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Why the most risk averse people sometimes take the riskiest decisions.

A perspective from psychology

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Context: a **tale of two headlines** on the same day (both reporting on the NREFS results)

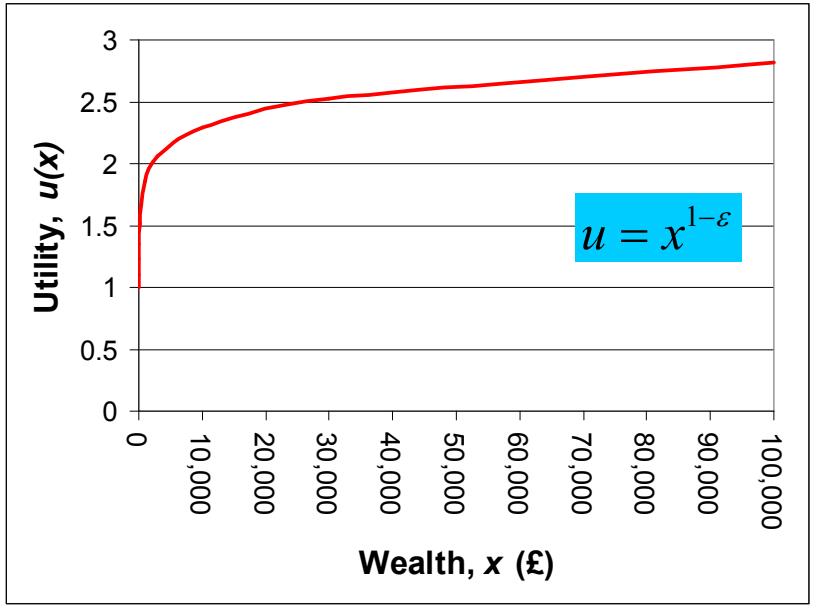
Nuclear disaster fallout 'would be no worse than living in London'
Oliver Moody, Science Correspondent
November 23 2017, 12:01am, ***The Times***

Living in London 'poses same risk to health as living in nuclear fallout zone'
Alexandra Richards, 23 November 2017
08:42, ***Evening Standard***

Risk aversion

- The Prime Minister of Japan was seriously considering evacuating Tokyo.
- In the end the Government asked 111,000 people to move out and a further 49,000 self-evacuated. 85,000 had not returned 5 years later.
- But no-one advocated that London be evacuated.

Mathematical/economic definition of risk-aversion in terms of utility of wealth



The mathematical definition of **risk-aversion, ε,** is found to correspond well with its every-day interpretation

Let m be the marginal utility of wealth:

$$m = \frac{du}{dx}.$$

The elasticity, η, of the marginal utility of wealth is the normalised derivative:

$$\eta = \frac{x}{m}\frac{dm}{dx}$$

Risk-aversion, ε, is the negative of η:

$$\varepsilon = -\frac{x}{m}\frac{dm}{dx} = -x\frac{u''(x)}{u'(x)}$$

This is dimensionless, making it possible **to generalise to quantities other than money**.

The psychological perspective

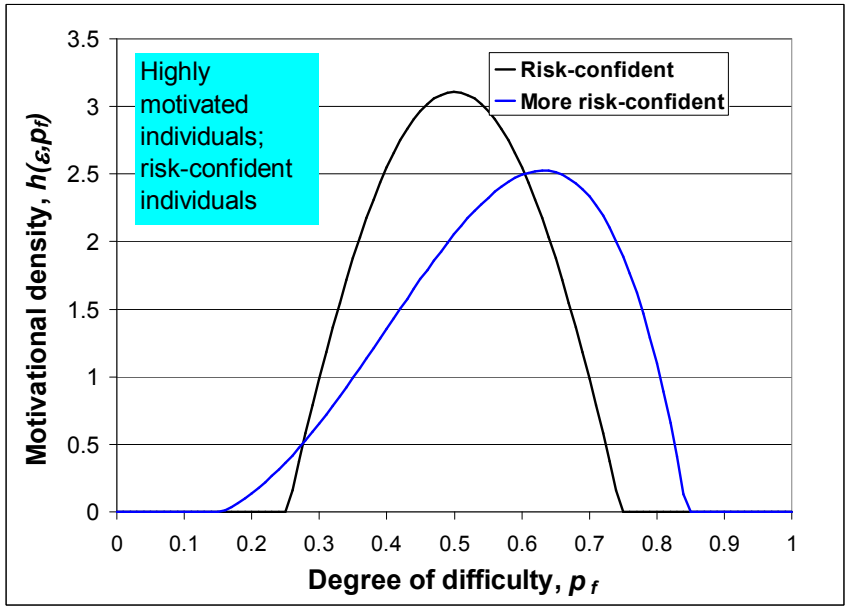
The hoop the peg experiments of John W. Atkinson, US psychologist (1923 – 2003)

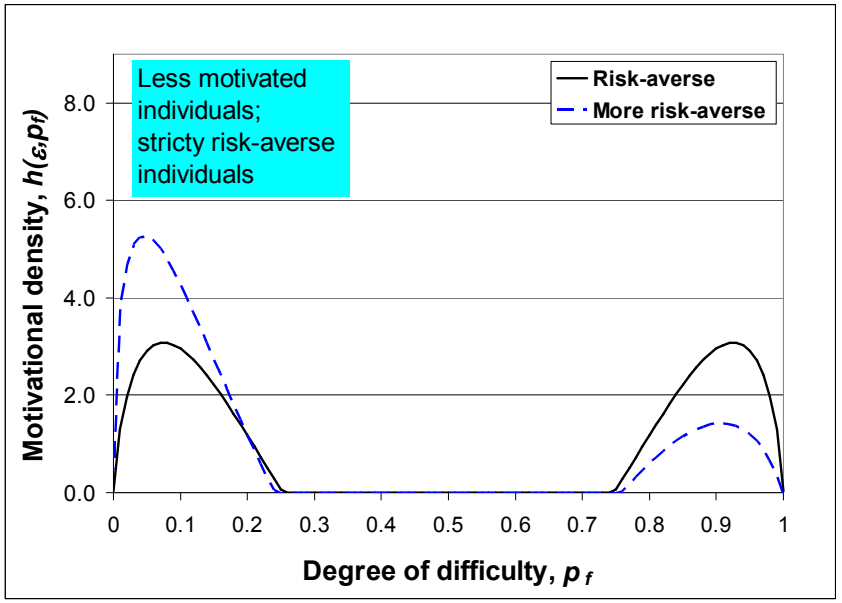
The experiment

- Let a group of people play hoop the peg and observe the distance they throw from.
- Measure, in an independent test, their motivation to achieve.
- Compare the two measurements.
- Draw conclusions.

- Atkinson's insight was that there were two competing pressures: (i) **motivation to achieve** and (ii) **motivation to avoid failure**. **Net motivation** was then simpy **the first minus the second**.
- He produced a simple mathematical model that came close to explaining the observed modes of behaviour.
- A **utility-disutility model** following Atkinson's insight, with risk-aversion, ε, as parameter can provide a good explanation of the distinctive modes observed.

5 year olds playing the game: modes of behaviour





Atkinson, J. W., 1957, "Motivational determinants of risk-taking behaviour", *Psychological Review*, Vol. 64, No. 6, 359 – 372.

Thomas, P. J., 2013, "The importance of **risk-aversion** as a measurable psychological parameter governing risk-taking behaviour", *Journal of Physics:Conference Series 459* http://iopscience.iop.org/1742-6596/459/1/012052

Atkinson's further study on university students

- The 1957 study had pinpointed the underlying modes, but good quantitative data was lacking.
- So in 1960 Atkinson followed it up with a further study on 45 male university students:
  - **Atkinson, J. W. and Litwin, G. H., 1960, "Achievement motive and test anxiety conceived as motive to approach success and motive to avoid failure", *Journal of Abnormal and Social Psychology*, Vol. 60,No. 1, 1960, 52 – 63.**

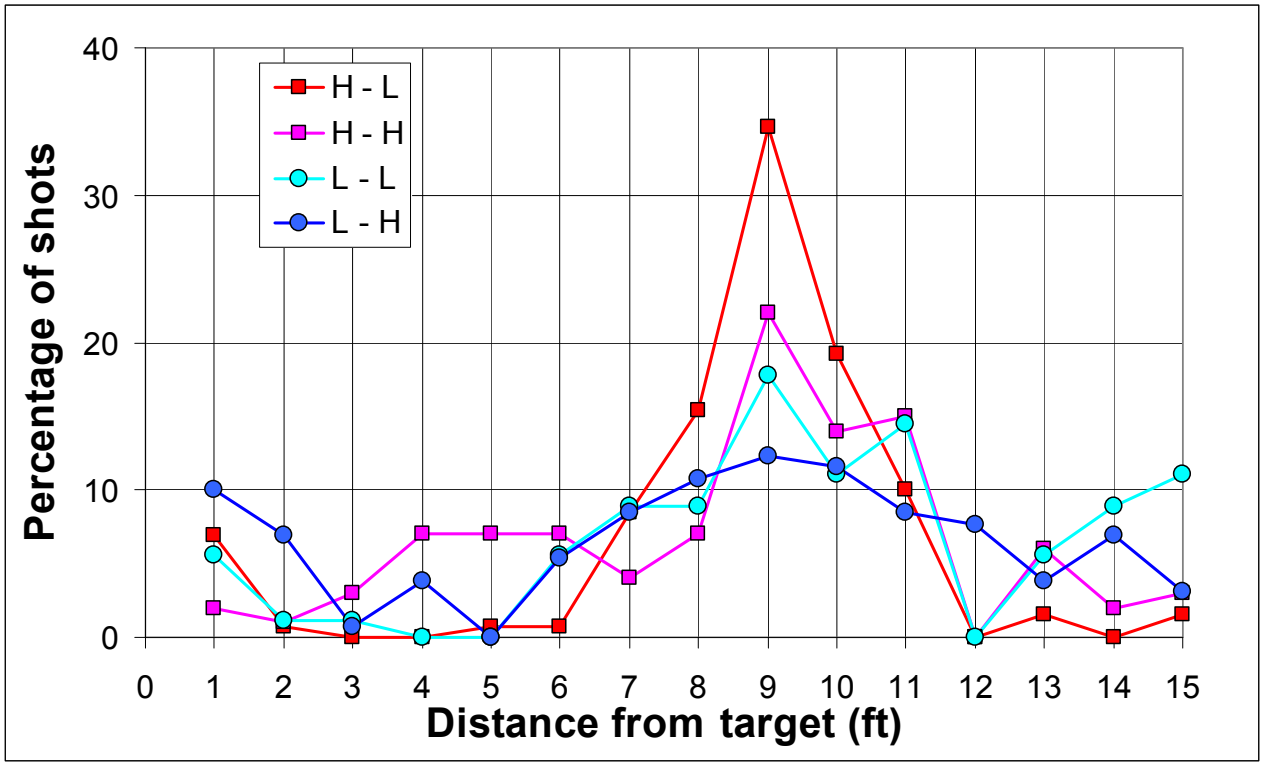
Independent tests allowed the cohort of 45 to be split into 4 groups:

1. Group 1, **high desire to achieve** and **low level of test anxiety**: **"H – L"** (13 subjects)
2. Group 2, **high desire to achieve** and **high level of test anxiety**: **"H – H"** (10 subjects)
3. Group 3, **low desire to achieve** and **low level of test anxiety**: **"L – L"** (9 subjects)
4. Group 4, **low desire to achieve** and **high level of test anxiety**: **"L – H"** (13 subjects)

A set of lines at discrete distances from the target were marked on the ground: at 1 foot, 2 feet, 3 feet, ..., and 15 feet (1 ft = 0.3048 m), and the students were given the instructions:

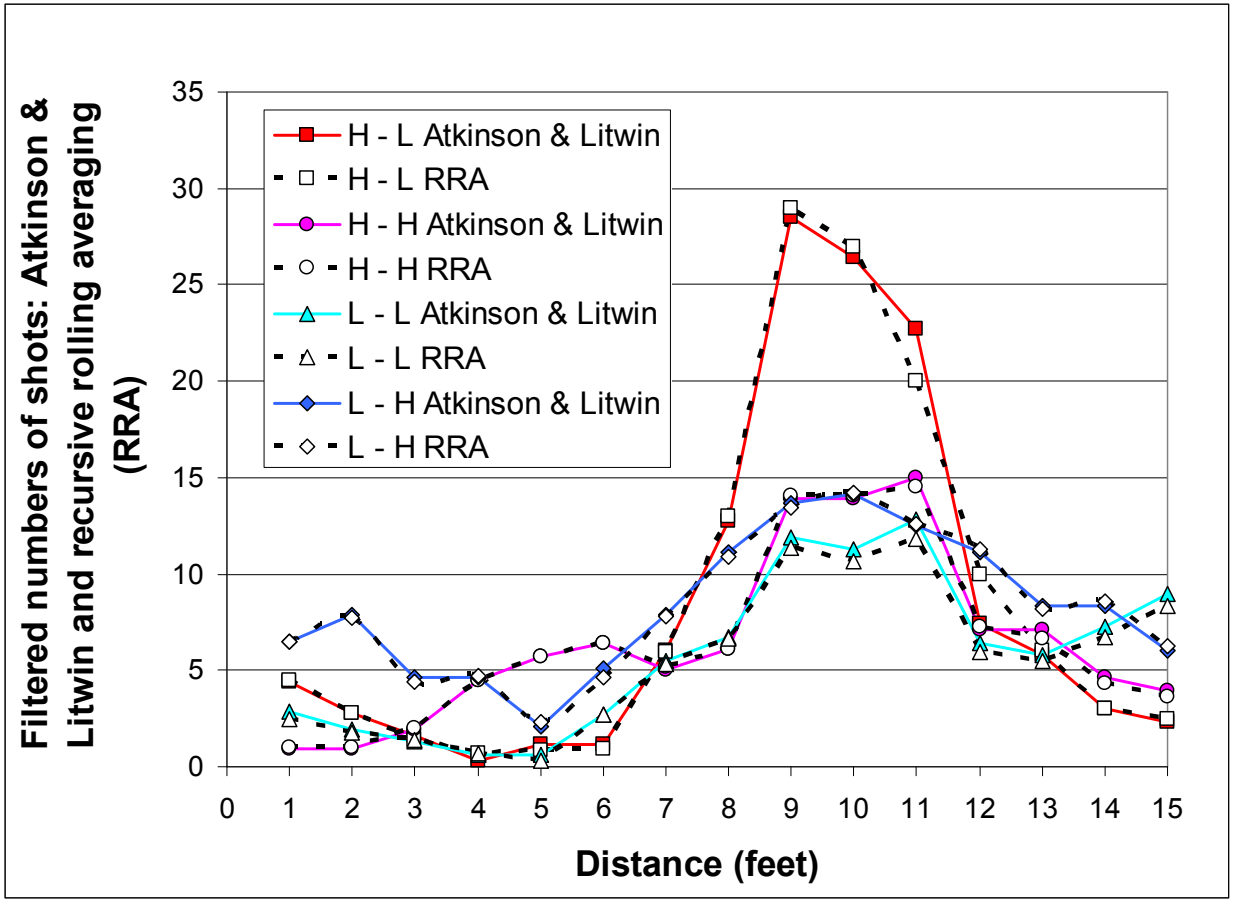
"Today you are going to play a ring toss game. You will have an opportunity to take 10 shots at the target from any line you wish. You may move after each shot or shoot from the same line. Someone will record your shots and get your code number when you finish. We want to see how good you are at this."

Atkinson's and Litwin's recorded shots (after deconvolution to remove the filtering they imposed)



1. H – L
2. H – H
3. L – L
4. L - H

Matching of shots after re-filtering to match Atkinson and Litwin filtered results



Points to note

- None of the groups conformed solely to either
  1. a risk-confident mode, or
  2. a strictly risk-averse mode.
- But the most achievement-minded (H – L) group took many more of its throws from mid-range positions than any other group.
- The group, L – H, spread its pitching positions over a much more evenly spread set of positions.
- The other two groups (H – H and L – L) exhibited behaviour somewhere between these extremes.

Modelling the observed behaviour

The behaviour of the groups may be modelled by a new probability density that is the expected value of a new, random probability density,

$$G\left(p_m \middle| \varepsilon_1, \varepsilon_2\right)$$

with an expected or average value:

$$E\left(G\left(p_m \middle| \varepsilon_1, \varepsilon_2\right)\right) = \alpha h\left(p_m \middle| \varepsilon_1\right) + \left(1-\alpha\right) h\left(p_m \middle| \varepsilon_2\right)$$

Risk-aversion is now regarded as a random variable that may take one of two values: negative risk-aversion for risk-confidence

$$\varepsilon_1 = -1.02$$

postive risk-aversion for true risk aversion

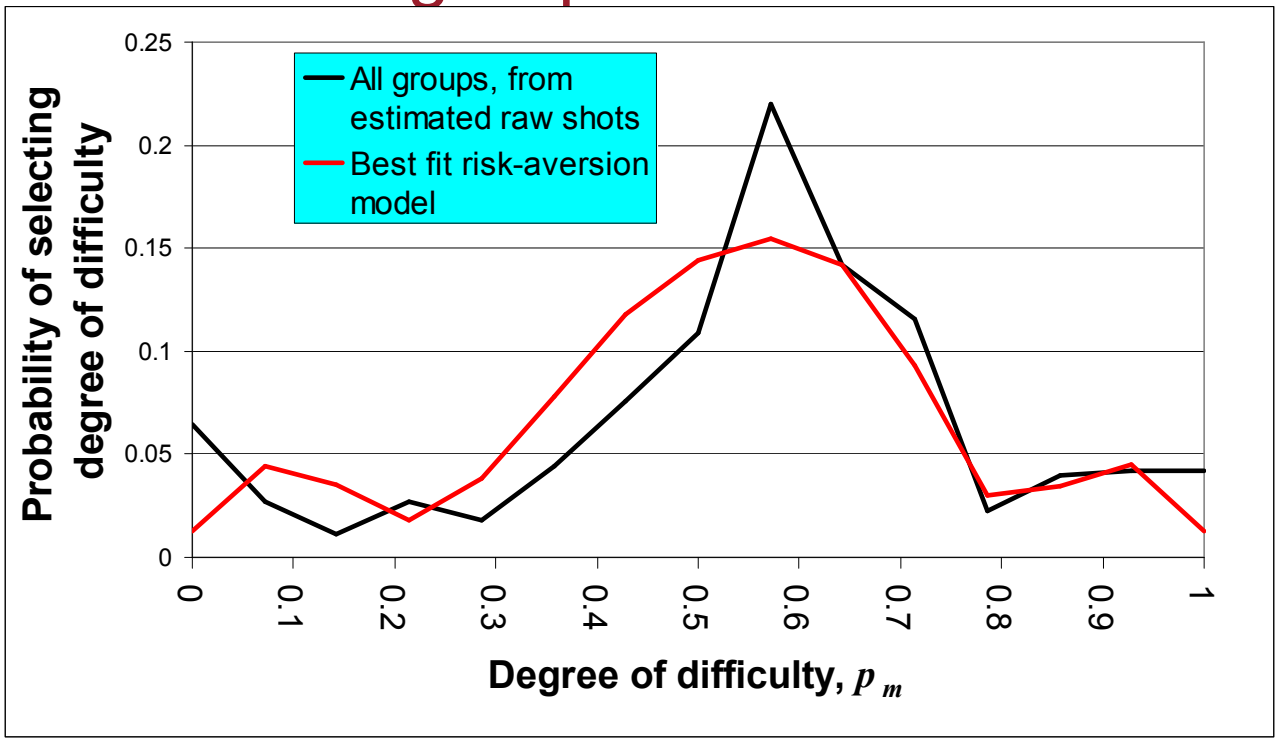
$$\varepsilon_2 = +1.0 \times 10^{-5}$$

α is the propensity to display risk confident behaviour

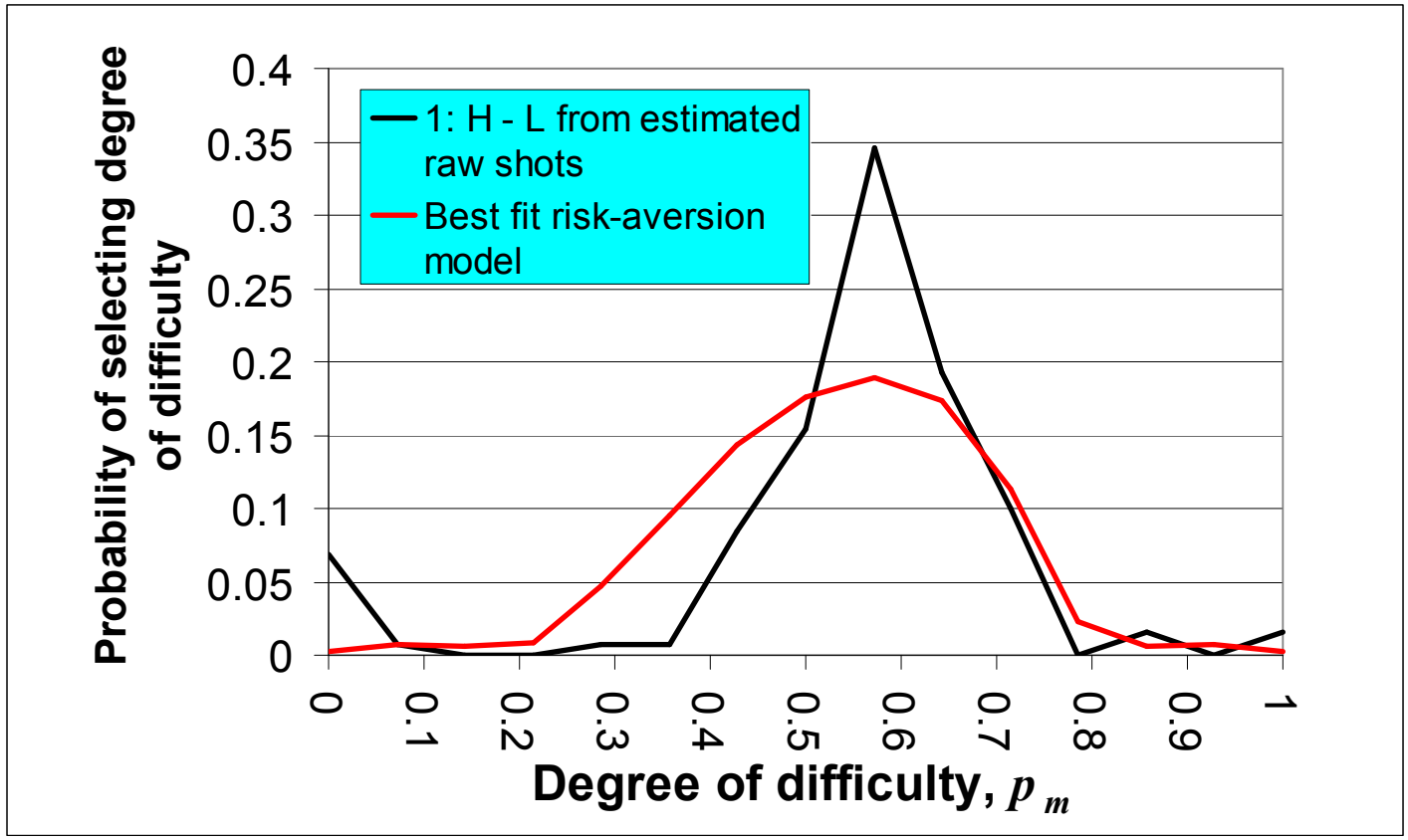
$1-\alpha$ is the propensity to display (strictly) risk averse behaviour

p_m is the degree of difficulty of the task chosen (= prob. of failure)

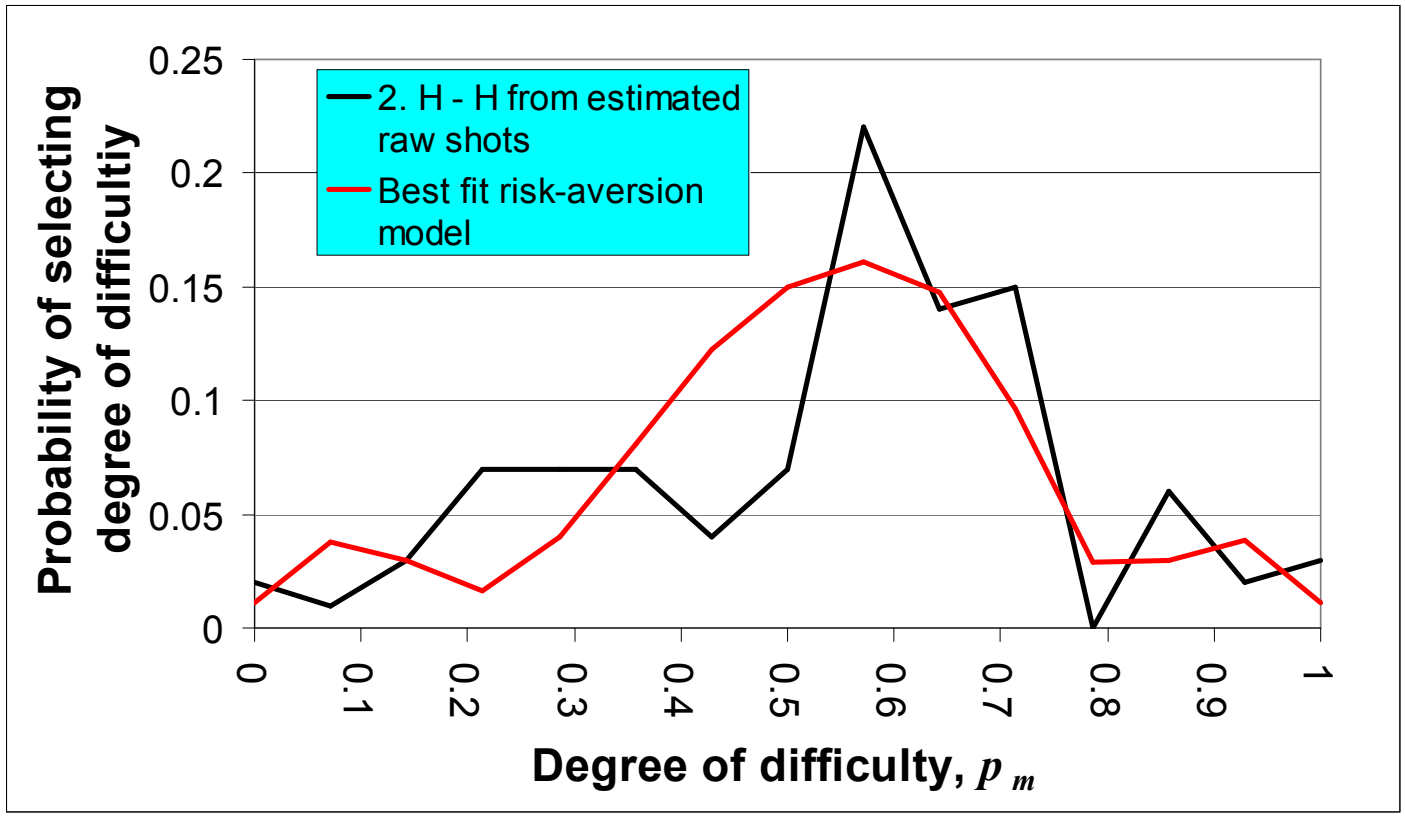
Matching the average probability density, conditional on **propensity for risk confidence/ risk-aversion**: all groups



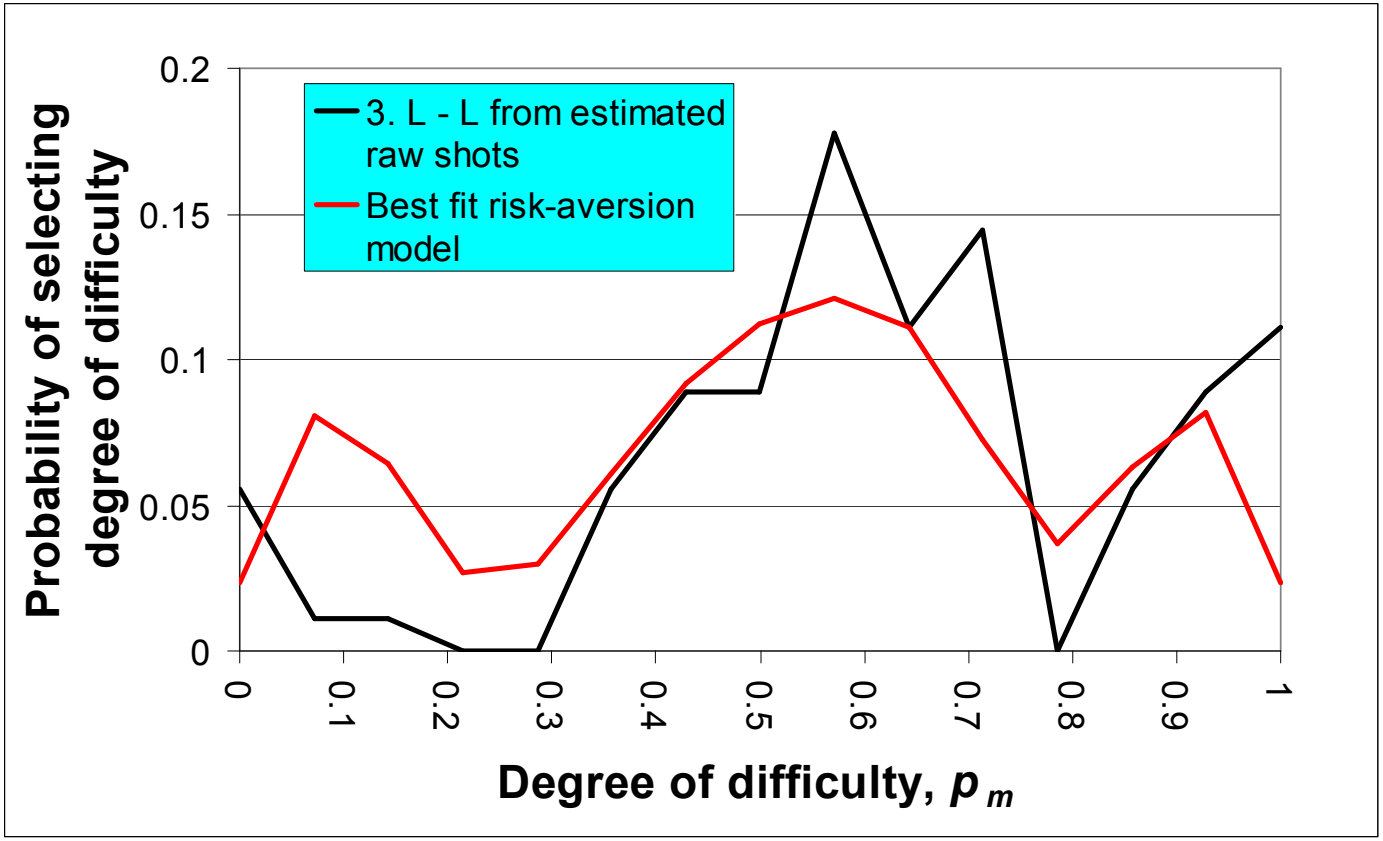
H – L Group


Probability of selecting degree of difficulty
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1: H - L from estimated raw shots
Best fit risk-aversion model
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Degree of difficulty, p_m

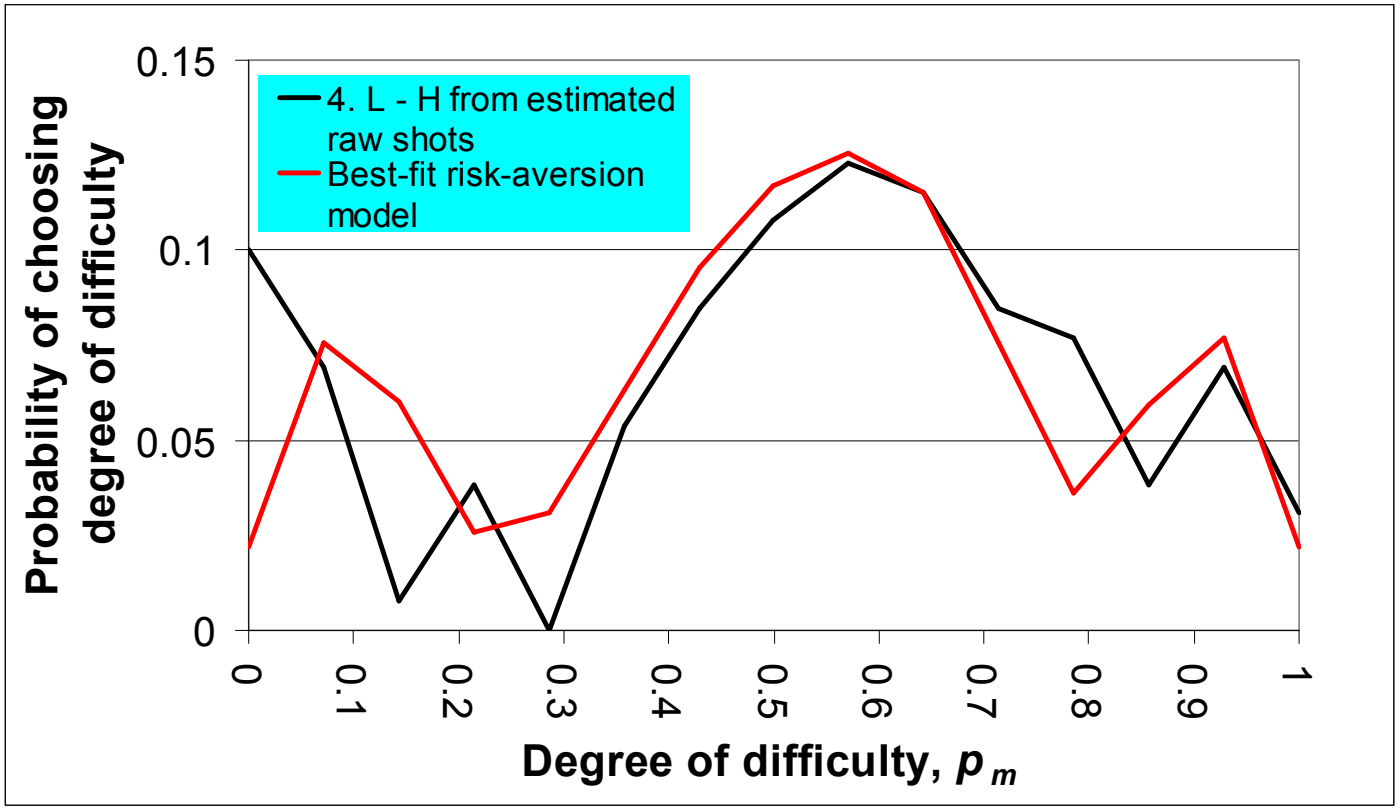
H – H Group


Probability of selecting degree of difficultiy
0.25
0.2
0.15
0.1
0.05
0
2. H - H from estimated raw shots
Best fit risk-aversion model
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Degree of difficulty, p_m

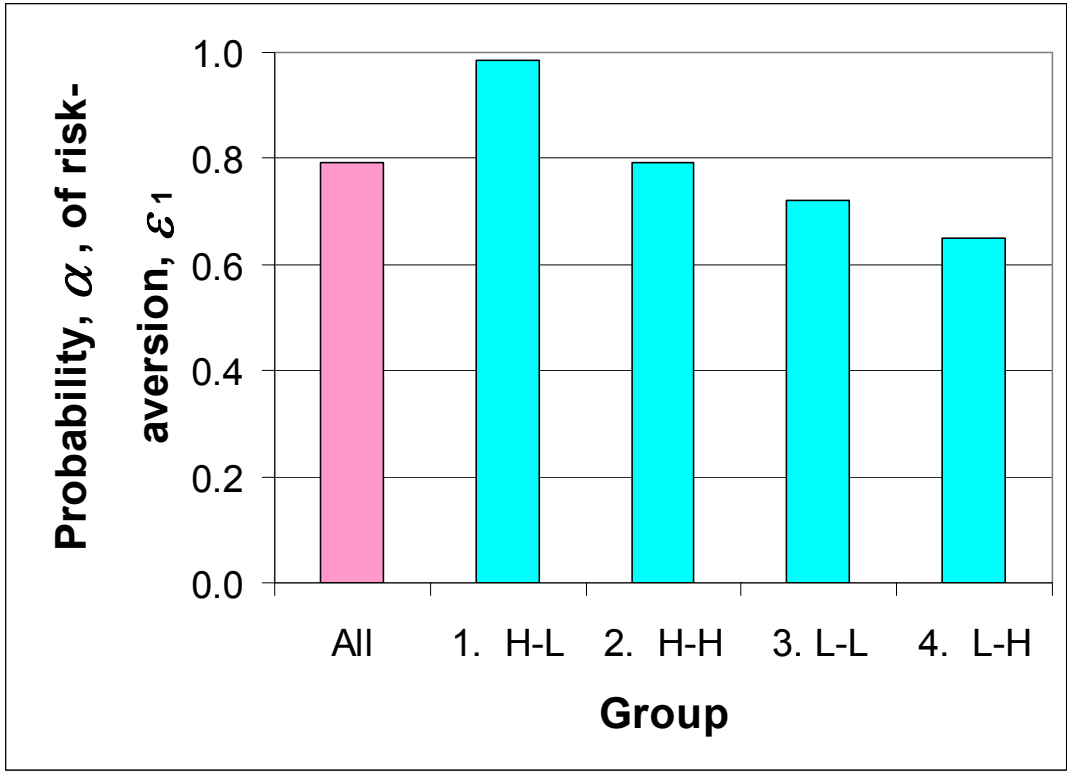
L – L Group


0.2
0.15
0.1
0.05
0
Probability of selecting degree of difficulty
3. L - L from estimated raw shots
Best fit risk-aversion model
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Degree of difficulty, p_m

L – H Group


0.15
0.1
0.05
0
Probability of choosing degree of difficulty
4. L - H from estimated raw shots
Best-fit risk-aversion model
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Degree of difficulty, p_m

Fraction of the time risk-confidence is displayed within the groups (minimising sum of squared errors)



Probability of exhibiting the risk-confident mode, ε_1

Conclusions

- The **risk-aversion parameter**, ε, and the **propensity to risk-aversion**, (1 – α), allow the behaviour of the 45 students to be modelled well, both overall and at the group level.
- The exercise suggests that an individual does not have a single value of risk-aversion, but will experiment to find the value that suits him/her and the situation best.
- The two basic descriptions and the four resultant classifications, H – L, H – H, L – L and L – H map well onto the **propensity to adopt a risk-averse strategy**.
- There is a variation in **propensity to risk-aversion** from group to group.
- That variation conforms with intuitive understanding:
  - those exbiting both a **high motivation to achieve** and a **low test anxiety** display the **lowest propensity to adopt a risk-averse strategy** (most risk confident)
  - those exhibiting a **low motivation to achieve** and a **high test anxiety** display the **highest propensity to adopt a risk-averse strategy** (most risk-averse)

Conclusions (continued)

- We may characterise those with the highest propensity to adopt a risk-averse strategy as "**most risk-averse**" and those with the lowest propensity to embrace such a strategy.
- By this definition, the **most risk-averse people** are the most likely to adopt a strategy with the **highest chance of failure**.
- Conversely, the **most risk-confident** are the **least likely** to take on such a strategy.

Wider implications

- Certain caveats need to be uttered:
  - the results come from a study of 45 male university students playing a game with not money at stake and no obvious carry-over into long-term career prospects.
  - The low stakes will have an effect on the range of risk-aversions, $\varepsilon_1, \varepsilon_2$, considered by the decision maker.
  - The range of propensities to be strictly risk-averse, $1 - \alpha$, are likely to reflect the groups of students studied in this exercise rather than be general.
- Nevertheless the ideas generated are intuitively appealing and their essence may transfer into real-world situations.

Fuller results

- Thomas, P., "Why the most risk averse take the biggest risks: a quantitative re-analysis of Atkinson's and Litwin's 'hoop-the-peg' experiments. Part 1: Simulation and model validation, Part 2: Establishing the raw data"
  Submitted to *Nanotechnology Perceptions*