



”Hunger Games II: Does Hunger Affects Risk Preferences?.”

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Hunger Games II: Does Hunger Affect Risk Preferences?

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- Part of an INRA Project:

*Impact of physiological/metabolic states on psychological traits:
Hunger and alcohol intoxication.*

- Growing evidence that our cognitive, emotional and visceral states fluctuate and mediate behavioral biases and preferences (DellaVigna, 2009; Hunter, 2013) \Rightarrow **biosocial science**.
- Important decisions are made under stress, fatigue, hunger, pain, or alcohol.

\Rightarrow What is the impact of hunger on underlying preferences of economic behavior: here risk attitudes.

Two original features of this research:

- Hunger manipulation mechanism using high-protein drink.
- Non-standard experimental method of elicitation of risk attitudes (under EUT and Prospect Theory, i.e. PT).

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States and traits: from Neuro to Eco

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Neuroeconomics: understanding how and which brain systems are associated with individual economic decisions (Camerer, Loewenstein, Prelec, 2005).

Empirically, there is some evidence of a link between physiological and biological factors and economic behavior.

For example, there are many empirical studies on the effect of emotions (anger, happiness, arousal, fear, surprise) on decision-making (Nguyen & Noussair, 2014 for a review with risk attitudes.)

Concerning risk attitudes:

- Stress induced by mild physical pain (Porcelli & Delgado, 2009) increases risk aversion in gain and risk seeking in losses and by cortisone pills (Kandasamy, & al, 2014) increases risk aversion and overweighting of small probabilities in gains.
- Effects of estrogen and testosterone on risk attitudes (Apicella & al., 2008) ≠ (Zethraeus & al., 2009) on postmenopausal women.

Hunger and neuroscience

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In Neuroscience, Hunger or food deprivation and satiety have been studied in great depth:

- Hunger associated with food deprivation increases the incentive value of food, which is reflected in enhanced responses to appetitive stimuli in reward-related brain areas .
 - Conversely, consumption of food is associated with reduced activity in reward circuitry
 - Reduction of BOLD activity to rewarding stimuli between satiety and pre-meal hunger state are confirmed (in vmPFC, OFC, ventral striatum, hypothalamus, insula, amygdala, and hippocampus). (Thomas & al, 2015).
- ⇒ Robust results even with pre-meal hunger and post-meal satiety.
- OFC is also the area that evaluates rewards (Wallis, 2007) and assigns value in economic choices (Padoa-Shiopa & Assad, 2006)
- ⇒ Hunger/satiety may have impact on economic decisions and thus on the underlying individual preferences.

Hunger and economic decision

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Studies on Hunger and economic decision

- *"Law is what the judge ate for breakfast"* : Danziger & al (2011) find that about 65% of favorable decision at the beginning of a session and drop nearly to zero at the end.
- High caloric intake leads to improvement in physical and cognitive tasks and increases productivity (Schofield, 2013) compared to low caloric intake (Ramadan cdt)
- Glucose increases individuals response times (Dickinson & al., 2014) and the likelihood of making a Bayesian choice over a heuristic-based choice.
- Meta-analysis of blood glucose effects on human decision-making (Orquin & Kursban, 2015): willingness to pay, to work, time discounting and decision style but no risk attitude.
- Hunger increases impatience (Ashton, 2016).

The Economy/Ecology analogy

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Physiological state-dependence play no part in economic theory in contrast to ecology theory: dependence of foraging behavior on metabolic state (Stephens, 1981; McNamara, 1999)

- If energy intake or reserves is below a certain reference point (survival or reproductive threshold), induces greater risk seeking, = **scarcity/risk hypothesis**
- Conversely, period of abundance can also induce greater risk seeking because animals can actually afford to forage or hunt: **abundance/risk hypothesis**.

⇒ Both hypothesis apply to wild chimpanzees and seem to depend of individuals risk attitudes (Gilby & Wrangham, 2007).

⇒ Pre-meal hunger induces less transitivity violations in food choices in captive marmoset monkeys (Yamada, 2017).

⇒ Prediction for humans is not straightforward: no evolutionary argument for risk seeking behavior in case of starvation threat.

Hunger and risk attitudes : benchmark studies

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Two empirical economics studies have highlighted how stock market volatilities declines sharply in Muslim countries during Ramadan (Seyyed & al., 2005; Bialkowski & al., 2012).

⇒ This suggests that hungry people feel less able to afford speculative risk and are therefore more risk averse.

This is confirmed by the following two experimental studies:

- Symmonds & al. (2010) find a decrease in risk aversion just after meal (metabolic states measures (acyl-ghrelin), N=19, within).
- Levy & al. (2013) extend previous study but find mixed effects: for risk averse subjects, hunger decreases risk aversion but increases risk aversion for risk seeking ones. (N=55, within)

⇒ Two benchmarks eliciting risk attitudes under EUT using multiple binary lottery choices.

Risk attitudes elicitation methods

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Heterogeneity of the scientific evidence on risk attitudes is also due to the numerous elicitation methods:

- Psychometric measure: Likert scale of willingness of taking risks (Dohmen & al), adapted for survey questionnaire but not for connecting with theoretical economics or decision theory.
- Binary lottery choices: Basis of thought experiment, most intuitive and easy task, require an high number of choices to account for individual heterogeneity of preferences (Hey & Orme, 1994) and parametric estimation of decision models.
- Equivalents' elicitation : Certainty equivalents or matching probability are points of indifference between two prospects: very informative continuous variable, choice list to help understanding the task, European School in DT.
- Budget allocation: Convex combination of two prospects: continuous variable, easy to understand, Californian school in DT and micro: Kariv, Andreoni, Gneezy etc.. \Rightarrow few studies outside EUT.

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Convex Budget Allocation: set-up

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- X the set of outcomes .
 - State space \mathcal{S} is partitioned by two events B , $R = B^c$ with $Pr(B) = p = 1 - Pr(R)$. (Risk=known probabilities).
 - DM's preferences are defined over the set of comonotonic acts $\{(x, B; y) \mid x \geq y \geq 0\} \subset \Delta(X)$
 - For simplicity, acts are lotteries denoted $(x, p; y)$ and constant acts $(x = y)$ are denoted z .
 - DM has to choose a convex combination of a sure gain $A = z$ and a lottery $B = (x, p; y)$ with $x > z > y$.
 - The choice variable is $\pi \in [0, 1]$ such that she obtains $\pi A + (1 - \pi)B$.
- ⇒ Portfolio allocation between a safe and a risky asset.
- ⇒ Closely connected to well-studied economic situation (Arrow, 1964).

Decision task

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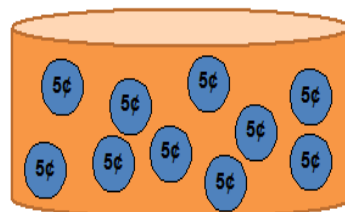
Period # 3

Remaining time 43

Lottery Decision

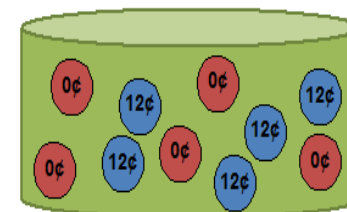
You have an **endowment of \$15.00** and **100 tokens** to allocate into the following lotteries:

Lottery A



Red Ball: Probability = 0.0 and Payout = 0¢
Blue Ball: Probability = 1.0 and Payout = 5¢

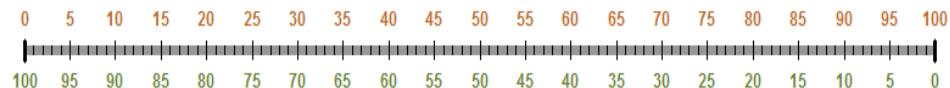
Lottery B



Red Ball: Probability = 0.5 and Payout = 0¢
Blue Ball: Probability = 0.5 and Payout = 12¢

Using the gray bar, which represents your 100 tokens, please indicate how many entries you would like to allocate for each lottery:

Entries for Lottery A



Entries for Lottery B

Skip

Please click on the line to indicate your choice!

Convex Budget Allocation: Maximization program

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Under EUT, with $A = z$ and a $B = (x, p; y)$

$$V_{EUT} = pu(\pi z + (1 - \pi)x) + (1 - p)u(\pi z + (1 - \pi)y).$$

The first-order condition is $\frac{\partial V_{EUT}}{\partial \pi} = 0$.

$$\Leftrightarrow \frac{u'(\pi z + (1 - \pi)y)}{u'(\pi z + (1 - \pi)x)} = \frac{p}{1 - p} \frac{(x - z)}{(z - y)}$$

Let assume $p = \frac{1}{2} \Rightarrow \frac{p}{1 - p} = 1$ and $y = 0$

$$\Leftrightarrow \frac{u'(\pi z)}{u'(\pi z + (1 - \pi)x)} = \frac{(x - z)}{z}$$

If $z = E(B) = \frac{x}{2}$, the interior solution is $\pi = [0, 1]$ and $u(x) = x$

\Leftrightarrow DM is risk neutral and indifferent to any allocation.

Proposition: (Arrow, 1964; Rothschild-Stiglitz, 1971). For A and $B \in \Delta(X)$, where B is a mean-preserving spread of A , then the asset allocation problem is resolved as follows:

- ☐ if the DM is risk neutral and $\pi \in [0, 1]$ and u is linear.
- ☐ if the DM is risk averse and $\pi = 1$ and u is concave.
- ☐ if the DM is risk seeking and $\pi = 0$ and u is convex.

\Rightarrow When $B \neq MPS(A)$, under power utility assumption ($u(x) = x^\alpha$), convenient way to estimate risk aversion parameter of a DM exhibiting an interior allocation:

$$\Leftrightarrow \frac{\pi z + (1-\pi)y}{\pi z + (1-\pi)x} = \left[\frac{p}{1-p} \frac{(x-z)}{(z-y)} \right]^{\frac{1}{\alpha-1}} = K$$

$$\pi_{th} = \frac{1}{1 + \frac{z(1-K)}{xK-y}}$$

Under PT, with $A = z$ and $B = (x, p; y)$ with $x > z > y > 0$

$$V_{PT} = w(p)u(\pi z + (1 - \pi)x) + [1 - w(p)]u(\pi z + (1 - \pi)y).$$

The first-order condition (for an interior solution) is $\frac{\partial V_{PT}}{\partial \pi} = 0$.

$$\Leftrightarrow \frac{u'(\pi z + (1 - \pi)y)}{u'(\pi z + (1 - \pi)x)} = \frac{w(p)}{1 - w(p)} \frac{(x - z)}{(z - y)}$$

$$\Leftrightarrow \frac{\pi z + (1 - \pi)y}{\pi z + (1 - \pi)x} = \left[\frac{w_\gamma(p)}{1 - w_\gamma(p)} \frac{(x - z)}{(z - y)} \right]^{\frac{1}{\alpha - 1}} = K(\alpha, \gamma)$$

$$\pi_{th}(\alpha, \gamma) = \frac{1}{1 + \frac{z(1 - K(\alpha, \gamma))}{xK(\alpha, \gamma) - y}}$$

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- 106 participants in Xlab at University of Berkeley.
- Sign-up process 24h before the experiment (requirement of minimal 3h fasting before the session).
- 55 computer-based experimental tasks of budget allocations.
- Maximal time of 45 sec per allocation. Total duration $\sim 45\text{min}$.
- One allocation is played randomly selected and played for real at the end of the experiment (RIS). $E(G) = \$38 +$ flat fee of \$10.
- One tasting activity before the tasks (Hunger = 0 or 1)
- 35,5 cl nutritional drink with high protein (35g), low calorie (160 cal), low sugar (1g). Protein: most satiating macro-nutrient.
- Psychometric scales of hunger measured before and after tasting
- One mental calculus activity before or after the tasks (Fatigue condition).

Practical set up

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Drink:



Xlab



The allocation tasks' module

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The 55 allocation tasks are divided as follows:

- 40 allocations between a safe and a risky asset, 15 between two risky assets.
- 25 allocations between an asset and a mean preserving spread (MPS): 10 between a safe and MPS, 15 between a lottery and a MPS.
- 19 allocations with a positive endowment: 11 involving losses, 8 gains \Rightarrow 36 without endowment.
- 8 allocations with varying gains \Rightarrow Estimation of the utility.
- 9 allocations with varying probabilities \Rightarrow Estimation of the pwf.
- 4 allocations as variation of Allais paradox

\Rightarrow I will focuss on 21 allocation tasks in this talk: for estimating RDU and 8 MPS

Mean preserving spread tasks (gain and loss)

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Table 1: Simple allocation with MPS lotteries (gain and loss)

	π between z and $(x, 1/2; y)$							
Task	1	2	3	4	1'	2'	3'	4'
z	15	30	30	35	-15	-30	-30	-35
x	20	40	50	45	-20	-40	-20	-45
y	10	20	10	25	-10	-20	-10	-25

- 1,...,4 (1',...,4') allows testing EUT prediction in the gain (loss) domain and comparison with the benchmark (Symmonds & al.).

Probability weighting and utility tasks

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Table 2: Utility allocation (outcomes changes)

	z and $(x, 1/2, y)$			
Task	5	6	7	8
z	5	10	15	20
x	12	25	35	50
y	0	0	0	0

⇒ Allow estimating utility in gain under EUT or PT.

Table 3: Pwf allocation (probability changes)

	π between z and (x, p, y)								
Task	9	10	11	12	13	14	15	16	17
z	2.5	5	10	15	20	25	30	35	40
x	50	50	50	50	50	50	50	50	50
y	0	0	0	0	0	0	0	0	0
p	0.05	0.1	0.2	0.3	0.4	0.6	0.7	0.8	0.9

⇒ Allow estimating pwf in gains (π should increase with p)

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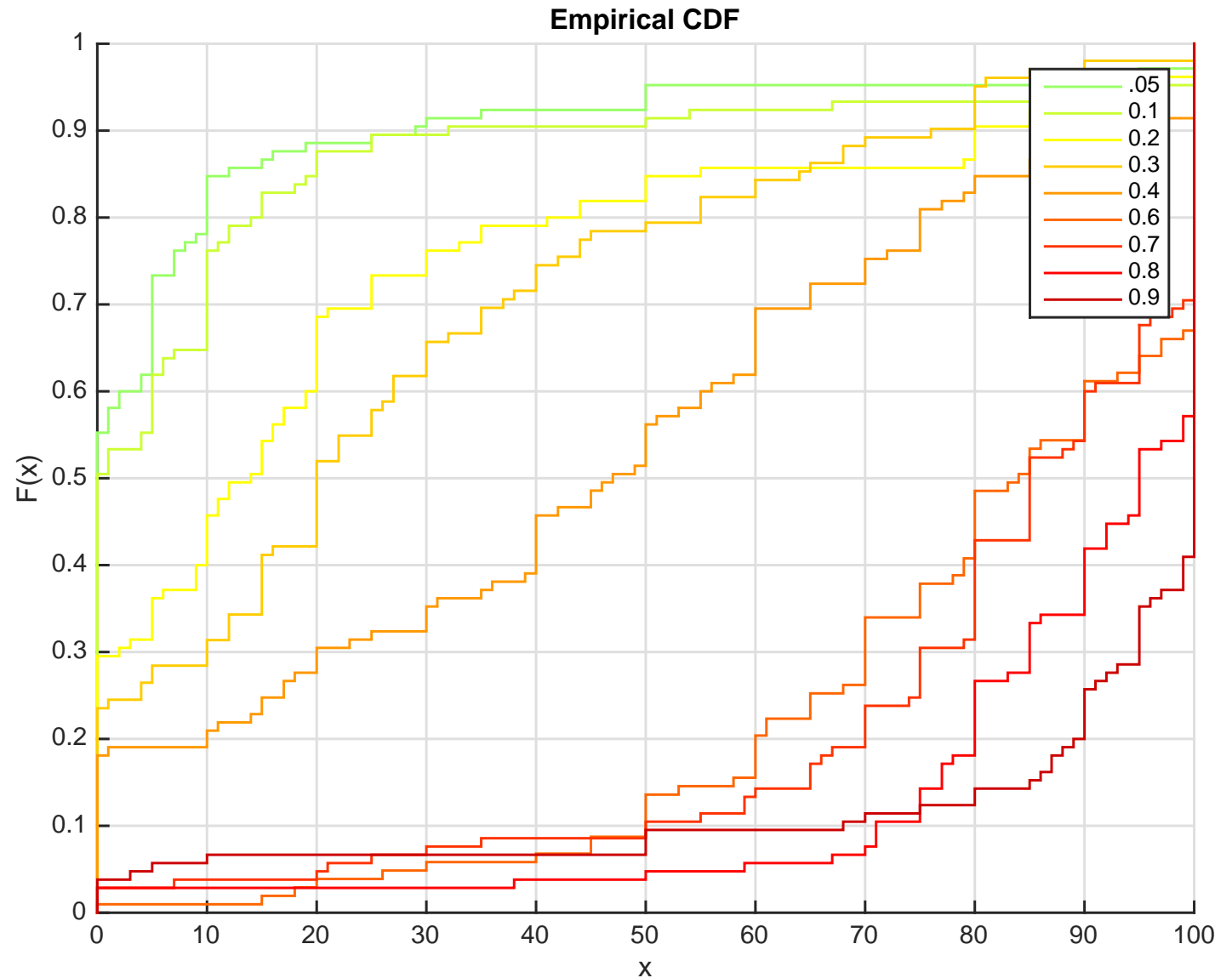
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MPS in gains: critical for EUT

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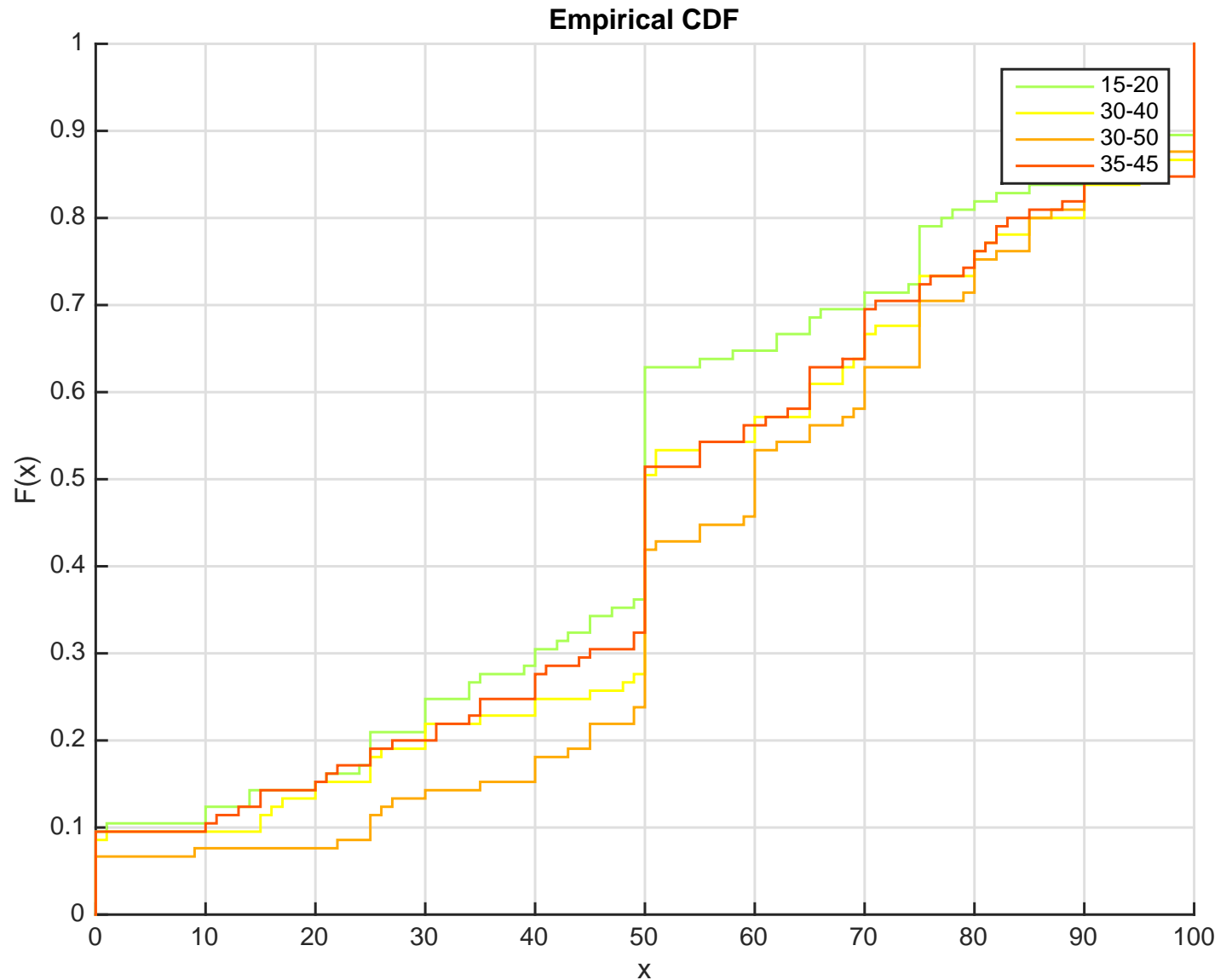
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- One **Hunger** condition but two variables to control for it:
 - The tasting condition: protein drink (H0) or water (H1).
 - A self assessed hunger level before the allocation tasks module
- ⇒ Both variable are correlated: efficiency of our hunger manipulation device.
- One **Fatigue** condition: no task (F0) or mental calculus (F1).
- One individual characteristic: **Gender**
- Power specification for utility: $u(x) = x^\alpha$
- Prelec one parameter probability weighting function:

$$w(p) = \exp(-(-\ln p)^\gamma)$$

⇒ The smaller α , the more risk averse

⇒ The smaller γ , the more probability distortion ($\gamma < 1$ corresponds to inverse S-Shape).

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- π_{th} is the theoretical allocation and π_{obs} the observed one.
- $\pi_{obs} = \pi_{th} + \epsilon$ with $\epsilon \sim N(0, \sigma)$ with σ log normally distributed across subjects.

Due to the measurement scale we only measure $\lfloor \pi_{obs} \rfloor$ which is the integer value of π_{obs} .

The probability of a given allocation is, without tremble:

$$P(\lfloor \pi_{obs} \rfloor) = P((\lfloor \pi_{obs} \rfloor - 0.5) < \pi_{obs} < (\lfloor \pi_{obs} \rfloor + 0.5))$$

If we assume a tremble, i.e. that a share μ of choices are given at random with μ varying across subjects according to a logistic distribution, then:

$$P(\lfloor \pi_{obs} \rfloor) = \frac{\mu}{100} + \frac{1 - \mu}{100} \left(\phi \left(\frac{\lfloor \pi_{obs} \rfloor - \pi_{th} + 0.5}{\sigma} \right) - \phi \left(\frac{\lfloor \pi_{obs} \rfloor - \pi_{th} - 0.5}{\sigma} \right) \right)$$

- Log-likelihood is calculated over the 13 allocations and maximized over α and γ as $\pi_{th}(\alpha, \gamma)$.

Structural equation model

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The structural equation model is then the following:

$$\pi_{obs} = \pi_{th}(\alpha, \gamma) + \epsilon$$

$$\log(\alpha_i) = \alpha_0 + \alpha_{hunger}\delta_{hunger,i} + \alpha_{gender}\delta_{male,i} + \alpha_{fatigue}\delta_{fatigue,i}$$

$$\log(\gamma_i) = \gamma_0 + \gamma_{hunger}\delta_{hunger,i} + \gamma_{gender}\delta_{male,i} + \gamma_{fatigue}\delta_{fatigue,i}$$

where $\delta_{k,i}$ is a dummy variable that takes value 1 if condition k is true.

- The model is estimated by maximum likelihood.
- For the random coefficients (σ and μ), the likelihood is simulated from 500 Halton draws.
- 50 different starting values in order to avoid local optima.

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	Estimate	SE	p values
α_0	-0.123	0.000	0.000
γ_0	-0.561	0.001	0.000
$\text{mean}(\mu)$	-0.415	0.184	0.024
α_{hunger}	-0.003	0.000	0.000
α_{male}	0.121	0.001	0.000
α_{fatigue}	-0.000	0.000	0.006
γ_{hunger}	-0.043	0.001	0.000
γ_{male}	-0.046	0.001	0.000
γ_{fatigue}	0.002	0.000	0.000

⇒ Gender effect is consistent with existing evidence.

⇒ Hunger induces more risk aversion and probability distortion.

⇒ Fatigue has little impact on risk preferences.

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Contributions and limitations of the study

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We add to the existing corpus of evidence by including:

- A tractable hunger manipulation device (protein drink) that allows for between-subject design.
- An elicitation method that allows parametric estimation of many refined risk attitudes features (pwf, loss aversion, utility in losses)

But there are several limitations in our study:

- No physiological measure of hunger, BMI control.
- Our between-subject design may require a bigger sample size.
- Randomization between hunger condition was made between and not within session.

⇒ Hunger increases risk aversion and probability distortion:
increases irrationality or heuristic based decisions?

⇒ Useful results to be extended in order to understand risk attitudes of at risk population (obese, poor population).

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Thank you for your attention!