Notes on Prospect Theory

Khurshid Ahmad,
Chair of Computer Science
Trinity College, Dublin, IRELAND

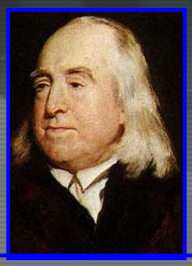
Utility Theory

In economics, utility is a measure of the relative satisfaction from, or desirability of, consumption of various goods and services. Given this measure, one may speak meaningfully of increasing or decreasing utility, and thereby explain economic behavior in terms of attempts to increase one's utility. For illustrative purposes, changes in utility are sometimes expressed in units called utils.

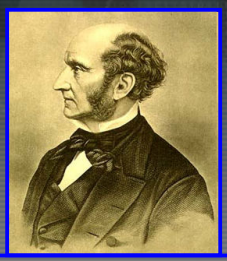
http://www.lse.ac.uk/collections/operationalResearch/pdf/working%20paper%20OR64.pdf

Utility Theory

The doctrine of utilitarianism saw the maximization of utility as a moral criterion for the organization of society. According to some 18th/19th century philosophers, referred to as utilitarians, Jeremy Bentham and John Stuart Mill, society should aim to maximize the total utility of individuals, aiming for "the greatest happiness for the greatest number".



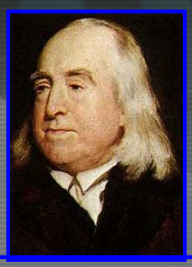
Jeremy Bentham
(1748-1832)



Stuart Mill
(1806-1876)

Utility Theory

In neoclassical economics, *rationality* is precisely defined in terms of imputed utility-maximizing behavior under economic constraints. As a hypothetical behavioral measure, utility does not require attribution of mental states suggested by "happiness", "satisfaction", etc.



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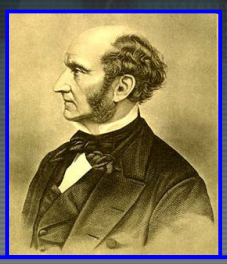


Stuart Mill
(1806-1876)

Utility Theory

According to conventional financial theory, the world and its participants are, for the most part, rational "wealth maximizers". However, there are many instances where emotion and psychology influence our decisions, causing us to behave in unpredictable or irrational ways.

http://www.investopedia.com/university/behavioral_finance/default.asp

Expected Utility Theory

Expected utility theorem or expected utility hypothesis predicts that the "betting preferences" of people with regard to uncertain outcomes (gambles) can be described by a mathematical relation which takes into account the size of a payout (whether in money or other goods), the probability of occurrence, risk aversion, and the different utility of the same payout to people with different assets or personal preferences

http://en.wikipedia.org/wiki/Expected_utility_hypothesis

Extended Utility Theory

Decision making under risk can be viewed as a choice between prospects or gambles. A prospect

$$(x_1, p_1; \ldots ; x_n p_n)$$

is a contract that yields outcome x_i with probability p_i, where

$$p_1 + p_2 + \ldots + p_n = 1.$$

To simplify notation, null outcomes are omitted and the tuple (x, p) is used to denote the prospect

$$(x, p; 0, 1 - p)$$

that yields x with probability p and *o* with probability 1-p.

The (riskless) prospect that yields x with certainty is denoted by (x).

Daniel Kahneman& Amos **Tversky. (1979) Prospect Theory: An Analysis of Decision under Risk** ***Econometrica*****, Vol. 47 (No. 2) (Mar., 1979), pp. 263-292**

Expected Utility Theory

The application of expected utility theory to choices between prospects is based on the following three tenets. Let *U* be the overall utility of a prospect, and $u(x_i)$ be the value function for an outcome x_i

(i) **Expectation**: $\mathbf{U(x_1, p_1; \ldots ; x_n\ p_n) = p_1\, u(x_1) + \ldots + p_n u(x_n).}$

(ii) **Asset Integration**: $(x_1, p_1; \ldots ; x_n\ p_n)$ is acceptable at asset position w if and only if $U(w+x_1, p_1; \ldots ; w+x_n\ p_n) > u(w)$ (utility function)

(iii) **Risk Aversion**: u is concave (second derivative of $u<o$)

Expected Utility Theory

The application of expected utility theory to choices between prospects is based on the following three tenets.

(i) **Expectation**: $U(x_1, p_1;. . ;x_n\ p_n) = p_1\ u(x_l)+ . . . +p_n u(x_n)$.

The overall utility of a prospect is the expected utility of its outcomes

Expected Utility Theory

The application of expected utility theory to choices between prospects is based on the following three tenets.

Asset Integration: $(x_1, p_1;. . ;x_n\ p_n)$ is acceptable at asset position w if and only if $U(w+x_1, p_1;. . ;w+x_n\ p_n) > u(w)$ (utility function)

The gamble is acceptable if the utility resulting from integrating the prospect with one's assets exceeds the utility of those assets alone.

Expected Utility Theory

The application of expected utility theory to choices between prospects is based on the following three tenets.

Risk Aversion: u is concave (second derivative of $u<0$)

A person is risk averse if he [or she] prefers *certain prospect* (x) to any risky prospect with the expected value x.

Risk aversion is equivalent to the concavity of the utility function.

This equivalence has led many to believe that utility is a concave function of money.

Irrational Behaviour of Otherwise Rational Agents (1936)

Most, probably, of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as the result of animal spirits—a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities.

Keynes, John Maynard (1936) *The General Theory of Employment, Interest and Money*. London: Macmillan (reprinted 2007)

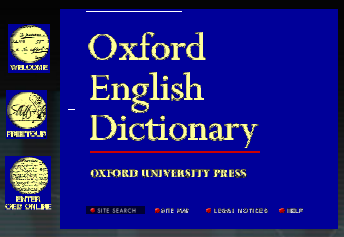
Irrational Behaviour of Otherwise Rational Agents (2008)

Ever since Maynard Keynes suggestion that there are "animal spirits" in the market, "economists have devoted substantial attention to trying to understand the determinants of wild movements in stock market prices that are seemingly unjustified by fundamentals"

Tetlock, Paul C. (2008). Giving Content to Investor Sentiment: The Role of Media in the StockMarket. *Journal of Finance.*
Paul C. Tetlock , Saar-Tsechansky, Mytal, and Mackskassy, Sofus (2005). More Than Words: Quantifying Language to Measure Firms' Fundamentals. (http://www.mccombs.utexas.edu/faculty/Paul.Tetlock/papers/TSM_More_Than_Words_09_06.pdf)

Being intelligent being?

Knowledge



Intelligence ⟷ Cognition

Being intelligent being?
with apologies to Plato

Knowledge about*, *knowledge by description: knowledge of a person, thing, or perception gained through information or facts about it rather than by direct experience.

Language; Images
Symbols; Planning;
Learning, Thinking;
Creativity

An impersonation of **intelligence**; an intelligent or rational being; esp. applied to one that is or may be incorporeal; a spirit

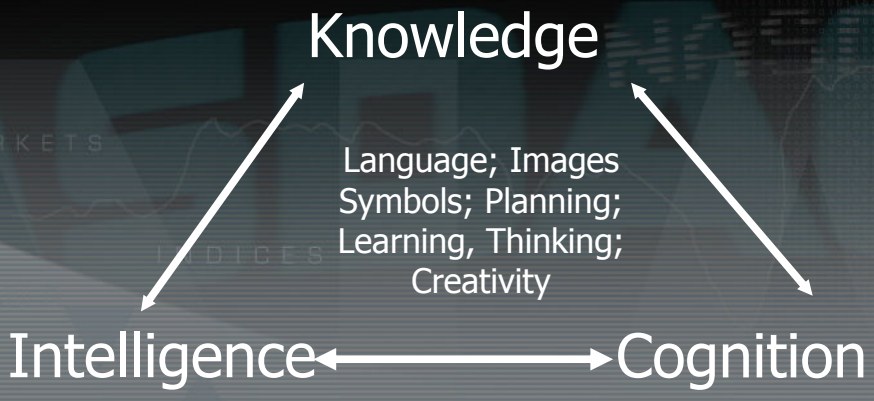
COGNITION: The action or faculty of knowing taken in its widest sense, including sensation, perception, conception, etc., as distinguished from feeling and volition.

Knowledge, Cognition and Intelligence

- Knowledge is acquired and disseminated by intelligent and cognate beings. The terms *knowledge*, *cognition* and *intelligence* are used interchangeably.
- And there is a good reason for this: Various cognitive processes help in converting information and stimuli into knowledge. Knowledgeable beings then act intelligently because of their greater awareness.

Knowledge, Cognition and Intelligence

Information exchange, processing and decision making; Knowledge is acquired and disseminated by intelligent and cognate beings.



Knowledge, Cognition and Intelligence

Human Information Exchange: The role of cognition, perception and movement

In everyday language *cognition* is used to refer to the 'higher' mental processes. In psychology cognition would generally be taken to include a variety of mental activities.

Knowledge, Cognition and Intelligence

Human Information Exchange: The role of cognition, perception and movement

Cognitive faculties include *attention, control, categorisation, creativity, decision making, language, learning, mental imagery, memory, problem solving, reasoning, representation.*

Perceptive capabilities enable humans to *hear, see, smell, taste, and touch.* These capabilities help humans to translate a variety of environmental input, for example, *acoustic, chemical, electromagnetic, mechanical, thermal*, into a language which can be understood by the human nervous system.

Motor skills underpin the cognitive faculties and perceptive capabilities through the complex network of muscles and nerve fibres for receiving inputs from and providing output to the external environment.

Cognition, perception and movement helps humans to exchange

Knowledge, Cognition and Intelligence

Kinds of Knowledge:

Cognitive psychologists have studied experts, in the physical, medical and engineering sciences, involved in problem solving, ranging from diagnosis, mental calculation, design and planning for example. The psychologists have also observed skilled performance in taxi driving, typing for instance. The observations have led to six major findings (Glaser 1994:140-141):

Knowledge, Cognition and Intelligence

Kinds of Knowledge:

1. Structured, Principled Knowledge
2. Procedural Knowledge
3. Skilled Memory
4. Automaticity
5. Effective Problem Representation
6. Strong Self-Regulatory Skills

Computing Intelligently & Heuristic Knowledge

Prevent the hi-jacking of airliners

Prevent hi-jackers from boarding the airliners

Heuristic technique

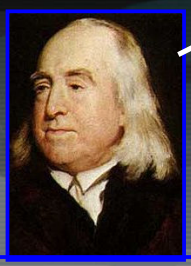
- Put passengers and luggage through a metal detector.
- Search only those who set off the detector
- Search those passengers that match a predetermined hi-jacker profile

Algorithmic route

- Strip search every person with access to the airlines (inc. passengers, flight crews & mechanics)
- Search all luggage

Utility Theory and After

To a person considered by himself, the value of a pleasure or pain considered by itself, will be greater or less, according to the four following circumstances: 1. Its *intensity*; 2. Its *duration*; 3. Its certainty or uncertainty; 4. Its propinquity or remoteness. (IV, 4, italics added).



Jeremy Bentham
(1748-1832)

Stuart Mill
(1806-1876)

Maynard Keynes
(1883-1946)

Daniel Kahneman
(1934-)

Read, Daniel. (2004). Utility theory from Jeremy Bentham to Daniel Kahneman, Working Paper No: LSEOR 04-64 . London:LSE

Utility Theory and After

There are three main puzzles associated with aggregate stock market behavior:
(i) the equity premium puzzle;
(ii) the volatility puzzle; and
(iii) the predictability puzzle.

Barberis, Nicholas., Huang Ming., and Santos, Tano. (2001). Prospect Theory and Asset Prices. *The Quarterly Journal of Economics*. Vol CXVI (Iss. 1) (available at http://web.cenet.org.cn/upfile/881.pdf

Utility Theory and After

Equity Premium Puzzle: The equity premium is the average return on the overall stock market minus the return on riskless government bonds. The puzzle is that in most countries, the historical equity premium has been much higher than our economic models would predict.

Barberis, Nicholas., Huang Ming., and Santos, Tano. (2001). Prospect Theory and Asset Prices. *The Quarterly Journal of Economics*. Vol CXVI (Iss. 1) (available at http://web.cenet.org.cn/upfile/881.pdf

Utility Theory and After

The **volatility puzzle** is that stock market levels appear to move around too much. For example, ratios of price to earnings in the U.S. stock market have often been very high. The standard rationalization of this is that investors must be expecting high cashflows and earnings *in the future*, and are therefore happy to pay high prices today. However, historical data shows that high levels of price-earnings ratios are *not*, on average, followed by higher earnings. In this sense, it is a puzzle why prices were so high to begin with.

Barberis, Nicholas., Huang Ming., and Santos, Tano. (2001). Prospect Theory and Asset Prices. *The Quarterly Journal of Economics*. Vol CXVI (Iss. 1) (available at http://web.cenet.org.cn/upfile/881.pdf

Utility Theory and After

Predictability Puzzle: Historical data also shows that the price-earnings ratio can predict *future* returns on the stock market. High levels of the price-earnings ratio have generally led to lower subsequent returns, and low levels of the ratio to higher returns. This evidence is known as the predictability puzzle.

Barberis, Nicholas., Huang Ming., and Santos, Tano. (2001). Prospect Theory and Asset Prices. *The Quarterly Journal of Economics*. Vol CXVI (Iss. 1) (available at http://web.cenet.org.cn/upfile/881.pdf

Prospect Theory

In 1979, Kahnemann and Tversky presented their 'critique of *expected utility theory* as a descriptive model of decision making under risk' and put forward their own model - *prospect theory*.

It appears that when faced with risky prospects, people typically made choices that are not consistent with the expected utility theory:

1. People underweight outcomes that are merely probable in comparison with outcomes that are obtained with certainty. This tendency, called the certainty effect, contributes to risk aversion in choices involving sure gains and to risk seeking in choices involving sure losses.

2. People generally discard components that are shared by all prospects under consideration. This tendency, called the isolation effect, leads to inconsistent preferences when the same choice is presented in different forms.

Daniel Kahneman& Amos **Tversky. (1979) Prospect Theory: An Analysis of Decision under Risk *Econometrica*, Vol. 47 (No. 2) (Mar., 1979), pp. 263-292**

Prospect Theory

In Kahnemann and Tversky *prospect theory,* 'value is assigned to gains and losses rather than to final assets and in which probabilities are replaced by decision weights'.

The value function is normally concave for gains, commonly convex for losses, and is generally steeper for losses than for gains.

Decision weights are generally lower than the corresponding probabilities, except in the range of low probabilities. Overweighting of low probabilities may contribute to the attractiveness of both insurance and gambling.

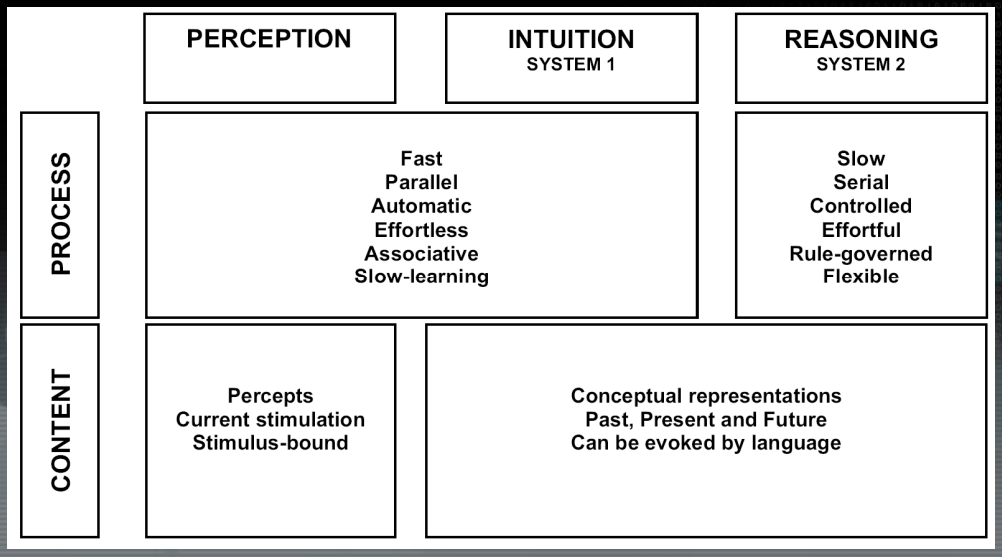
Daniel Kahneman& Amos **Tversky. (1979) Prospect Theory: An Analysis of Decision under Risk** ***Econometrica*****, Vol. 47 (No. 2) (Mar., 1979), pp. 263-292**

Prospect Theory

Kahnemann:

Our normative treatment of the utility of temporally extended outcomes adopts a hedonic interpretation of utility, but no endorsement of Bentham's view of pleasure and pain as sovereign masters of human action is intended. Our analysis applies to situations in which a separate value judgment designates experienced utility a criterion for evaluating outcomes.'

Notes on Prospect Theory: Two Systems View



http://nobelprize.org/nobel_prizes/economics/laureates/2002/kahnemann-lecture.pdf

Notes on Prospect Theory: Framing

Framing of Outcomes:

'Risky prospects are characterized by their possible outcomes and by the probabilities of these outcomes. The same option can be framed in different ways. For example, the possible outcome of a gamble can be framed either as gains or losses relative to the status quo or as asset positions that incorporate initial wealth or as asset positions that incorporate initial wealth. Invariance requires that such changes in the description outcomes should not alter the preference order' (Kahneman and Tversky 2000:4) (Emphasis added)

Kahneman, D & Tversky, A. (2000). Choices, Values, and Frames. In (Eds.) D. Kahneman, & A. Tversky. *Choices, Values, and Frames*. Cambridge, New York: Cambridge University Press. pp 1-16

Notes on Prospect Theory: Framing

Framing of Outcomes:

Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences are as follows:

If Program A is adopted, 200 people will be saved.

If Program B is adopted, there is 1/3 probability that 600 people will be saved and 2/3 probability that no people will be saved.

Which of the two programs would you favor?

Kahneman, D & Tversky, A. (2000). Choices, Values, and Frames. In (Eds.) D. Kahneman, & A. Tversky. *Choices, Values, and Frames*. Cambridge, New York: Cambridge University Press. pp 1-16

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In Kahneman and Tversky (2000:5) the results were

Program	Your response
A: 200 people will be saved	
B: 1/3 chance 600 be saved; 2/3 chance all die	

Kahneman, D & Tversky, A. (2000). Choices, Values, and Frames. In (Eds.) D. Kahneman, & A. Tversky. *Choices, Values, and Frames*. Cambridge, New York: Cambridge University Press. pp 1-16

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Program	Poll Results
A: 200 people will be saved	72%
B: 1/3 chance 600 be saved; 2/3 chance all die	28%

Kahneman, D & Tversky, A. (2000). Choices, Values, and Frames. In (Eds.) D. Kahneman, & A. Tversky. *Choices, Values, and Frames*. Cambridge, New York: Cambridge University Press. pp 1-16

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Program	Your response
C: 400 people will die	
D: 1/3 chance that nobody will die; 2/3 chance all 600 will die	

Kahneman, D & Tversky, A. (2000). Choices, Values, and Frames. In (Eds.) D. Kahneman, & A. Tversky. *Choices, Values, and Frames*. Cambridge, New York: Cambridge University Press. pp 1-16

Notes on Prospect Theory: Framing

Framing of Outcomes:

Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences are as follows:

In Kahneman and Tversky (2000:5) the results were

Program	Poll Results
C: 400 people will die	22%
D: 1/3 chance that nobody will die; 2/3 chance all 600 will die	78%

Kahneman, D & Tversky, A. (2000). Choices, Values, and Frames. In (Eds.) D. Kahneman, & A. Tversky. *Choices, Values, and Frames*. Cambridge, New York: Cambridge University Press. pp 1-16

Notes on Prospect Theory: Framing

Framing of Outcomes:

Failure of invariance against changes in description. Spot the difference between A & C and B &D. The failures are common to expert and naïve; failures persist when A,B, C and D are asked within minutes of each other

Program	Poll Results
A: 200 people will be saved	72%
C: 400 people will die	22%
B: 1/3 chance 600 be saved; 2/3 chance all die	28%
D: 1/3 chance that nobody will die; 2/3 chance all 600 will die	78%

Notes on Prospect Theory: Framing

Framing of Outcomes:

Failure of invariance against changes in description.

Program	Risk	Poll Results
A: 200 people will be saved	Risk Averse	72%
C: 400 people will die		22%
B: 1/3 chance 600 be saved; 2/3 chance all die		28%
D: 1/3 chance that nobody will die; 2/3 chance all 600 will die	Risk seeking	78%

Notes on Prospect Theory: Framing

Framing of Outcomes:

Framing effects resemble perceptual illusions more than computational errors. Violation of the dominance requirement of rational choice

Gamble	Your response
A: 25% chance to win $240; 75% chance to lose $760	
B: 25% chance to win $250; 75% chance to lose $750	

Kahneman, D & Tversky, A. (2000). Choices, Values, and Frames. In (Eds.) D. Kahneman, & A. Tversky. *Choices, Values, and Frames*. Cambridge, New York: Cambridge University Press. pp 1-16

Notes on Prospect Theory: Framing

Framing of Outcomes:

Framing effects resemble perceptual illusions more than computational errors. Violation of the dominance requirement of rational choice

Gambling Decision	Poll Results
E: 25% chance to win $240; 75% chance to lose $760	0%
F: 25% chance to win $250; 75% chance to lose $750	100%

Kahneman, D & Tversky, A. (2000). Choices, Values, and Frames. In (Eds.) D. Kahneman, & A. Tversky. *Choices, Values, and Frames*. Cambridge, New York: Cambridge University Press. pp 1-16

Notes on Prospect Theory: Framing

Framing of Outcomes:

Framing effects resemble perceptual illusions more than computational errors. The so-called dominance requirement of rational choice is obeyed in certain cases. For example:

Gamble	Poll Results
A: 25% chance to win $240; 75% chance to lose $760	0%
B: 25% chance to win $250; 75% chance to lose $750	100%

Kahneman, D & Tversky, A. (2000). Choices, Values, and Frames. In (Eds.) D. Kahneman, & A. Tversky. *Choices, Values, and Frames*. Cambridge, New York: Cambridge University Press. pp 1-16

Notes on Prospect Theory: Framing

Framing of Outcomes:

But there are many instance where dominance choice principle is violated

Gambling Decisions	Your response
Decision 1: Choose between	
A: 100% chance or a sure gain of $240	
B: 25% chance of gaining $1000; 75% chance to gain nothing	
Decision 2: Choose between	
C: 100% chance or a sure loss of $750	
D: 75% chance of losing $1000; 25% chance of losing nothing	

Notes on Prospect Theory: Framing

Framing of Outcomes:

But there are many instance where dominance choice principle is violated

Gambling Decisions	Poll Results
Decision 1: Choose between	
A: A sure gain of $240	84%
B: 25% chance of gaining $1000; 75% chance to gain nothing	16%
Decision 2: Choose between	
C: A surety of a $750 loss	13%
D: 75% chance of losing $1000; 25% chance of losing nothing	87%

Notes on Prospect Theory: Framing

Framing of Outcomes:

But there are many instance where dominance choice principle is violated

Gambling Decisions	Poll Results
RISK AVERSE Decision 1: Choose between	
A: A sure gain of $240	84%
B: 25% chance of gaining $1000; 75% chance to gain nothing	16%
RISK SEEKING Decision 2: Choose between	
C: A surety of a $750 loss	13%
D: 75% chance of losing $1000; 25% chance of losing nothing	87%

Notes on Prospect Theory: Framing

Framing of Outcomes:

But there are many instance where dominance choice principle is violated

		A	B	C	D	E	F
Disease	You	69%	31%	50%	42%		
	K&T	72%	28%	22%	72%		
Gambling 1	You					0%	100%
	K&T					0%	100%
Gambling 2	You	44%	56%	8%	92%		
	K&T	84%	16%	13%	87%		

Notes on Prospect Theory: Framing

Framing of Outcomes:

But there are many instance where dominance choice principle is violated. Decisions A&D dominate over B&C. Now, if you take options A&D together means a 75% chance of a loss of $760 ($1000-$240) and 25% (A: 100%- D 75%) chance of wining $240. This combination (A&D) was approved by 84% of respondents but rejected by all when the same decision was framed in Decision E!!!!

Gambling Decisions	Poll Results
RISK AVERSE Decision 1: Choose between	
A: A sure gain of $240	84%
B: 25% chance of gaining $1000; 75% chance to gain nothing	16%
RISK SEEKING Decision 2: Choose between	
C: A surety of a $750 loss	13%
D: 75% chance of losing $1000; 25% chance of losing nothing	87%

Gambling Decision	Poll Results
E: 25% chance to win $240; 75% chance to lose $760	0%
F: 25% chance to win $250; 75% chance to lose $750	100%

Notes on Prospect Theory: Framing

Framing of Outcomes:

But there are many instance where dominance choice principle is violated. Decisions A&D dominate over B&C. Now, if you take options B&C together suggests that a 25% chance to win $250 and a 75% chance to lose $750. The combination B&C has an approval of 13%. BUT, but, a differently framed Decision (F) had an approval rating of 100% !!!!

Gambling Decisions	Poll Results
RISK AVERSE Decision 1: Choose between	
A: A sure gain of $240	84%
B: 25% chance of gaining $1000; 75% chance to gain nothing	16%
RISK SEEKING Decision 2: Choose between	
C: A surety of a $750 loss	13%
D: 75% chance of losing $1000; 25% chance of losing nothing	87%

Gambling Decision	Poll Results
E: 25% chance to win $240; 75% chance to lose $760	0%
F: 25% chance to win $250; 75% chance to lose $750	100%

Notes on Prospect Theory: Framing

Framing of Outcomes:

One might argue that frame invariance should be preserved as invariance is 'normatively essential, intuitively compelling, and psychologically unfeasible' (Kahneman and Tversky 2000:6). One way of doing it will be to look at each decision in terms of total assets rather than in terms of gains or loses – but this is usually not possible except in ruinous circumstances.

Gambling Decisions	Poll Results
RISK AVERSE Decision 1: Choose between	
A: A sure gain of $240	84%
B: 25% chance of gaining $1000; 75% chance to gain nothing	16%
RISK SEEKING Decision 2: Choose between	
C: A surety of a $750 loss	13%
D: 75% chance of losing $1000; 25% chance of losing nothing	87%

Gambling Decision	Poll Results
E: 25% chance to win $240; 75% chance to lose $760	0%
F: 25% chance to win $250; 75% chance to lose $750	100%

Notes on Prospect Theory: Framing

Framing of Outcomes:

Equally, it is not possible to compound all the outcomes of concurrent decisions (A&B and C&D) because this will be beyond the limits of intuitive computation. And the case of pandemics and other major catastrophies, one is being asked to 'aggregate' overall mortality, mortality due to diseases, or number of fatalities associated with the particular disease in consideration.

Program	Poll Results
A: 200 people will be saved	72%
C: 400 people will die	22%
B: 1/3 chance 600 be saved; 2/3 chance all die	28%
D: 1/3 chance that nobody will die; 2/3 chance all 600 will die	78%

The Value Function

Kahneman and Tversky's *prospect theory* helps in computing utility over gains and losses – *returns*- rather than levels of wealth. The value function in prospect theory is defined as:

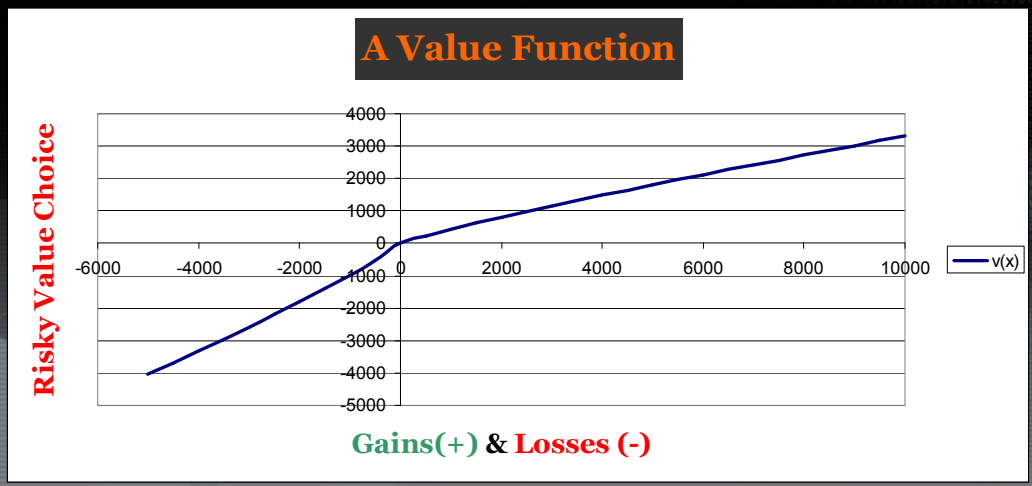
$$v(x) = \begin{cases} x^{\alpha} & if \ x \geq 0 \\ -\lambda(-x)^{\beta} & if \ x < 0 \end{cases}$$

Kahneman and Tversky have estimated α, β and λ, the loss aversion coefficient, as

$$\alpha \approx 0.88;$$
$$\beta \approx 0.88;$$
$$\lambda \approx 2.25$$

Benartzi, Shlomo & Thaler, Richard H. (2000). Myopic Loss Aversion and Equity Premium Puzzle. In (Eds.) Daniel Kahneman & Amos Tversky. *Choices, Values and Frames*. New York: Cambridge Univ. Press. pp 301-316

The Value Function



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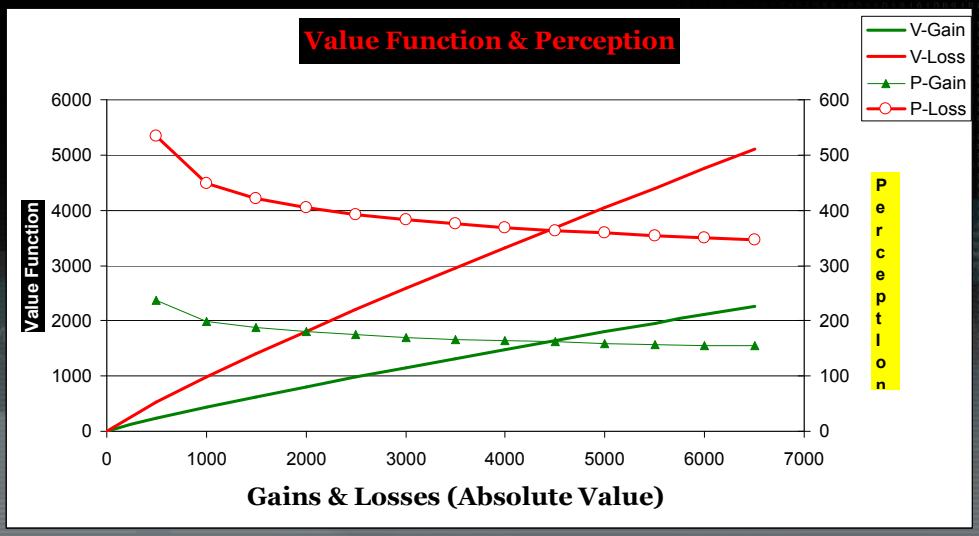
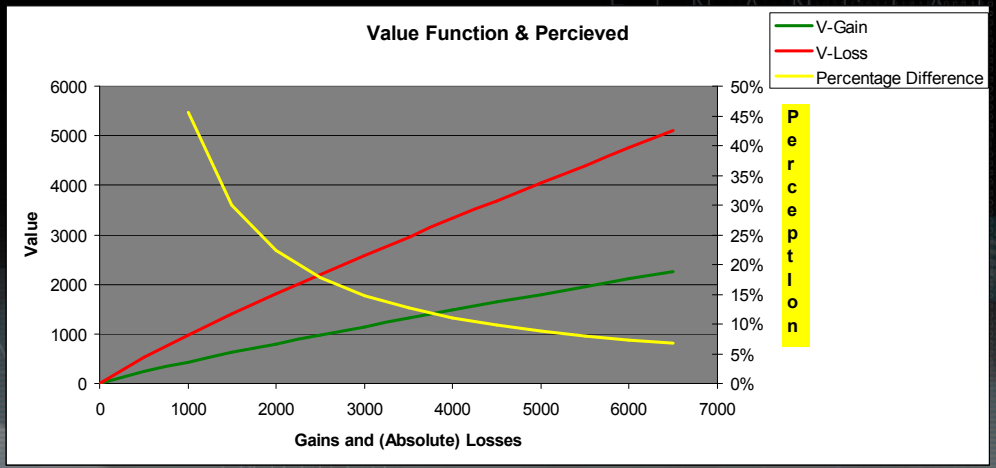


The Value Function



Value Function and Mental Accounting

Principles of Hedonic Framing: alternative frames of mental accounts lead to different prospective value.

Observation	Action
Gain function is concave	**Segregate gains**
Loss Function is convex	**Integrate Losses**
Offset Loss Aversion	**Integrate smaller losses with larger gains**
Gain function is steepest at the origin	**Segregate small gains → silver linings**

Thaler, Richard (2000). 'Mental Accounting Matters. In (eds.) Daniel Kahneman and Amos Trevsky., pp 241-268

Prospect Theory:
Mental Accounting

What will you do to save €5?

Your local 'superstore', Loc-Money sells calculators and DVD players. A well known brand of calculator will cost €15 and an equally well known DVD player is selling for €125. There is a chatty salesperson who just lets you know that there are two new specialist stores opened –Zippity specializing in calculators (and computers) and Seeall specialising in DVDs. Both are discounting heavily to get more custom and are giving €5 euros less than Loc-Money , but are 20 minutes walk from Loc-Money.

Calculator: Will you go to Zippity to save €5 on the purchase of the calculator?

DVD: Will you go to Seeall to save €5 on the purchase of the DVD?

Prospect Theory:
Mental Accounting

		Stay at Loc-Money	Go to Zippitty
Calculator	YOU!!	29%	71%
	K&T	32%	68.00%
		Stay at Loc-Money	Go to Seeall
Jacket	YOU!!	36%	64%
	K&T	71%	29%

Prospect Theory:
Mental Accounting

Accounting: The action or process of reckoning, counting, or computing; numeration, computation. Now esp. the management of financial affairs, e.g. those of a business enterprise (OED).

Accounting is governed by the laws of the Land, conventions, and precedence.

Prospect Theory:
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Prospect Theory:
Mental Accounting

Accounting: System of recording and summarizing business and financial transactions in books, and analyzing, verifying, and reporting results.

Mental Accounting: The set of cognitive operations used by individuals and households to organize, evaluate, and keep track of financial activities → psychology of choice.

Thaler, Richard (2000). 'Mental Accounting Matters. In (eds.) Daniel Kahneman and Amos Trevsky., pp 241-268

Prospect Theory:
Mental Accounting

Mental Accounting: The set of cognitive operations used by individuals and households to organize, evaluate, and keep track of financial activities.

Three 'components' of mental accounting:

1. How outcomes are perceived and experienced & how decisions are made and subsequently evaluated;
2. Assignment of activities to specific accounts;
3. Frequency by which accounts are evaluated and read.

Thaler, Richard (2000). 'Mental Accounting Matters. In (eds.) Daniel Kahneman and Amos Trevsky., pp 241-268

Prospect Theory:
Mental Accounting

Mental Accounting: The set of cognitive operations used by individuals and households to organize, evaluate, and keep track of financial activities.

Accounting decisions as to which category to assign a purchase, whether to combine with others in that category, and how often to 'balance' the [mental account] 'books' can affect the perceived attractiveness of choices.

Thaler, Richard (2000). 'Mental Accounting Matters. In (eds.) Daniel Kahneman and Amos Trevsky., pp 241-268

Prospect Theory:
Mental Accounting

OED: When a thing which is the subject of an obligation..must be delivered in specie [In kind; in respect of kind; specifically], the thing is not fungible, i.e. that very thing, and not another thing of the same or another class in lieu of it must be delivered. Where the subject of the obligation is a thing of a given class, the thing is said to be fungible, i.e. the delivery of any object which answers to the generic description will satisfy the terms of the obligation.

Thaler: Mental accounting violates the economic notion of fungibility. Money in one mental account is not a perfect substitute for money in another account. Because of violations of fungibility, mental accounting matters.

Thaler, Richard (2000). 'Mental Accounting Matters. In (eds.) Daniel Kahneman and Amos Trevsky., pp 241-268

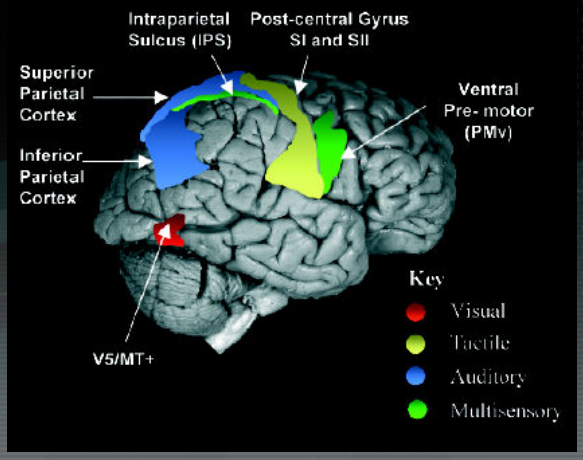
Numerosity: *distance* and *magnitude* effect phenomena → Psychophysical 'Laws'

- The greater occurrence of errors found when comparing numbers that are close together in magnitude as opposed to further apart is known as the **distance effect.**
- **The magnitude effect is the drop in performance observed when comparing numbers that are equal in distance, but have larger magnitudes.**
- **Fechner's law** states that the perceived intensity of a number stimulus is proportional to the logarithm of the actual intensity→**hence the internal representation of number is *compressed* at higher magnitudes.**

Neural Correlates of Behaviour:
Modality and Neuronal Correlation

Neural underpinnings of Multisensory Motion Integration:

'In addition to […] modality-specific motion-processing areas, there are a number of brain areas that appear to be responsive to motion signals in more than one sensory modality [….] the **IPS**, [..] **precentral gyrus** can be activated by auditory, visual or tactile motion signals'



Soto-Faraco, S. *et al* (2004). 'Moving Multisensory Research Along: Motion Perception Across Sensory Modalities'. *Current Directions in Psy. Sci.* Vol 13(1), pp 29-32

Neural Correlates of Behaviour:
Synaesthesia and beyond

Stimulation in one modality results in simultaneous subjective experience in another modality

• 1 in 2000 people (6:1 female/male ratio) associate words or letters with particular colours;

• Vision-touch Synaesthesia in which vision and tactile perception are inextricably linked (Blakemore et al 2005):
  - •The observation of somebody being touched is experienced as tactile simulation on the equivalent part of the synaesthesteʼs own body;
  - • IPS sulcus 'contains bimodal cells responsive both to visual and tactile stimulation' (Blakemore et al 2005:1580)

Blakemore, S.J., Bristow, D., Bird, G., & Ward, J. (2005). 'Somatosensory activations during the observation of touch and a case of vision-touch synaesthesia'. *Brain* Vol. 128, pp 1571-1583

Neural Correlates of Behaviour:
Synaesthesia and beyond

Stimulation in one modality results in simultaneous subjective experience in another modality

•Blakemore et al have reported fMRI studies of a synaesthetic female and 12 healthy male volunteers to assess the following reasons of vision-touch synaesthesia

- The somatosensory regions are over-activated during the observation;
- There is a direct, hitherto unknown, connectivity between visual and somatosensory regions;
- Bi-modal cells in the parietal cortex, specifically the intraparietal sulcus, which respond to both visual and tactile stimuli.

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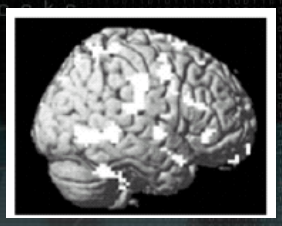
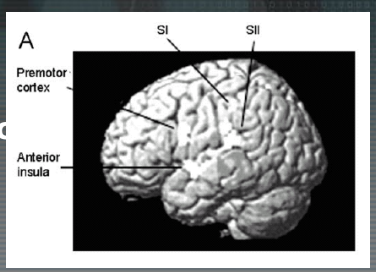
'Healthy



Synasetheti



Blakemore, S.J., Bristow, D., Bird, G., & Ward, J. (2005). 'Somatosensory activations during the observation of touch and a case of vision-touch synaesthesia'. *Brain* Vol. 128, pp 1571-1583

Learning to Compute:
Cross-Modal Interaction and Spatial Attention

The key to spatial attention is that different stimuli, visual and auditory, help to identify the spatial location of the object generating the stimuli.

One argument is that there may be a neuronal correlate of such crossmodal interaction between two stimuli.

Information related to the location of the stimulus (*where*) and identifying the stimulus (*what*) appears to have correlates at the neuronal level in the so-called *dorsal* and *ventral* streams in the brain.

Learning to Compute:
Cross Modal Interaction and 'Numerical' Neurons

Numerosity*, *numerons*, *single neuron arithmetic **and *number sense* in humans and some primates.**

- **Observations on enumeration without having been taught a number system, *subitisation* or visual enumeration, or approximate calculation without rigorously carrying out arithmetic procedures, lead to the speculation that there may be areas in the brain where the visuo-spatial information about the objects, for instance, is processed such that the number information is preserved**

Learning to Compute:
Numerosity, Number Sense and 'Numerons'

- Number sense has played a major role in psychology where many earlier studies were dedicated to 'the mathematical description of how a continuum of sensation, such as loudness or duration' is represented in the brain/mind.
- The 19th century psychophysicist, Gustav Fechner, had observed that 'the intensity of subjective sensation increases as the logarithm of the stimulus intensity'.
- One of the 21st century rendition of this 'law' is that the 'external stimulus is scaled into a logarithmic internal representation of sensation'

Learning to Compute:
Numerosity, Number Sense and 'Numerons'

- Number related behaviours 'depend on the capacity to abstract information from sensory inputs and to retain it in memory' and that in monkeys this capacity is in the 'prefrontal cortex' and there are reports of activation in humans in proximate regions of the brain.
- As predicted by Fechner, there is a compressed scaling of numerical information, and this information is stored in the prefrontal cortex of the monkey and the parietal cortex of the human.

Learning to Compute:
Numerosity, Number Sense and 'Numerons'

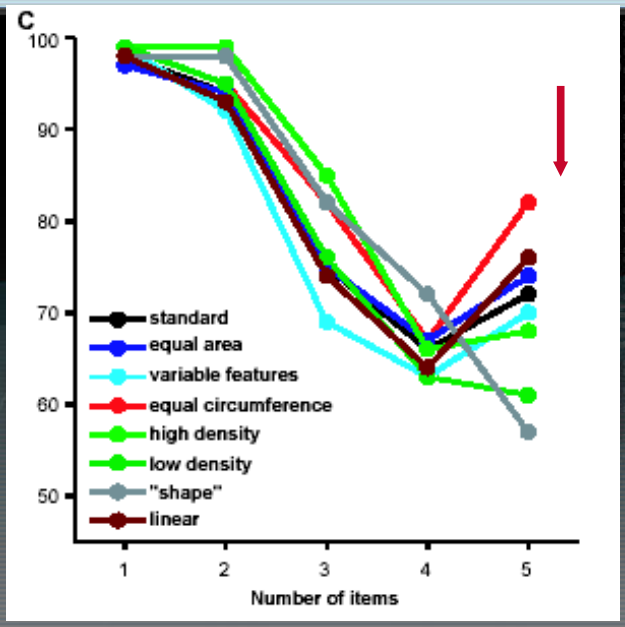
Neider et al report over a third of the 352 randomly selected neurons from the lateral prefrontal cortex of two monkeys 'showed activity that varied significantly with the number of items in the sample display': this suggests that certain neurons specialise as 'number detectors' – the illusive numerons perhaps have been found.

The two key areas involved are the principal sulcus and arcuate sulcus[1].

[1]Nieder, A., & Miller, E. K. (2003). 'Coding of Cognitive Magnitude: Compressed Scaling of Numerical Information in Primate Prefrontal Cortex'. *Neuron* Vol 37, pp 149-157.

Learning to Compute:
Numerosity, Number Sense and 'Numerons'

'Monkeys watched two displays (first sample, then test) separated by a 1-s delay. [the displays varied in shape, size, texture and so on.] They were trained to release a lever if the displays contained the same number of items. Average performance of both monkeys was significantly better than chance for all tested quantities, with a decline when tested for higher quantities similar to that seen in humans performing comparable tasks.



Andreas Nieder, David J. Freedman, Earl K. Miller (2002). 'Representation of the Quantity of Visual Items in the Primate Prefrontal Cortex'. *Science* Vol. 297, pp 1709-11.

Learning to Compute:
Numerosity, Number Sense and 'Numerons'

- The compressed number line theory can be used to explain the observation that neonates and monkeys, and adults in a hurry, can accurately enumerate quantities less than 5 without recourse to overt counting.
- Higher numbers cannot be enumerated with any accuracy through visual enumeration or *subitisation* and that within the numbers 1-5, there is a diminution in accuracy as we approach the higher number.
- Subitisation is sometimes related to the existence of 'preverbal numerical abilities'

Processes in Prospect Theory

http://io.uwinnipeg.ca/~epritch1/jdm99b.htm

Mental operation	That facilitates the Decision Makers to
1. *coding*	(1.1) define an (arbitrary?) reference point (1.2) cast the options in terms of gains and losses
2. *combination*	aggregate the likelihood of events that present identical outcomes
3. *segregation*	(3.1) focus on the aspects they find most relevant to the problem, (3.2) omit others aspects
4. *cancellation*	ignore the dimensions in the evaluation of two alternatives that are identical
5. *simplification and dominance*	(5.1) round up probabilities (5.2) discard small probabilities are discarded and highly likely outcomes are treated as certainties

Processes in Prospect Theory

Prospect theory assumes the following:
Discontinutity of weighting function
Subadditivity
Subcertainty
Regressiveness
Reference Point
Slope of value function - Prospect theory assumes that losses have greater weight than gains, which explains why people tend to be risk seeking for losses but not for gains.

http://io.uwinnipeg.ca/~epritch1/jdm99b.htm

Processes in Prospect Theory

Translation - People take the outcome of the available alternatives and translate them into subjective values, and similarly they translate the probabilities associated with those outcomes into decision weight (ã)
Combination - After the translation, the values & weights are combined into prospect values.
Decision - The prospect values are then applied to make the appropriate decision - whether that be an evaluation or a choice.

http://io.uwinnipeg.ca/~epritch1/jdm99b.htm

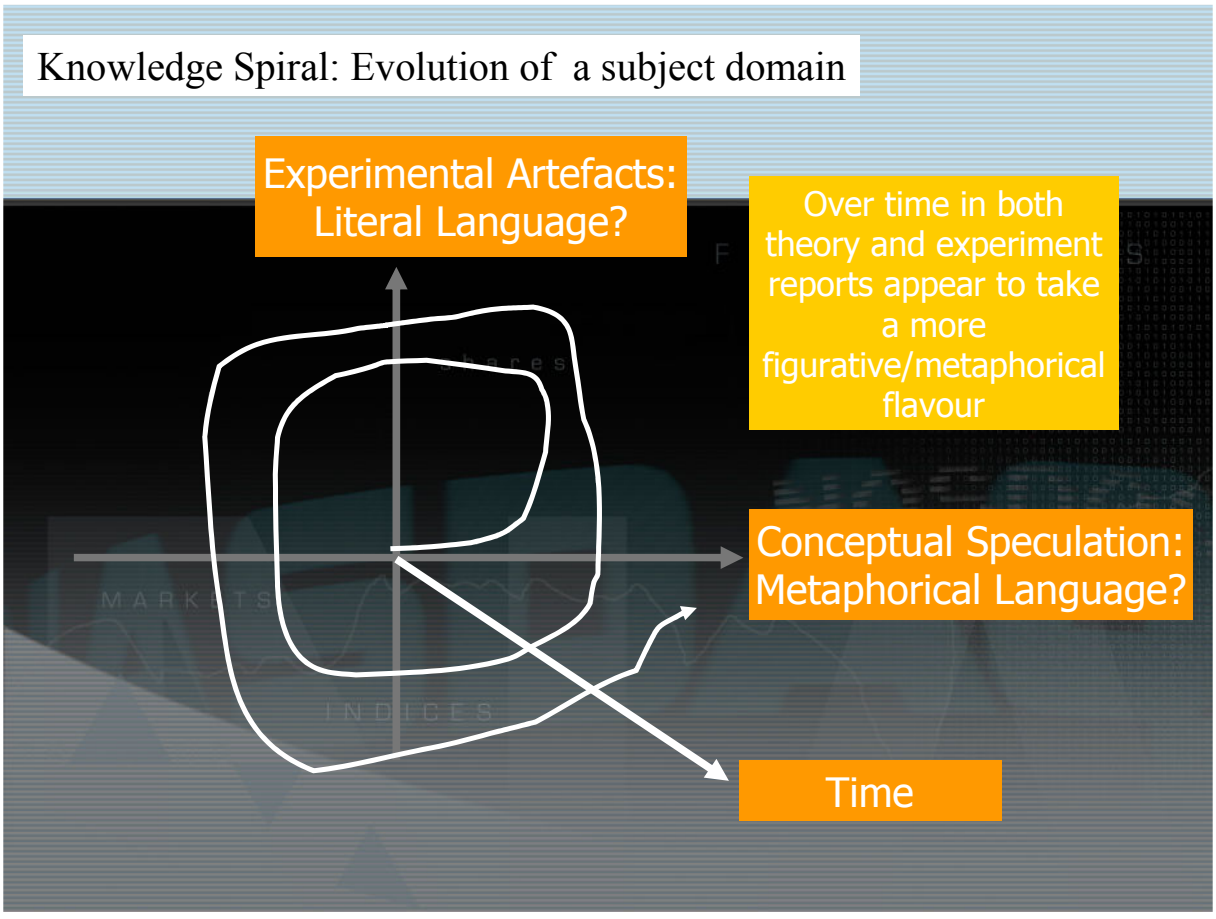
After Prospect Theory?

You have just been through a lecture where we have looked at two different theories of decision making in economics and finance.

Almost all theories provide a partial explanation, description and sometimes prediction of a complex phenomenon. The explanation, description and prediction of human behaviour is not an easy task. So utility theory provides an understanding some economic behaviour and prospect theory of other economic behaviour.

Theories are constantly modified, updated, refined and occasionally discarded. Experimentation and theorising have a symbiotic relationship – one reinforces and eggs the other one on. Here is an example from the growth of nuclear physics

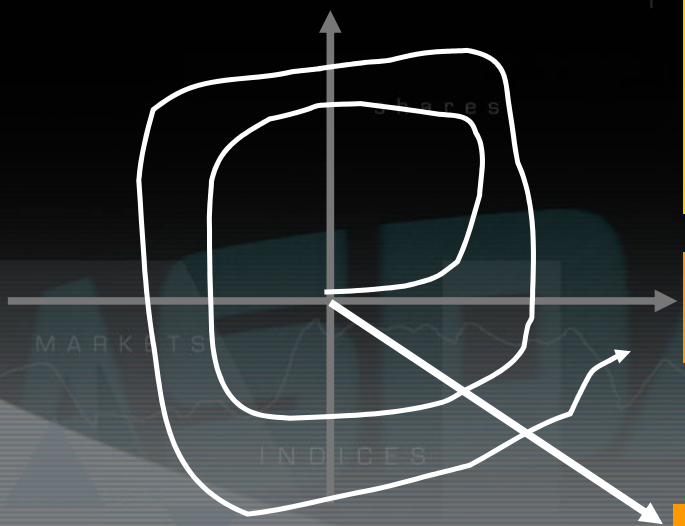
Knowledge Spiral: Evolution of a subject domain



Knowledge Spiral: Evolution of nuclear physics

Experimental Artefacts: Literal Language?

Over time in both theoretical and experimental nuclear physics, reports appear to take a more figurative/metaphorical flavour



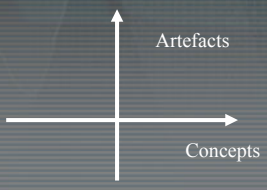
Conceptual Speculation: Metaphorical Language?

Time

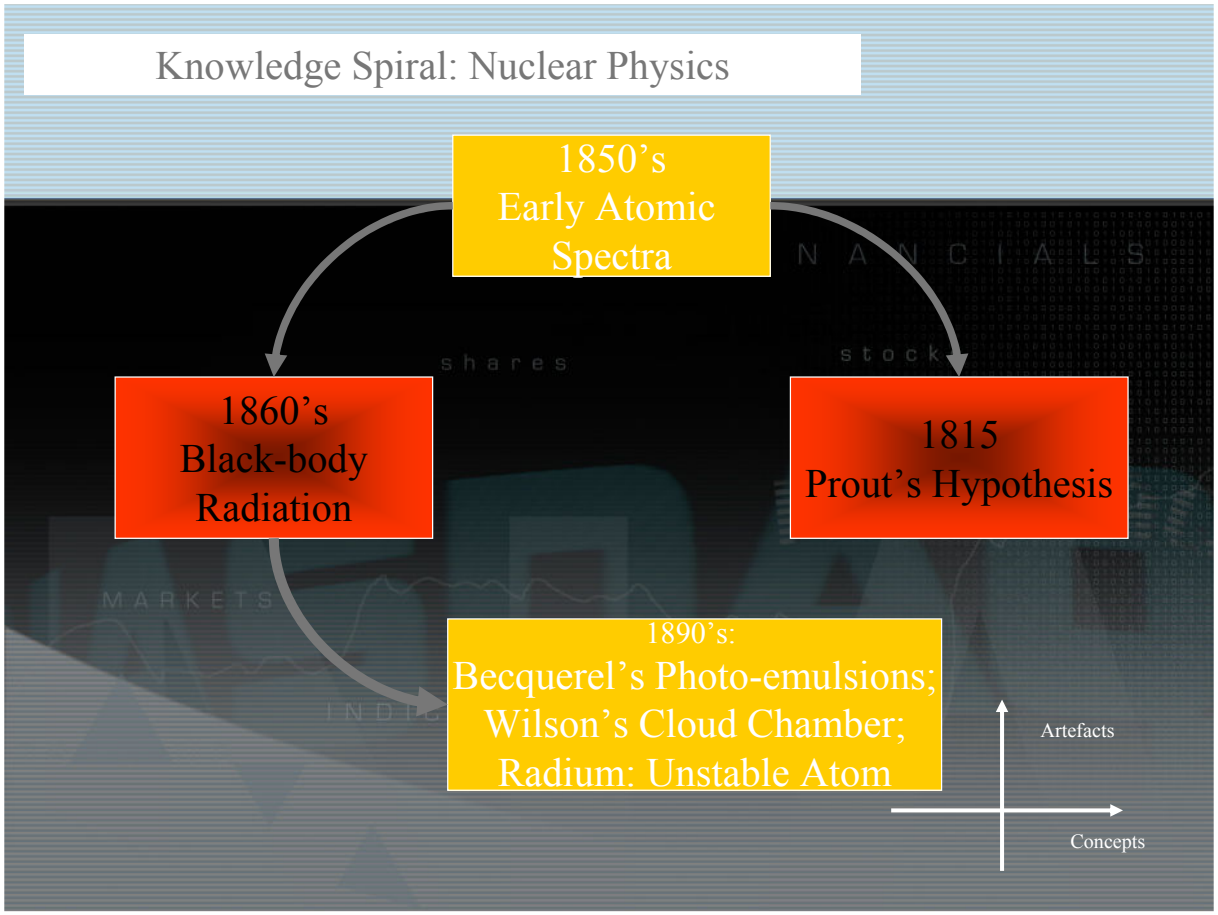
Knowledge Spiral: Nuclear Physics

A visible, sensuous, perceptible, literal Universe: Comprising indivisible atoms and governed by deterministic equations of motion

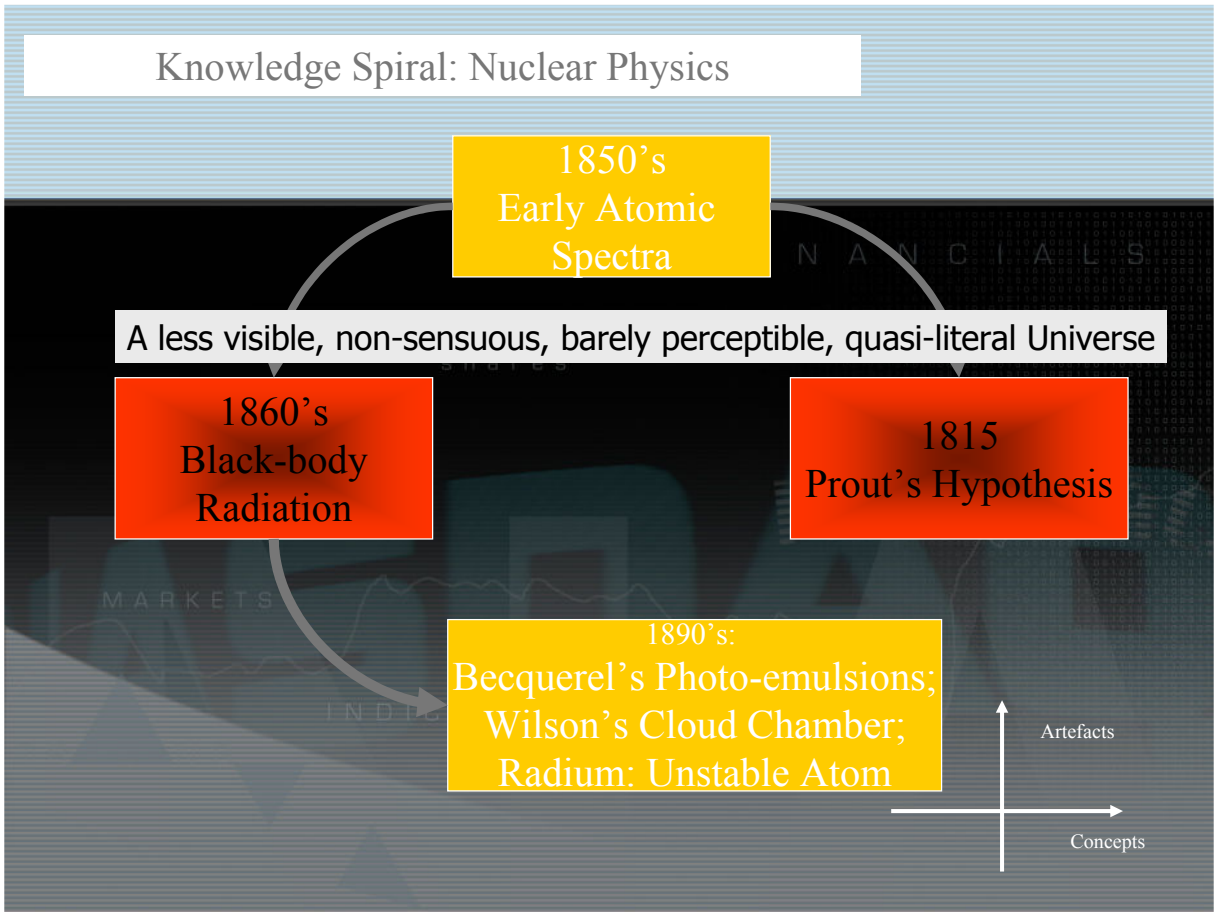
1815: Prout's Hypothesis
(Specific gravities are integral multiples of hydrogen)

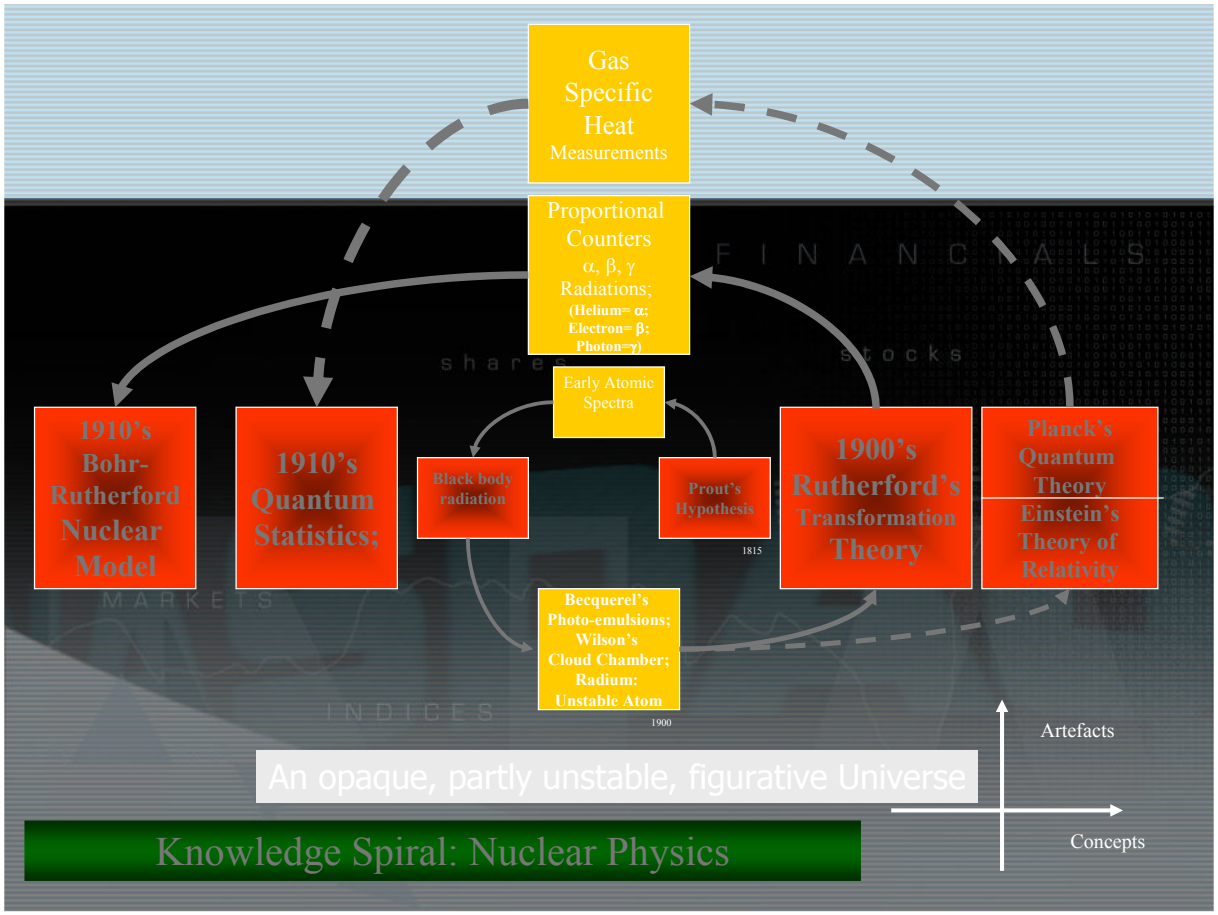


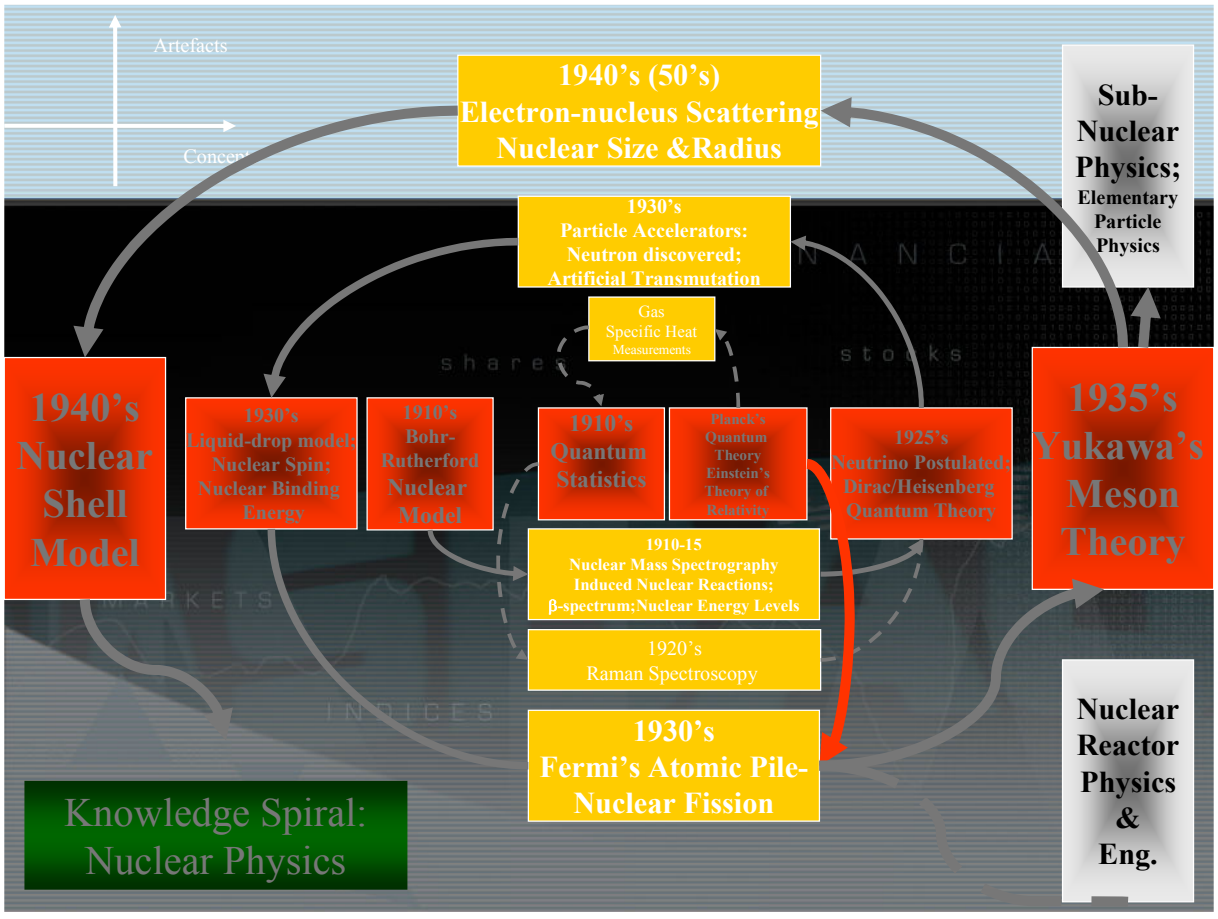
Knowledge Spiral: Nuclear Physics

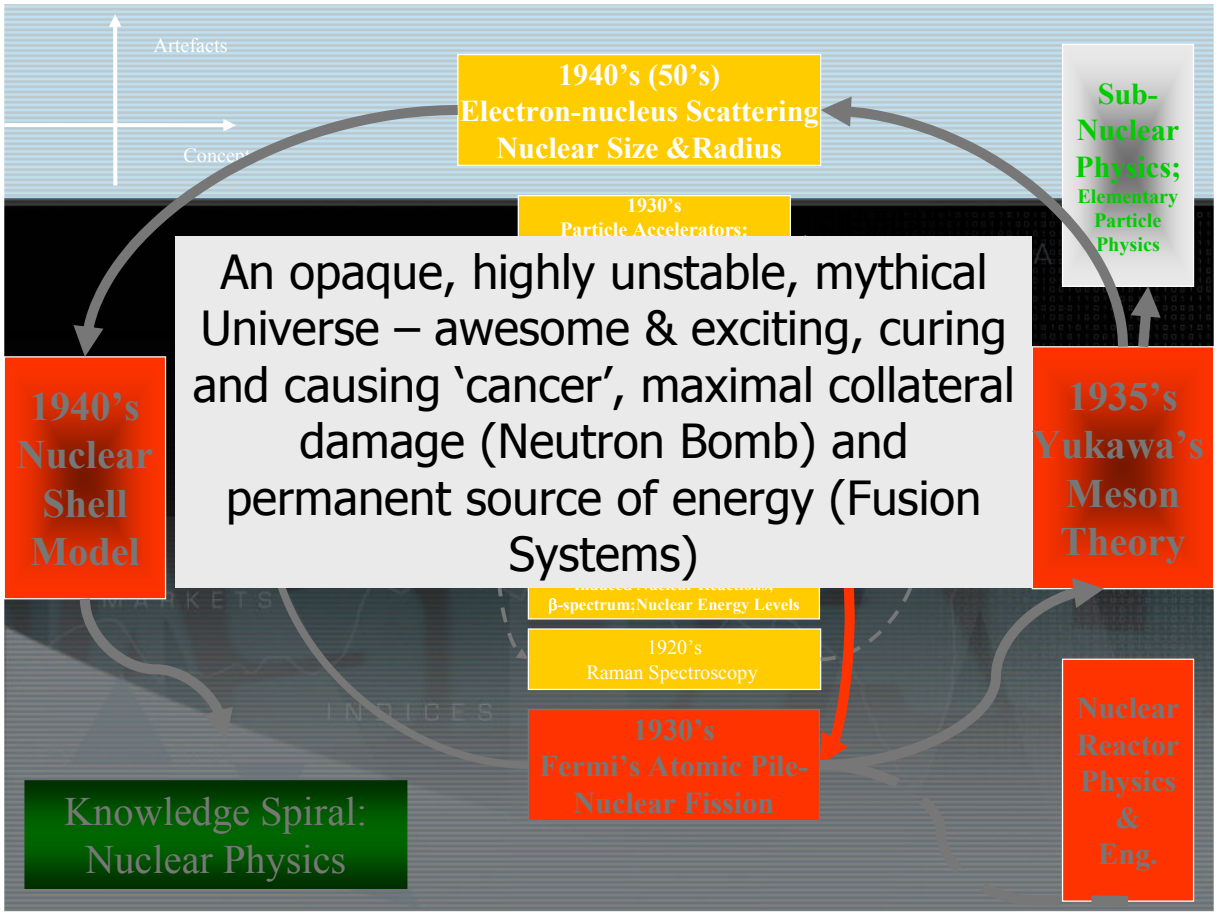


Knowledge Spiral: Nuclear Physics

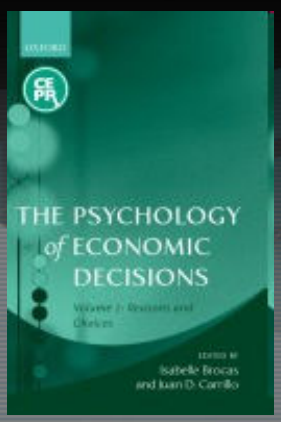



Gas Specific Heat Measurements
Proportional Counters α, β, γ Radiations; (Helium= α; Electron= β; Photon=γ)
Early Atomic Spectra
1910's Bohr-Rutherford Nuclear Model
1910's Quantum Statistics;
Black body radiation
Prout's Hypothesis
1815
1900's Rutherford's Transformation Theory
Planck's Quantum Theory
Einstein's Theory of Relativity
Becquerel's Photo-emulsions; Wilson's Cloud Chamber; Radium: Unstable Atom
1900
Artefacts
Concepts
An opaque, partly unstable, figurative Universe
Knowledge Spiral: Nuclear Physics


Artefacts
1940's (50's) Electron-nucleus Scattering Nuclear Size &Radius
Sub-Nuclear Physics; Elementary Particle Physics
1930's Particle Accelerators: Neutron discovered; Artificial Transmutation
Gas Specific Heat Measurements
1940's Nuclear Shell Model
1930's Liquid-drop model: Nuclear Spin; Nuclear Binding Energy
1910's Bohr-Rutherford Nuclear Model
1910's Quantum Statistics
Planck's Quantum Theory Einstein's Theory of Relativity
1925's Neutrino Postulated; Dirac/Heisenberg Quantum Theory
1935's Yukawa's Meson Theory
1910-15 Nuclear Mass Spectrography Induced Nuclear Reactions; β-spectrum;Nuclear Energy Levels
1920's Raman Spectroscopy
1930's Fermi's Atomic Pile-Nuclear Fission
Nuclear Reactor Physics & Eng.
Knowledge Spiral: Nuclear Physics



Decision Making



The psychology of economic decisions
Von Isabelle Brocas, Juan D. Carrillo
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Oxford University Press, 2004
ISBN 0199257213, 9780199257218

Processes in Prospect Theory

The behavioural outcome of an estimation task may simply be the result of multiple, diverse scaling schemes at different processing stages. In other words, at the behaviour level, it may look like magnitude estimations are following Weber-Fechner laws, but the underlying neural code could actually look quite different.