



Erasmus Centre for  
Neuroeconomics





# Introduction to Neuroeconomics – Lecture 1

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## Neuroeconomics: How the brain makes decision

Clement Levallois – September 3, 2009.

Minor provided by

Department of Marketing  
Rotterdam School of Management  
&  
Donders Institute for Brain, Cognition and Behavior, Radboud University, Nijmegen

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NEUROECONOMICS

BEHAVIORAL ECONOMICS

NEURO MARKETING

SOCIAL NEUROSCIENCE

EXPERIMENTAL ECONOMICS

BIOECONOMICS

EVOLUTIONARY ECONOMICS

EVOLUTIONARY PSYCHOLOGY

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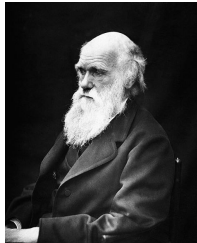
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**Robert Malthus**

**Charles Darwin**

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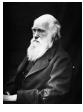


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1859

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ON THE ORIGIN OF SPECIES

DARWIN

Darwin, 1859

In the next chapter the Struggle for Existence amongst all organic beings throughout the world, which inevitably follows from their high geometrical powers of

INTRODUCTION.

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increase, will be treated of. This is the doctrine of Malthus, applied to the whole animal and vegetable kingdoms. As many more individuals of each species are born than can possibly survive; and as, consequently, there is a frequently recurring struggle for existence, it follows that any being, if it vary however slightly in any manner profitable to itself, under the complex and sometimes varying conditions of life, will have a better chance of surviving, and thus be *naturally selected*. From the strong principle of inheritance, any selected variety will tend to propagate its new and modified form.

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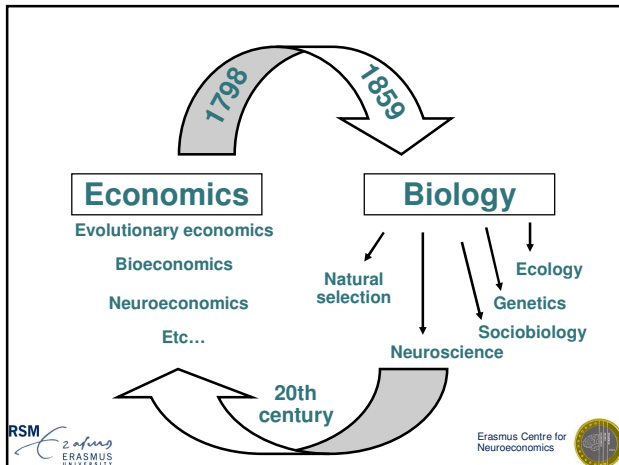
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## Biology in economics?

### 1. The Theory of the Firm

central idea: economic competition between firms can be compared to a process of natural selection



Classic references  
 1950: "Uncertainty, Evolution, and Economic Theory" by Armen Alchian (economist from UCLA)  
 1982: "An Evolutionary Theory of Economic Change" by Richard Nelson and Sidney Winter (economists from UPenn and Columbia)  
 Check also the Journal of Evolutionary Economics at the Erasmus Library ([online](#))

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## Biology in economics?

### 1. The Theory of the Firm

central idea: economic competition between firms can be compared to a process of natural selection



We can expect firms to be relatively efficient,  
 not because they are perfect profit maximizers,  
 but because the worst performing firms ultimately fail and the remaining population of firms is comparatively more efficient.  
 so in the long term...

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## Biology in economics?

### 2. Bioeconomics

central idea: many deviations from pure economic egoism (altruism, costly signaling, cooperation, ...) can be explained by evolutionary models



Classic references

1975: "Sociobiology" by Edward O. Wilson (biologist from Harvard)

1977: "Economics from a biological perspective" by Jack Hirshtleifer (economist from UCLA)

Check also the "Journal of Bioeconomics" in the Erasmus Library ([online](#)).



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## Biology in economics?

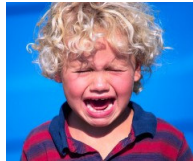
### 2. Bioeconomics

central idea: many deviations from pure economic egoism (altruism, costly signaling, cooperation, ...) can be explained by evolutionary models



Cooperation can occur in nature when it brings long term evolutionary benefits

Altruism can develop in the family, even if each member is self-interested



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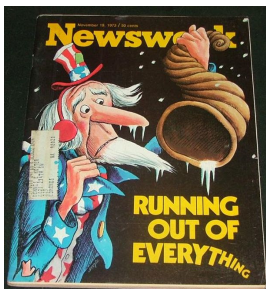
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## Biology in economics?

### 3. Ecological economics

central idea: natural resources are not infinite. Economics should take it into account in its models.



Classic references

1968: "On economics as a life science"

by Herman Daly, economist from Vanderbilt University

1971: "The Entropy Law and the Economic Process"

by Nicholas Georgescu-Roegen, economist from Vanderbilt University

Today: check the journal "Ecological economics" at the Erasmus Library ([online](#))



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## Biology in economics?

### 3. Ecological economics

central idea: natural resources are not infinite. Economics should take it into account in its models.



"Life" consists in taking energy (food, material for shelter...) from the environment and use it to reproduce.

"Economics" consists in taking energy (food, material for shelter...) from the environment and use it to enjoy life. But for how long?




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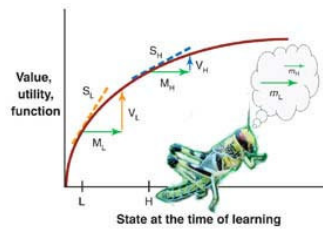
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## ... and also a bit of economics in biology

central idea: economists assume that consumers make optimal choices when they purchase things. That should be the same for animals when they search for food!



Classic references

1966: "On the optimal use of a patchy environment"  
by Robert MacArthur and Eric Pianka (biologists)

1981: "Demand curves for animal consumers"  
by John Kagel and colleagues (economists)

(check also the "optimal foraging theory" article on [wikipedia](#)).




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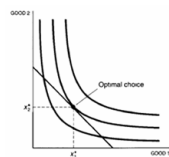
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## ... and also a bit of economics in biology

central idea: economists assume that consumers make optimal choices when they purchase things. That should be the same for animals when they search for food!



Robert  
MacArthur

Animals and human consumers share...

- a budget constraint (typically: income for humans, time and energy for animals)
- choice between alternatives (good 1, good 2 or prey 1, prey 2)
- a procedure for maximization




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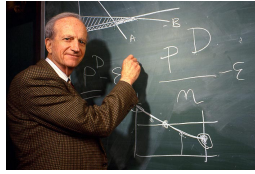
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## The divorce



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Short history of **consumer choice theory** in economics...

## 1870. Marginalism, cardinal utility



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Short history of **consumer choice theory** in economics...

## 1870. Marginalism, cardinal utility



Problems:

1. How to measure those utility values? Are they really additive?
2. Is it not crude to derive utility from physiological pain and pleasures?

→ **Divorce with  
psychology and biology**



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Short history of **consumer choice theory** in economics...

## Since the 1930s: Marginalism, *ordinal* utility



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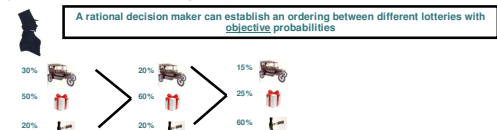
### 1938: *Revealed preferences*

(by Paul Samuelson)



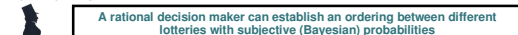
### 1944: *Expected utility*

(by John von Neumann and Oskar Morgenstern)



### 1954: *Subjective expected utility*

(by Jimmy Savage)



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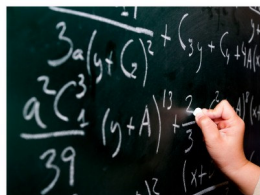
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## What happened to decision making?

### Economics

➡ Choice theory in economics became an axiomatic theory.

It describes choices made by an ideal, perfectly rational decision maker



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## What happened to decision making?

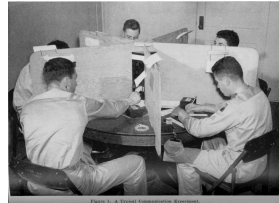
### Psychology



Decision-making has been studied in experimental settings.

In general and applied contexts.

One of the goals: to test the axioms of choice.  
Are they realistic?



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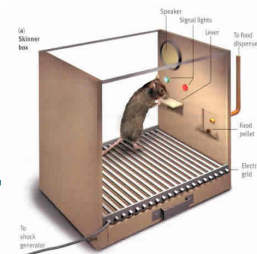
## What happened to decision making?

### Psycho / Biology



Decision-making has been studied with “animal models”: neurology and psychology applied to rats, monkeys, cats, pigeons, etc.

What is the physiological underpinning to decision making?



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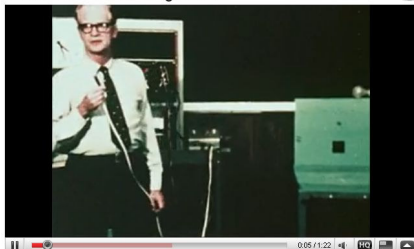
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BF Skinner Foundation • Pigeon Turn



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## Neurobiology

Decision making related to many other aspects of cognition

=> How is "decision making" related to those basic cognitive functions?



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## Phineas Gage



1823-1860



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## How did Phineas's behavior changed?

after a period of guess by the students:

- Motor
- Sensation and perception
- Emotions
- Attention
- Language
- Learning and memory



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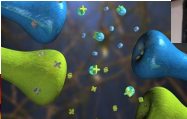
# Neurobiology




Genetics and genetic engineering





Electro Encephalogramme (EEG)



Neurotransmitters, Cell physiology, ...



Neuropharmacology

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# Since the 1970s, 1980s, 1990s...

Economics, psychology and biology converge again

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# Behavioral economics



Amos Tversky  
Daniel Kahneman



⇒ Prospect theory (1979): a new theory of choice under risk suggested by psychologists

⇒ Use **experiments in labs** to demonstrate it

⇒ Kahneman receives Nobel Prize in Economics in 2002

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## Experimental economics

Vernon Smith



- ⇒ Convinced that markets work efficiently
- ⇒ Proves it in **laboratory experiments** with classrooms etc.
- ⇒ Smith receives Nobel Prize in Economics in 2002 with Kahneman.



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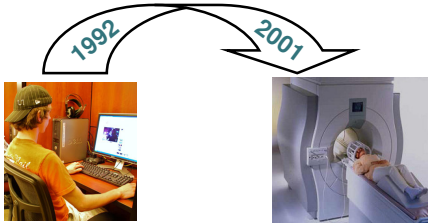
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## Neuroeconomics



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## Two famous studies in neuroeconomics (from an economist perspective!)

Kevin McCabe, **Vernon L. Smith**, Michael LePore.  
"Intentionality detection and 'mindeading': Why  
does game form matter?" (2000)

Hans C Breiter, Itzhak Aharon, **Daniel Kahneman**  
et al. "Functional imaging of neural responses to  
expectancy and experience of monetary gains  
and losses" (2001)



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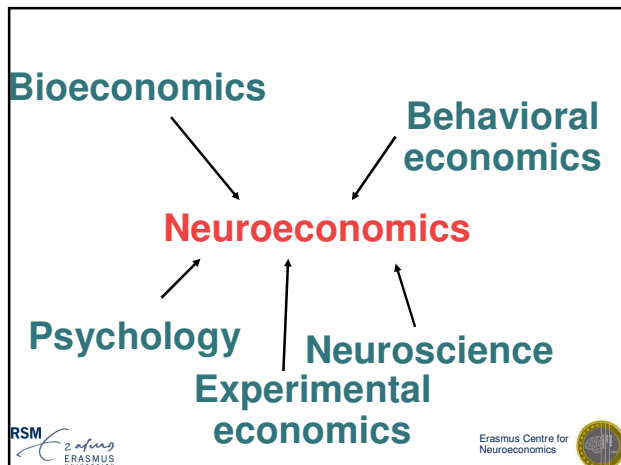
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## A definition of neuroeconomics

"The study of the neural basis of decision-making"

=> Involves primarily neuroscientists, psychologists and economists.

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## Big themes in neuroeconomics...

Where and how is utility computed in the brain ?



Which neurons react to a reward?  
To a punishment?

What is the influence of probabilities, risk and ambiguity in the neural computation of value?

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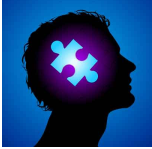
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## Big themes in neuroeconomics...

Time preferences?



Short-term and long-term decisions:  
do they activate the same brain  
regions?

How does time discounting operate?



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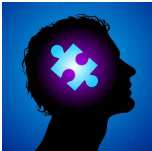
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## Big themes in neuroeconomics...

How much are we influenced by social  
interactions?



Are we emotional in rational  
games?

What is the neural definition of  
empathy?

Is there a physiological substrate to  
“trust”?



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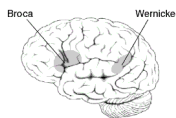
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## Perspectives in neuroeconomics



Understand better the role of  
local brain regions in  
decision-making

Understand better the  
network connecting those  
local regions to achieve  
integrated behavior



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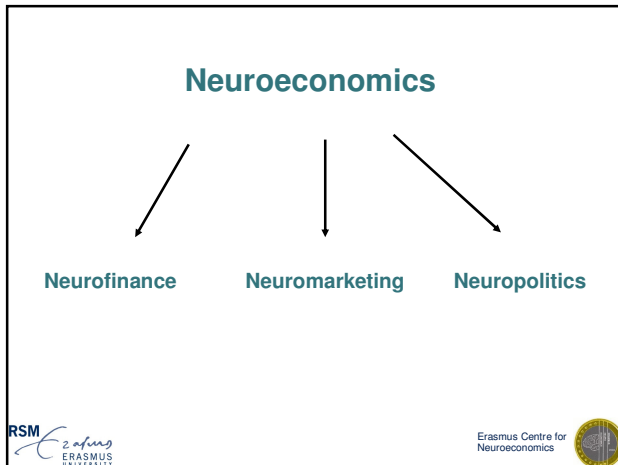
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**In marketing**





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Neuron, Vol. 44, 379-387, October 14, 2004, Copyright © 2004 by Cell Press


**Neural Correlates of Behavioral Preference for Culturally Familiar Drinks**

Samuel M. McClure,<sup>1,2</sup> Jian Li,<sup>1</sup> Damon Tomlin,<sup>1</sup> Kim S. O'Connell,<sup>1</sup> Leland M. Montague,<sup>1</sup> and P. Read Montague<sup>1,2</sup>


<sup>1</sup>Department of Neuroscience  
<sup>2</sup>Moninger Department of Psychiatry


neural responses, and the modulation of both by non-odor or nonflavor stimuli—that is, the sensory problem. Ultimately, such sensory discriminations and the variables that influence them serve to influence expressed behavioral preferences. Hence, there is another large





**which one do you prefer... and why?**





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## Anonymous brands

When subjects drink Pepsi or  
Coca-Cola, this region activates for  
both brands

**vmPFC**  
=  
Ventro-medial Prefrontal-Cortex

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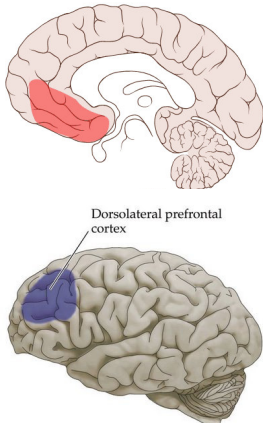
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## Named brands

### Behavioral preferences

if people drank Coca-Cola,  
and if it was cued by the name  
"Coca-Cola",  
an extra region activates  
- Not for Pepsi!

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## Questions...

Does the vmPFC express the "real preference" of the subject?

Does the DLPFC express a taste ingrained by the ads?  
**dlpfc = control** area, may suppress automatic evaluation  
because of the goal (= knowing it is Coke)

"There are visual images and marketing messages that  
have insinuated themselves into the nervous systems of  
humans that consume [Pepsi and Coke]" (McClure and  
al., 2004)

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## Prospects for the neuromarketing industry



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## In management

Attitude towards risk and ambiguity

Over-bidding in auctions

Fairness and self-interest in bargaining



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## In economics

Common picture: individuals as utility-maximizing agents.

What about sacrifice, revenge, altruism...?

What about the multiple bias in our decisions?  
(entrenchment, preference reversal, etc.)



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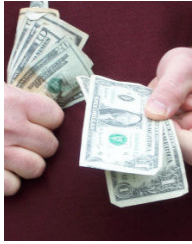
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## Ultimatum game



- Player 1 gets 10 euros
- Player 1 can offer from 0 to 10 euros to player 2.
- Player 2 has just one choice:
  - ⇒ Accept (she receives the offer, player 1 gets the rest)
  - ⇒ Reject (both player 1 and 2 get nothing)



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## Let's play a ultimatum game

- What would you expect for player's 1 offer?
- Why would one reject player 1's offer?
- What would be the "rational" solution to the game?



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## Conclusion

- For long, economics remained isolated from psychology and biology
- fMRI data + experiments in labs challenge some common assumptions in economics, leading to neuroeconomics
- Neuroeconomics: "consilience" finally achieved?



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Thank you.



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