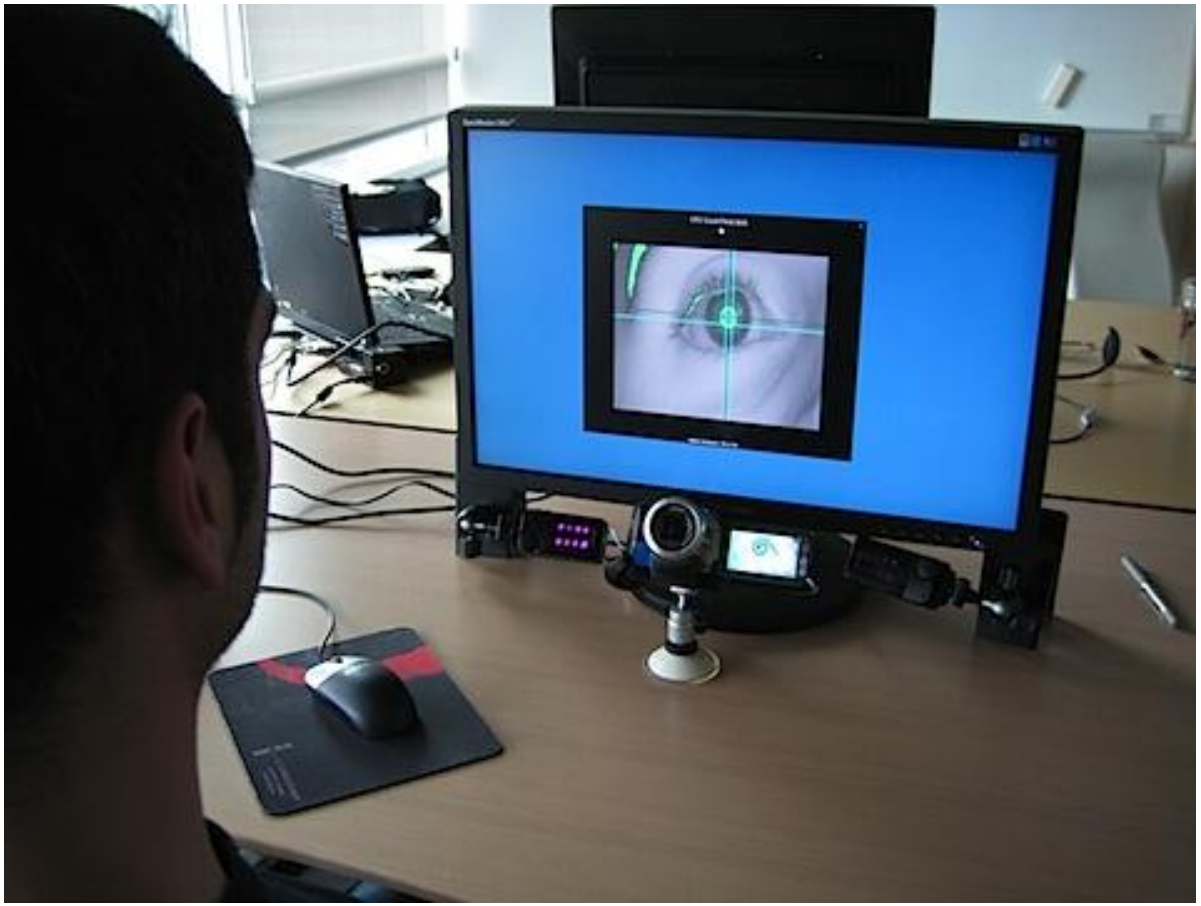
- Overwhelming evidence that subjects' information-gathering decisions are systematically biased in favor of information which is potentially confirming
- But behavior seems to have been closer to Bayesian rationality than in many other selection task experiments
- Especially the drinkers story facilitates Bayesian rationality (why?)
- What is the effect of financial incentives?
- Application to economic learning: an agent who repeatedly faces the same set of options might retain the false belief that a particular option was optimal, even after long exposure to evidence which, rationally interpreted, would indicate the contrary

EXP. 2 Eyetracking and overconfidence

- Eye tracker movements provide quantitative evidence on subjects' visual attention and on the relation between attentional patterns and external stimulus.

- Individuals perceive clearly what they look at only in the central area of their visual field and to observe wider areas they execute frequent and very fast eye-movements.

Eye-tracker



A bit of introduction

- Gaze direction alternates between eye fixations (longer than 200 ms), and saccades, which are fast transitions between two consecutive fixations.
- Visual information is acquired during the fixations but the visual field looked at depend on saccades, which are so fast as not to be fully controlled.
- First fixations are determined automatically and unconsciously.

Findings on eye-movements

- For reading, it has been shown that, as text becomes conceptually more difficult, fixation duration increases and saccade length decreases

  ⇓

  longer fixations imply more cognitive effort.

- For scene screening, participants get the gist of a scene very early in the process of looking, even from a single brief exposure

  ⇓

  first fixations gives the essence of the scene and the remainder is used to fill in details.

Attention allocation as foveation

- Attention as brain's "allocation of limited processing resources to some stimuli or tasks at the expense of others" (Kowler, et al, 1995)
- For this reason, the retina has evolved a fovea, which is a dense concentration of rod and cone cells collecting most of the information extracted from the visual scene.
- This process is called foveation, the brain directs its attention to different objects in a visual field.

Attention and preferences

- Brain allocates its attentional resources toward a subset of the necessary information first, before reallocating them to another subset.
- Mere exposure effect (Zajonc 1980) - subjects tend to like stimuli we are exposed to even when the presentation is entirely subliminal.
- Advertising - Repeated exposure to the brand and its products is thought to increase viewer's preference towards them.

Gaze cascade effect

- When subjects allocate attention to decide what they prefer, they exhibit a *gaze cascade effect*, i.e. they look progressively more toward the item that they are about to choose. (Shimojo et al 2003)
- This evidence is interpreted that as the brain is about to settle on a choice, it biases its gaze toward the item eventually to be chosen in order to "lock in" that preference.
- Gaze direction would participate directly in the preference formation processes and could also be interpreted as preference at a subconscious level.

Starting hypotheses

- The rationality assumption implies that a player will look up all costlessly available information that might affect his beliefs and update consequently these beliefs.
- Behavioral evidence contradicts this assumption (Costa Gomes-Crawford 2006, Johnson et al. 2002, Laibson et al 2006, Camerer et al. 2009, Chen et al 2009)
- Subjects collect and process information by means of heuristic procedures and rules of thumb to limit cognitive effort.

Starting hypotheses

- Subjects collect only a limited portion of the available information.
- Gaze direction often exhibit biases in scrutinizing information which depend on subjects' cognitive attitude and past experience
- Players' types defined on actual choices and gaze direction are correlated.

Our inquiry

- Can gaze bias predict the orienting behavior for decision processes that are not driven by individual preferences, but related to an uncertain event to be guessed on partial-information clues?
- Cognitive reference theory: **dual process theory of reasoning and rationality** (System 1 vs. System 2)
- Experimental setting: **informational cascades** - model of sequential decision for rational herding

Dual process theories

- Since the 1970s a lot of experimental and theoretical work has been devoted to describe attention orienting as a dual processing activity (Schneider and Shiffrin 1977, Cohen 1993, Birnboim 2003)
- Selective attention is defined as "control of information processing so that a sensory input is perceived or remembered better in one situation than another according to the desires of the subject" (Schneider and Shriffin 1977, p. 4)
- This selection process operates according two different patterns: controlled search and automatic detection

Controlled vs. Automatic

- Controlled search is a serial process that uses short-term memory capacity, is flexible, modifiable and sequential
- Automatic detection works in parallel, is independent of attention, difficult to modify and suppress once learned
- Each subject adopts two types of cognitive processes, named System 1 and System 2 (Stanovich and West 1999, Kahneman and Frederick 2002)

System 1

- System 1 collects all the properties of automaticity and heuristic processing as discussed by the literature on bounded rationality
- System 1 is fast, automatic, effortless, largely unconscious, associative and difficult to control or modify
- The perceptual system and the intuitive operations of System 1 generate non voluntary *impressions* of the attributes of objects and thought

System 2

- System 2 encompasses the processes of analytic intelligence, which have traditionally been studied by information processing theorists
- System 2 is slower, serial, effortful, deliberately controlled, relatively flexible and potentially rule-governed
- In contrast with System 1, System 2 originates *judgments* that are always explicit and intentional, whether or not they are overtly expressed

Eye-movements and Systems 1/2

- Both System 1 and System 2 are an evolutionary product. People heterogeneity as the result of individually specific patterns of interaction between the two systems

- If eye movements and attention shifts are tightly tied, gaze direction could represent a signal of how automatic and immediate reactions (giving right or wrong information) to visual stimuli are modified or sustained by more conscious and rational processes of information collecting

Informational cascades

- Informational cascade - model to describe and explain herding and imitative behavior focusing on the rational motivation for herding (Banerjee 1992, Bikhchandani et al. 1992)

Key assumptions

- Other individuals' action but not information is publicly observable
- private information is bounded in quality
- agents have the same quality of private information

Informational Cascade

The restaurant example

- Consider two restaurants named "A" and "B" located next to one another
- According to experts and food guides A is only slightly better than B (i.e. the prior probabilities are 51 percent for restaurant A being the better and 49 percent for restaurant B being better)
- People arrive at the restaurants in sequence, observe the choices made by people before them and must decide where to eat
- Apart from knowing the prior probabilities, each of these people also got a private signal which says either that A is better or that B is better (of course the signal could be wrong)

The restaurant example

- Suppose that 99 of the 100 people have received private signals that B is better, but the one person whose signal favors A gets to choose first
- Clearly, the first chooser will go to A. The second chooser will now know that the first chooser had a signal that favored A, while his or her own signal favors B
- Since the private signals are assumed to be of equal quality, they cancel out, and the rational choice is to decide by the prior probabilities and go to A

The restaurant example

- The second person thus chooses A regardless of her signal
- Her choice therefore provides no new information to the next person in line: the third person's situation is thus exactly the same as that of the second person, and she should make the same choice and so on
- Everyone ends up at restaurant A even if, given the aggregate information, it is practically certain that B is better (99 people over 100 have private signal that is the case)
- This takes to develop a “wrong” information cascade, i.e. that is triggered by a small amount of original information followed by imitations

What is wrong?

- A is chosen although almost all people receive private signal that B is better than A and there is no clear prior evidence that A is better than B (51% vs. 49%)
- If the second person had been someone who always followed her own signal, the third person would have known that the second person's signal had favored B. The third person would then have chosen B, and so everybody else
- The second person's decision to ignore her own information and imitate the first chooser inflicts a negative externality on the rest of the population
- If she had used her own information, her decision would have provided information to the rest of the population, which would have encouraged them to use their own information as well

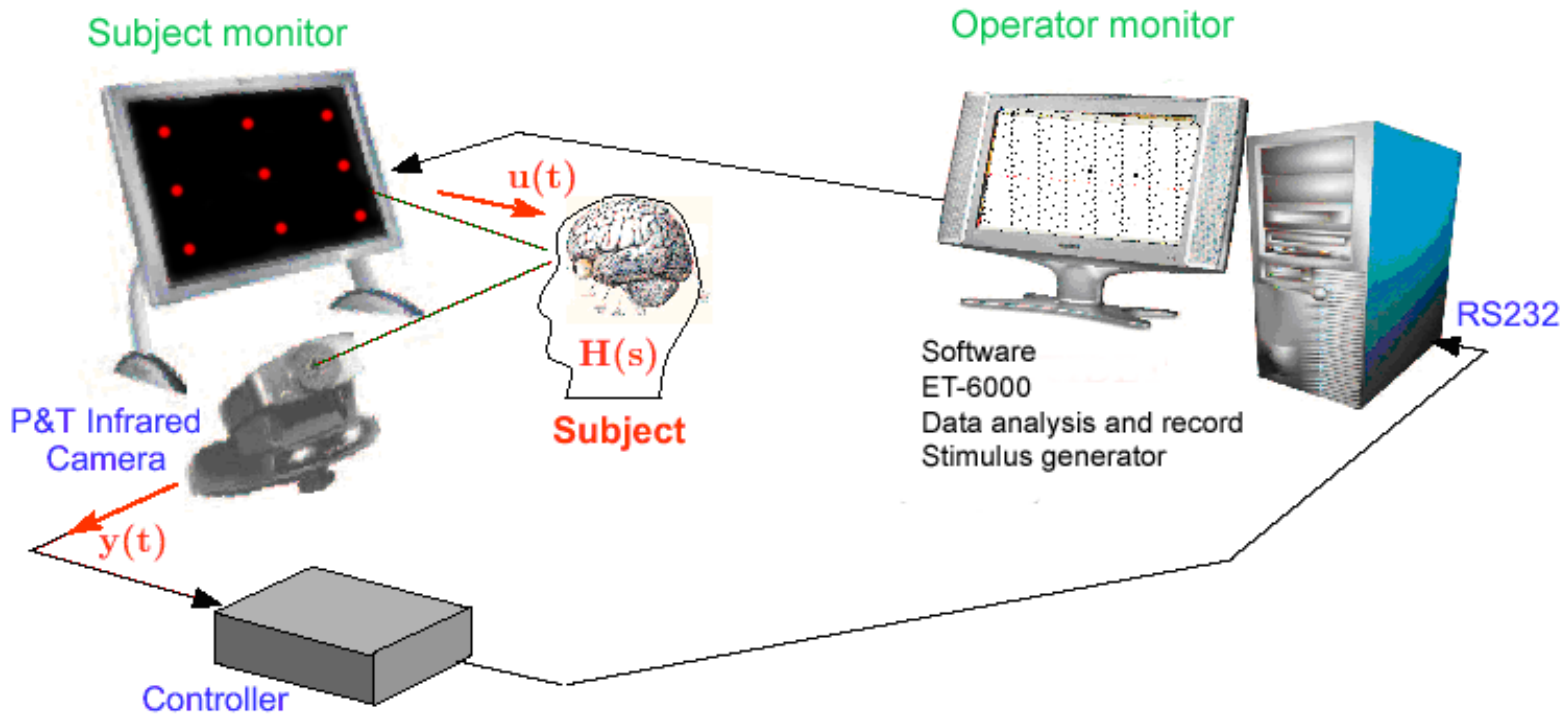
Model's key features

- People have private information ("signals") and can also observe public information
- Public information is a history of all the actions (not information) of predecessors
- People are rational because they are assumed to update their prior probabilities by using Bayes' rule to process the public and private information they possess
- An individual herds on the public belief when his action is independent of his private signal
- If all agents herd there is an informational cascade that may be both "wrong" or "right"

Heuristics and biases in cascades

- The theory of informational cascades assumes that decision makers behave rationally in processing all the available information
- Experimental evidence points out how subjects exhibit in the laboratory various cognitive biases in deciding if entering or not a cascade:
- One third of the subjects exhibit a tendency to rely on the mere counting of signals (Anderson-Holt 1997)
- Subjects' overconfidence consistently explains the deviations from Bayes' rule (Huck-Oechssler 2000, Nöth-Weber 2003, Spiwoks et al. 2008)

Experimental setting



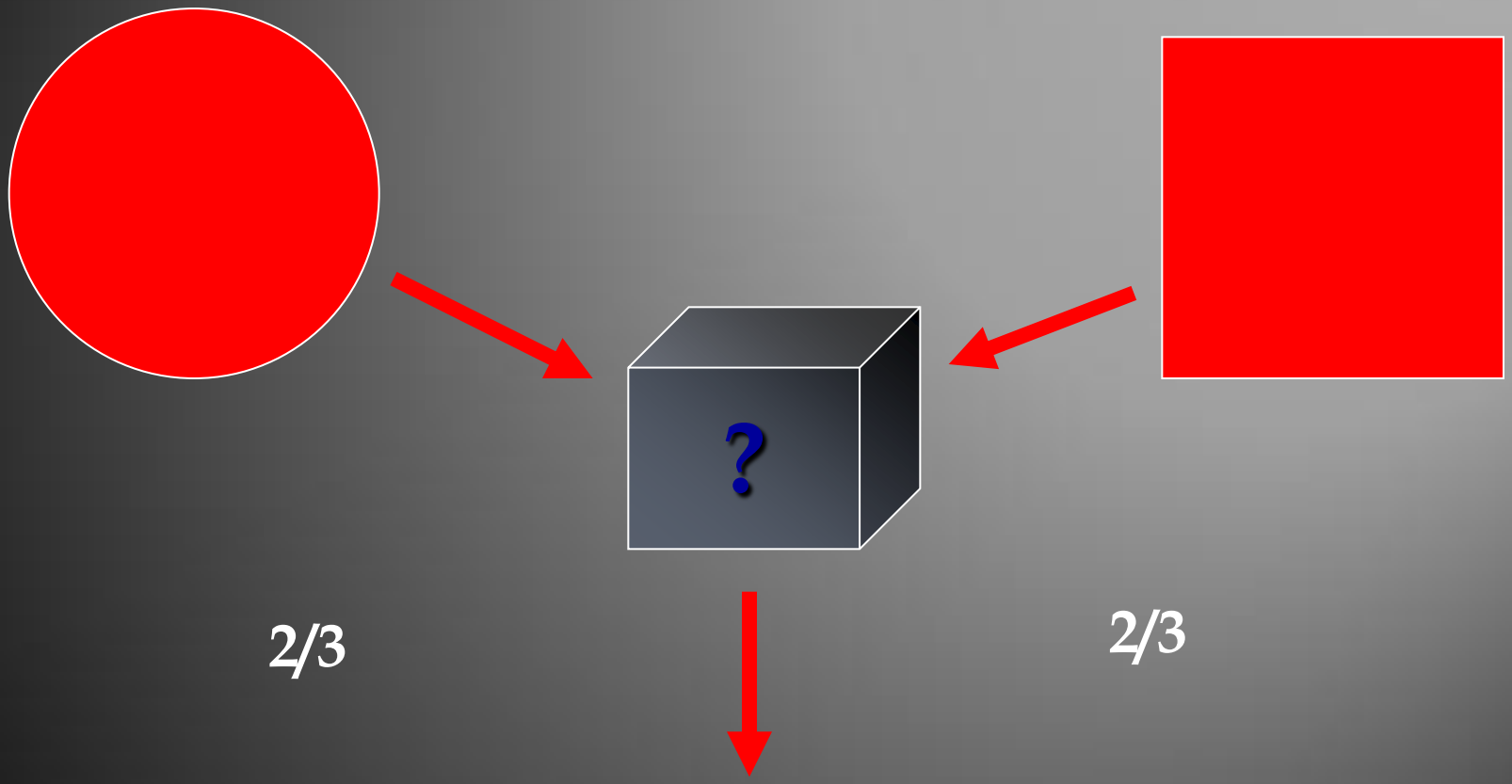
Experimental Design

- Two events - Square and Circle - may occur with equal probability.
- For each session, **9 students** were arranged in a pre-specified order and asked to predict the state with a monetary reward for a correct prediction

Each subject observes:

- an independent and private signal (Private Draw) which has a 2/3 chance of indicating the correct event
- the predictions (Previous Choices) made by the subjects choosing previously

Private draw



Bayesian learning

- HP: rational subjects process information according to Bayes' rule and predict the event indicated as more probable by the combination of private signals and publicly known predictions

- This implies that the choice of the first decision maker reveals the private signal he has drawn

- For example, if he chooses A, later decision makers will infer that he has observed the signal *a*

$$[\Pr(a|A)=2/3 > \Pr(a|B)=1/3]$$

Bayesian learning

- If the second decision maker observes the same private signal *a* he will predict accordingly.
- If she receives the other signal *b*, he will assign a 50% probability to the two events and both predictions will be equally rational.
- If the second decision maker chooses A, the third decision maker will observe two previous choices of A. If her private signal is *b*, it will be rational to ignore this private information and to predict A as the previous choosers (information cascade).

Bayesian learning

If (a,b) indicates the numbers of signals a and b received or inferred, Bayes' rule imposes:

$$\Pr(A|a,b) = \frac{[\Pr(a,b|A)\ \Pr(A)]}{[\Pr(a,b|A)\ \Pr(A) + \Pr(a,b|B)\ \Pr(B)]}$$

In the example, the third decision maker observes two signals a inferred and receives one signal b received and the expression above gives:

$$\Pr(A|a,b) = \frac{(2/3)^2(1/3)(1/2)}{(2/3)^2(1/3)(1/2) + (1/3)^2(2/3)(1/2)} = 2/3$$

Bayesian learning

- Being signals balanced [Pr(A|*a*) = Pr(B|*b*) = 2/3], the difference between the number of signals *a* and *b* inferred or observed determines the more probable event.

- In this simplified case, Bayes' rule corresponds to a very simple and intuitive counting heuristic, which is easily computable by all subjects.

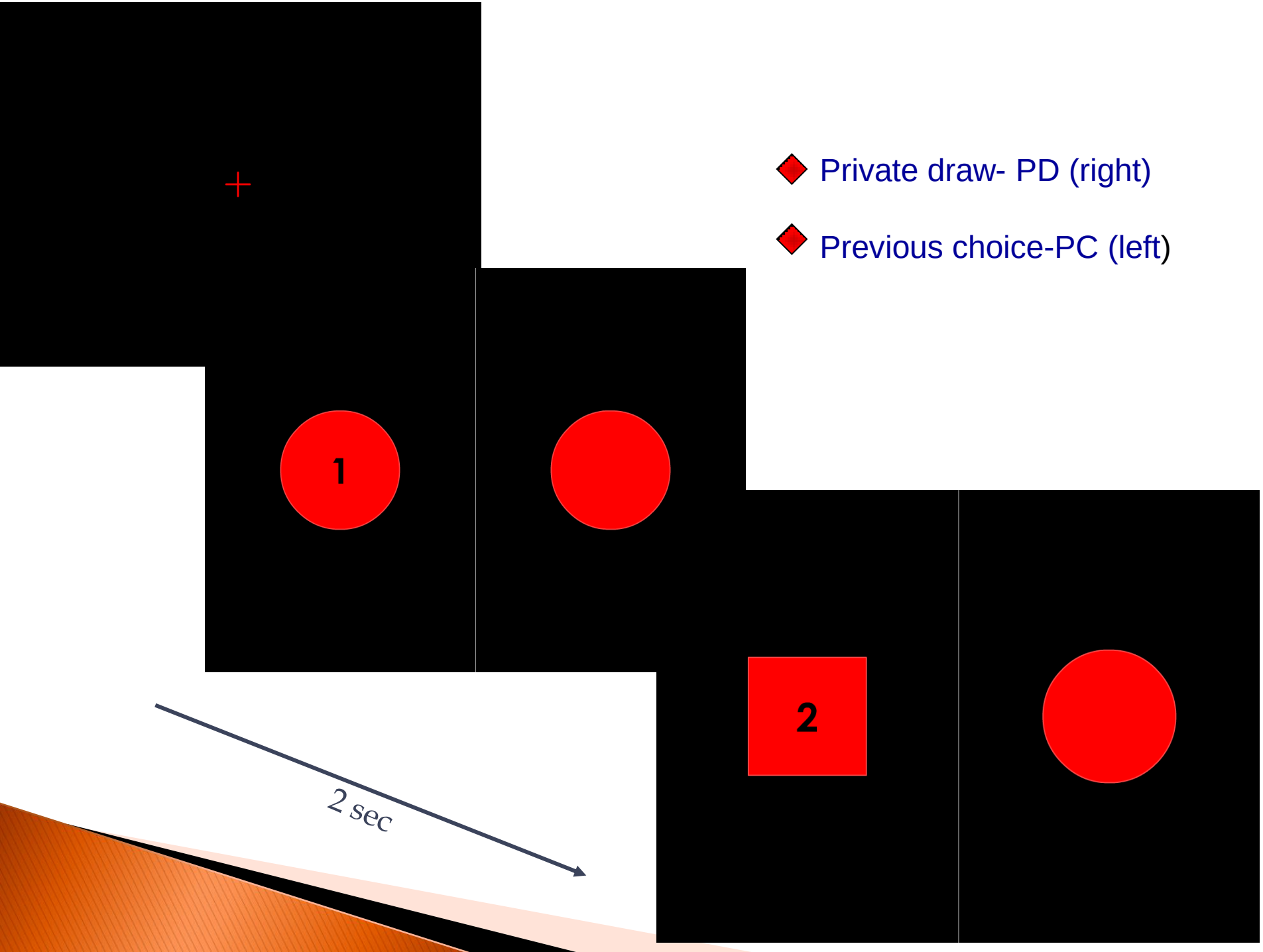
- In the example above, the third decision maker has to count two previous choices over his/her only one private signal to determine her choice of A as rational

Experiment 1

Session	Treatment	Participants (women + men)
1	(PD left - PC right)	9 (4 + 5)
2	(PD left - PC right)	9 (5 + 4)
3	(PD left - PC right)	9 (6 + 3)
4	(PC right - PD left)	9 (4 + 5)
5	(PC right - PD left)	9 (5 + 4)
6	(PC right - PD left)	9 (5 + 4)
7	(PD left - PC right)	9 (3 + 6)
8	(PD left - PC right)	9 (5 + 4)
9	(PD left - PC right)	9 (4 + 5)
Total		81 (41+40)

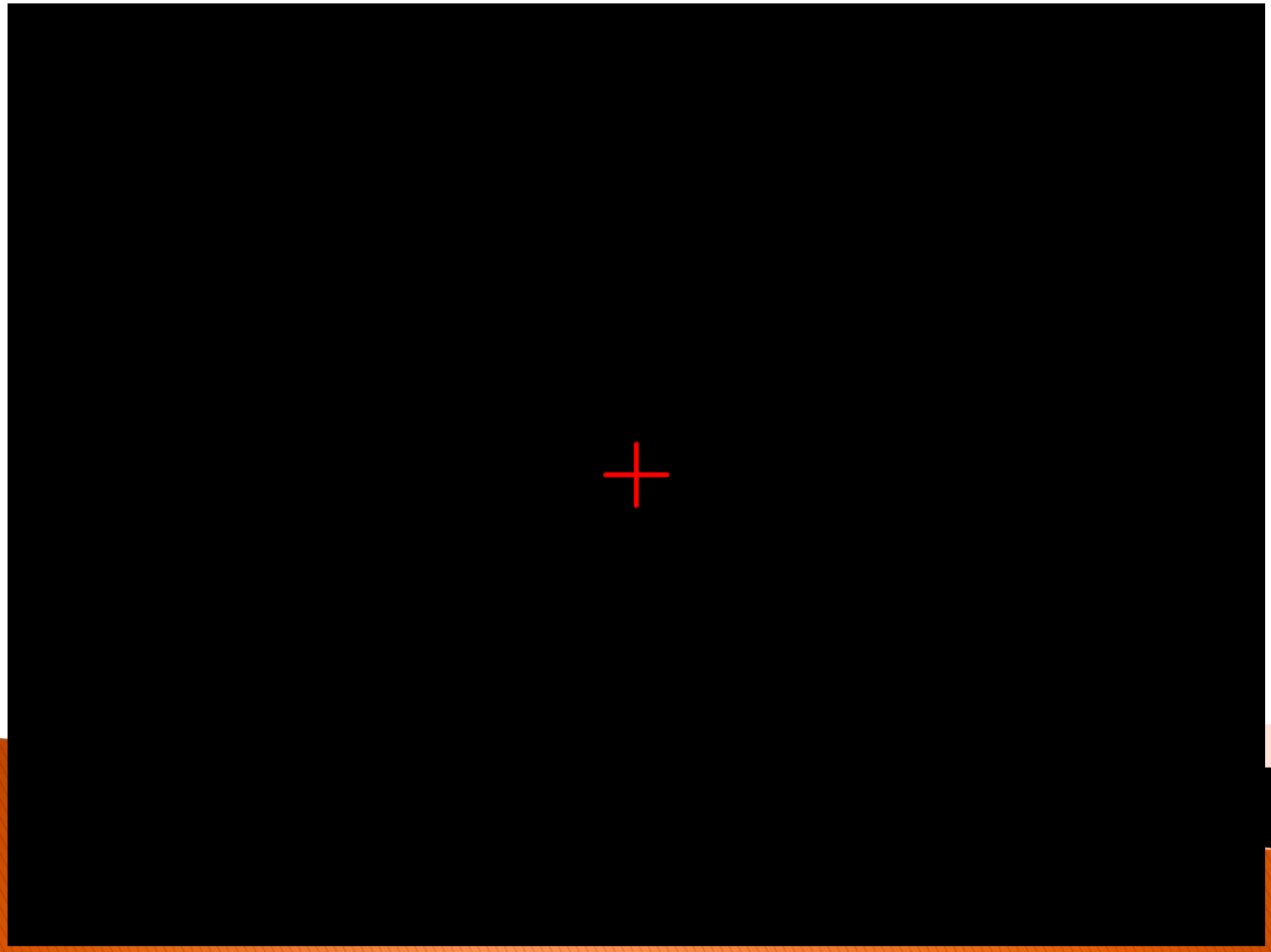
Participants: 81

Mean age: 22,4 Years

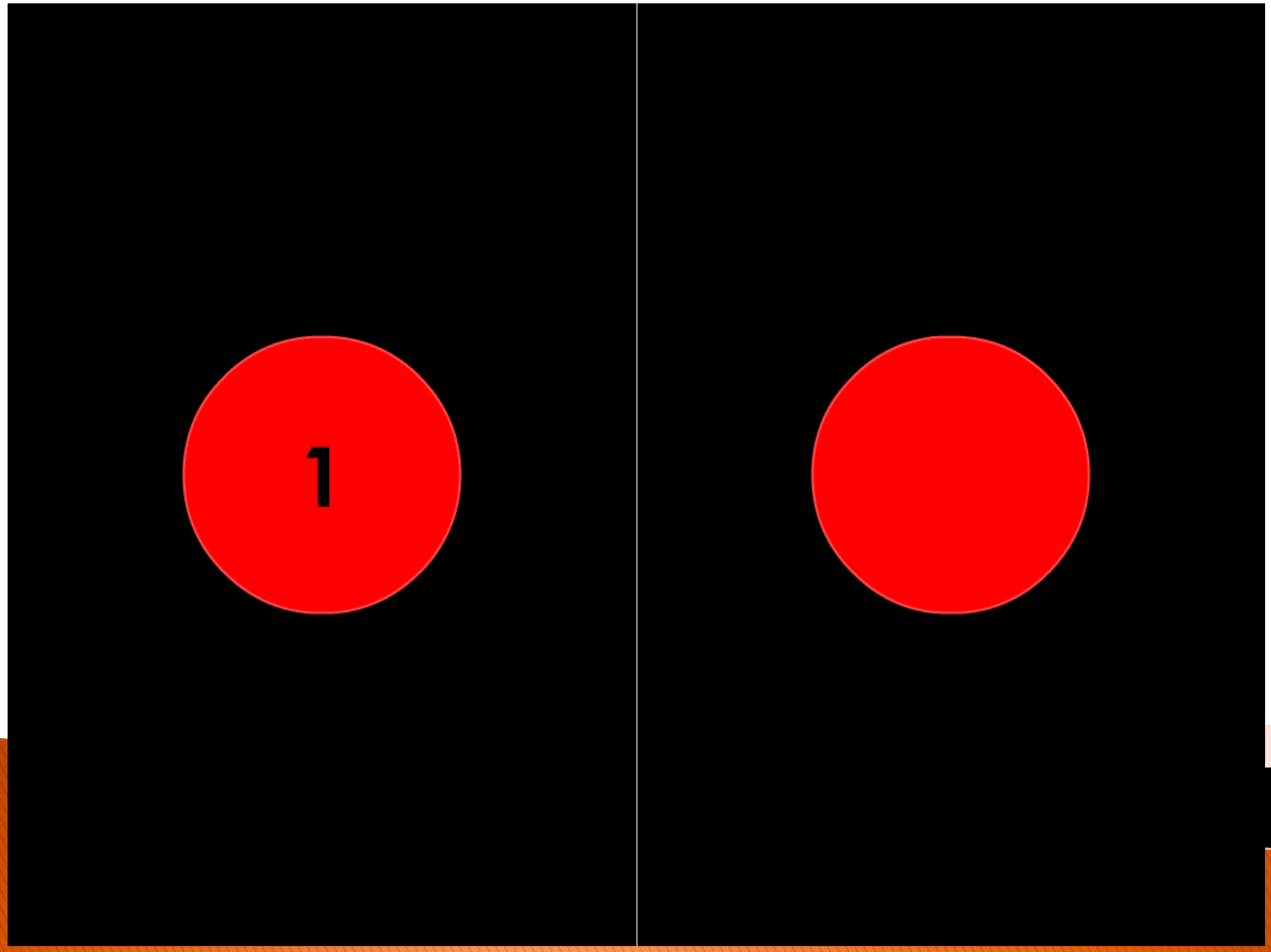


- Private draw- PD (right)
- Previous choice-PC (left)

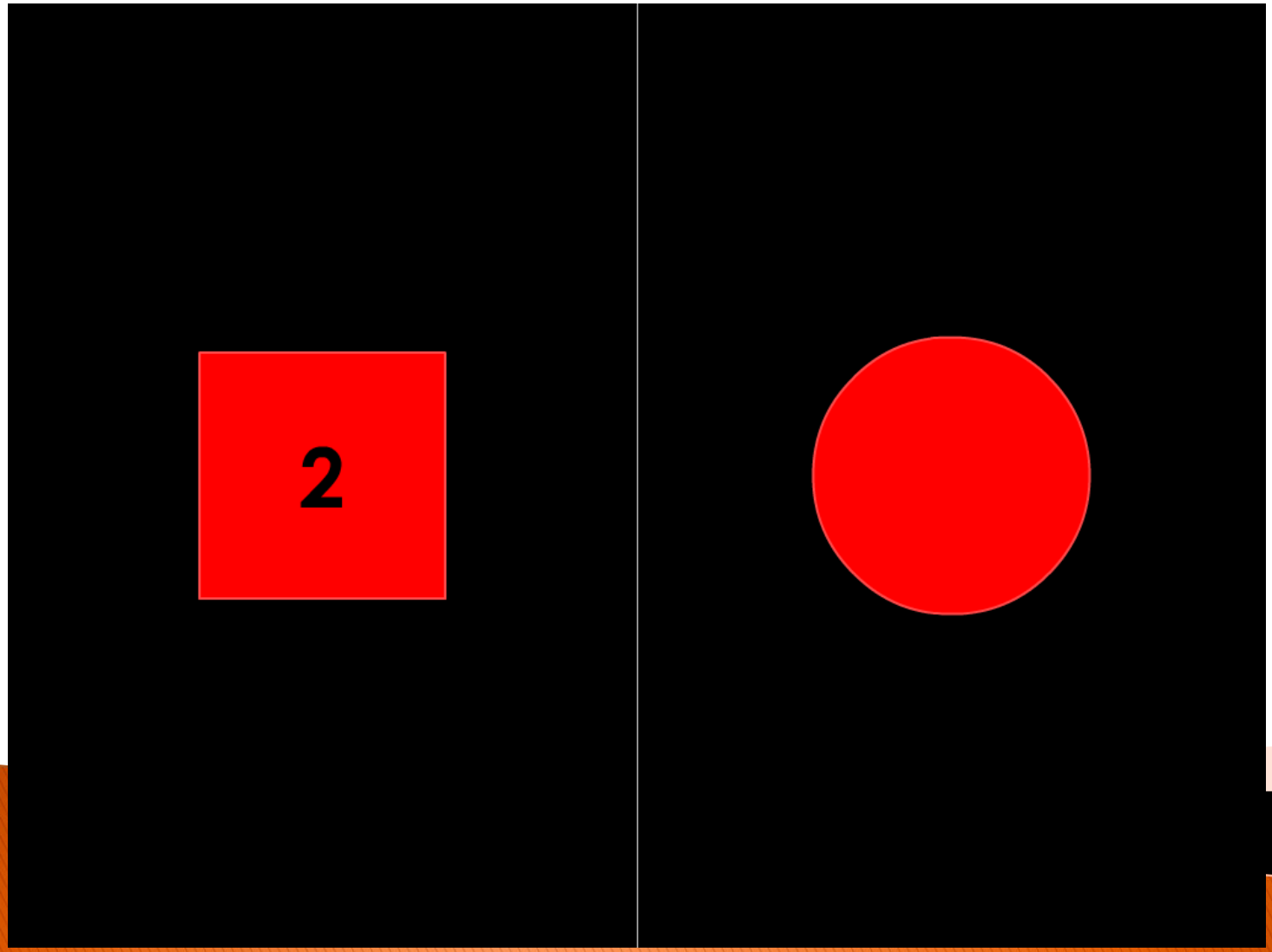
Initial screen (2 seconds)



First screen (5 seconds)



Second screen (5 seconds)



Experimental variables

- First Fixations
- Total number of fixations (Fixations = gazing at region of interest –ROI- for at least 200 milliseconds)
- Relative time spent fixating ROI (relative time = time in a ROI divided by the total time spent on a task)
- Sequence of last fixations

Subjects' types

- **BAYESIAN** - the equal probability of the two states implies that the optimal Bayesian decision rule is to predict the state which obtains the greatest number of observed (Private draw) and inferred signal (Previous choices).

If subjects choose differently from what implied by Bayesian update:

- **OVERCONFIDENT** - if subject's choice is equal to his Private draw
- **IRRATIONAL** - if subject's choice is not equal to his Private draw

Subjects' types

Order of choice	Bayesian	Overconfident	Irrational
1st	6	0	3
2nd	9	0	0
3rd	5	2	2
4th	6	2	1
5th	7	1	1
6th	6	2	1
7th	6	3	0
8th	6	3	0
9th	6	3	0
Total	57	16	8
Total (first chooser excluded)	51	16	5

Total allocation of attention

Table 5. Total allocation of attention (percentage of total time)

	Private Draw (PD)	Former Choices (FC)	No fixation	Total	Former Choices/ n. of former choices
Bayesian	26.9	63.0	10.1	100	22.4
Overconfident	10.4	86.4	3.2	100	19.5
Irrational	47.1	39.9	13.0	100	22.6
Total	25.6	65.3	9.1	100	21.8

Table 6. Total allocation of attention by screen side (percentage of total time)

	Private Draw			Former Choices / n. of former choices		
	Left side	Right side	Total	Left side	Right side	Total
Bayesian	19.5	29.5	26.9	25.5	21.2	22.4
Overconfident	9.2	10.9	10.4	16.8	20.7	19.5
Irrational	52.0	12.7	47.1	21.4	27.5	22.6
Total			25.6			21.8

- Only irrational subjects were significantly more inclined to look at private draw (47.1%) than at former choices (22.6%).

First fixations

		Private Draw		Previous Choices		
	Latency of first fixations	N. of first fixations	%	N. of first fixations	%	Average duration
Bayesian	0.306 sec	27 (13L+14R)	52.9	24 (13L+11R)	47.1	0.838 sec
Overconfident	0.412 sec	13 (6L+7R)	81.2	3 (1L+2R)	18.8	0.523 sec
Irrational	0.191 sec	3 (2L+1R)	60.0	2 (0L+2R)	40.0	0.835 sec
Total	0.321 sec	43 (21L+22R)	46.8	25 (14L+15R)	53.2	0.775 sec

•Overconfident subjects allocated their initial attention to private draw in 81% of the cases, and exhibited a longer average reaction time (0.412 sec.) and a shorter average duration of first fixation (0.523)

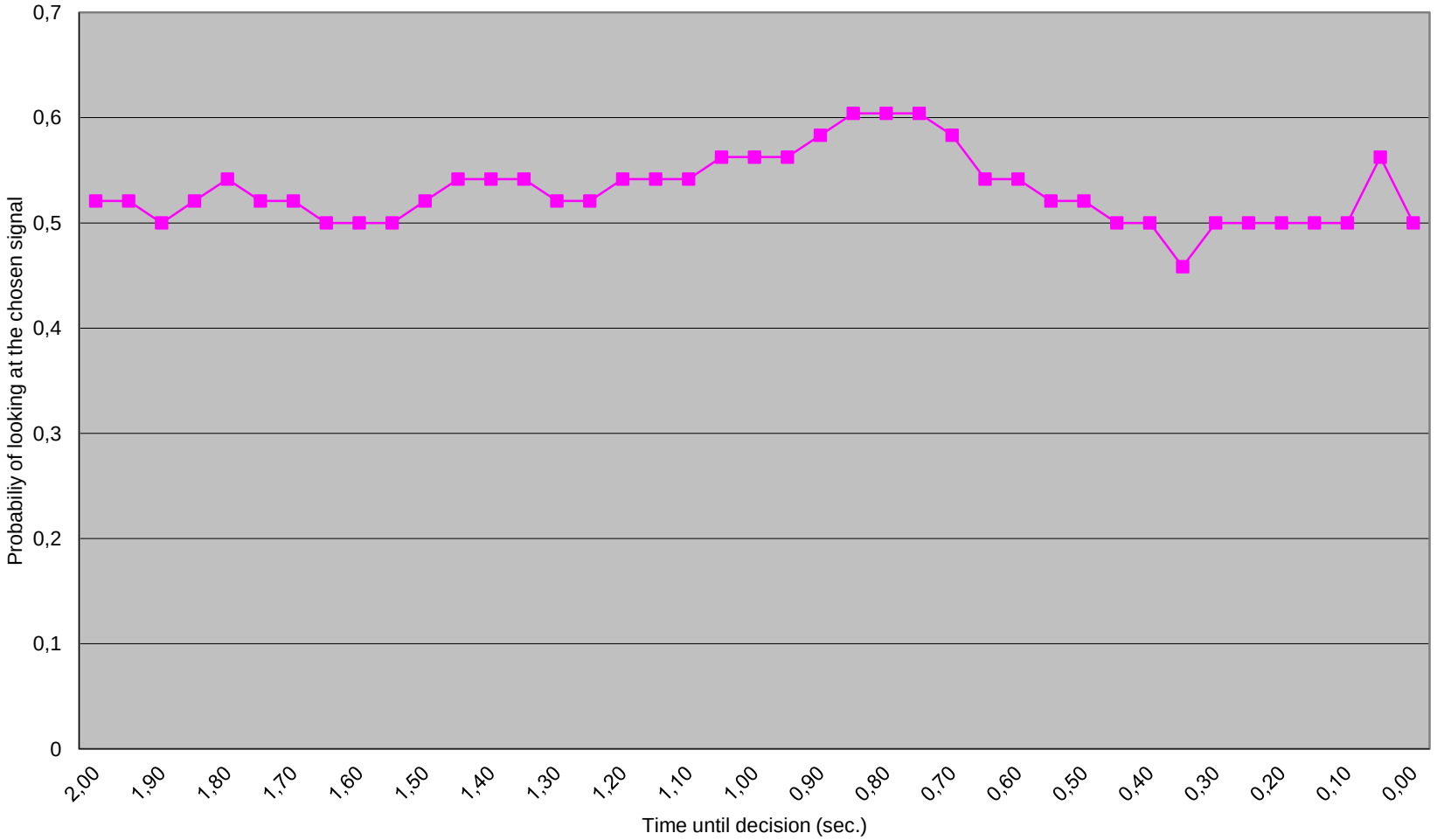
First fixations by side

TABLE 4. FIRST FIXATION BY SCREEN SIDES (FIRST CHOOSERS EXCLUDED)

	PRIVATE DRAW (PD)						FORMER CHOICES (FC)					
	LEFT			RIGHT			LEFT			RIGHT		
	N.	TOT.	%	N.	TOT.	%	N.	TOT.	%	N.	TOT.	%
BAYESIAN	8	14	57.1	20	30	66.6	16	38	42.1	6	16	37.5
OVERCONFIDENT	5	9	55.6	9	15	60.0	2	6	33.3	1	3	33.3
IRRATIONAL	1	1	100	2	3	66.6	2	4	50.0	0	3	0
TOTAL	14	24	58.3	31	48	64.6	21	48	43.7	8	24	33.3

- No statistically significant difference between left and right orientation of the screen was detected and the pattern of first fixations across subjects' types

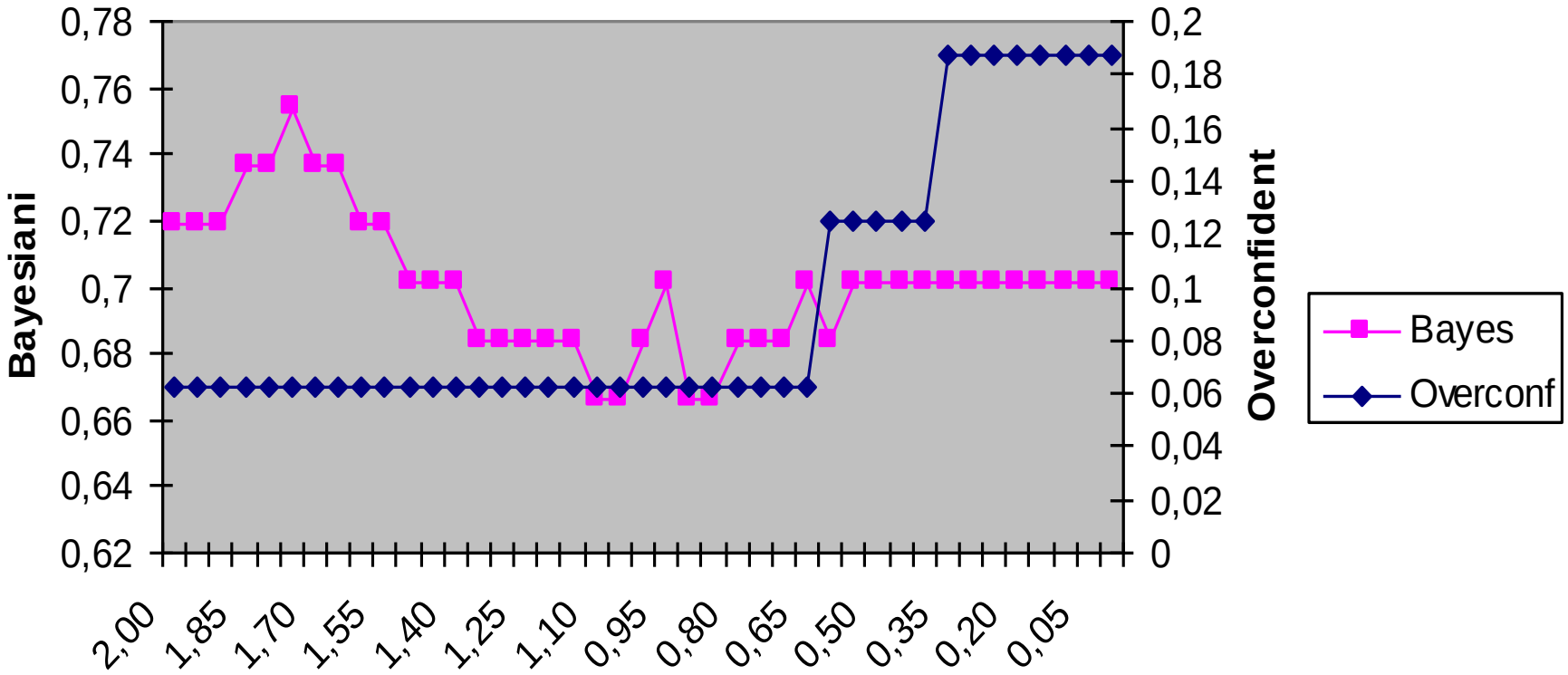
Likelihood to look at the chosen item



No gaze cascade effect: observers gaze was not increasingly directed towards the chosen signal

Likelihood by types

Fig.2 Likelihood that subjects look at the chosen signal as a function of time until decision (by subjects' types)



Findings

- Overconfident subjects allocate the first fixation (initial attention) toward private draw and take more time than others to decide if the private signal is on the right or the left of the screen.
- Bayesian subjects allocate their initial attention to both kinds of information without exhibiting any particular bias
- No evidence of the gaze cascade effect

Interpretation

- In terms of the Dual Process theory, our findings support the hypothesis that automatic detection, as inferred from gaze direction, depends on cognitive biases.

- The heuristic and automatic functioning of System 1 orients attention so as to confirm rather than to eventually correct these biases.

- The controlled search attributable to System 2 does not significantly differ across subject types.

Conclusions (1)

"Highly accessible impressions produced by System 1 control judgments and preferences, unless modified or overridden by the deliberate operations of System 2." (Kahneman and Frederick 2002, p. 53)

Gaze participates actively in the process of choice under uncertainty

first fixation effect ⇒ orienting choice

gaze cascade effect ⇒ reinforcing choice

Conclusions (2)

- Heuristic processes of System 1 select the aspect of the task on which gaze direction is immediately focused
- Analytic processes of System 2 derive inferences from the heuristically-formed representation through subsequent visual inspection
- This dual account of visual attention orienting may explain the emergence of cognitive biases whenever relevant information is neglected at the heuristic stage.