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Can heuristics be useful for entrepreneurs facing uncertainty?

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Introduction

This thesis aims at investigating whether heuristics can be useful tools for entrepreneurs that face uncertainty. The method used consists in (1) analysing how behavioural economics has evolved in the study of heuristics and bias, covering the most important concept of prospect theory, bounded rationality, judgmental heuristics, ecological rationality, and fast an frugal heuristics, and (2) showing how fast and frugal heuristics can be applied by entrepreneurs in successful manners.

Traditionally behavioural economics, the branch that studies how cognitive and psychological factors among other influence individuals' economic decisions, has considered heuristics as a source of systematic errors that negatively affect judgment. Behavioural economics demonstrates that people systematically deviate from rational models of decision-making because of (1) their own cognitive limitation and (2) external condition such as shortage of time and information cost. For these reasons, individuals are assumed to be bounded in their rationality and because of bounds they rely on cognitive short-cuts i.e. heuristics to make decisions. The issue that concerns heuristics is related to bias that can arise from inappropriate use of cognitive short-cuts because they can produce an inaccurate judgment. In recent years with the introduction of ecological rationality, heuristics have been considered as simple strategies that, if applied in proper environments, can be highly effective to cope with uncertainty.

The work is divided into four chapters and it is structured as follows:

The first chapter starts introducing what decisions are and the two main classes of decision-making models: (1) rational and (2) non-rational. Rational models are based on Expected Utility theory and assume that individuals are fully rational and therefore they are able to compute the optimal solution in every situation.

On the other hand, non-rational models are based on the concept of bounded rationality theorized by Simon and they aim at explaining why individuals systematically deviate from Expected Utility Theory and its axioms.

The most important non-rational model is the so-called Prospect Theory and Kahneman and Tversky developed it in order to give a more realistic view of people's decision-making process. The chapter is concluded with the concept of bounded awareness, a set of phenomena in which individuals fail to see and use easily available information.

The second chapter introduces biases that result from attention and memory related constraints, showing how individuals' cognitive limitation actually affect judgment, starting from information collection. Later in the chapter judgmental heuristics (representativeness, availability, simulation and anchor and adjustment), are presented as cognitive shortcuts or strategies that enable individuals to compute decisions in faster and easier ways but that almost systematically lead to bias, errors that negatively affect judgment. The last part of the chapter is dedicated to the role of intuition in managerial decision-making and how it can provide accurate judgment when paired with a proper amount of expertise.

The third chapter introduces the so-called entrepreneurial cognition that studies how entrepreneurs think and act in highly uncertain and complex environments that can increase the chance for them to be subjected to bias, since they often rely on heuristics to cope with such situations. Then the concept of opportunity is introduced, analysing its essential role in entrepreneurship; the goal is to understand how entrepreneurs make decisions that are related to the evolution of an opportunity, so how they recognize opportunities, how they actually evaluate and decide whether exploit them.

The fourth chapter illustrates the concept of ecological rationality that assumes people are ecological rational when they use heuristics that match the environment in which they are applied. From this point of view heuristics, especially fast and frugal are defined as adaptive responses and can be useful and successful strategies for entrepreneurs. Later

in the chapter it is described how three different fast and frugal heuristics can be successfully applied by entrepreneurs in three different contexts (investments decisions, business locations and product development).

1 The decision-making process

Decisions are situation-behaviour combinations[1] that can be described by three main elements: (1) alternative actions, (2) consequences, and (3) uncertain events. When deciding, individuals combine their desires and beliefs to choose a course of action, i.e. choosing among options and alternatives. Each of the alternatives, leads to different outcomes, objective situations that occur as the result of choosing one option rather than another one and outcomes are subjectively evaluated by decision makers as consequences, measurable on a good-bad, gain-loss scale. Each decision carries some level of uncertainty that refers to the probability/likelihood of conditioning events to occur according to people's judgments. Indeed, judgments concern assessing, estimating, and inferring what events will occur and with what consequences.

There are many theoretical models that aim at understanding how people choose among alternatives, what course of action they to take in order to achieve their goals. These models can be classified into two categories: (1) rational models and (2) non-rational models. Rational models imply that individuals can access to all the available information and have the time, cognitive abilities and resources to evaluate each alternative in order to find the optimal solution. On the other hand, non-rational models argue that people rarely can access to all the available information and that evaluating each alternative is not possible since

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[1] Hastie R. (2001). *Problems for Judgment and Decision Making*, Annu. Rev. Psychol. 52:653–83

their rationality is somehow limited, therefore they find an acceptable solution rather than the optimal one.

1.1 Rational decision-making model

The rational decision-making model[2] assumes that individuals are fully rational and have access to all the information required to compute the optimal solution. It is made of sub sequentially steps, from problem definition to the optimal solution computation: (1) *problem definition* – it is necessary to clearly understand problem's domain, if not, time and resources are wasted in solving the wrong problem; (2) *criteria identification* – criteria represent what the goals are and they must be relevant to the problem; (3) *criteria weighting* – criteria are ordered according to the decision maker's preferences, from the most important to the least; (4) *alternatives generation* – alternatives are the different courses of action that can be undertaken. Generating alternatives is a time-consuming process so it is conducted until the value of added information is worth the cost of the search; (5) *alternatives rating* – each alternative is evaluated according to each criterion; (6) *optimal solution computation* – the alternative that has the highest sum of the weighted ratings is chosen as the optimal solution.

1.1.1. Expected Utility Theory

In rational models the optimal decision is the one with the highest utility and it can be explained by the so-called Expected Utility Theory (EUT) that is a normative theory, it provides prescriptive functions or rules that aim at maximizing the expected utility of outcomes. The theory was developed by Nicolas Bernoulli that presented the so-called St Petersburg paradox[3] where he demonstrated that the expected monetary value could not be

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[2] Bazerman and Moore, *Judgment in Managerial Decision Making*, 7th Edition, John Wiley & Sons, 2008
[3] Vivian (2007), *Solving Daniel Bernoulli's St Petersburg Paradox: The Paradox which is not and never was, MPRA Paper No. 5233*

the only factor taken into consideration by rational people under uncertainty[4]. It is based on a theoretical lottery game "*that leads to a random variable with infinite expected value but nevertheless seems to be worth only a very small amount to the participants*" (Arrow, 1974). The game consists in flipping a fair coin (50% heads, 50% tails) until tails come up and the number of flips determines the prize $\$2^n$. If the person who flips the coin gets heads, he will flip the coin again whereas if he gets tails the game stops and he will win the prize. The key in the paradox is to determine how much a person would be willing to pay to participate in it. There are infinite possible consequences, the probability of a consequence of n° flips P(n) is 1 divided by 2^n, and the expected payoff is the prize times its probability. For 10 times the result would be:

N° flips	P(n)	Prize	Expected payoff
1	1/2	2	$1
2	1/4	4	$1
3	1/8	8	$1
4	1/16	16	$1
5	1/32	32	$1
6	1/64	64	$1
7	1/128	128	$1
8	1/256	256	$1
9	1/512	512	$1
10	1/1024	1024	$1

The expected value of the game is the sum of all the expected payoff and since there are infinite the sum is an infinite number of dollars. A rational individual is willing to pay less

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[4] Schotter (2009), *Microeconomics: A Modern Approach*, 1st Edition, South-Western, Chapter 6

than the expected value and in this case each entry price would be less than the expected value, so the rational player would play no matter what the entry price would be. Here the issue arises, for some people, even rational players, the price would be too high. Bernoulli proposed a solution introducing the concept of the utility function and of diminishing marginal utility:

> *The determination of the value of an item must not be based on the price, but rather on the utility it yields…. There is no doubt that a gain of one thousand ducats is more significant to the pauper than to a rich man though both gain the same amount*

The expected utility[5] measures an individual's valuation of prospects that can be pure prospects (certain future events) and lotteries (probability distribution over events).
EUT assumes that there is a fixed set of prospects for every agent and that agents can always state if they prefer one prospect to another or are indifferent to them. It means that agents have a preference ordering and it has to satisfy some conditions (axioms). If axioms are satisfied an individual is defined as rational and as having a utility function that measures his preferences over a set of goods and services.

The axioms, introduced by John von Neumann and Oskar Morgenstern, are the following:
Completeness.
$X \geq Y \; or \; Y \geq X \; for \; all \; X, Y \in$
An individual has defined preferences and can always decide between two alternatives;

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[5] Levin (2006), *Choice under Uncertain*, Stanford University

Transitivity.

$X \geq Y$ and $Y \geq Z$ then also $X \geq Z$ for all $X, Y, Z \in$

An individual's preferences are consistent;

Continuity.

For all X, Y, Z where $X \geq Y$ and $Y \geq X$ there is some p such that $(X, p; Z, 1 - p) \sim Y$

There is a possible combination of X and Z such that an individual is indifferent between this combination and Y;

Independence or substitution

$p(X) + (1 - p)Z \geq p(Y) + (1 - p)Z$

An individual's order of preference remains the same, independently of the presence of Z.

These conditions imply that preferences over prospects can be represented by a numerical function u() such that for all X, Y $X \geq Y \leftrightarrow u(x) \geq u(Y)$. It means that a person prefers prospect X over prospect Y if and only if the utility assigns a higher value to X than to Y. If all these four axioms are satisfied, preferences over lottery prospects are represented by the utility function:

$$u(X) = \sum pi \times u(Xi) \text{ such that for all X, Y: } X \geq Y \leftrightarrow \sum pi \times u(Xi) \geq \sum pi \times u(Yi)$$

From the utility function, three different approaches to risk[6] emerge and people are classified according to:

Risk neutrality. An individual is defined as risk neutral if every time he receives one dollar, his utility increases by the same amount, so the marginal utility of an additional dollar is constant. The utility function is linear, and a risk neutral individual chooses between

gambles depending on the expected monetary value and he is indifferent in participating in a fair gamble.

E.g. between two gambles A and B where A (50, 0) and B (100, 0.5; 0, 0.5) an individual that is risk neutral is indifferent between them since they both have the same expected return of $50.

Risk aversion. An individual is defined as risk averse if he exhibits diminishing marginal utility for income. E.g. between two gambles A and B where A (50, 0) and B (100, 0.5; 0, 0.5) an individual that is risk averse chooses the first option because it is risk free. From the risk-free amount any income results to be less important, that is why his utility function is represented by a curve which slope is decreasing. Moreover, such individual rejects the opportunity to participate in a fair gamble, since he is not willing to gain more dollars that have less value (lower marginal utility).

Risk preference. An individual is defined as risk preferer if he prefers gambles over certain events. E.g. between two gambles A and B where A (50, 0) and B (100, 0.5; 0, 0.5) an individual that is risk preferer chooses option B since it may allow him to gain more. His marginal utility is increasing for income and so the utility function is represented by a convex curve.
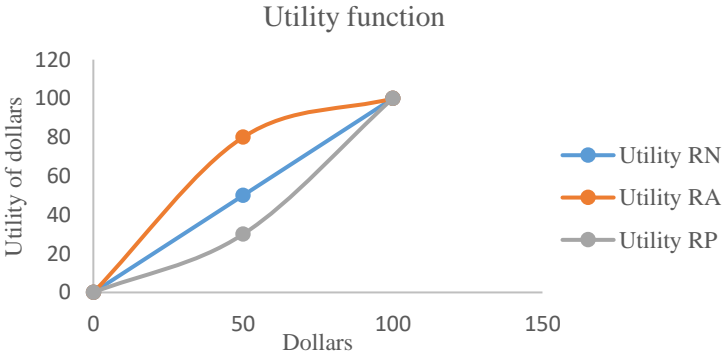
The expected utility theory has been criticised since it assumes that individuals are completely rational; the main critic is based on the independence axiom and evidence about its violation are shown in the Allais' paradox.

The Allais' paradox[7] was formulated by Maurice Allais and it showed that individuals' preferences are inconsistent with the expected utility theory.

Consider two pairs of gambles: A, B and C, D

A: (0.11) 100 + (0.89) 0   C: (1) 100

B: (0.1) 500 + (0.9) 0   D: (0.1) 500 + (0.1) 0 + (0.89) 100

To be consistent with the independence axiom, preferences should be A > B and C > D or B > A and D > C however, often people choose A > B and D > C.

To show that this choice is inconsistent it is possible to decompose the gambles such that:

A: (0.11) 100 + (0.89) 0   C: (0.11) 100 + (0.89) 100

B: (0.1) 500 + (0.1) 0 + (0.89) 0   D: (0.1) 500 + (0.1) 0 + (0.89) 100

⬇   ⬇

A: (0.11) 100   C: (0.11) 100

B: (0.1) 500 + (0.1) 0   D: (0.1) 500 + (0.1) 0

In this way it is possible to see that A and C, B and D pay the same but in both A and B gambles there is a risky component, so people are willing to risk more to gain more. In the second pair of gambles C is risk-free so people prefer this choice even if D would pay more.

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[7] Grüne-Yanoff (2007), *Bounded Rationality*, Philosophy Compass 2/3 (2007): 534–563

In light of this, there other models that consider these constraints and aim at explaining the decision-making process in a more realistic way: the bounded rationality models.

1.2   Bounded Rationality

It has been seen that people systematically violate the EUT axioms and the main criticisms to rational models are based on two points: (1) utility maximisation is not always computable, and (2) cognition is costly so individuals use cognitive processes that are low in cost but effective.

Indeed, the expected utility theory assumes that the decision makers have an unlimited ability to collect, store and process information so that they are able to have preferences over all outcomes and to maximise and update them.

Simon in 1957 theorized the concept of bounded rationality[8] referring to limitations that humans have; people cannot be fully rational due to: (1) personal cognitive limitations, (2) complexity of the environment, (3) tendency to work on goals in a sequential way rather than simultaneously, and (4) the satisficing phenomenon rather than optimizing. It does not mean that individuals are irrational, it means that there are limits that prevent them from being fully rational. Simon's idea opposed the concept of maximization of expected utility, the concept of full rationality and the optimization.

The concept of bounded rationality, in the years, has been interpreted in different ways[9], usually considering the two sets of bounds (1) internal, such as the cost to search information, and (2) internal, such as cognitive limitations, as unrelated. Following this approach bounded rationality can be seen as:

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[8] Jones (1999), *Bounded Rationality*, Annu. Rev. Polit. Sci. 1999, 2:297-321
[9] Todd and Gigerenzer (2003), *Bounding rationality to the world*, Journal of Economic Psychology 24 143–165

Optimization under constraints. Individuals cannot access to all relevant information at no cost therefore constraints arising from the external environment, such the cost to gain information, were introduced by Stigler in order to develop a more realistic economy theory. From this point of view, bounded rationality can be seen as optimization under constraints, where the bounds are the constraints.

Irrationality and cognitive illusions. This perspective mainly focuses on internal bounds, cognitive limitations and systematic errors that affect judgment and decision-making, making humans biased and irrational. Individuals are subjected to cognitive illusions, interactions based on subjective assumptions about the world, which lead to unconscious inferences.

Both views are in contrast with the concept of bounded rationality: the former adopts a more realistic approach considering external constraints, but the concept of optimization itself requires abilities that are in contrast with the concept of bounded rationality, while the latter in demonstrating cognitive illusions, accept as normative the optimization theories. According to Simon himself, bounded rationality cannot rely on optimization and performing it is not always possible in many natural situations.

Under these constraints (limitations of the human minds and the environment's structure), individuals rely on satisficing, a heuristic, that allows them to search for an acceptable solution rather than the optimal one. Decision makers consider one potential move at a time and choose the first that they believe being satisfactory, instead of examining all the alternatives, a task that would require too much time and resources. Therefore, people look for a solution that is good enough i.e. it reaches an acceptable level of performance.

1.2.1 Prospect theory

There are many theories that aim at explaining how these cognitive limitations actually affect the decision-making process and most of them are based on EUT.

The prospect theory[10] was formulated by Kahneman and Tversky and it states that *"People make decisions based on the potential value of losses and gains rather than the final outcome."* It is a descriptive theory that aims at explaining real-life choices and explicating how individuals think and deliberate.

This theory assumes that the decision-making process is made of two phases: the editing and the evaluation. The editing phase is a preliminary analysis in which prospects are organized and reformulated in order to simplify the following evaluation phase. To simplify prospects people, use a series of operations:

Coding. People consider outcomes as gain or losses that are defined starting from a reference point and it can be influenced by the formulation of prospects and by expectations. Subsequently it influences the coding of outcomes;

Combination. People combine the probabilities associated with identical outcomes so that the prospect (200, .25; 200, .25) becomes (200, .50);

Segregation. If prospects contain a riskless component, it is segregated from the risky component. It means that the prospect (300, .80; 200, .20) is divided into a sure gain of 200 (riskless) and the risky prospect (100, .80);

Cancellation. People discard the components that are shared by prospects. This operation shows the so-called isolation effect that induces people to consider only the components that differentiate prospects, leading to a possible inconsistency of preferences;

Simplification. People round the probabilities of outcomes and in some cases it leads to discarding extremely unlikely outcomes;

Detection of dominance. If there are alternatives that are dominated they are not considered.

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[10] Kahneman and Tversky (1979), *Prospect Theory: An Analysis of Decision Under Risk*, Econometrica, Vol.47, Nº2, pp. 263-291

The evaluation phase is the moment during which the prospects are evaluated according to a weighting factor and the prospect that has the highest value is chosen. The value is not attached to final outcomes but to changes in wealth, that is why the focal point of this theory is that the value is a function of two arguments: a reference point and the magnitude of change from that reference point.

During the evaluating phase, individuals evaluate each of the edited prospects and choose the prospect with highest value.

The overall value V (defined by prospects) is expressed by two different scales:

- The scale π associates each probability p with a decision weight $\pi(p)$ and represents the impact of p on the over-all value of the prospect. It is not a probability measure since $\pi(p) + \pi(1 - p) < 1$;

- The scale v assigns each outcome X a number $v(x)$ that reflects the subjective value of that outcome, so v measures the deviation from the reference point, it represents gains and losses.

If the prospect is regular $V(x, p; y, q) = \pi(p)v(x) + \pi(q)v(y)$, in case the prospect is either strictly positive or negative $V(x, p; y, q) = v(y) + \pi(p)[(v(x) - v(y)]$.

The value function is S shaped; it means that the domain (gains or losses) affects the risk propensity, and it is asymmetric (steeper for losses).

(Value Function)[11]

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[11] http://www.paulcohen.com/the-key-implications-of-prospect-theory/
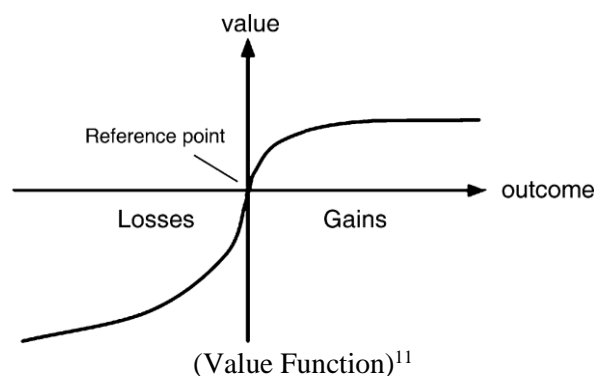
Authors interpret these properties (S-shaped and asymmetric as "diminishing sensitivity" and "loss aversion". Diminishing sensitivity means that the psychological impact of gains and losses is reduced while moving away from the reference point. Loss aversion means that losses are weighted more than gains.

From the value function it is possible to understand how people systematically violates expected utility's axioms. The first phenomenon that violates them is the so-called certainty effect in which outcomes that are certain are more weighted.

e.g. A person is asked to choose between two positive gambles: A and B:

A	B
(1) 3000	(0.8) 4000 + (0.2) 0

Prospect B has a higher expected utility but according to prospect theory, prospect A is weighted more than B because the outcome is certain and individuals do not want to take the risk of win nothing.

Again, a person is asked to choose between two negative gambles: A and B:

A	B
(1) - 3000	(0.8) - 4000 + (0.2) 0

Prospect A has a higher expected utility and is certain, but in the domain of losses, people are willing to take some risk in order to avoid the loss completely, therefore in this case they would choose prospect B. This phenomenon is called reflection effect, indeed the reflection of prospects around 0 reverses the preference order.

Another phenomenon that violates the EUT is the so-called isolation effect that occurs when people, trying to simplify choice, ignore any element that is common to both options, in an effort to simplify and focus on what differs with the risk of having inconsistent preferences. Focusing on different elements makes sense, to reduce the complexity of the choice but at the same time it can lead to incocsistent choices, depending on how propects are presented. e.g

In Scenario 1, participants are given an initial amount of $1000 and then are asked to choose between A or B.

A	B
(1) 500	(0.5) 1000 + (0.5) 0

In Scenario 2, the same participants are given an initial amount of $2000 and then are asked to choose between C and D.

C	D
(1) -500	(0.5) - 1000 + (0.5) 0

In the first scenario, people usually choose prospect A to get the certain gain while in the second scenario people usually choose option D to try avoiding the loss. People do not consider the initial given amount because it is common between the two choices. In reality, taking into consideration the initial amount, it is seen that option A is equal to option C, and option B is equal to option D. In this case preferences are altered by different representation of outcomes. A = (2,000, 0.50; 1,000, 0.50) = C and B = (1,500) = D.

In prospect theory decision weights "*measures the impact of events on the desiderability of prospect, and not merely the perceived likelihood of these events*" (Kahneman and Tversky, 1979). People do not always consider probabilites in a linear way, moreover they tend to overweight small probabilites and underweight large probabilites.

Each outcome is times its decision weight and it measures the impact of events on the desiderability of prospects and derive from choices between prospects.

(Weighting Function)[12]
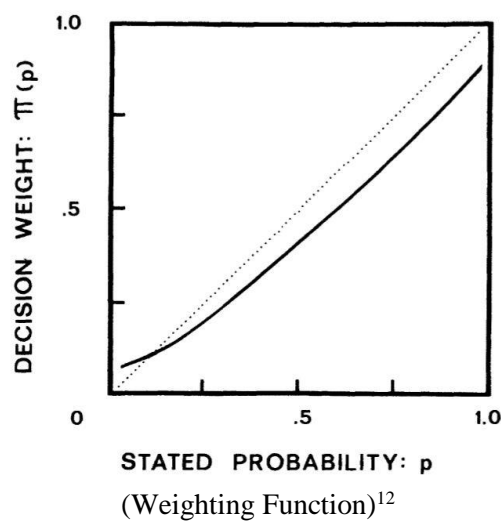
The weighting function[13] π is an increasing function of p, with $\pi(0) = 0$ and $\pi(1) = 1$ and since the outcomes related with impossible events are ignored (scale is normalized) the $\pi(p)$ is the ratio of the weight associated with the probability p to the weight associated with the certain events. The function is characterized by:

- Very low probabilities are overweighted such that $\pi(p) > p$

- For small probabilites π is a subadditive function of p so $\pi(rp) > r\pi(p)$ for $0 < r < 1$

    There two prospects A (6,000, 0.001) and B (3,000, 0.002) and their values are

[12] Kahneman and Tversky (1979), *Prospect Theory: An Analysis of Decision Under Risk*, Econometrica, Vol.47, Nº2, pp. 263-291

[13] Modigliani Group (2012), *Notes on: Prospect Theory: An Analysis of Decision Under Risk* (Kahneman and Tversky 1979)

$V(A) = \pi(0.001)v(6000)$ and $V(B) = \pi(0.002)v(3000)$. Considering that the 73%

of subjects chose A, $\pi(0.001)v(6000) > \pi(0.002)v(3000)$

$2v(3000) > v(6000)$ due to the concavity of the value function,

$\pi(0.001)2v(3000) > \pi(0.002)v(3000) \rightarrow 2\pi(0.001) > \pi(0.002) \rightarrow$

$\pi(0.5*0.002) > 0.5\pi(0.002)$

- For all $0 < p < 1, \pi(p) + \pi(1-p) < 1$, this property is defined as subcertainty.

The slope of the weighting function in the interval (0,1) measures the sensitivity of preferences to changes in probability. Subcertainty involves that π is regressive to p so that preferences are generally less sensitive to variations of prability than expectation principle indicates, so that the sum of the weights associated with complementary events is less than the weight associated with the certain events.

Consider two pairs of prospects:

| A: 2400 | C: (0.34) 2400 |

| B: (0.33) 2500 + (0.66) 2400 | D: (0.33) 2500 |

In the first pair A was choosen by 83% of subjects, in the second pair D was choosen by 83% of subjects, showing a violating of the independence axioms.

$(2400, 1) > (2500, 0.33; 2400, 0.66)$ and $(2500, 0.33) > (2400, 0.34)$

$\pi(1)v(2400) > \pi(0.33)v(2500) + \pi(0.66)v(2400)$ and

$\pi(0.33)v(2500) > \pi(0.34)v(2400)$ recombining the two equations

$[1 - \pi(0.66)]v(2400) > \pi(0.34)v(2400) \rightarrow$

$1 - \pi(0.66) > \pi(0.34) \rightarrow \pi(0.66) + \pi(0.34) < 1$

- Subproportionality. $\frac{\pi(pq)}{\pi(p)} \leq \frac{\pi(pqr)}{\pi(pr)}$ for $0 < p, q, r \leq 1$.

  For a fixed ratio of prababilities, the ratio of the corresponding decision weight is closer to unity when the probabilities are low than when they are high.

  $(3000, 1) > (4000, 0.8)$ and $(4000, 0.2) > (3000, 0.25)$

  $v(3000) > \pi(0.8)v(4000)$ and $\pi(0.2)v(4000) > \pi(0.25)v(3000)$

  $\pi(0.8)/\pi(1) < v(3000)/v(4000)$ and $v(3000)/v(4000) < \pi(0.20)/\pi(0.25)$

  Recombining the two equations $\pi(0.80)/\pi(1) < \pi(0.20)/\pi(0.25)$

1.3 Bounded Awareness

Other than the concept of bounded rationality, it is important to consider the so-called bounded awareness. This concept indicates that individuals' awareness is bounded so they fail to see and use easily available information. Bounded awareness is "*the phenomenon in which individuals do not see accessible and perceivable information during the decision-making process, while seeing other equally accessible and perceivable information; as a result, useful information remains out of focus for the decision-maker.*" (Chugh and Bazerman, 2005)

There are different processes that belong to the bounded awareness[14]:

Inattentional blindness. During an experiment a group of subjects was asked to count the number of passes made between two basketball teams. Subjects had to stay focus and pay attention in order to count the correct number. At the end of the experiment only 21% of participants said they noticed a woman that during the match walked in the court and opened an umbrella. Only when they were shown the videotape again without having to count the

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[14] Chugh and Bazerman (2007), *Bounded Awareness: What You Fail to See Can Hurt You*, Mind & Society 6(1):1-18

passes the subjects realized they missed the obvious. It shows that people tend to miss relevant and easily accessible information if they are focused on other tasks.

Change blindness. People tend to miss the changes in available information; in an experiment conducted by Levin and Simons, participants watched a videotape where easily visible clothing or objects were altered when the camera cut to different angles. Many subjects did not notice the change even if they clearly perceived the initial state of information. Some studies conducted by Mitroff, Simons and Franconeri confirmed the failure in perceive changes but shown that individuals have a sort of representation of both the initial and final information and so the change is perceived at some unconscious level. Moreover, people tend to miss changes more often if they occur gradually.

Focalism and the focusing illusion. People tend to pay too much attention to a particular event and too little on others that are happing at the same time and the main consequence is that "*people overestimate both the degree to which their future thoughts will be occupied by the focal event and the duration of their emotional response to the event*" (Bazerman and Moore, 2008). The focusing illusion is the "*tendency of people to make judgments based on their attention to only a subset of available information, to overweight that information, and to underweight unattended information*" (Bazerman and Moore, 2008).

E.g. The Challenger space shuttle showed how focalism works. In 1986 the Challengers was launched at the lowest temperature ever reached and this led to a massive failure of the "O-rings" that led to several causalities. Before the launch NASA examined seven prior launches that involved issues between temperature and O-rings, without finding any patterns that could have affected the launch, but no one considered the other seventeen launches that did not show problems with O-rings. The point is that examining all twenty-four launches would have shown a connection between temperature and O-ring failure so to find out that the Challenger had more than 99% chance of malfunction.

2 Bias and Judgemental Heuristics

2.1 Common bias in collecting information

The concepts of bounded rationality, bounded awareness, and satisficing demonstrate that people deviate from rationality but do not explain how judgment is affected. In making decisions, individuals use different strategies or shortcuts to simplify the complex environment: these tools are called heuristics. Heuristics can be helpful since they allow people to deal with environment complexity, but the issue that concerns them is that an inappropriate application that can lead to bias. Bias are cognitive errors that negatively affect people, along with inclination and preferences. In collecting information, bias usually result from attention and memory related constraints, the most common are[15]:

Salience and Vividness Effects. Accessing to all available information is not possible, therefore people focus on information that catches their interest the most, that is easy to understand and to process. Usually, to stand out, this information is well presented, but its appealing does not say much about their relevance. Salient information sticks out in one particular setting, whereas vivid information always sticks out regardless of the context and is more connected to emotions, so it allows a deeper and more concrete attach to individuals' minds. Concrete information has a more significant emotional impact and affects individuals directly so that they are more likely to be influenced by such information. An example of concrete information is the first-hand experiences, they are considered to be more relevant than second-hand experiences and can have a disproportionate impact on judgments.

Context effects. The context influences how individuals perceive stimuli so, judgments are highly affected by the environment. The most common biases regarding the context are contrast, assimilation and framing. Contrast is a shift in judgment away from a reference

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[15] *Biases in Managerial Decision Making*, Ch 17th, Cengage

point whereas assimilation is the shift in judgment toward a reference point. Framing is the shift in judgment when focusing on different reference points.

An example of framing is shown by an experiment made by Kahneman and Tversky in which they asked participants to decide between two treatments for 600 people sick with a fatal disease.

Scenario 1 (positive)	Scenario 2 (negative)
A: 200 people will live	A: 400 people will die
B: 33% saving all 600 people	B: 33% no one will die
66% saving no one	66% all will die

In the positive case A was chosen by 72% whereas in the negative case A was chosen by 22% even if they would lead to the same outcome.

Biased Assimilation. Information is evaluated more positively if it is belief-consistent, whereas being belief-inconsistent leads to a more negative evaluation. People tend to interpret information in a way that supports their desired conclusions.

Group decision making. It is thought that, when facing a decision, multiple decision makers contribute to bringing more ideas and perspectives. Actually, during a meeting for example, most information is already familiar among the participants and this leads to the so-called common knowledge effect that makes previously known information to be more influencing. Another phenomenon related to groups is the group polarization effect that moves decisions toward the preferences shared by the majority. Group think means thinking collectively with one mind and it takes place when group members try to minimize conflicts to reach a consensus decision eliminating the critical evaluation of alternatives.

2.2   Judgemental Heuristics

When using information people can process only a limited amount of it and so they tend to simplify the decisional process relying on heuristics. Kahneman and Tversky, the authors of the prospect theory, highlighted four heuristics that underlie judgments: representativeness, availability, simulation, and anchor and adjustment.

2.2.1 Representativeness

This heuristic[16] is used when probabilistic questions have to be answered and "*probabilities are evaluated by the degree to which A is representative of B, that is, by the degree to which A resembles B*" (Kahneman and Tversky, 1974).

To illustrate how representativeness works, Kahneman and Tversky presented a short description about a person and then asked to determine, according to the information given, if it is more probable A or B

> *Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations. Is it more probable that Linda is a bank teller or that Linda is a bank teller and is active in the feminist movement?*

If people base on the representativeness heuristic, they would choose the second option, so that Linda in addition to be a bank teller, she is also active in feminist movement because it fits stereotypes in the given description. Actually, the second option is a subset of the first

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[16] Kahneman and Tversky (1974), *Judgment under Uncertainty: Heuristics and Biases*, Science, New Series, Vol. 185, No. 4157

one and so it is more likely she is just a bank teller. This approach can lead to errors in judgment since representativeness presents some characteristics:

Insensitivity to prior probability of outcomes. If people use representativeness to determine the probability of an outcome, prior probabilities are not considered, and the judgment is entirely based and influenced by descriptions or stereotypes. People only consider prior probabilities if there is no other available information. Tversky and Kahneman presented a description to subjects of an experiment: "*Dick is a 30-year-old man. He is married with no children. A man of high ability and high motivation, he promises to be quite successful in his field. He is well-liked by his colleagues*" Then participants were asked to determine the probability of Dick being an engineer or a lawyer in a group made of 100 people. In the first scenario subjects were told the group was made of 70% engineers and 30% lawyers while in the second scenario 30% engineers and 70% lawyers. If participants relied on prior probabilities, in the first case the probability Dick would be an engineer were 70% and while in the second case 30%. The results showed that subjects estimated a probability of 50% for Dick being an engineer in both cases, demonstrating that in representativeness prior probabilities are not taken into consideration. The subjects were able to properly consider prior probabilities when they were not given any description, in this case the probability for Dick being an engineer was 70% in the first case and 30% in the second case.

Insensitivity to sample size. To determine the probability of an event, people compare it to a population parameter without considering the sample size, even if it is clearly specified in the problem, and they tend to produce identical distributions among different sized samples. People should be aware that the variation (extreme outcomes) is higher in small samples while the bigger the sample, the more stable the result converge to 50%.

Misconception of chance. People believe that a short sequence of random choices must have the same characteristics of a longer one. As said before, a small sample will have more extreme outcomes and so it deviates systematically. For example, when tossing a coin,

people consider being more likely the sequence H-T-H-T-T-H than H-H-H-T-T-T and H-H-H-H-T-H because the first one looks more random and to have the fairness of the coin. Another phenomenon related to the misconception of change, is the so-called gambler's fallacy; it happens when, after watching a long run of red at the roulette, people believe that it will be the turn of black, because wrongly chances are thought to be self-corrective, i.e. a deviation to one side provokes a deviation the other to obtain equilibrium.

Insensitivity to predictability. When people make predictions, they tend to predict future performance mainly by the similarity of description to future results; for example, a group of subjects was given a description about the performance of a student teacher during a lesson. Some subjects were asked to evaluate the quality of a practise lesson while other subjects were asked to predict the standing of the student teacher 5 years after that lesson. The evaluation and the prediction were identical meaning that the group of subjects predicted future performance on a single practice lesson.

Illusion of validity. People estimate probabilities by selecting the outcome that most represents the input and the more it is representative, the more confidence they have in their judgment. This confidence represents the illusion of validity that persists even if proofs against the judgment are shown. The confidence is influenced by the pattern of inputs, so the more the inputs are highly redundant or correlated the more confidence people have. In reality the situation is the opposite, a prediction based on many independent variables is more accurate.

Misconception of regression. People do not have correct intuitions about regressions, because they do not expect them to be present in many contexts and even in case they are able to recognize them, individuals prefer to rely on some casual explanations. Since in the representativeness heuristic the outcome has to represent the input maximally, the concept of the regression goes against this belief and it remains elusive. People having difficulties in understanding this concept, leads to overestimate the power of punishment and to

underestimate the power of reward. This happens because it is not clear that when change is involved and phenomena depend on many variables, extreme outcomes tend to be followed by more moderate outcomes.

2.2.2 Availability

The availability heuristic[17] is used to determine the probability of an event and it is based on how easily an instance can be brought to mind. Indeed, if something can be recalled in an easy and effortless way, it has to be important and has a great influence on predictions. For example, if a person is asked to choose which job is more dangerous between being a police officer or a lumberjack, he recalls in his mind that a police officer can be involved in shootings or chasings, so he believes it is more dangerous than being a logger. That is because his mind can recall more easily police officers involved in accidents than lumberjacks, so he thinks they are more common. This heuristic presents some characteristics:

Biases due to the retrievability of instances. This phenomenon can be seen when the size of a class is judged by its instances so the easier to recall the instance is, the bigger the size of a class appears to be. Salience affects the retrievability because as said before salient information is processed more easily and can be recalled faster in mind. Different groups of subjects were told a list of names of famous people and then, they were asked to determine if there were more female or male names. The lists presented to groups differed from one another, in some of them males were more famous than women and in other lists vice versa. Subjects that were presented lists with men more famous judged the class (sex) of male more numerous while subjects that were presented lists with women more famous believed that the class of women is bigger.

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[17] Kahneman and Tversky (1974), *Judgment under Uncertainty: Heuristics and Biases*, Science, New Series, Vol. 185, No. 4157

Biases due to effectiveness of a search set. Judgments depend on the set from which people recall an instance. For example if a person is asked to determine if it is more likely that a 3 letter word starts with "r" or if "r" is the third letter, he starts to recall in his mind both words that start with "r" and words that have "r" as the third letter. The ease in recalling words determines the frequency and since it is easier to recall the first letter he answers that is more likely that a word starts with a consonant than that has a consonant as third letter.

Biases of imaginability. Sometimes can happen that instances are not already in an individual's mind so different instances can be created according to given rules and then the evaluation of frequency or probability is based on how easily the relevant instance haa been generated.

Illusory of correlation. People to judge the frequency with which two events co-occur, often overestimate the correlation, even when contradictory data are shown. The most common example of illusory correlation is the association of minority groups with negative behaviours. When a member of a minority group misbehaves, it is easier to recall, resulting in these groups are more likely to misbehave in people opinion.

2.2.3 Simulation

The simulation heuristic[18] is a step further from the availability heuristic and the biases of imaginability. It was formulated by Kahneman and Tversky in 1981, eight years after the availability heuristic. This implementation happened because recalling instances and generating scenarios required different processes and are used in different situations. Depending on how easily the outcomes are simulated, the likelihood of a real system to produce these outcomes is assessed. The simulation heuristic can be used both in the past (counterfactual judgment and assessments of causality) and future (predictions, assessing the probability of a specified event, assessing conditioned probabilities) thinking.

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[18] Kahneman and Tversky (1981), *The Simulation Heuristic*, Technical rept.

Counterfactual judgment is related to the "distance" between what happened and what could have happened.

> *Mr Crane and Mr Tees were scheduled to leave the airport on different flights, at the same time. They travelled from town in the same limousine, were caught in a traffic jam, and arrived at the airport 30 minutes after the scheduled departure of their flights. Mr Crane is told that his flight left on time. Mr Tees is told that his flight was delayed, and just left five minutes ago. Who is more upset? Mr Crane or Mr Tees?*

The majority (96%) of subjects answered Mr. Tees. The point of this experiment was to show that there were no real differences between the two characters, but people chose Mr. Tees because they felt that for him was "more possible" to get the plane than for Mr. Crane. Mr. Tees could imagine easier to arrive five minutes earlier and to get the flight and for the subjects it was easier to step into Mr. Tee's shoes. This phenomenon shows that the simulation process has some constraints.

When people create alterations in stories, alterations can be classified as downhill, uphill, or horizontal changes. Downhill changes consist of removing a surprising or unexpected part of the story, or in increasing its internal coherence. Uphill changes consist of inserting unlikely occurrences. Horizontal changes consist of replacing an arbitrary value with another arbitrary value.

e.g.

Route version

> *Mr. Jones was 47 years old, the father of three and a successful banking executive. His wife has been ill at home for several months. On the day of the accident, Mr. Jones left*

his office at the regular time. He sometimes left early to take care of home chores at his wife's request, but this was not necessary on that day. Mr. Jones did not drive home by his regular route. The day was exceptionally clear, and Mr. Jones told his friends at the office that he would drive along the shore to enjoy the view.

The accident occurred at a major intersection. The light turned amber as Mr. Jones approached. Witnesses noted that he braked hard to stop at the crossing, although he could easily have gone through. His family recognized this as a common occurrence in Mr. Jones' driving. As he began to cross after the light changed, a light truck charged into the intersection at top speed, and rammed Mr. Jones' car from the left. Mr. Jones was killed instantly. It was later ascertained that the truck was driven by a teenage boy, Tom, who was under the influence of drugs.

Time version

Mr. Jones was 47 years old, the father of three and a successful banking executive. His wife has been ill at home for several months. "On the day of the accident, Mr. Jones left the office earlier than usual, to attend to some household chores at his wife's request. He drove home along his regular route. Mr. Jones occasionally chose to drive along the shore, to enjoy the view on exceptionally clear days, but that day was just average." The accident occurred at a major intersection. The light turned amber as Mr. Jones approached. Witnesses noted that he braked hard to stop at the crossing, although he could easily have gone through. His family recognized this as a common occurrence in Mr. Jones' driving. As he began to cross after the light changed, a light truck charged into the intersection at top speed, and rammed Mr. Jones' car from the left. Mr. Jones was killed instantly. It was later ascertained that the truck was driven by a teenage boy, Tom, who was under the influence of drugs.

The study consisted of giving these two stories to two different groups respectively made of 62 and 61 subjects asking them to continue the "if only…" sentence, common in counterfactual thinking. They had to undo the event and state what part of the story could have changed the outcome. The results were:

	Route Version	Time Version
Route	33	8
Time leaving the office	2	16
Crossing at the amber light	14	19
Removing Tom	13	18
Other	3	1

From the experiment two general rules that are used to create undo scenarios can be extracted: first, it is more likely that people change an event from an exceptional state to its normal state and not vice versa. In the example the outcome could have been different if Mr. Jones had left the office at the same time as usual and in the case of route version it is not believed that leaving earlier would have avoid the accident. From this observation the authors proposed that "*the psychological distance from an exception to the norm it violates is far less than the psychological distance from the norm to an exception*" (Kahneman and Tversky, 1981).

Second people tend to undo events, not adding an exceptional variable but restoring its normal value so in the time case subjects removed the unusual event (leave earlier) and replaced it with a normal event. The same behaviour can be found in the route version; the unusual route was removed in favour of the usual. These two changes are both downhill alterations, uphill alterations are rare. The "remove Tom" option was not considered by

many subjects and this can be explained by the phenomenon called focus rule. In this story the focus is Mr Jones and subjects were instructed to sympathize with him and his family. Different scenarios are constructed in order to estimate probabilities and a good scenario is the one "*who bridge the gap between the initial state and the target events by intermediate events, with general downhill trend and no significant uphill move along the way*" (Kahneman and Tversky, 1981). The credibility of a scenario can depend either on the credibility of its weakest link or on the number of intermediate steps. It is obvious that scenarios are schematic and incomplete so people tend to choose scenarios as the events that form them are little or no redundant (they represent the local minimum in the predictability and from that point alternatives arise) and that have a high casual significance (when this kind of event occurs, it alters the value that is considered to be normal for other events.) These two factors can lead to overestimating scenarios where dramatic events mark casual transitions and underestimating scenarios produced by slow and incremental changes. Moreover, if an event is represented by one plausible scenario, it will be considered more favourable than an event that can be represented by multiple and unlike ways.

2.2.4 Anchor and adjustment

Often to make estimations, people start from an initial value and then adjust it, in other words, they start from an initial fact and subsequently develop from it. This concept is called anchoring and it can happen both when the starting point is given and when it comes from individuals' computation:

Insufficient adjustment. Often adjustment is insufficient and leads to underestimation. Two groups of student have to estimate each a numerical expression, the first group "8 x 7 x 6 x 5 x 4 x 3 x 2 x 1", the second "1 x 2 x 3 x 4 x 5 x 6 x 7 x 8" and the hypothesis is that the result of the first numerical expression is judged to be higher since the first multiplications

involves bigger numbers. The results are respectively 2,250 and 512 while the correct answer 40,320.

Biases in the evaluation of conjunctive and disjunctive events. People tend to overestimate the probability of conjunctive events and to underestimate disjunctive events.

A conjunctive event represents the probability of two events that occur together, so it calculates the probability of two or more events both happening. A disjunctive event represents the probability of the occurrence of one of two events. In probability a conjunctive event is always less probable than a single event such that $P(A \cap B) \leq P(A)$. In a study conducted by Bar-Hillel subjects were asked to bet on one event among: a simple event consisting of drawing one red marble from a bag containing 50% red marbles and 50% white marbles, a conjunctive event consisting of drawing a red marble seven times in succession, with replacement, from a bag containing 90% red marbles and 10% white marbles, a disjunctive event consisting of drawing a red marble at least once in seven successive tries, with replacement, from a bag containing 10% red marbles and 90% white marbles. The majority of subjects betted on the conjunctive event rather than on simple event and preferred the simple event on the disjunctive events. In reality the probability of such events is $P(A \lor B) \geq P(A) \geq P(A \cap B)$. This happens because people consider as the starting point the simple event and since the adjustment is insufficient the final estimation remains close to the starting point.

Anchoring in the assessment of subjective probability distribution. When people are forming subjective probability distributions, often the distributions are too tight in relation to the actual probability distributions.

2.3   The role of intuition

2.3.1 Dual process theory

According to the dual processing theories[19], there are two ways with which human beings process information: system 1 and system 2. System 1 is the intuitive system that is fast, automatic, and does not require conscious effort; it is made of sub-systems and involves instinctive behaviours. System 2 is the reasoning system that is slower, conscious, and effortful; it has limited capacity (since it depends on memory), but it allows abstract and hypothetical thinking. Often in making decisions people rely on past experiences that concern system 1 but when no previous experience is available system 2 provides support thanks to its ability of abstract thinking. One example that supports this dual process was proposed by Evans and it is called "belief-bias". He aimed at creating a conflict between prior belief (system 1) and logical (system 2) responses about the truth of conclusions.

To create such conflict, subjects were presented some syllogism and were asked to deal with the problem just with logical reasoning, drawing a conclusion based only on the information given in arguments. The validity of a syllogism comes from the validity of its arguments and not from the believability of its conclusion. An argument to be valid must have premises that imply the conclusion. People often evaluate arguments considering how believable their conclusions are, so instead of focusing on the validity of arguments, they tend to focus on conclusions that agree with their belief; that is why often people accept invalid arguments that lead to a believable conclusion and do not accept valid arguments that lead to a conclusion that they do not accept:

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[19] Evans (2003), *In two minds: dual-process accounts of reasoning*, TRENDS in Cognitive Sciences Vol.7 No.10

Valid argument, unbelievable conclusion (Conflict)	Invalid argument, believable conclusion (Conflict)
No nutritional things are inexpensive	No addictive things are inexpensive
Some vitamin tablets are inexpensive	Some cigarettes are inexpensive
Therefore, some vitamin tablets are not nutritional	Therefore, some addictive things are not cigarettes

Results showed that prior beliefs strongly influence responses, especially those that lie on invalid arguments.

These two systems work together and interact each other so that system 1 gives suggestions to system 2 and system 2 develops them turning into beliefs and voluntary actions; it is important to note that often rationalisations do not change from the initial judgment provided by system 1. Intuition was defined as a process of thinking in which its input *"is mostly provided by knowledge stored in long-term memory that has been primarily acquired via associative learning. The input is processed automatically and without conscious awareness. The output of the process is a feeling that can serve as a basis for judgments and decisions."(Betsch, 2010).*

2.3.2 Intuition

Intuition can be attributed to system 1 and it is characterized[20] by:

1. Nonconsciousness. The process is not accessible to conscious thinking, the way it works is not understandable;

2. Holistic associations. Stimuli from the environment are associated with the nonconscious pre-existent category in individuals' minds. These associations are not

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[20] Dane and Pratt (2007), *Exploring intuition and its role in managerial decision making*, Academy of Management Review 2007, Vol. 32, No. 1, 33–54

logical and so they are defined as holistic and these associations are made through the use of cognitive structures. Research shows two kinds of cognitive structures: simple structures such as heuristics and complex structure such as those used by experts;

3. Rapidity. It allows to know immediately what action is best to take and it is faster than rational decision-making processes.

Intuition under appropriate circumstances can be useful and can be more efficient than rational decision-making processes in management decisions. There are three factors that affect the intuition effectiveness[21]: (1) the domain knowledge of the decision maker, (2) the task characteristics, and (3) the decision environment. The domain knowledge refers to "schemas", cognitive structures that individuals have about the domain. Schemas can be either domain independent (little domain knowledge) or domain relevant (much domain knowledge). It is important to distinguish between heuristic schemas and expert schemas. Heuristics schemas are simple and therefore are not considered to be suitable to process complex environmental stimuli. Moreover, they are domain independent so they can be applied to a wider variety of situations, often in an erroneous way.

On the other hand, expert schemas are highly complex and domain relevant; intuition that exploit them can be described as a "pattern matching process" so that experts recognize stimuli and react applying the correct schema. Expert schemas make intuition more effective than heuristic schemas because intuition in order to be effective requires that schemas are both complex and domain relevant.

The second factor that influences intuition effectiveness is the problem structure; when a problem is not well structure, intuition plays an important role in making decisions because there are not strict rules to cope with the problem and holistic associations are helpful in defining and figuring out possible solutions.

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[21] Salas, Rosen, and DiazGranados (2009), *Expertise-Based Intuition and Decision Making in Organizations*, Journal of Management XX(X) 1–31

The third factor is the environment structure; time pressure is an important element that contributes in increasing the intuition effectiveness since in such cases the decision maker does not have the time to follow a rational model strategy and therefore he relies on his intuitive thinking.

The intuitive process comes from experience and learning and therefore intuition is neither the opposite of rationality nor it means guessing; people store experience and knowledge and in certain moments, when reacting to stimuli from the environment, they make individuals able to recognise patterns, giving hints about what to do.

To acquire complex schemas a learning process is involved, and it includes both explicit and implicit learning[22]. Explicit learning occurs when an individual is conscious that changes are affecting his knowledge, so he deliberately acquires and stores new schemas in his memory in order to be able to cope with decisions in a more efficient and automatic way. The explicit learning is positively influenced by three factors: duration (it requires time), repetition (practise makes perfect), and feedback.

Implicit learning refers to a nonconscious process about gaining new knowledge and research indicates that implicit learning can be as useful as explicit learning to develop complex schemas. So, even if implicit and explicit learning can take place at the same time, acquisition and storage are different. Implicit learning is an automatic process that does not require efforts, but some research has shown that might be ways to process stimuli that make implicit learning more effective such as "*by consciously paying attention to the stimuli in question*" (Dane and Pratt, 2007) , looking at stimuli as their whole.

Intuition in this sense is defined as expertise-based and Baylor[23] proposed how it is developed.

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[22] Dane and Pratt (2007), *Exploring intuition and its role in managerial decision making*, Academy of Management Review 2007, Vol. 32, No. 1, 33–54

[23] Baylor (2001), A U-shaped model for the development of intuition by level of expertise, New Ideas in Psychology 19 (2001) 237–244
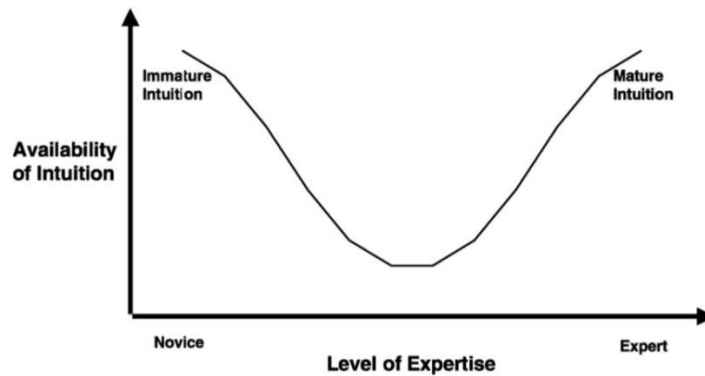
(Intuition development)[24]

A U-shaped progression can describe the development of intuition. At the beginning of the progressions the level of intuition available is high but it is considered to be immature and domain independent. After there is a shift to a more analytical understanding due to the gain of more concepts; the growth of knowledge stops the immature intuition but enable the development of the so-called mature intuition. The mature intuition is a complex cognitive structure. The main difference between immature and mature intuition is the qualitative analysis of the problem and it depends on the level of expertise acquired by an individual. Both immature and mature intuition are characterized by immediacy and reason, but the level of expertise determines "*what relationships can be sensed*" (Baylor, 2001). The mature intuition can be defined as the intuition that occurs when a person has developed a large amount of knowledge about a determined field from previous experience.

In managerial decision-making intuition has an effective role since strategic problems are not well structured so they lack of complete and accurate information. The environment is not stable and so different issues arise such as: limited time to collect data, the need to collect a lot of data to cope with the unstable environment, and the lack of reliability of data.

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[24] Baylor (2001), A U-shaped model for the development of intuition by level of expertise, New Ideas in Psychology 19 (2001) 237–244

3   Entrepreneurs, heuristics and biases

Entrepreneurs make decisions under extreme conditions such as uncertainty, complexity, time pressure, emotionality, and identity investment therefore, they must act strategically in order to keep up with changes that occur in the environment and to maintain the competitive advantage[25]. One of the most important skills for successful entrepreneurs is the ability to recognize opportunities and uncertainty is the most challenging factor in recognizing, evaluating and exploiting opportunities. Entrepreneurs to quickly face uncertainty, often rely on heuristics to make decisions, otherwise "*without these heuristics, entrepreneurs would often miss out on opportunities as the window of time to act on opportunities tends to close quickly*" (Sheperd and Patzelt, 2018).

3.1   Entrepreneur cognition

As discussed in section 1.2, human beings are bounded in their rationality, meaning that they cannot be fully rational when making decisions. The main consequences of bounded rationality are: (1) the capacity to process new information is limited and the amount of information that can be processed is often exceeded and (2) people try to minimize efforts, including cognitive efforts and so they use cognitive shortcuts called heuristics when making decisions. All individuals in making their decisions rely on such shortcuts that can "*entrepreneurs can regularly face situations that can maximize the potential impact of various biases and errors*" (Baron, 1998). Such situations can be described as overloading (they involve a huge amount of information), highly uncertain (they are new to entrepreneurs, so mental schemas cannot be applied), emotions intense and scarce of time. Indeed, entrepreneurs face such situations often because the nature of their activity is complex, unpredictable and requires a full-time commitment both in time and emotional

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[25] Shepherd and Patzlet (2018), Entrepreneurial Cognition: Exploring the Mindset of Entrepreneurs, Palgrave Macmillan

component. According to a study conducted by Baron[26], the errors and biases that are related to the entrepreneurial thinking are:

Counterfactual thinking. Counterfactual judgment or counterfactual thinking is defined as the metaphorical distance between what actually happened and what could have happened. When a person simulates an event that has never happened, that event can strongly impact the emotional state, influence the future decisions and overt behaviours[27]. If an individual simulates to have a better situation, he will feel more disappointed about his current situation whereas imagining a worse situation would make the individual happier about his current situation. The phenomena of counterfactual thinking and entrepreneurial thinking are linked through the concept called the experience of regret. The nature of regret changes over time, when an event is recent individuals tend to regret decisions that they have made with disappointing outcomes whereas when an event is old, people tend to regret past opportunities that they have missed. This shift can be explained by two factors: (1) people can cope better with disappointing events than with missed opportunities because it is easier for humans' minds to rationalize what the wrong decisions were while missed opportunities are more difficult to be rationalized and people tend not to understand why they missed them, and (2) how people consider the "*costs of having failed to act or having failed to seize an opportunity*" (Baron, 1998). The costs associated with a disappointing event can be easily calculated whereas the costs associated with a never happened event are really difficult to be established and so while the negative consequences about a disappointing event are clear, the positive consequences related to an event that did not happen are uncertain and over time people tend to elaborate in a positive way the benefits that would have been related to a missed opportunity. These

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[26] Baron (1998), *Cognitive Mechanisms in Entrepreneurship: Why and When Entrepreneurs Think Differently Than Other People*, Journal of Business Venturing 13, 275–294

[27] Mandel and Lehman (2006), *Counterfactual Thinking and Ascriptions of Cause and Preventability*, Journal of Personality and Social Psychology 71(3):450-63

asymmetries make disappointing events less regretted over time and the missed opportunities more regretted. Entrepreneurs tend to regret past missed opportunities, and since entrepreneurs' level of commitment is high the negative effect that the simulation has on their emotions is amplified especially when they perceive that a particular past failure to act is the responsible for the current negative results.

Affect infusion. The affect infusion is based on current moods that can influence different aspects of cognition significantly. The affect infusion model[28] explains how affective states influence judgments about other and totally unrelated events. The influence acts through two mechanisms: (1) affect priming and (2) affect-as-information. In the affect priming the current moods influence judgments because they influence how easily an individual can recall information that is consistent with moods. For example, a positive mood stimulates positive thoughts, while a negative mood stimulates negative thoughts. In the affect-as-information the affective state acts as a heuristic and individuals use this short cut when making decisions, examining their feelings towards the event/person involved in the decision-making process. If the feelings are positive the judgment is more likely to be positive and vice versa if the feelings are negative. In the case of affect infusion, the feelings are not generated by the event/person involved in the evaluation, but they are irrelevant to the context. The degree to which the judgments are influenced depends on how much individuals engage in effortful thoughts about an issue. The more intense the effort is, the more the judgments are influenced by current moods; if the decision process is simple and automatic judgments are less likely to be influenced by moods. Since the entrepreneurial activity is non routine and complex, entrepreneurs have to think more carefully and effortfully, so they are more prone to be subjected to the affect infusion. Moreover, entrepreneurs usually are fully involved in their activity and

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[28] Forgas (1995), Mood and Judgment: The Affect Infusion Model (AIM), Psychological Bullettin – February 1995

committed to their companies and so they have a stronger emotional connection in relation to their work.

Attributional. Individuals want to understand why events happen, and "*the process through an individual seeks to identify the causes of events, others' behaviour, or practically anything that is encompassed by their experience*" (Pittman, 1993) is called attribution. When people engage in attribution to determine the causes of an event, they carefully analyse information related to: (1) consensus – how much other people act in the same manner besides the individual who is the focus of attention, (2) consistency – how much the individual who is the focus of attention acts in the same manner in this situation at other times, and (3) - distinctiveness how much the individual who is the focus of attention acts in the same manner in other, related situations. All this information is useful in order to understand if the behaviour of a determined person is influenced by internal factors or external factors. If the consensus, consistency and distinctiveness are high, people tend to attribute actions to external factors whereas when consensus and distinctiveness are low, and consistency is high actions are attributed to internal factors. This process is subjected to biases and the most relevant to entrepreneurs is the so-called "self-serving bias". This bias consists of two related parts (1) "*a strong tendency on the part of most people to attribute positive outcomes to internal causes and (2) a corresponding tendency to attribute negative outcomes to external causes*" (Baron, 1998). Entrepreneurs usually prefer to have direct and personal control over the outcomes, and they tend to perceive their abilities as crucial for success so the self-serving bias can often lead to interpersonal friction. According to Venkataraman, successful entrepreneurs are more capable of creating relationships that are vital to the growth and development of their business and so, successful entrepreneurs are less subjected to the self-serving bias.

Planning fallacy. This fallacy in influenced mainly by two factors: (1) The first factor is that often entrepreneurs underestimate risk and overestimate the likelihood of positive

events. According to Kahneman and Lovallo (1994), this happens because entrepreneurs do not fully perceive real risk, since they tend to isolate the current situation from experience, considering it as unique. This leads to making predictions that are almost exclusively based on future images and that are too positive. (2) The other factor that is involved in the planning fallacy is the tendency of people to "*overestimate how much they can accomplish in a given period of time, or underestimate how long it will take them to complete a specific project*" (Baron, 1998). The planning fallacy arises for two main reasons: first when people plan the process to complete a task/projects they focus primarily on the future and so, for example what steps are necessary to finish it etc. The issue with the planning is that the experience in similar events is not considered due to some cognitive obstacles, indeed people to make estimates focus much more on the current situation and on the future. Even in case people consider past experiences, if the project takes longer than estimated to be completed, they attribute the cause to external factors and so are subjected to the self-serving bias. Entrepreneurs focus more than other people on the future, and they are more prone to the planning fallacy also because they often face new situations that are unique and so they have little relevant experience.

Escalation of commitment. The decision-making process is a process, so it is made of subsequent decisions and the next decision is based on the previous one. The problem arises when the outcome of the previous decision is not what expected and a lot of time, effort and resources were invested, in such situation an individual is more willing to keep persisting because he made an investment, and he feels the need to justify it. The factors that make people persisting are: (1) responsibility - about the initial decision, people feel responsible for carrying on their initial idea, (2) effort - the decision-making process requires effort, people are not willing to start it over again and so prefer to stuck with the current idea, (3) loss of face - in admitting to made a mistake, and (4) justification - of themselves about the soundness of the first idea. It is believed that entrepreneurs are more

susceptible to the escalation of commitment because when an entrepreneur discover and then exploit an opportunity, they put all his efforts and going back is not an acceptable solution. Another concern of them is to lose face. Since their commitment they can really feel the pressure to justify their initial idea.

3.2   Entrepreneurial opportunities

The study of entrepreneurship (Venkataraman, 1997) involves:

- How opportunities are discovered, evaluated and exploited
- Who discovers, evaluates and exploits opportunities
- What effects these opportunities lead to

Opportunities are the foundation of entrepreneurship; without them entrepreneurship would not exist. Therefore, understanding how opportunities are recognized, evaluated, and exploited is extremely relevant to understand entrepreneurship . Entrepreneurial opportunities[29] are defined as "*those situations in which new goods, services, raw material, and organizing methods can be introduced and sold at greater than their cost of production*" (Casson, 1982); since these opportunities involve the "*discovery of new means-ends relationships*" (Kirzner, 1997) the entrepreneurial process does not consist in optimizing. Opportunities can be found in different forms, such as in product markets or factor markets. Product markets opportunities were categorized by Drucker into (1) the creation of new information, (2) the exploitation of market inefficiencies that result from information asymmetry, and (3) the reaction to shifts in the relative costs and benefits of alternative use of resources.

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[29] Shane and Venkataraman (2000), *The Promise of Entrepreneurship as a field of research,* Academy of Management Review 2000, Vol. 25, No. 1, 217-226.

To exist entrepreneurial opportunities require that "*different members of society have different beliefs about the relative value of resources*" (Shane and Venkataraman, 2000); indeed, these different beliefs enable people to make different conjectures about prices and markets developments. An opportunity is discovered is when "*someone makes the conjecture that a set of resources is not put to its best use so that the resources are priced too low, given a belief about the price at which the output from their combination could be sold in another location, at another time, or in another form*" (Shane and Venkataraman, 2000). There are two main reasons for which entrepreneurship needs individual to have different beliefs: (1) it also consists in joint production, so for entrepreneurs to obtain resources it is necessary that the owners of resources have a different conjectures about price, otherwise if conjectures are the same the profit for entrepreneurs would be nil, (2) if all people share the same conjunctures about prices, everyone would compete for the same profit, eliminating the incentive to compete for the opportunity.

People have different expectations about prices because they base their decisions on heuristics that lead to errors and biases, so expectations about prices are hijacked by heuristics. In addition, the economy operates in a condition of disequilibrium and so, different agents have different information at different times, leading to different expectations. There is not a predetermined duration for a new opportunity, it can depend on different factors such the speed of information, the faster they are, the lesser the opportunity last, the presence of patents and the ability of competitors to imitate.

3.2.1 Opportunity recognition

The first phase is the opportunity recognition. When entrepreneurs recognize opportunities, they use the so-called pattern recognition models[30], cognitive processes that consist in

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[30] Baron (2006), *Opportunity Recognition as Pattern Recognition: How Entrepreneurs "Connect the Dots" to Identify New Business Opportunities*, Academy of Management Perspectives, 20(1):104-119

"*cognitive frameworks they have acquired through experience to perceive connections between seemingly unrelated events or trends in the external world. In other words, they use cognitive frameworks they possess to connect the dots between changes in technology, demographics, markets, government policies, and other factors*" (Baron, 2006).

The main factors that positively influence the recognition of opportunities are:

Active search. In the context of pattern recognition, it consists of actively searching for either links or connections between seemingly unrelated events and trend or information that are considered to be relevant. It means first to identify the changes, trends and events and then search for potential links between them;

Alertness. It consists of entrepreneurs being alert, i.e. prepared to recognize opportunities, so that they engage in a passive search in which they are receptive. Alertness belongs to own cognitive abilities that help in identifying new solution starting from existing information, relying on cognitive structures such as prototypes or exemplars. It can be influenced by personal traits such as creativity (entrepreneurs are considered to be more creative than other people and therefore are more alert), optimism, and risk perception;

Prior knowledge. It derives from information gained from both varied business and work experience are useful in recognizing opportunities, since it enables entrepreneurs to develop more accurate and appropriate prototypes and exemplars;

Social networks. The wider the number of relationships, the more opportunities are identified. The reason is that social networks are sources of information that can contribute to expanding entrepreneurs' knowledge and as a consequence to develop their cognitive frameworks.

These factors are related among one another; the active search may not be necessary when the alertness is high, or the prior knowledge is wide. Entrepreneurs that have high alertness have well-developed cognitive frameworks that are useful for perceiving more meaningful patterns in the environment so, they do not need to engage an active search for opportunities

because their ability to perceive such frameworks allow them to interpret and process new information. Equivalently, a wider amount of prior knowledge can assist in forming broad and richly connected cognitive frameworks, so that an active search is less important.

There are two propositions that underpin the application of pattern recognition models: (1) the patterns from which opportunities are recognized are complex and are characterized from changing conditions such as technology, economic, political, social, and demographic and they start existing in the precise moment because of a juxtaposition of these conditions which did not exist previously but is now present, (2) the recognition of opportunities depends on cognitive structures possessed by individuals, so on frameworks of stored experience that enable individuals to perceive connections between seemingly unrelated changes or events. According to the author there are different models of pattern recognition but all of them focus on the fact that people notice various events in the external world and use cognitive frameworks that they have developed through experience to determine whether these events are related in any way, i.e. if they form a discernible pattern.

The process of opportunity recognition usually occurs in many steps and repeated efforts rather than in one single step. Entrepreneurs do not recognize all the aspects of an opportunity at first sight therefore, the recognition process can be considered as never completed since each time entrepreneurs gain new experience and information, their view of an opportunity is expanded and refined.

3.2.2 Opportunity evaluation

The second phase, subsequent to the recognition, is the evaluation that consists of assessing if an opportunity is worth or not. Wood and Williams[31] demonstrated that entrepreneurs use cognitive structures to evaluate opportunities systematically and such opportunities are

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[31] Wood and Williams (2014), Opportunity Evaluation as Rule-Based Decision Making, Journal of Management Studies 51:4

evaluated according to subjective interpretations. These cognitive structures are defined as rule-based decision making to structure opportunity evaluation decisions by applying rule content i.e. it is a structured way to think about a complex decision problem. The rule content concerns different aspects of opportunities: (1) the degree of novelty, (2) the resource efficiency, (3) and the worst-case scenario. These rules are influenced by individual differences in knowledge resources such as knowledge of the opportunity market and opportunity technology. The authors showed that entrepreneurs tend to develop opportunity templates around three broad categories of rule content:

Demand-side considerations (novelty). An opportunity to be considered as an entrepreneurial opportunity must introduce new means-ends relationships, it must be novel in some way. Novelty belongs to the demand-side consideration and its degree influences both risk and potential reward; the more novel an opportunity is, the higher the risk and the higher the potential reward. The increase in risk means the environment to be more uncertain so that not all entrepreneurs are willing to introduce such novel means-ends relationships; despite this situation, novelty is considered to be a positive factor in the evaluation process so that an opportunity is more attractive when the level of novelty is high rather than low.

Supply-side considerations (resource efficiency). Entrepreneurs try to optimize the deployment of resources to reach the so-called resource efficiency. In evaluating an opportunity, the resource efficiency factor plays a relevant role, indeed entrepreneurs seek to determine if the resources mobilized are put at their first and best use to justify their deployment for a particular opportunity rather than for another opportunity. When resource efficiency is high rather than low, an opportunity is considered more attractive.

Personal considerations (worst-case scenario). Another factor that is considered by entrepreneurs is the worst-case scenario; since personal risk is involved entrepreneurs consider the consequences of an opportunity and determine if they can be bearable in the

event the worst case can happen. The concept of the worst-case scenario is related to counterfactual thinking, entrepreneurs simulate all possible future scenarios that they can think of, in order to "*anticipate and avoid situations where they will regret their choices*" (Loomes and Sugden, 1982). An opportunity is considered to be attractive when the worst-case scenario is mild rather than severe and the worst-case scenario can strongly influence considerations on novelty and resource efficiency; if both the novelty and the resource are high but the worst case is severe, the attractiveness is lowered.

The application of these rules is influenced by the differences between individuals, one relevant element is the prior knowledge about both the demand-side (opportunity market) and the supply-side (opportunity technology) held by entrepreneurs. Prior knowledge strengthens the positive relationship between novelty and attractiveness and between resource efficiency and attractiveness but at the same time, it strengthens the negative relationship between worst-case scenario and attractiveness. The prior knowledge reinforces the relationships, it does not change them.

Evaluating an opportunity involves judgments made under conditions of uncertainty and complexity therefore the way entrepreneurs perceive risk influences how they evaluate an opportunity; when entrepreneurs perceive a low probability of failure and are confident about how well the business will do so that an opportunity is associated with a lower level of risk, they tend to evaluate it more positively.

According to a study conducted by Keh, Foo and Lim[32] there are different cognitive biases that can affect the decision-making process during the opportunity evaluation phase: (1) overconfidence, (2) belief in the law of small numbers (representativeness), (3) illusion of control, and (4) planning fallacy.

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[32] Keh, Foo and Lim (2002), Opportunity Evaluation under Risky Conditions: The Cognitive Processes of Entrepreneurs, Entrepreneurship: Theory and Practice 27(2):125 - 148

Overconfidence is related to the anchor heuristic and it means that people are overconfident about the accuracy of their own judgments. Schaefer defined it as "*a positive difference between confidence and accuracy*". When individuals are overly optimistic about their initial judgment, they are not willing to modify it, adding new information. Overconfidence allows entrepreneurs to act even when it does not make complete sense, to convince other people about the soundness of an opportunity, for example of a new project or a new investment. This bias usually occurs in situations that are ill-structured and leads entrepreneurs to perceive less risk;

The law of small numbers (representativeness) is related to generalizing from small, non-random samples as personal experience to obtain accurate judgments, whereas the inference process has to start from large and random samples. Small, non-random samples do not have statistic validity and do not represent the whole population. Entrepreneurs rely on representativeness because they do not have large, random examples and because collecting all the information available is both time consuming and costly and often information is rarely available. In order to act as fast as possible, before the opportunity window closes, entrepreneurs have to rely on small samples and on their personal experience. The law of small numbers leads entrepreneurs to perceive less risk especially if the available information is positive;

Planning fallacy. As said before, the planning fallacy consists in making predictions about how much time is necessary to complete a determined task, without considering past situations that presented similar characteristics, leading to underestimating it. This bias occurs more often "*in situation that are unique, filled with uncertainties, and where there is a need for focus on the future*" (Baron, 1998). The planning fallacy leads entrepreneurs to perceive less risk;

Illusion of control. It is a bias that makes entrepreneurs to overemphasize the degree to which they believe that their abilities can positively influence firms' performance in

situations in which chance plays a significant role. The illusion of control arises mainly for two reasons: (1) people want to control the environment and (2) "*skills and chance factors are closely associated, and it is often hard to discriminate between chance and skill elements*". (Keh, Foo, and Lim, 2002).

If the entrepreneurs are biased when evaluating opportunities, they perceive less risk and so are more willing to evaluate positively and opportunity. The problem is that perceiving less risk can lead to making risky decisions that can seriously damage the company.

A study conducted by Bryant[33] showed that in the opportunity evaluation phase, entrepreneurs use heuristics to assess if an opportunity is worth to be further pursued and to cope with the risk that surrounds it. He identified four heuristics:

Strategic fit. The first phase in assessing if a new opportunity is worth or not is to check if it fits the core strategy of the firm or if it fits its vision. This first phase aims at assessing the risk and if it does not suit the core strategy it is considered too risky and the opportunity is discarded. If the opportunity fits the core strategy, it is considered to be worth and it is explored deeper. Sometimes if the fit with the strategic core or the vision is really strong, an entrepreneur can proceed without any further analysis:

Market knowledge. An opportunity is considered to be worth if the entrepreneur already knows the market in which operates. The previous experience and the expert knowledge underpin intuition that can enable entrepreneurs to have or not a good feeling about the opportunity. Intuition can be useful for assessing both the strategic fit and the market knowledge.

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[33] Bryant (2007), *Self-regulation and decision heuristics in entrepreneurial opportunity evaluation and exploitation*, Management Decision Vol. 45 No. 4, 2007 pp. 732-748

Worst case. If the worst case is considered to be unacceptable the opportunity is discarded, in this situation an entrepreneur has to determine the affordable loss that he would be willing to bear in case of the worst scenario.

Trusting others. Firms often have to rely on third party collaborators such as suppliers, consultants etc. If the third party is considered as trustable and plays a fundamental role in the new opportunity it is considered as worth whereas if the third party is not trustable the opportunity is rejected.

3.2.3 Opportunity exploitation

Exploiting an opportunity means "*to gain returns from the new product arising from the opportunity through the building of efficient business systems for full-scale operations*" (March, 1991). Entrepreneurial opportunities have as outcomes new products/services, therefore the novelty increases the level of uncertainty; essentially entrepreneurs in the exploitation phase have to decide between (1) after evaluation an opportunity, exploit it immediately to maximize lead time, facing a high level of uncertainty and (2) delaying the exploitation phase in order to reduce uncertainty and gain the necessary resources[34].

According to the resource-based view, it is important that a product is inimitable other than being new; inimitability allows a firm to have a sustainable competitive advantage because it can lengthen the lead time, that is considered to be a relevant aspect for a successful launch of a new product. The lead time is the period prior competitors' entrance, during which the first entrant has the monopoly and therefore, lengthening it can provide different performance benefits.

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[34] Choi and Sheperd (2004), *Entrepreneurs' Decisions to Exploit Opportunities*, Journal of Management 2004 30(3) 377–395

The necessary resources are (1) enabling technologies, (2), managerial capabilities, and (3) stakeholder support and they impact entrepreneurs' decisions to exploit opportunities along with the customer demand:

Demand uncertainty. Exploiting new opportunities involves a high degree of uncertainty over the value of the new product for its final users. When a product is new, customer demand is uncertain since customers may not be aware of the new product or how valuable it can be. If the perceived knowledge of customer demand is high, the exploitation is more likely to be positively considered;

Enabling technologies. Technology has a key role in the development of new products, it has to be sufficiently developed so that it can enable products to meet quality and efficiency expectations. If the technology is not sufficiently developed, entrepreneurs may face difficulties in translating the opportunity into product specifications. If the perceived development of enabling technologies is high, the exploitation is more likely to be positively considered;

Managerial capabilities. Management is required for exploiting opportunities since it involves handling critical and complex task, therefore appropriate managerial capabilities make the firm to operate more efficiently and effectively. If the perceived capability of the management team is high, the exploitation is more likely to be positively considered;

Stakeholder support. The whole organization's support is important for successful exploitations, so stakeholders' commitment in terms of money, time and skills is required. If the perceived stakeholder support is high, the exploitation is more likely to be positively considered.

All the resources are influenced by the lead time that is an enhancing moderator in the decision to begin exploitation so that if all resources are high, the likelihood to begin the exploitation is magnified when the lead time is perceived as being long.

According to Venkataraman other two factors that influence entrepreneurs' decision to exploit an opportunity are: (1) the nature of an opportunity, and (2) the individual differences. The nature of an opportunity can influence entrepreneurs' willingness to exploit them. According to different research , entrepreneurs usually tend to exploit opportunities that have a higher expected value, large expected demand, high industry profit margins, low cos of capital and the number of competitors is neither too high nor too low.

The decision to exploit an opportunity differs among entrepreneurs because of individual differences. In order to exploit an opportunity, for example entrepreneurs consider the costs necessary to obtain the necessary resources, therefore entrepreneurs that have greater financial capital usually are more willing to exploit opportunities.

The willingness to bear risk is another factor that has a relevant role in deciding whether exploit opportunities or not; if an entrepreneur is willing to bear more risk, it is more likely that he will decide to exploit an opportunity. High tolerance for ambiguity can positively affect the exploitation decision as well as the need for achievement; if an entrepreneur manifests them in a high degree he may be more likely to exploit opportunities.

4   Heuristics as useful tools

4.1   Ecological rationality and fast and frugal heuristics

The ecological rationality is a step further the bounded rationality; Gigerenzer proposed that internal and external bounds have to be considered as related to each other[35]. When the bounds fit each other, people can make good decisions by exploiting the structure of the environment so "*ecological rationality sees human rationality as the result of the adaptive fit between the human mind and the environment*" (Mata et al. 2012).

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[35] Todd and Gigerenzer (2003), *Bounding rationality to the world*, Journal of Economic Psychology 24 (2003) 143–165

It aims at explaining how mind interacts with the environment and how this interaction can produce good decision making. Individuals constantly deal with the external environment that is uncertain and complex therefore, they have to able to make inferences that are fast, frugal, and accurate; the environment is seen as useful patterns of the available information in the world and these patterns can be exploited by heuristics in order to produce adaptive behaviour.

It has been said that individuals in making decisions, rely on cognitive short-cuts such as heuristics; when heuristics are matched to particular environmental structures, they enable people to be ecologically rational, indeed in appropriate circumstances these simple rules can work as well as complex strategies.

Ecological rationality is made possible by domain-specific solutions, it means that different environments require different fast and frugal heuristics in order to exploit the particular patterns of available information. The simplicity of such heuristics makes them able to change and to adapt to new situations; they are adaptable thanks to their robustness that allows them to work as well as complex structures that involve many parameters. Such heuristics are not too specific, indeed that they work well in particular environments but do not contain enough detail to suit any one environment specifically. Being too specific would lead to be highly predictive in certain situations and to be minimal predictive in others leading to the overfitting phenomenon. Fast and frugal heuristics are based on generalization rather than fitting, so they do not require too many parameters.

Fast and frugal heuristics are considered to be adaptive responses to the environment, and they require a minimum of time, knowledge and computation. Indeed, they "*limit their search of objects or information using easily computable stopping rules, and they make their choices with easily computable decision rules*" (Gigerenzer, 1999). Usually fast and frugal heuristics are defined as one-reason decision making so that they just need only a

piece of information to determine the decision. The need for people to rely on single pieces of information is due to (1) incommensurability – not all reasons can be converted into a single currency, therefore individuals need to use a fast and frugal heuristic based on a single clue , (2) environment structure, and (3) information inconsistency or abundance. Fast and frugal heuristics can ignore information and it is considered as a positive aspect because they enable individuals to make quick and accurate decisions in an uncertain environment. Because of the environment's characteristics, strategies for decision making have to adapt and it is easier to adapt simple strategies rather than complex ones. Fast and frugal strategies are defined as fast because they do not involve a lot of computation and as frugal because they search only for some of the available information. Indeed, they need just a limited amount of time, knowledge, and computation in order to make adaptive choices in the real world.

Fast and frugal heuristics are based on[36]:

Exploit evolved capacities. It means that heuristics are simple mechanisms that can be easily taught and understood and that can be generalized to new situations;

Exploit structures of environment. This concept is related with the ecological rationality concept and it means that heuristics are not good or bad, they have to be considered according to the environment where they are applied.

Distinct from "as-is" optimization models. A model is called as-is when optimization is proposed to explain human behaviour. Heuristics deviate from as-is models because they can produce predictions that cannot be obtained by as-is models.

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[36] Gigerenzer (2004), *Fast and Frugal Heuristics: The Tools of Bounded Rationality*, Blackwell handbook of judgment and decision making (pp. 62–88)

The computational model of fast and frugal heuristics specifies principles[37] that guide the search, that stop the search and that eventually make decisions:

Principle for guiding search. When deciding people have to gather information about alternatives that are considered. Depending on different heuristics, there are different principles for guiding the search, so search for hints is based on specific criteria for each heuristic;

Principles for stopping search. The searching for information has to stop at some point, therefore it is necessary to determine a simple stopping rule. The stopping rule is not based on optimal cost-benefit trade-off, and it is different for each fast and frugal strategies. It stops the search as soon as a hint that distinguishes between alternatives is found;

Principle for decision making. When cues are found and the search is stopped, a decision rule is used to make the decision or inference based on the results of the search.

These principles can be considered as the building blocks of fast and frugal heuristics therefore, starting from these blocks different heuristics can be built in order to be adapted to different and particular environments; there are two main models to construct fast and frugal heuristics (1) combining building blocks and (2) nesting existing heuristics. In the first case, building blocks can be combines in multiple ways to create one-reason decision making, in the second one fast and frugal heuristics are nested one inside another.

There are numerous kinds of fast and frugal heuristics and each of them has its own guiding, stop, and decision principle.

Fast and frugal heuristics are domain specific cognitive mechanisms contained in the so-called adaptive toolbox. The adaptive toolbox contains both "*lower order perceptual and memory process and high order process that are based on the lower process and can be at least partly accessible to consciousness*" (Gigerenzer, 2004).

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[37] Todd and Gigerenzer (2007), *Environments That Make Us Smart*, Current Directions in Psychological Science, Vol 16 – Number 3

It has been said that human beings are somehow limited in their cognition but the way their minds adapt to the real-world environment can enable them to make good decisions, from this point of view heuristics is not considered as negative.

Heuristics' evaluation[38] is not based on coherence, it is based on how they make reasonable and adaptive inferences considering limited time and knowledge. Therefore, their performance has to be evaluated according to domain-specific situations because what can works effectively and accurately in one environment, may fail in another one. Being simple allows fast and frugal heuristics to be robust and to adapt well to new situations, indeed they are not too specific so, even if they can be applied to specific environments, they "*do not contain enough detail to match any one environment precisely*" (Gigerenzer et. Al., 1999). On the other hand, they are not too general, otherwise they could lead to overfitting (every detail is of utmost relevance), a situation in which the model has minimal predictive value in other situations. Fast and frugal strategies focus on generalization, so to predict new data, rather than on fitting. In generalizing, lots of information are usually not required. Actually, using only a few of the available information can lead to a more robust strategy. Heuristics' effectiveness is measured comparing their performance with the actual requirements of the environment and measures that are related with the evaluation of heuristics are called correspondence criteria (accuracy, frugality, speed) and these criteria are considered in relation to each other. For example, in some situation the speed of a decision is more important than its accuracy.

During the years, heuristics' consideration has changed, from being considered as the expression of people's irrationality, to becoming useful tools that individuals use to cope with the complex and uncertain environment when making decisions.

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[38] Gigerenzer, Todd, and ABC Research Group (1999), Simple Heuristics That Make Us Smart, Ch.1, Oxford University Press

Behavioural economics has focused mainly on describing cognitive fallacies and to extend models based on expected utility, adding parameters to make them more realistic. Adding parameters can increase a theory's fitting but it can decrease its predictive ability since it can lead to an increase in errors.

The concept of fast and frugal heuristics indeed represents an alternative vision[39] of behavioural economics that aims at achieving higher predictive ability, dealing with uncertainty rather than risk, and demonstrating that cognitive fallacies are not errors.

Heuristics decision-making does not need much information, computation and cognitive effort but it can be more accurate and more efficient; ecological rationality, that is the match between heuristics and environments, explains how fast and frugal heuristics exploit environmental structures to make adaptive responses that can be defined as accurate and efficient. A heuristic is ecologically rational when it matches a particular environmental pattern and it leads to a correct decision that is aligned with decision-makers' goals. For this reason, heuristics are not general rules, but they are elements in the adaptive toolbox that are domain specific. Gigerenzer defined heuristics as:

> *Fast and frugal heuristics are simple yet robust tools in the adaptive toolbox of individuals and institutions that produce a beneficial trade-off between bias and variance so that people can make effective choices under uncertainty.*

4.2 Heuristics as useful tools for entrepreneurs

According to Gigerenzer, heuristics generate adaptive responses when applied in a proper environment. Entrepreneurial environment is highly uncertain so that they do not know all

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[39] Mousavi, S., Gigerenzer, G., & Kheirandisch, R. (2016). *Rethinking behavioural economics through fast and frugal heuristics*. In R. Frantz, S.-H. Chen, K. Dopfer, F. Heukelom, & S. Mousavi (Eds.), Routledge handbook of behavioural economics (pp. 280-296). London: Taylor & Francis.

the alternatives and consequences related to their decisions. In such uncertain environment fast and frugal heuristics that, on purpose, ignore part of information can be useful strategies since situations that are faced by entrepreneurs are usually ill-structured in which information is incomplete or not quantifiable. The concept of opportunities is central in entrepreneurship, their identification, evaluation and exploitation are what makes the entrepreneurial activity possible. Opportunities are surrounded by unpredictability and randomness, moreover entrepreneurs usually do not have past data to rely on, therefore they rely on heuristics[40] rather than on available data.

Fast and frugal heuristics are linked to the less-is-more effect, that is based on the idea that "*more information and computation beyond certain point can in fact decrease performance, even if there are no costs associated with information search*" (Gigerenzer et al., 1999).

The less-is-more effect can be explained by the bias-variance dilemma: in an uncertain environment $Total\ error = (bias)^2 + variance + noise$ where (1) bias is the difference between the average prediction and the correct value i.e. the deviation of the mean across sample from the true underlying mean, (2) variance is the variability of model prediction for a given value which shows the spread of our data i.e. it reflects the degree of systematic variation of the individual sample means, and (3) noise refers to unsystematic variation of the data and it cannot be reduced. Fast and frugal heuristics are simple, usually they are based only on one piece of information, therefore they try to minimize variance, errors are generated mainly by bias.

For this reason, simple heuristics can be better than complex rational strategies. Fast and frugal heuristics can be better than complex strategies if: (1) environment is highly

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[40] Busenitz and Barney (1997), *Differences Between Entrepreneurs and Managers in Large Organizations: Biases and Heuristics in Strategic Decision-Making*, Journal of Business Venturing 12(1):9-30

uncertain, (2) sample size is relatively small, and (3) environment is less stable so it is dynamic.

Fast and frugal heuristics that have been proven to be useful in the entrepreneurial context are:

	Search	Stop	Decision	Entrepreneurial
Satisficing	Set an aspirational level and search for objects that meet it	As soon as the first object meets the set aspirational level	Choose the object that meet the set aspirational level	Business location
Sequential	Order cues according to their perceived validity	When the first cue that discriminates between alternatives is found	Choose the alternative with the higher cue value	Product development
Recognition	Search for an object that is recognized	When an object is recognized	Choose the object, inferring it has the higher value	Investments decisions

Satisficing. The satisficing heuristic theorized by Simon, does not rule out the possibility to adjust the aspirational level during the research. The aspiration adaptation, on the other hand, allows to modify the initial aspirational level so that the guiding principle determines an aspirational level α, and the search starts in any order; when the first object with value $\geq$ α is found, the stopping principle stops the search. If after time β, no object is found, the aspirational level is lowered by δ so that it is equal to α-δ and the search continues until a choice can be made. When the aspiration level is fixed, error related to variance is reduced, whereas when the aspiration level is adaptable, error related to bias is reduced.

Berg[41] conducted a study that aimed at identifying the process that entrepreneurs use to locate their business or new branches of an existing business. He interviewed 49 well placed business owners asking them what information they considered as being relevant when deciding their business location. The investments were classified as large if equal or greater than 1 million dollars, otherwise small. The variables (categories of information) collected were:

Types of information. How many pieces of information entrepreneurs need to compute a decision; if they mentioned more than 4 pieces they were classified as high-info whereas, if they mentioned less than 4 pieces they were classified as low-info;

Locations in consideration set . How many locations were considered when deciding; nine owners considered only 1 location, and twenty owners considered 3 locations;

The process related to choosing a specific location. Entrepreneurs were asked what process they focus on when deciding the location, such as maximization (2%), satisficing (100%), or imitation (79.6%);

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[41] Berg (2014), *Success from satisficing and imitation: Entrepreneurs' location choice and implications of heuristics for local economic development,* Journal of Business Research 67: 1700-1709

Characteristics of business owners and investment. Characteristics related to local economic development policy, such as tax incentives, public transportation etc.

Rate of return. Entrepreneurs were asked to state if the actual rate of return of their investments was below (29%), meeting (33%), or above (39%) the expected rate on return at the time of decision.

With the collected data, Berg constructed a standard linear-index model using seven of all variables and compared it with a non-compensatory classification tree (using only a subset of variables) based on heuristics in order to determine which model had the higher predictive accuracy both in fitting and in out-of-sample prediction. The first model correctly predicted the recent year's returns in 46.9% of the times and somewhat lower in out-of-sample prediction, whereas the second model had a predictive accuracy of 91.8%, and 80% in out-of-sample prediction.

Information-Frugal Classification Tree of Entrepreneurs' Investment Returns (Whether Returns are Below, Meet, or are Above Expected Return in the Most Recent Year)
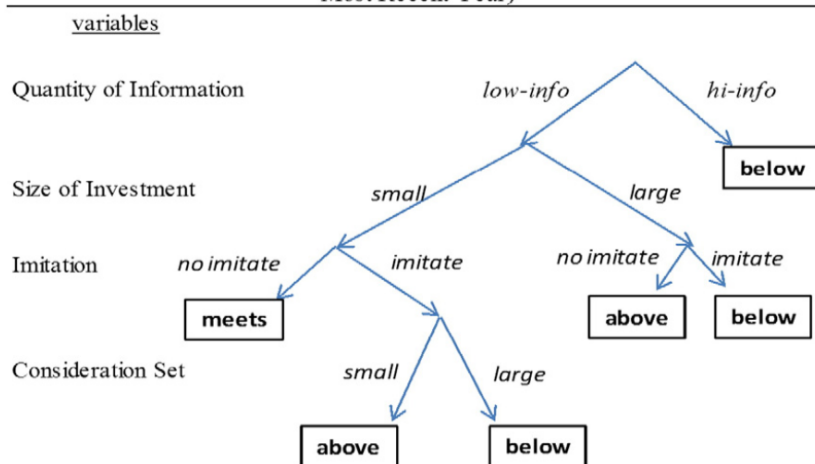
From the classification tree he discovered that: (1) high-info entrepreneurs perform below average, so when collecting information the less is more, (2) if the investment's size is small

firms can benefit from imitation heuristics whereas if it is large benefits from "*bold contrarian heuristic*", (3) consideration sets are small, so the number of alternatives is limited in order to choose quicker and achieve higher return, and (4) entrepreneurs do not employ a process that can be relatable to an optimal stopping condition for continuing searching.

Take-the-best heuristic. Cues are searched in a simple sequence and people order them according to their perceived validities. The guiding principle instructs that it tries first the cue with the highest validity, and if it does not discriminate between alternatives, it tries the next cue, until a discriminating one is found.

The stopping rule indicates to stop the search when one object has a positive cue value and the other does not. The decision rules predict that the object with the positive cue value has the higher value on the criterion.
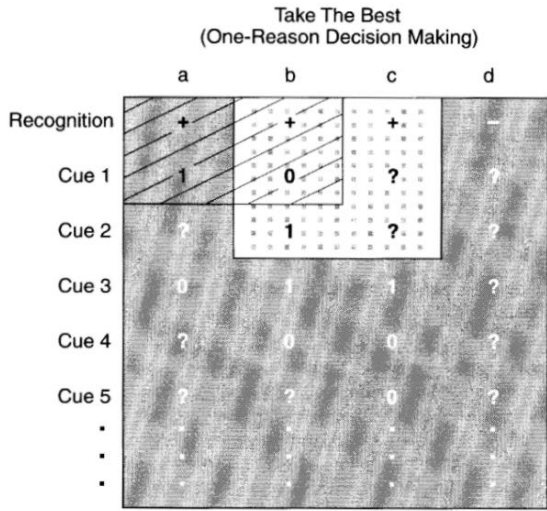
(Take the best heuristic)[42]

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[42] Gigerenzer, Todd, and ABC Research Group (1999), Simple Heuristics That Make Us Smart, Ch.4, Oxford University Press

In this case, objects a, b, and c are recognized whereas d is not. Positive cue value is indicated by 1, negative cue value is indicated by 0, and missing knowledge is marked by a question mark. Only the object that has been recognized are taken into consideration, therefore it is necessary to infer only between a and b and c and c. Cue 1 is discriminating between objects a and b; search is stopped, and object a is the higher criterion value. This heuristic works step-by-step so that cues are looked up one by one, until the stop principle is satisfied.

In entrepreneurship, take the best heuristics can be useful in the early stage of new product development. A research[43] conducted by Jetter and Albar demonstrated that sequential heuristics (take-the-best heuristic and tallying) could be relevant strategies for entrepreneurs to determine to pursue a project idea further i.e. they can be useful strategies in the fuzzy front-end stages of product development. These stages include opportunity recognition and usually they present a high degree of uncertainty in which there is a lack of information and time, therefore entrepreneurs compute their decisions on the basis of few if not single cue. The aim of this research was to show how fast and frugal heuristics performed, comparing them with a regression model.

Researchers created 52 projects and described them using seven evaluation criteria (expressed with verbal value: very good, good, neutral, poor) that were established choosing among the most common criteria used to forecast project outcome in product screening. At the end of each project's description the expected outcome was assigned (failure or success) according to the plausibility of descriptions.

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[43] Jetter and Albar, (2013), *Fast and Frugal Heuristics for New Product Screening - Is Managerial Judgment "Good Enough?*. Engineering and Technology Management Faculty Publications and Presentations. 25

e.g.	Profitability	Risk	Superiority	Technical Feasibility	Market	Payback	Competition	Outcome
Project1	Good	Good	Neutral	Good	Very good	Poor	Neutral	Success

The regression model predicted project failure correctly 87.09% of the time, project success 71.4%, and overall it correctly classified 80.7% of the projects.

The take-the-best model was used to "*forecast the success of each project individually by focusing on the first criterion that discerns between positive and negative project forecast*" (Jetter and Albar, 2013) . This model started evaluating the first criterion, profitability, and if it was evaluated as good or very good the search stopped and the project idea was accepted, if the criterion was poor the search stopped, and the project idea was rejected. In case the criterion was neutral or not known, the model moved to the second criterion. This model in 92% of projects used just the first criteria and it predicted project performance correctly 55.77% of the time. It predicted projects' success correctly 90.47% and projects' failure correctly 32.25%. The fact that it predicted successes better than failures means that when a project is selected using simple heuristic have much greater probability of success, therefore take-the-best can be useful in identifying quickly projects that are worth to be studied further.

Recognition heuristic. Recognition heuristic[44] is the simplest heuristic and it based on exploiting the ability of recognition to make inferences; it is frugal because it benefits from lack of knowledge. It can be considered as a simple rule that divides the environment in novel and previously experienced. In turn the previously experienced part of the environment can be further divided into mere recognition and familiarity. Recognition

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[44] Gigerenzer, Todd, and ABC Research Group (1999), Simple Heuristics That Make Us Smart, Ch.2, Oxford University Press

heuristic is used when a subset of objects has to be selected from a larger set, determining which object has the higher value on some criterion. The recognition heuristic states that if one of the two objects is unknown, and the other one is recognized, the latter has the higher value. It can be applied only if one of the two elements in unknown.

To work properly it must be applied to a proper environment, that is where recognition is correlated with the criterion. The correlation can be (1) genetically coded or (2) learned through experience. There are some cases in which the criterion is not available, such in prediction, but there are some elements that act as mediators, reflecting the criterion. There are three variables that explain the relationship between the criterion, the mediator and mind: (1) the recognition validity expresses the relationship between recognition and the criterion, and it is defined as "*the proportion of times a recognized object has a higher criterion value than an unrecognized object in a given reference class*" (Gigerenzer et. Al., 1999), (2) ecological correlation expresses the relation between the criterion and the mediator, and (3) surrogate correlation expresses the relation between the mediator and the contents of recognition memory.

When there is a reference class of objects N and two pairs of randomly objects are drawn there are three scenarios:

Only one object is recognized. When one object is recognized and the other one is not so that n $=$ Nn, α represents the recognition validity so the probability of getting a correct answer;

Both objects are not recognized. When both objects are not recognized so that n $=$ 0 the probability of getting the correct answers is 0.5, it is guessing;

Both objects are recognized. When both objects are recognized so that n $=$ N, β represents the knowledge validity, so the probability of getting a correct answer.

The function that expresses the proportion of correct inferences made using recognition heuristic is:

$$f(n) = 2\left(\frac{n}{N}\right)\left(\frac{N-n}{N-1}\right)\alpha + \left(\frac{N-n}{N}\right)\left(\frac{N-n-1}{N-1}\right)\frac{1}{2} + \left(\frac{n}{N}\right)\left(\frac{n-1}{N-1}\right)\beta$$

The recognition heuristic is linked to the phenomenon called less-is-more, so when individuals know less, they exhibit higher inferential accuracy. It occurs when the recognition validity α is greater than the knowledge validity β.

The principle for guiding search is limited to recognition memory, so no other information is necessary, the stopping principle indicated to stop as soon as recognition has been assessed for both objects, since a lack of knowledge is essential to apply recognition, this heuristic is defined as ignorance-based decision making. In situations where knowledge is limited, recognition heuristic is ecologically rational that is, it exploits the environment's characteristics.

Borger demonstrated how recognition heuristic works well in investments decisions[45]. Recognition heuristic can be generalized to decisions wider than two-alternative choice so that "*choosing a subset of objects from a larger set, choose the subset of recognized objects*" (Borges, 1999) and it is effective when the lack of knowledge is systematic rather than random. In investments context, this heuristic can be applied by people that have a "beneficial degree of ignorance" i.e. neither by experts that know all the names of major stocks nor by people that have not heard any names. A group of subjects made of Germans and Americans was asked to recognized companies from the New York Stock Exchange and from German stock exchange. Then subjects were divided into four groups (groups are

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[45] Borges et al. (1999), *Simple Heuristics That Make Us Smart*, Ch.3, Oxford University Press

presented according to the number of companies recognized, in decrescent order): (1) American experts, (2) American laypeople, (3) German experts, and (4) German laypeople. Two investment portfolios for each group were constructed and consisted one of highly recognized companies within the group's home country (domestic recognition) and the other of 10 companies that each group recognized most often from the other country (international recognition).

After an observation period of six months, comparing the performance of these portfolios with the unrecognized ones, the result indicated that (1) recognized stock outperformed unrecognized stocks, (2) the international recognition lead to higher returns than domestic recognition, and (3) the performance of the recognition heuristic was particularly strong in the two most ignorant groups, German experts and German laypeople.

To test the actual effectiveness of recognition heuristic, market indexes were used as benchmarks in which American market index (Dow 30) increased by 23%, German market index (Dax 30) increased by 34%.

	American (Dow 30)	German (Dax 30)
Market Index	23%	34%
Domestic recognition	-10% American laypeople -6% American experts	+10% German laypeople +17% German experts
International recognition	+7% German laypeople +6% German experts	+30% American laypeople +23% American experts

In all four cases, the international recognition led to higher return than domestic recognition. Therefore, the experiment demonstrated that recognition heuristic is effective since *"the predictive power of the recognition heuristic corroborates the notion that a lack of recognition can contain implicit knowledge as powerful as explicit knowledge"* (Borges et al, 1999).

Conclusion

Behavioural economics has changed the way in which it considered heuristics; initially cognitive short-cuts or heuristics were believed to generate bias that negatively affected judgment systematically, and the main aim in models was to reduce bias themselves. Over the years, research has shown that heuristics are fast and frugal strategies composed three building blocks: guiding search, guiding stop, decision rule that can be effective in complex and uncertain environments. Fast and frugal heuristics are simple tools in the adaptive toolbox that people can use to make effective decisions in contexts of uncertainty and their effectiveness depends on their robustness that enables them to adapt to different environments easily. Fast and frugal heuristics are domain-specific solutions so that if a heuristic works well in an environment, it cannot be said for each environment in which it is applied. Indeed, heuristics are not universal rules; recognition heuristic, for example, can be useful in situations in which there is a systematic lack of knowledge; in the stocks study the best performance was obtained by the most ignorant groups of subjects rather than by groups with a wider knowledge. To determine the effectiveness of a heuristic strategy it is necessary to consider the concept of ecological rationality i.e. the match between a particular heuristic and a particular environment.

Fast and frugal heuristics can be express through models that are testable so that their effectiveness can be evaluated. In this work, three research that tested heuristics models in business context was mentioned.

The first research aimed at demonstrating what process entrepreneurs follow to decide where to locate their companies. The result showed that they rely on satisficing heuristics to choose the location; indeed 81,7% of subjects' consideration set involved three or less alternatives, and these alternatives were discovered by chance rather than through a systematic search. Comparing satisfying heuristic model with a compensatory model shown a predictive accuracy respectively of 91.8% and 46.8% in forecasting the investment return correctly.

The second research aimed at investigating if sequential heuristics, especially take-the-best heuristic, can perform well in the fuzzy front-end stages of product development where the level of uncertainty is high, and information are usually inconclusive. The result showed that regression model was more accurate overall but take-the-best performance was more accurate in forecasting successful projects ideas, meaning that take-the-best can be useful in identifying quickly projects that are worth to be studied further.

The third research aimed at determining if recognition heuristic can be a good strategy in investments decision creating portfolios of recognized heuristics and comparing them with non-recognized portfolios and with market indexes. Recognized portfolio outperformed non-recognized ones and in six out of eight tests they outperformed the market indices.

Concluding, it can be said that fast and frugal heuristics can be useful in entrepreneurial contexts where the level of uncertainty is high, information cannot be easily accessed, and the time is scarce.

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Summary

In decision-making field there are many theoretical models that aim at understanding how people choose among alternatives, what course of action they to take in order to achieve their goals. These models can be classified into two categories: (1) rational models and (2) non-rational models. In rational models the optimal decision is the one with the highest utility and it can be explained by the so-called Expected Utility Theory (EUT) that provides prescriptive functions or rules that aim at maximizing the expected utility of outcomes. Non-rational models strongly criticize this approach and have shown evidence that people systematically violate the EUT axioms because their own cognitive limitation and external condition such as shortage of time and information cost.

Rational model assume that decision makers have an unlimited ability to collect, store and process information so that they are able to have preferences over all outcomes and to maximise and update them. On the other hand, non-rational models assume that individual are bounded in rationality, it does not mean individuals are irrational, it means that there are some limits that prevent them from being fully rational. Among non-rational models, the most famous is prospect theory that was formulated by Kahneman and Tversky and it aimed at explaining how cognitive limitations actually affect the decision-making process. This theory states that people do not base their decisions on final outcomes but on the potential value of losses and gains with respect to a reference point and is made of two phases: the editing and the evaluation. The editing phases is a preliminary analysis in which prospects are organized and reformulated in order to simplify the following evaluation phase. After the editing phase, from which many anomalies of preference can result, there is the evaluating phase during which individuals evaluate each of the edited prospects and choose the prospect with highest value.

In making decisions individuals use different strategies or cognitive shortcuts in order to simplify the complex environment and to reduce their cognitive effort: these tools are called heuristics. Heuristics can be helpful since they allow to deal with environment complexity, but the issue is that a misapplication of them can lead to bias, cognitive errors that negatively affect people judgement along with inclination and preferences.

Judgmental heuristics involve representativeness, availability, simulation, and anchor and adjustment heuristic. Representativeness is based on the similarity of objects and poor judgment arises because an object that is more representative does not automatically imply that it is more likely. Stereotypes, for example, negative influence judgement and these phenomena are related to representativeness heuristic. Availability is based on how easily an instance can be brought to mind and when something can be recalled easily and effortlessly it has a great influence on predictions. Simulation is a step further from the availability heuristic and it is based on mentally simulation of events, both in past and in future situations. The likelihood of a real system to produce these outcomes is determined on how easily the simulation is. Anchor and adjustment consist in starting from an initial value and then adjust it, the main issue concerning this heuristic is that individuals tend to heavily rely on the first piece of information, making the adjustment to be insignificant.

According to the dual processing theories, there are two ways with which human beings process information: system 1 and system 2. System 1 is the intuitive system that is fast, automatic, and does not require conscious effort; it is made of sub-systems and involves instinctive behaviours. System 2 is the reasoning system that is slower, conscious, and effortful; it has limited capacity (since it depends on memory), but it allows abstract and hypothetical thinking. Often in making decisions people rely on past experiences that concern system 1 but when no previous experience is available system 2 provides support thanks to its ability of abstract thinking. Intuition therefore can be attributed to system 1

and under appropriate circumstances can be useful and can be more efficient than rational decision-making process in management decisions. Indeed, intuition is the ability to recognize patterns in the environments without reasoning, allowing a more rapid response to stimuli. The intuitive process comes from experience and learning, and these two factors play an important role since they enable individuals to recognize patterns more accurately. Intuition is neither the opposite of rationality nor it means guessing; people store experience and knowledge and in certain moments, when reacting to stimuli from the environment, they make individuals able to recognise patterns, giving hints about what to do.

Entrepreneurs make decisions under extreme conditions such as uncertainty, complexity, time pressure, emotionality, and identity investment therefore, they must act strategically in order to keep up with changes that occurs in the environment and to maintain the competitive advantage. One of the most important skills for successful entrepreneurs is the ability to recognize opportunities and uncertainty is the most challenging factor in recognizing, evaluating and exploiting opportunities. Entrepreneurs more than other people face situations that can be overloading (they involve a huge amount of information), highly uncertain (they are new to entrepreneurs, so mental schemas cannot be applied), emotions intense and scarce of time. Such situations are common in entrepreneurial activity because the nature of their activity itself that is complex, unpredictable and requires a full-time commitment both in time and emotional component. Since entrepreneurs strongly rely on heuristics they are subjected to different bias, the most common ones related with the entrepreneurial thinking are counterfactual thinking, affect infusion, attributional, planning fallacy, and escalation of commitment.

Opportunities are the foundation of entrepreneurship to such an extent that without them entrepreneurship would not exist therefore, understanding how opportunities are recognized, evaluated, and exploited is extremely relevant to understand entrepreneurship and how it can be successful.

The first phase is the opportunity recognition and it has been demonstrated that entrepreneurs to recognize opportunities use the so-called pattern recognition models, cognitive processes that exploit cognitive frameworks gained from previous experience to connect seemingly unrelated events or trends in the environment. The main factors that positively influence the recognition of opportunities are the active search, alertness, prior knowledge, and social networks. These factors are related among one another; the active search may not be necessary when the alertness is high, or the prior knowledge is broad. Entrepreneurs that have well-developed cognitive frameworks are highly alert, being able to perceive more meaningful patterns in the environment. They do not need to engage an active search for opportunities because their ability to perceive such frameworks allow them to interpret and process new information. Equivalently, a wider amount of prior knowledge can assist in forming broad and richly connected cognitive frameworks, so that an active search is less important.

The second phase, subsequent to the recognition, is the evaluation that consists in assessing if an opportunity is worth or not to be pursued. Entrepreneurs use cognitive structures to systematically evaluate opportunities and such opportunities are evaluated according to subjective interpretations. These cognitive structures are defined as rule-based decision-making which aim at structuring opportunity evaluation decisions by applying rule content i.e. it is a structured way to think about a complex decision problem.
Opportunity templates are developed around three broad categories of rule content: demand-side considerations (opportunity novelty), supply-side considerations (opportunity resource efficiency), and personal considerations (opportunity worst-case scenario).

Differences among individuals influence the application of these rules, one relevant element is the prior knowledge held by entrepreneurs. Prior knowledge reinforces the positive relationship between both novelty and opportunity attractiveness and between resource efficiency and opportunity attractiveness. At the same time, it strengthens the negative relationship between worst-case scenario and opportunity attractiveness; therefore, prior knowledge reinforces the relationships, it does not change them.

Evaluating an opportunity involves judgments made under conditions of uncertainty and complexity consequently the way entrepreneurs perceive risk influences how they evaluate an opportunity; when entrepreneurs perceive a low probability of failure and they are confident about how well the business will do, an opportunity is associated with a lower level of risk and they tend to evaluate it more positively.

In the opportunity evaluation phase, entrepreneurs mainly rely on heuristics to cope with the risk and assess if an opportunity may be worth to be pursued. Heuristic used in this phase works as: if the answer to the first criterium is "yes" the analysis can go on, if the answer is "no" the evaluation stops, and the opportunity is rejected. Four criteria have been identified and each of them has a different weight, indeed some of them can strongly influence the whole process.

The first criterium in assessing if a new opportunity is worth or not consists in checking if it fits either the core strategy of the firm or its vision. If the opportunity fits the core strategy, it is considered to be worth and it can be explored deeper.

The second criterium is the market knowledge; an opportunity is considered to be worth if the entrepreneur already knows the market in which he operates. The previous experience and the expert knowledge underpin intuition that can enable entrepreneurs to have or not a good feeling about the opportunity. Intuition can be useful for assessing both the strategic fit and the market knowledge.

The third criterium consists in considering if the worst case can be bearable. If not, the opportunity is discarded; in this situation an entrepreneur has to determine the affordable loss that he would be willing to tolerate in case of the worst scenario.

The fourth criterium refers to third party collaborators that work with firms. If the third party is considered as trustable and plays a fundamental role, the opportunity it is considered worthy.

The third phase is the exploitation. Exploiting an opportunity means to gain returns from the new product arising from the opportunity through the building of efficient business systems for full-scale operations. Entrepreneurial opportunities have as outcomes new products/services, therefore the novelty increases the level of uncertainty; essentially entrepreneurs in the exploitation phase have to decide between (1) after evaluating an opportunity, to exploit it immediately to maximize lead time, facing a high level of uncertainty and (2) to delay the exploitation phase in order to reduce uncertainty and gain the necessary resources.

According to the resource-based view, it is important that a product is inimitable other than being new; inimitability allows a firm to have a sustainable competitive advantage because it would lengthen the lead time, that is considered to be a relevant aspect for a successful launch of a new product. The lead time is the period prior competitors' entrance, during which the first entrant has the monopoly and therefore, lengthening it can provide different performance benefits.

The necessary resources are enabling technologies, managerial capabilities, and stakeholder support and they impact entrepreneurs' decisions to exploit opportunities along with the customer demand. All the resources are influenced by the lead time that is an enhancing moderator in the decision to begin exploitation so that if all resources are high, the likelihood to begin the exploitation is magnified when the lead time is perceived as being long. The nature of an opportunity can influences entrepreneurs' willingness to exploit it.

According to different research , entrepreneurs usually tend to exploit opportunities that have higher expected value, large expected demand, high industry profit margins, low cos of capital and the number of competitors is neither too high nor too low.

The decision to exploit an opportunity differs among entrepreneurs because of individual differences. In order to exploit an opportunity, for example entrepreneurs consider the costs necessary to obtain the necessary resources, therefore entrepreneurs that have greater financial capital usually are more willing to exploit opportunities.

The willingness to bear risk is another factor that have a relevant role in deciding whether exploit opportunities or not; if an entrepreneur is willing to bear more risk, it is more likely that he will decide to exploit an opportunity. A high tolerance for ambiguity can positively affect the exploitation decision as well as the need for achievement; if an entrepreneur manifests them in a high degree he may be more likely to exploit opportunities.

The issue that concerns heuristics is related to biases that can arise from an inappropriate use of cognitive short-cuts because they can produce inaccurate judgment. In recent years with the introduction of ecological rationality, heuristics have been considered as simple strategies that, if applied in proper environments, can be highly effective to cope with uncertainty. The ecological rationality is a step further the bounded rationality; Gigerenzer proposed that internal and external bounds have to be considered as related to each other. When the bounds fit each other, people can make good decisions by exploiting the structure of the environment, indeed it aims at explaining how mind interacts with environment and how this interaction can produce good decision making.

Individuals constantly deal with the external environment that is uncertain and complex therefore, they have to able to make inferences that are fast, frugal, and accurate; environment is seen as useful patterns of available information in the world and these patterns can be exploited by heuristics in order to produce adaptive behaviour.

Ecological rationality is made possible by domain-specific solutions, it means that different environments require different fast and frugal heuristics in order to exploit the particular patterns of available information. The simplicity of such heuristics makes them able to change and to adapt to new situations; they are adaptable thanks to their robustness that allows them to work as well as complex structures that involve many parameters. Such heuristics are not too specific, indeed that they work well in particular environments but do not contain enough detail to suit any one environment specifically. Being too specific would lead to be highly predictive in certain situations and to be minimal predictive in others leading to the overfitting phenomenon. Fast and frugal heuristics are based on generalization rather than fitting, so they do not require too many parameters.

Fast and frugal heuristics are considered to be adaptive responses to environment, and they require a minimum of time, knowledge and computation. Usually fast and frugal heuristics are defined as one-reason decision making so that they just need only a piece of information to determine the decision.

During the years, heuristics' consideration has changed, from being considered as the expression of people's irrationality, to becoming a useful tool that individuals use to cope with complex and uncertain environment when making decisions. Behavioural economics has focus mainly on describing cognitive fallacies and to extend models based on expected utility, adding parameters to make it more realistic. Adding parameters can increase a theory's fitting but it can decrease its predictive ability since it can lead to an increase in errors.

The concept of fast and frugal heuristics indeed represents an alternative vision of behavioural economics that aims at achieving higher predictive ability, dealing with uncertainty rather than risk, and demonstrating that cognitive fallacies are not errors.

Heuristics decision making does not need much information, computation and cognitive effort but it can be more accurate and more efficient than rational decision making;

ecological rationality, that is the match between heuristics and environments, explains how fast and frugal heuristics exploit environmental structures to make adaptive responses that can be defined as accurate and efficient.

According to Gigerenzer, heuristics generate adaptive responses when applied in a proper environment. Entrepreneurial environment is highly uncertain, so it is not possible to know all the alternatives and consequences related to decisions. In such uncertain environment fast and frugal heuristics that, on purpose, ignore part of information can be useful strategies since situations that are faced by entrepreneurs are usually ill-structured in which information is incomplete or not quantifiable. The concept of opportunities is central in entrepreneurship, their identification, evaluation and exploitation are what makes the entrepreneurial activity possible. Opportunities are surrounded by unpredictability and randomness, moreover entrepreneurs usually do not have past data to rely on, therefore they rely on heuristics rather than on available data.

Fast and frugal heuristics that have been proven to be useful in the entrepreneurial context are satisficing, sequential, recognition. These heuristics can be expressed through models that are testable so that their effectiveness can be evaluated. In this work, three research that tested heuristics models in business contexts were mentioned.

The first research aimed at demonstrating what process entrepreneurs follow to decide where to locate their companies. The result shown that they rely on satisficing heuristics to choose the location; indeed 81,7% of subjects' consideration set involved three or less alternatives, and these alternatives were discovered by chance rather than through a systematic search. Comparing satisfying heuristic model with a compensatory model shown a predictive accuracy respectively of 91.8% and 46.8% in forecasting correctly the investment return.

The second research aimed at investigating if sequential heuristics, especially take-the-best heuristic, can perform well in the fuzzy front-end stages of product development where the level of uncertainty is high, and information are usually inconclusive. The result shown that regression model was more accurate overall but take-the-best performance was more accurate in forecasting successful projects ideas, meaning that take-the-best can be useful in identifying quickly project that are worth to be studied further.

The third research aimed at determining if recognition heuristic can be a good strategy in investments decision creating portfolios of recognized heuristics and comparing them with non-recognized portfolios and with market index. Recognized portfolio outperformed non-recognized ones and in six out of eight test they outperformed the market indices.