Making Decisions under Uncertainty
Emotions, *Risk* and *Biases*

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Abstract. The difficulty in deciding and facing up to uncertainty is not only linked to the inadequacy of the architecture of our minds but also to an 'external' model of uncertainty which does not correspond to the way in which our mind naturally functions. New conceptual paradigms and new programmes for experimental research are called for in order to redefine the role of internal and external restrictions on human action (resources and available information, limitations on calculation ability, on the capacity of memory, cognitive styles, gender differences and so on). All this should be contemplated in a more general theoretical framework – natural logic – based not on metaphysical assumptions but on the concrete evidence provided by cognitive neurosciences.

Keywords: Decision-making, risk, gender differences, biases, uncertainty.

1 Introduction

During the 20th century economists and mathematicians went to great lengths to neutralise risk and associated concepts such as uncertainty and unforeseeability. The demonstration of the limits of the neoclassical paradigm based on the simple calculation of costs and benefits made it more difficult to arrive at a scientific evaluation of risk and uncertainty. From the seventies onwards a large quantity of theoretical and empirical studies have investigated the heuristic principles and cognitive strategies which individuals use to deal with risky and uncertain situations. This research has shown how the explicative and predictive shortcomings of normative risk analysis depend in many respects on undervaluing the continuous interaction between the individual and the environment. These are factors which day by day represent significant obstacles in decision making (1). Conventionally, when one speaks of uncertainty one refers to situations in which the individual knows the outcomes of the choice but not the probabilities involved. The problem of uncertainty is central to the study of decision-making processes because the consequences of the actions an individual undertakes are often prolonged into the future, and one can never be completely sure that the hoped-for outcome will in fact be achieved. Although uncertainty is a key concept in discussions of decision making, there is no real consensus of opinion as to its meaning. One can find as many definitions of it as there are ways of

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approaching it (2). In order to clarify the nature of the uncertainty, (3) identified three basic situations:

1. uncertainty is the sense of doubt that blocks or delays action. We can identify three essential features in this definition: 1) it is subjective (different people can be subject to different doubts in identical situations); 2) it is inclusive (no particular form of doubt, such as ignorance of future results, is specified); 3) it conceptualises uncertainty in terms of its effect on action (hesitation, indecision, procrastination).
2. the uncertainty with which decision makers must cope depends on the model of decision making adopted. In other words, models implemented which have different informational requisites will be blocked or delayed by different doubts;
3. different types of uncertainty can be classified according to their issue (what the decision maker is unsure about) and source (what determines the uncertainty). The fundamental problems include results, situations and alternatives. As for the causes, incomplete information is the most commonly cited cause of uncertainty. On occasions, however, decision makers are incapable of acting not so much out of lack of information but because they are disoriented by conflicts generated by the surfeit of meanings the information gives rise to. Moreover the causes of uncertainty are not limited to incomplete information and inadequate comprehension. Decision makers may be prevented from acting even if they have understood the alternatives perfectly but are unable to differentiate between them.

2 Risk and Biases

The concept of uncertainty goes hand in hand with that of risk: a risky situation is always determined by a certain degree of uncertainty concerning the results of future actions.The first scientific study on the perception of risk was carried out by the director of the Atomic International Division, Starr. Published in "Science" in 1969 (4), it looked at safety in nuclear power stations and proposed a procedure for calculating the level of technological risk acceptable to society in view of the attendant social benefits. Even though it relied on a mathematical/probabilistic evaluation of risk, the results revealed an enormous discrepancy between the objective risk and the perception on the part of the population. The variant of "social acceptance" soon proved to be complex, eluding concrete estimates and classifications, leading researchers to talk about different levels of risk. In particular, it was shown that the risks perceived as voluntary (such as risks associated with smoking or the failure to prevent certain illnesses) were considered more acceptable and less probable than the risks perceived as involuntary or imposed (as for example those of nuclear power stations). Moreover, as is shown by Starr's correlation function (1969), when the events are very familiar, objective and perceived risk coincide; as they become less frequent, the perceived risk increases unduly; and finally, in cases of extreme rarity, it diminishes unduly.

Subsequently Starr's research discussion of risk, which had been restricted to the sphere of technological safety, spread to such sectors as psychology and sociology.

Psychology has contributed considerably to risk analysis, progressing from the classic concept of the calculation of probabilities of an undesirable event to the concept of subjective risk based on perception and individual evaluation. In this line of research the most commonly used methodology is known as the psychometric paradigm, proposed by Slovic and his group. The main aim of this research is to identify the mental strategies people use in formulating risk assessments. According to Kahneman, Slovic and Tversky (5), heuristic judgement often constitutes the only practical way to evaluate uncertain elements. In fact, unlike what happens in formal calculus, heuristic evaluation of probability is generally based on immediate solutions which do not consider all the factors at stake, but only the peculiar features of the object being evaluated, the way in which the problem has been formulated, the clarity with which the situation has been described, the degree of control, the seriousness of the consequences, previous knowledge and experiences and so on. These factors, whether separately or in conjunction, influence decision-making behaviour and can easily lead to distortions of judgement or biases (6). Among others, particular attention has been paid to the following phenomena:

Confirmation bias
In interpreting events there is a general tendency to attribute little importance to the contradictory information or else to only contemplate events which are coherent with one's expectations. We often appear to base our judgement on information that confirms our hypotheses rather than the contrary. These affirmations are borne out by the well known experiment devised by Wason (7) known as the four-card selection task. Participants were shown the following four cards. Each card has a letter on one side and a number on the other. Participants were informed of the rule that if a card has a vowel on one side, it must have an even number on the other. The task is to say how many cards need to be turned over in order to verify whether this rule holds good or not. The correct answer, rarely given, is to turn over only two cards: card E and card 7. In fact, if on the back of E there is an odd number, the rule is false; if on the back of 7 there is a vowel, again the rule is false. In other words, any card with a vowel on one side and an odd number on the other breaks the rule. On the contrary, opting for card 4 and card B, the ones most often chosen by participants, is pointless because the rule states "if there is a vowel then there is an even number" and not "only if" there is a vowel, so that on the other side of 4 there could be either a vowel or a consonant, just as on the other side of B there could be either an odd or an even number. This experiment demonstrates the tendency, very common in inferential tasks, to acquire information which only goes to confirm a hypothesis, without checking the falsifying cases.

Consent heuristic
The consent heuristic is a cognitive strategy based on the observation that when a reasonably large number of people reach a consensus on the assessment of an event, individuals taken one by one undergo a sort of psychological pressure and tend to adopt the common point of view in a reaction which is gregarious and conformist but rationally inexplicable. This cognitive strategy is adopted more commonly if the subject

is unfamiliar or there is low motivation or limited possibility of processing the information. In the specific context of risk behaviour it has been observed that, if we are given information on the preventive behaviour of others, this modifies our intentions concerning the use of safety measures in a directly proportional ratio. In a classic experiment, the psychologist Asch (8) asked a group of participants to state whether two lines were the same length. All the participants were his accomplices apart from one. Asch discovered that it was enough for the other participants to answer in a certain way, even if it was patently wrong, for the judgement of the individual whose behaviour he was studying to be influenced.

Illusion of control

The illusion of control is defined «as an expectancy of a personal success probability inappropriately higher than the objective probability would warrant» (9). In other words, people tend to believe that the risks inherent in such behaviour, such as driving at high speed, can be controlled by their own ability. This betrays an excessive and unjustified belief in oneself (overconfidence), since even an expert driver cannot control all the factors which contribute to causing a road accident. A series of studies was conducted to elucidate this phenomenon. A common example is smoking. Those who smoke, in fact, believe they can control their behaviour more than is actually the case in real life. Several studies have shown that among occasional smokers only 15% believed that over the next 5 years they would become heavy smokers. In reality, 5 years on about 43% of them had done so, showing a significant over-estimation of their ability to control events. Among heavy smokers, on the other hand, about 32% believed that over the next 5 years they would still be smoking, and 68% thought they would have given up. In reality 5 years on 70% continued to smoke.

Unrealistic optimism

Unrealistic optimism is closely connected to the illusion of control. It represents the difference between what we consider risky for ourselves and what we consider risky for others (10). Numerous experiments have shown that this bias derives from two dynamics. The first (cognitive) consists in overestimating the number and efficacy of the precautions you yourself take with compared to those taken by others. The reason is that one's own behaviour is more readily accessible in one's memory than that of others with the consequence that the evaluation is distorted by a recollection that favours oneself. The second dynamic (motivational) shows how the individual also uses optimistic distortions to safeguard self esteem. If there were no such distortions, in fact, we would perceive the risks inherent in consciously dangerous activities – such as smoking or driving without a seatbelt – and this would reflect badly on our self image. Interestingly, in some conditions not only does the optimistic bias disappear but it is replaced by pessimistic bias (11), a tendency which is apparently correlated to the nature of the risk. If, in fact, the optimistic bias characterises risks which are incidental, potential and familiar, pessimistic bias corresponds to risks perceived as common, real and unfamiliar (for example the health effects linked to radiation following a nuclear accident). In terms of adaptation, in fact, in the first case an optimistic attitude can free us from anxiety and help us to cope more serenely with everyday activities; while in the second case one is induced to pay more attention to the risks.

Expertise

Numerous experiments show that the level of expertise - where the term refers not to actual experiences of dangerous situations, but to the competence of individuals acquired during their professional activity - generally influences risk evaluation. For example, the studies carried out by Klein and colleagues (12) on decision making by experts (doctors, fire fighters, pilots and others) have shown how in critical situations they tend not to follow normative models, but they "photograph" the current situation and act on the grounds of intuition deriving from past experience. A significant example is provided by the so-called circumstantial paradigm typical of medical semiotics. It is based not on analytical reasoning but on an intuitive activity enabling the medical expert to diagnose pathologies which are inaccessible to direct observation on the basis of superficial symptoms that are insignificant to the untrained eye. It is one of the gifts of the expert: being able to make a correct diagnosis at a glance, in next to no time and with very few elements to go on. In this type of knowledge there are imponderable elements which come into play: flair, instinct, intuition. Some elements only reveal themselves to a scrupulous, practised observer, endowed with that "third eye" which is sometimes called a "clinical gaze" and which is developed in the course of time, through experience. Moreover numerous experiments have shown that – even in the presence of high quality scientific information and data like those provided by the EBM – in many routine clinical decisions (for example the interpretation of a diagnostic test, the choice between different therapeutic options, the identification of a patient's preference, and so on) cognitive errors are commonly made. Furthermore, even when both the exact percentage of error for a certain diagnostic test and the general frequency of an illness are known, doctors are often unable to infer the probability that a patient showing a positive outcome from a certain test actually has that illness. Gigerenzer (13) has labelled "statistical illiteracy" the inability to interpret probabilistic problems and draw inferences based on Bayesian calculus.

3 Risk Assessment and Emotions

The emotions represent an important system of monitoring for relations between the individual and the environment because they pinpoint situations that regard us directly, highlighting what is at stake and which resources we can call on in order to modify these situations. The emotions fulfill both a communicative and a motivational function. In the former the subject is rapidly alerted to the situation with respect to his/her needs and goals, showing third parties, by means of non verbal language, the affective reaction in progress; the latter consists in preparing the organism to react to the emotive situation, adopting appropriate modes of behaviour, which may involve inaction or the rejection of inter-relations, as when somebody is feeling demoralised. Of relevance, in this sense, is the notion of 'risk as feelings' (14), which refers to our fast, instinctive, and intuitive reactions to danger. In other words, the choices made in situations of risk are in part the result of the direct influence of the emotive reactions on the cognitive process. The studies carried out by Loewenstein suggest that in conditions of risk, emotive and rational reactions can diverge on account of

risk assessment. Nonetheless judgement is often determined by the former rather than the latter. In a state of anger, for example – as demonstrated by Lerner and Keltner (15) – angry people express more optimistic risk assessments and manifest risk-seeking behaviour. This conclusion is coherent with Lerner and Keltner's theory of assessment, whereby anger is associated with the perception of greater certainty and control over the outcome of one's behaviour and decisions. On the contrary, sadness seems to be characterised by a lack of physiological excitation and thus scarce propensity to action, associated with a sense of resignation and impotence. This sensation reduces risk aversion, and the consequences of one's decisions are often attributed to the situation rather than to personal factors. Fear and anxiety, while not being synonyms – fear in fact refers to knowable causes, while in anxiety the threat is represented by uncertainty regarding future states or situations concerning individual well-being – produce a common impulse concerning action: evasion or flight. In a state of anxiety there is no concrete threat prompting evasion or flight. The behavioural correlates of anxiety are more common, and the effects on behaviour more pervasive and long-lasting (16). Fear and anxiety derive from assessments of uncertainty and lack of control over the situation. Unlike anger, they are associated with pessimistic evaluations of the environmental conditions. Thus people manifest a contrary impulse to action: instead of being optimistic with respect to risk, they display risk aversion and a pessimistic assessment of the situation. A manager prone to fear or anxiety, for example, is likely to pay more attention to their own behaviour and arrive at a negative risk assessment (17).

There is ample evidence to indicate that joy and happiness favour a sociable, cooperative attitude towards others, reducing interpersonal conflicts. Happiness induces a sense of security and control in people's perception of the environment, making them more ready to adopt risky decisions.

4 Gender Differences and Brain

Right from infancy, hormones such as estrogens and testosterone play a part in the development of the brain, highlighting the differences between the genders. From the outset, the study of faces and the immediate environment models and moulds the cerebral development of males and females alike. Numerous studies show that through eye contact and the observation of faces, the skills of female infants within the first three months are much more developed than those of males. Furthermore, in subsequent phases of development, females tend, for example, to look at their mothers' faces, seeking signs of approval or disapproval, 10 to 20 times more than males in the control group (18). Similarly, during puberty, estrogens and testosterone continue to influence development. If estrogens drive male adolescents to exert more energy in building relationships and in competing for sex, testosterone in boys gives rise to a tendency towards solitude. In fact, testosterone reduces their desire to socialize, except when searching for sex, sport, independence-related challenges and authoritativeness through competitive behaviour. These behaviour models will influence men and women throughout adulthood.

On the evolutionary level, consequently, the female brain is supposedly "programmed" in order to maintain social harmony, while for males it serves to compete, reproduce and transmit its own genes. This dynamic is the basis of our social system: males engaged in competition to become fathers, females in tasks related to child rearing.

The current problem is that while it may be true that our society has radically changed, our brain is still controlled by the same hormonal mechanisms. Deborah Tannen (19) has shown how businesswomen in western cultures still search for eye contact and look into people's faces for approval or disapproval. Men often interpret this behaviour as a sign of insecurity more than as the ability to observe and assess. In the workplace men, due to their tendency to compete, show little inclination to regard a woman as a leader, especially if she is not fiercely competitive. However, for a woman the psychological stress originating from a situation of conflict is very deep-seated, and therefore, it is not surprising that even the most competitive businesswoman tends not to attack others or to engage in shouting matches. One of the main reasons why women leave organizations is that they do not wish to involve themselves in political power struggles, because they experience these as a sheer waste of energy.

One of the structural differences between the male and female brain is the size of the amygdale: in the adult, in fact, that of the male is bigger than that of female (18). In women, the amygdale, which is smaller, but better connected to the cortex, is a key factor in the decision-making process, giving greater emphasis to the emotional co potent than is the case with men. (20). The latter, as a matter of fact, tend to process surrounding reality by making particular use of the rational, logical and linear left hemisphere. Women, on the other hand, use mainly the right hemisphere for multi-tasking operations, underlining their strong intuitive faculties. Interestingly, the regions of the brain which differ in size between men and women are the same as those which contain high concentrations of sexual hormone receptors, all of which goes to prove the importance of identifying the sizes of specific regions of the brain during development.

The corpus callosum (a thick structure made up of myelinated fibres joining both cerebral hemispheres) is denser in females, permitting them to use both hemispheres in a more integrated fashion than men (21). In the case of women, in particular, these junctures allow them to express their emotions more effectively, remember details of emotive events and to communicate them: here the hippocampus is decisive – a structure strongly involved in learning, memory and the emotions – larger and more active in the female brain (particularly sensitive to estrogens) (18).

In the sphere of the decision-making process it is interesting to note how the prefrontal cortex, the brain's 'work space' devoted to decision-making, is larger in women and matures more rapidly than in men. This difference, combined with the fact that women have lower levels of testosterone and higher levels of estrogens, allows the latter to seek solutions to conflict, often causing them to stand back in order that the situation may be resolved. Men, on the other hand, tend to emerge as winners.

The anterior cingulate cortex, another important part of the brain's decision-making workspace which weighs up options, is also larger in women, and has been

defined as the "apprehension centre" of the feminine brain. Numerous studies, in fact, show that anxiety is four times more common in women than it is in men and this leads them to be extremely cautious and collaborative, especially with regard to defending their young ones. This caution today, especially in the workplace and the business world, may be interpreted by men as an indicator of insecurity when it comes to taking on and assessing uncertain and risky situations.

5 Men vs Women: Cognitive and Decision-Making Styles

Individuals do not possess uniform and stable cognitive faculties within time. The current scientific debate tends to consider individual differences in terms of cognitive styles, than cognitive ability. In the realm of studies on decision-making it has become apparent that in most situations and problems related to our day to day life, at any level of complexity, there is no single solution. In fact, given the same situation, different people will act in different ways and adopt different cognitive strategies. But how is one to decide? What are the neural correlates pertaining to differences in cognitive and decision-making styles? In a study conducted by Podell and coll. (22) such issues were addressed by designing the so-called Cognitive Bias Task (CBT). One group of healthy subjects were shown stimuli depicting various simple geometric designs differentiated by colour (red/blue), outline (indicated and coloured in), number (one/two), shape (circular/square) and size (big/small), for a total of 32 possible combinations. Each test consisted of three stimuli: one target stimulus and two possible choices aligned vertically beneath it (Fig. 1). The target figure was presented for two seconds, followed by the simultaneous presentation of two possible choices. The subject, seated in front of a computer was asked to look at a target card and then to select one of two alternatives. The subjects were exposed to different models of response which centred on distinct strategies.

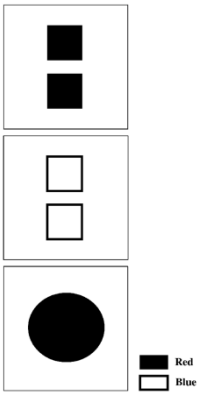

Fig. 1. In the Cognitive Bias Task, a subject is instructed to look at the target form at the top (in this case, a filled-in red circle) and is then asked either to choose the bottom form that is most similar to it (or most different from it) or to choose the bottom form he or she likes best. (From: Goldberg, 2001)

Certain subjects tend to link their choice to the target and when this changed, so did their preference. Such a decision-making strategy is called contest-dependent. Other subjects, on the other hand, tended to make a decision based on stable preferences, irrespective of the target: that is, they always chose blue, red, a circle or a square. This last decision-making strategy is instead known as contest-dependent. An interesting aspect is that males and females presented their choices in surprisingly different ways: males were more dependent on contest than were females (Fig. 2).

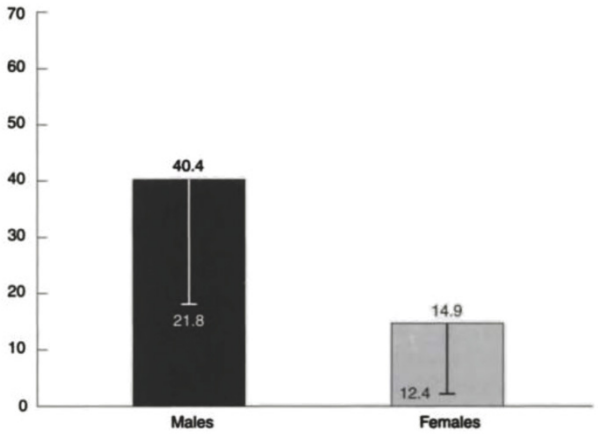

Fig. 2. Sex differences in actor-centered decision-making. Males exhibit a more context-dependent response selection pattern on the Cognitive Bias Task. Females exhibit a more context independent response selection pattern (23).

In the CBT experiment Goldberg (23) examined whether the observed differences between the genders might correspond to real life situations. The contest dependent strategy may be considered a universal default strategy, an attempt on the part of the individual to formulate the best answers in all possible real life situations. The organism accumulates a repertoire of responses corresponding to the sum total of its own life experiences that are slowly but surely updated with new experiences. The problem with such a strategy is that often real-world situations are so different from one another that any attempt to adapt old strategies to new problems becomes meaningless. Nevertheless, such a default strategy may represent the best solution when one is confronted with a totally new situation, for which there is no specific experience or knowledge with which to deal with it. On the other hand, a contest-dependent strategy reflects the propensity to capture the specific properties of the situation and personalise the individual response. Confronted by another situation the organism attempts to recognize it as a familiar model, with known features. However, confronted by a situation which is completely new, such an attempt can only have a negative outcome. In this case, an organism guided by a contest related strategy will seek to capture the properties unique to the situation, even though the available information may be insufficient. The optimum decision-making strategy is probably reached by means of a dynamic balance between the two approaches. Few people, in fact, adhere to either strategy in its pure form, but rather adopt a mixture of strategies, depending on the situation.

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