A Cognitive Approach to Context Effects on Individual Decision Making Under Risk[1]

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Abstract

This chapter compares and contrasts various approaches to understanding human decision-making under risk, and is trying to formulate requirements for a cognitive economics theory of risky decision-making. Then a first attempt is made to put forward such a theory by proposing a cognitive model JUDGEMAP based on the general cognitive architecture DUAL. This allows the model to be integrated with other cognitive processes such as perception, analogical reasoning, spreading activation memory retrieval, etc. The fact that all processes in DUAL are based on local computations and parallel processing allows for modeling the interplay between various cognitive processes during the decision-making process, in particular the model predicts that the unconscious and automatic process of spreading activation will influence the conscious process of argument building and comparison. This prediction is tested and confirmed by a psychological experiment that demonstrates that seemingly remote and irrelevant aspects of the environment can change the decision we make.

Introduction

Both individual and societal prosperity are closely related to human willingness to risk. Risky behaviour is related to better exploration of the environment and its opportunities and thus to learning and acquiring new knowledge, better skills, diverse practice, and richer experience. Risky behaviour is also related to obtaining higher rewards and profit (simply because there is less competition for these new unexplored resources), and is at the heart of entrepreneurship. Having more individuals who are willing to risk in a society and who are exploring new spaces, who are starting new types of business, who are trying out new technologies, results in faster economic development and growth. However, risk is also associated with failure, with loss, with possible punishment and that makes many individuals risk averse. At the societal level unwillingness to risk is associated with conservatism, with tradition – they ensure that

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some rules will be kept constant, that the world will be more predictable and that the coherence of the society will be preserved.

The concept of "risk" is central to many disciplines nowadays: sociology, economics, psychology, cognitive science. We will briefly review some theoretical approaches towards "risk" in these disciplines and then we will try to formulate what would be characteristic for a desired cognitive economics approach towards risk. An attempt will be made towards formulating one possible such approach. We will then present the cognitive architecture DUAL that might be a basis for building a model of individual decision-making under risk and its predictions, and finally an experimental study that tests these predictions.

Approaches to Risk Understanding

Sociology. There are various schools of thought in sociology that view risk from different perspectives. One can see risk as something objective resulting from the use of complex technology, from the potential dangers of physical and social environment. In this case the emphasis will be on risk analysis. Alternatively, one can see risk as a social construction – people are worrying about those aspects of the environment that happened to be culturally central, that are focal for the discussions in the society or group. Thus, for example, the objective risk of humans distorting the environment has always been high; however, this has only recently become to be perceived as a risk, after it became the cultural focus of discussions. This second approach concentrates on the study of risk perception and its relation with the socio-cultural level. Another example would be the perceived danger of immigrants, of followers of a different religion, of different ethnic group, etc. This is the fear of the Other as traditionally considered in the socio-cultural tradition.

Another influential line of research steams from the work of Beck (1992, 1999) who argues that we are entering a new era – the era of the risk society. This era can be characterized as a society using complicated technologies that necessarily have both good and bad sides, as a society where the traditionally established social institutions, such as marriage and family, are falling apart. Thus the overall order and predictability is decreasing and the uncertainty is increasing and we have to adapt to this new situation by learning to manage the risks in our own lives without relying on social institutions and social norms but by finding our own solutions. Thus Beck argues that risk management becomes an individual responsibility which is accompanied with less trust and reliance on experts, governments, authorities. Furedi (1997, 2003) argues for the developing of a new culture of fear or a therapy culture in which the individuals are left with more freedom from official intervention. This line of research with its focus on the individual risk perception and individual risk response is closer to the psychological view of risk.

Economics. Frank H. Knight (1921) is recognized as the first economist suggesting a clear definition of risk within economic context. In his eminent book "*Risk, uncertainty and Profit*", he made an essential distinction between risk and uncertainty: when the decision-maker is unaware of the probability distribution of the possible outcomes, or the consequences of his or her possible actions then he or she is faced with uncertainty; when the decision-maker is facing a situation where he or she knows in advance the probabilities of all possible outcomes and has to choose among them, then this is called decision-making under risk. In real life it is much more often that the decision-maker has to deal with uncertainty, but there are situations in which the risk is well defined, like in lotteries and gambles, in often repeated situations for which there is a statistics know to the decision-maker. Even though

uncertainty is the ecologically more valid situation, researchers in economics and psychology study much more often risk since it is a simpler and more controllable situation. This paper is also about risk although some of the ideas could easily be extended to uncertainty.

Based on the assumption that probabilities are objective and they cannot be influenced by the agent, John Von Neumann and Oskar Morgenstern (1944) developed the expected utility theory which is the single most influential theory of decision-making under risk. In this theory the decision-maker is supposed to know the probability of occurrence in each state of the world and the related consequences of each possible choice. The expected utility is calculated as a weighted sum of the utility (the monetary benefit) of each possible outcome multiplying it by the probability of this outcome to occur. And the decision-maker is considered as maximizer of this expected utility. For example, if someone has a choice between two lotteries: Lottery A ensures 100% chance to win EURO 100, and Lottery B provides you with a 50% chance to win EURO 300, and 50% chance to win nothing (for example, tossing a coin), then this person should always choose Lottery B which has an expected utility of EURO 150, greater than the expected utility of A - EURO 100. In consequence the neoclassical economic theory assumes an ideal economic agent, either a firm or a household that is fully informed, able to make computations of the outcomes with perfect accuracy and maximizing the utility. Such decisions are called rational. That is why this theory is also referred to as the Rational Choice Theory.

Everyday situations are usually unique and unrepeatable, and therefore the probabilities cannot be made objectively. That is why Savage (1954) suggested replacing the objective probabilities with subjective estimation of these probabilities. Thus his model is favoring the alternative with the highest *subjective* expected utility. The probability judgment is based on the subject's beliefs about frequencies or about the set of logical possibilities, thus different individuals could have different subjective probabilities associated with each outcome. Once formed the subjective probabilities they play the same role as the objective ones.

Various economists have pointed out various shortcomings and paradoxes of these normative theories (Allais, 1954, Camerer, 1992, Rabin & Thaler, 2001) however; no better theory has been suggested in the field of economics. The strength of this theory is based on its simplicity and beauty which make it so widespread and a common basis for neoclassical economic theories. Alternatives have been proposed within cognitive science and cognitive economics is trying to rebuild economic theory using some of these theories.

Psychology. Classical psychology has also provided various treatments of risk that have proved not to be very useful for modern economic theories.

The psychoanalytic tradition considers risk-taking behaviour as a violation of rationality and interprets it as being an expression of an unconscious death wish ("Thantos"), or repressed feelings of masculine inadequacy. Thus they treat risk-takers (such as alpinists, financial brokers, etc), as being illogical or even pathological. However, there is no empirical support of that claim; on the contrary, it has been demonstrated that ocean sailors and people who take financial risks at their work are often with higher self-esteem and tend to be more successful in their jobs, so risky behaviour could not be considered as self-defeating.

Evolutionary psychology suggested that risk taking behaviour has evolved for its survival value since "early humans" (*Australopithecus)* have lived in a very hostile and hazardous

environment and if they were “playing safe” not changing the inhabitant location they would soon die from starvation. Humans with risk-seeking behaviour are typically dominating in the group and are considered to be more sexually attractive and that is why “risk-taking behaviour” has been selected and transferred through the generations.

Finally, personality psychology considers risk seeking and risk aversion as personality traits. This means that they are underlying characteristics of the individual that are relatively stable over time, and explain regularities in people's behaviours. Thus psychologists have developed various batteries to measure the internal inclination of a given person to take risks. These results could be used for describing individual differences and explain why some people could systematically violate the expected utility theory principles but could hardly be used for building adequate new economic theories.

Cognitive Science. There are various treatments of risk-seeking and risk-averse choices in cognitive science but it has also not yet provided an adequate and satisfactory theory that could easily be used by economists. However, the advantage of cognitive science is that it is interested in the mechanisms underlying judgment and choice. Knowing the mechanisms could potentially be useful for making predictions about what kind of behaviour might be expected in a given situation. That would be directly useful for building a more flexible economic theory that would have greater predictive power. Another advantage is the combination of various methodologies used in exploring these mechanisms (computational modelling, psychological experimentation, brain imaging, neuropsychological data, etc.).

Simon (1955) argued that the actual understanding of decision-making would require examination on how various cognitive processes (e.g. perception, learning, reasoning) may influence human decision behaviour. He suggested that decision-makers have limited cognitive resources (such as memory and attention) and limited computational capabilities (such as reasoning mechanisms) to interact with the complexity of the environment. Therefore, he suggested human beings are rational but they have *bounded rationality,* i.e. if there were not resource limitations the outcome would have been corresponding to the rational choice theory. As a result, Simon (1978) argued that the process of reaching a conclusion or decision might be considered rational (since it uses the given resources in the best possible way) even though its outcome is not rational.

Kahneman and Tversky (1974) suggested that people are using specific heuristics (such as representativeness, availability, etc.) for judging probabilities of events which is a specific proposal for a bounded rationality procedure. They demonstrate that although these heuristics lead to good estimation in many cases, there are situations in which the heuristics produce strong biases which lead to “irrational” decisions. From evolutionary perspective it might be expected that these kind of situations are relatively rare and in the vast majority of cases they produce reasonable results. In this way humans have the advantage to reach the adequate decision in a very fast and efficient way in the majority of cases and therefore the probability of survival will be higher.

Among the various attempts for creating an alternative to utility theory following the bounded rationality prescription merely Prospect theory has achieved recognition in economics. Kahneman and Tversky (1979) proposed a descriptive theory called *prospect theory*, which could account for almost all of the available at that time data concerning decision under risk. Prospect theory has probably done more to bring psychology into the heart of economic analysis than any other approach. It aims to modify expected utility theory as little as possible

in order to take account for the observed violations and to explain why and how our choices deviate from the normative model. Unlike expected utility theory, which deals with how decisions under uncertainty should be made (a prescriptive approach), prospect theory deals with how decisions are actually made (a descriptive approach).

Prospect theory postulates that we make decisions by multiplying something like subjective probability to something like utility. For instance, if the consequence of *x* is more probable than the one of *y*, we may weight the utility of option *x* more heavily, than we do for *y*, i.e. certainty is over-weighed and lower values of probability are under-weighed. Thus, prospect theory predicts that stated probabilities are not accepted as ought to be in mathematical average values of choice. Furthermore, according to prospect theory the value function of outcomes is compared to some imaginary reference point that is relatively easy to be manipulated (e.g. easy to be affected by irrelevant factors that may lead to different decisions for similar problem, depending on how the decision situation is described or how we describe the choice to ourselves (framing effect)).

Despite the fact that prospect theory has a solid mathematical basis, making it comfortable for economists to play with, it has not been applied very far from behavioural economics. In addition, some new paradoxes have shown where prospect theory is self-contradicting or has false predictions. Therefore, it has a disputed status as a new general theory of decision-making, which can replace expected utility theory. Nonetheless, prospect theory has provided important insights into choice behaviour.

Tversky and Kahneman (1981) described the so called *framing effect*, which shaped a supplementary investigation of description variance. Framing effect presumes that the choice we made is dependent on how the situation is perceived, or "framed". Many experimental results have demonstrated that decision-makers respond differently to logically equivalent lotteries, which are described in different terms (e.g. in terms of gains or in terms of losses).

Framing effects have been widely investigated. Over the past decades studies of framing effects in the area of judgment and choice have been expanded and included domains such as psycholinguistics, cognition, perception, social psychology, health psychology, clinical psychology, education psychology, and business. Levin, Schneider, and Gaeth (1998) introduced a typology of framing effects. They start with the "classical" framing effect, which they labelled "risky choice" framing and introduce two other types: "attribute framing" and "goal framing". The typology of framing effects was based on differences in information encoding of positive and negative features in the decision task. Despite the wide spread interest and the amount of accumulated evidence, there is a lack of understanding of the basic cognitive mechanisms that underlie framing effects.

Shafir, Simonson and Tversky (1993) proposed a theory that may explain why a change in the description of two gambles reflects in a change of the evaluation of the objective known probabilities. The theory is called *reason-based choice*. Rational choice assumes that options are ordered according to their value in a context independent way where the more attractive options are selected and the less attractive ones are rejected. In contrast, reason-based choice argues that we raise different arguments in different context, i.e. each context provokes specific type of arguments, which might not be raised in a different context. As a result when we face decision under risk in different contexts we tent to arrive at different number of arguments "in favour" and "against" each option and therefore different choices are made. In contrast to the more abstract prospect theory, reason-based choice suggests specific

mechanisms of how choices are made. In addition this theory explains a really wide set of experimental data that looked strange and “irrational” before.

Finally, some cognitive scientists have introduced mechanisms based on emotions which could also explain why people are not always rational. The main reasoning is that the emotional system is very rapid and could produce a result (an emotional state and a behavioural response) even before the cognitive processing could take place. Zajonc (1980) was the first to demonstrate this effect – he obtained an effect on interpreting a Chinese character providing the subject in the experiment with subliminal image presentation of a smiling face vs. a neutral geometric figure. His interpretation is that the emotional processing of the smiling face has been faster than the information processing process and has changed its results. Following this line of research Epstein (1994) and Slovic, Finucane, Peters, and MacGregor (2004) suggested that there are two “thinking modes” or two systems called analytic (rational) and experiential (emotional) that together form the decision in a “dance of affect and reason”. Each of these systems has its advantages – the analytical is supposed to provide more precise results but only when we have a lot of information about the domain and a lot of time to process it, while when there is a little information or high time pressure the experiential system reacts fast and to even peripheral aspects of the problem and thus ensures that a decision will be made in the required time period – this usage of emotions is called “affect heuristics” and can be considered as one of the available heuristics. Damasio (1994) provides neurological evidence supporting the claim of usage of emotions in decision making and that people with specific brain damage related to their ability for emotional response may degrade in their decision performance. He introduced the so called somatic markers which are positive or negative and which are directly related to the images. Thus the presence of an image could directly activate the positive or negative marker associated with it and thus influence the decision to be taken.

The main problem with all these theories of decision-making proposed within cognitive science is that they are not yet detailed enough to be strongly testable. There is generally a lack of computational models that could provide the details of how exactly the decisions are made and to explain the existing data and more importantly to predict new data.

Cognitive Economics. Many of the theories discussed above can be brought under the heading of cognitive economics, however, we will leave this section empty since we are not satisfied with any account proposed so far. That is why we will rather list the requirements that such a theory would have to meet.

First of all, a theory of decision-making should be detailed enough in terms of mechanisms and representations and implemented in a computational model. This will allow predictions to me made and tested comparing human data against simulation data.

Second, the model of decision-making should be closely integrated with models of other cognitive processes since as it is evident from the review above deciding is not an isolated process – it is being influenced by and influences perception, judgment, categorization, memory, reasoning, emotions, etc. that is why the best approach for us would be to integrate a decision model into a general cognitive architecture.

Third, the model should explain context-sensitivity of human decision-making and even predict new types of context effects.

Forth, the outcomes of the model should be easily usable in building a new economic theory of decision-making which will not be based on the rational choice assumption, but rather the "rational choice" or "maximizing expected utility" would be one possible outcome of the process among many possible behaviours. Moreover, the theory should predict under what circumstances "rational choice" behaviour will be produced.

A DUAL-based Approach towards Decision-Making under Risk

In this section we present an outline of a possible theory of decision-making under risk. This is just a first step and we are far away from having a properly developed theory. We still lack a fully implemented model and simulation data. Still some predictions will follow out of it.

Since we would like to integrate decision-making with other cognitive processes we will base our theory of decision-making on a general cognitive architecture – DUAL (Kokinov, 1994a, 1994b, Petrov & Kokinov, 1999). DUAL consists of a great number of micro-agents (simple computational units) that collectively produce the emergent behaviour of the whole system. Each micro-agent is hybrid. It has a symbolic part and a connectionist part. The symbolic part represents a simple piece of knowledge; it has local memory which holds symbolic structures representing a simple statement or a piece of procedural knowledge. The connectionist part represents the relevance of that knowledge to the current context by the level of activation computed by this node. The connectionist units spread activation over all existing links between the micro-agents. The symbolic units exchange messages over specific semantic links (superclass, subclass, instance-of, c-coreference, etc.) between them. All the communication and therefore all computations are local only. Global processes (such as, reasoning, problem solving, judgment, and decision-making) emerge out of these local communications. There is no centralized device to coordinate the whole process. Moreover, each symbolic processor runs at its own speed and this speed varies dynamically; it is proportional to the activation level computed by the paired connectionist processor. This mechanism ensures that whatever is considered relevant to the context, and therefore highly activated, runs faster and thus has priority. This makes all the computations in the architecture context-sensitive.

The set of all micro-agents form the so called Long-Term Memory (LTM) of the system. This is what the DUAL-based system "knows": this includes concepts, general facts, episodes from past experience as well as skills, including motor programs, mental operations, etc. However, the vast majority of these micro-agents will be in "sleeping mode", i.e. they will not be active, and therefore they will not take part in the computation process. This means that even though they may contain important information that might be useful for solving the task at hand, this information is not available at that moment. The subset of active micro-agents at a particular moment of time is called Working Memory (WM). Only they participate in the computations. Moreover, they participate at various speeds depending on their current activation levels. In different contexts different sets of agents will be present in WM and they will be running at different speeds and therefore they could produce different outcomes at the emerging global level, i.e. the cognitive system will arrive at different solutions or decisions.

Several models have been developed on the basis of the DUAL architecture: AMBR – a model of analogy-making and memory (Kokinov, 1994c, Kokinov & Petrov, 2001), PEAN – a model of perception (Nestor & Kokinov, 2004), and JUDGEMAP – a model of judgment and choice (Petkov & Kokinov, in press). They all use the same knowledge structures and the

same mechanisms which are provided by DUAL. Thus JUDGEMAP basic mechanisms are spreading activation, mapping, and constraint satisfaction – all these mechanisms were initially introduced for modelling the process of analogy-making and they are reused in JUDGEMAP for modelling the processes of scaling and choice (Figure 1).

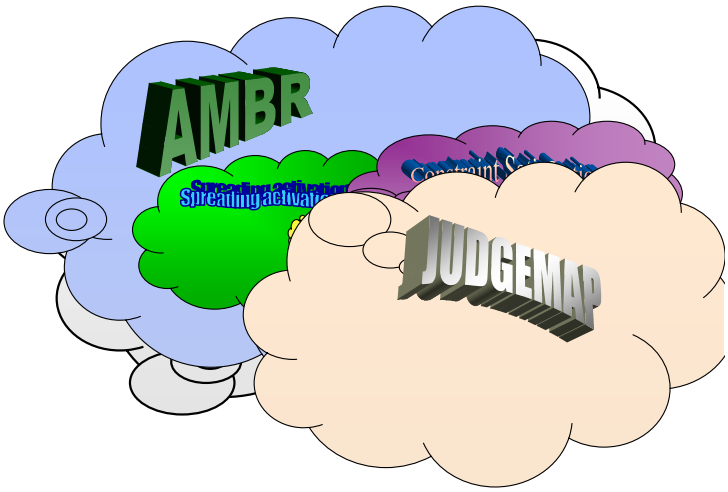

Figure 1. AMBR and JUDGEMAP models using the same mechanisms (spreading activation, costrant satisfaction, mapping) from the cognitive architecture DUAL.

The choice could be modelled by JUDGEMAP in the following way. There will be a coalition of agents each of which representing a possible alternative and an agent representing the positive choice. Each of the alternatives will try to form hypotheses (represented by other micro-agents) for possible pairing with the choice-agent. All of these hypotheses will compete and one of them will finally win. These hypotheses may have justifications which support them (similarly to the reason-based choice theory) and they will receive additional activation from these justification-agents. Finally the constraint satisfaction mechanism will decide who is the winner; this will depend on the supporting structure of justifications, but it will also depend on various other factors such as the activation level of the alternatives themselves (if some of them are perceived in the moment they will get additional activation through perception), the activation level of concepts related to these justifications (e.g. the concept of size would activate a justification-agent claiming that one option is bigger than another one), etc. Thus if we compare this model to reason-based choice theory we can assume that all the power of reason-based choice is included in JUDGEMAP, but in addition there is an unconscious process of spreading activation which adds on the explicit mechanisms of comparison and building arguments in favour of one or another option. Thus making choice in JUDGEMAP is an interplay of conscious (explicit) and unconscious (implicit) processes. Compared to the "two thinking modes" theory JUDGEMAP acknowledges the complementary role of two or more processes in decision-making, but the rapid unconscious process is not necessarily an emotion-based mechanism, it could be an associative process of information processing. Of course, emotions do play a role in making choices, but the way they could be integrated into the model is yet to be established. They could influence direct self-activation of a specific (positively charged) alternative, or they can act as a general parameter changing the pattern of spreading activation. These alternatives have yet to be explored.

Figure 2 presents an example of choice-making between two options – one is more risky than the other, but offers higher profit. This is a case of a strong conflict. Each of the two options has formed a hypothesis for possible pairing with the choice response. Each of these hypotheses has been formed on the bases of some justification-agent (one is safer than the other, and the second one is more profitable than the first one). There could be second-order relations representing which difference is bigger than the other one – they are not depicted in the figure since in this particular case the differences are equal and therefore do not play a significant role. The concept of "safety" is connected to the "risk comparison" justification, while the concept of "profit" is connected to the "profit comparison" and when activated they send activation to the corresponding justification nodes. Various other concepts or specific instances and episodes could be connected to the concepts of "safety" and "profit" in our case. Let us assume that the concept of "baby" is strongly associated with "safety", while the image of "James Bond" is strongly associated with success and profit. In that way we arrive at a specific prediction that this model is making.

Prediction. If the external environment provides a clue that is strongly associated with the concept of a "baby" then the concept "safety" will be strongly activated and this will result in greater activation of the safety comparison and the cognitive system will prefer the more safer Alternative 1. On the contrary, if the environment happens to provide a clue for James Bond than this will result in activating the concepts of "success" and "profit" and as result the cognitive system will activate highly the profit comparison justification and finally will prefer Alternative 2. In this example we can see the interplay between the conscious processes of making comparisons and building justifications and the unconscious process of spreading activation that might be triggered by any environmental stimulus, even if this stimulus is not part of the task, it would be sufficient to ensure that it will be presented in the visual field of the human decision-maker to ensure that it will be perceived. Thus the specific prediction of the model to be tested is that if we present a supposedly irrelevant picture of James Bond human decision-makers will tend to prefer the more risky option, while presenting a supposedly irrelevant picture of a baby will result in a preference for the safer option.

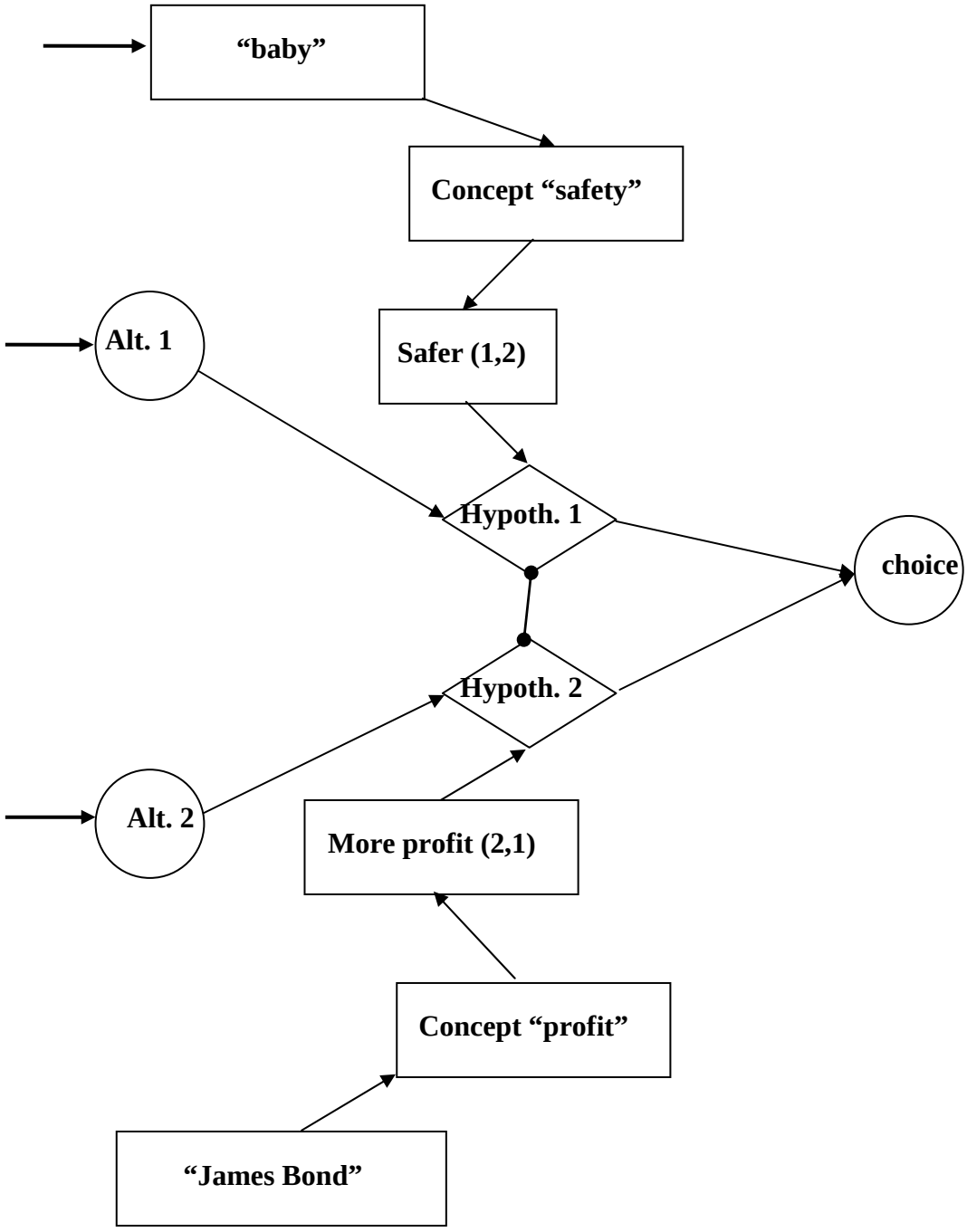

Figure 2. The constraint satisfaction network built by the model to provide a choice between two options (Alternative 1 and Alternative 2). Alternative 1 is safer than Alternative 2 and the corresponding comparison relation becomes a justification for hypothesis 1 (Alternative 1 is chosen), Alternative 2 is more profitable than Alternative 1 and the corresponding comparison becomes justification for hypothesis 2 (alternative 2 is chosen). Other concepts and instances linked to the comparison relations are also shown and they emit activation toward the hypotheses when activated.

Experimental Study

The experimental study described here tests the above prediction of the model. It is a continuation of previous work on context effects on problem solving (Kokinov, Yoveva, 1996, Kokinov, Hadjiilieva, Yoveva, 1997) where AMBR predicted distant context effects. A similar methodology is used here in a decision-making context. We present a risky choice task to the participants in the study and at the same time we either present them with a picture of James Bond or a picture of a baby. The picture is not part of the task or the instruction and thus has to be considered as completely irrelevant by the participants. That is why we call such context effects (if we obtain them) distant context effects (DICE).

In the experiment people played gambles. Participants were invited to play a game on a PC in a soundproof boot. On the computer screen they were presented with a stack of cards that has an Ace in it. The card stack consists of 10 cards, which are randomly distributed over two rows (Figure 3). The particular position of the Ace is randomly chosen on each trial. The participants had to guess where (in which row) the Ace is. If they guess correctly they win a certain amount of points, which are accumulated in a general score and later on paid to the participants. The amount of points was selected in such a way as to make the expected value of the two rows equal. Thus in the example provided in Figure 3 we have expected value of 24 points for each of the rows (4/10 x 60 for the first row and 6/10 x 40 for the second row). According to the rational theory we should obtain a random 50:50 choice of either option. On each trial participants faced a different configuration which varied from 1 card in the first row and 9 cards in the second row to 9 cards in the first row and 1 card in the second row (excluding 5 cards on each row). Every trial displays a different not-repeating configuration.

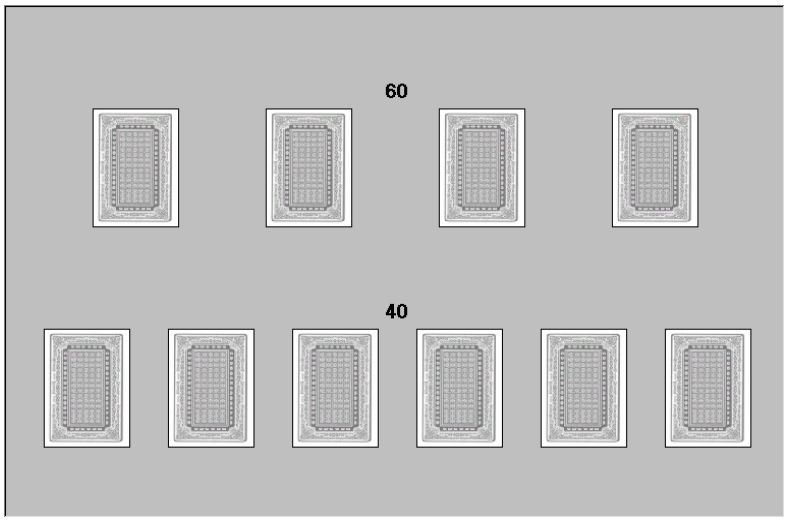

Figure 3. An example display of a trial from the gamble.

Three conditions have been used: control condition (the cards have a neutral back), “risk seeking” condition (the cards have a picture of James Bond as their back), and “risk aversion” condition (the cards have a sleeping baby as their back). The dependent variable was the percentage of risk responses during the game. People have seen many card stacks and they know that the back of the cards may vary, but the particular picture on the back do not play any role in any card game. Thus participants were supposed to ignore (at the conscious level)

the picture at the back of the card (and thus this to be an example of a good distant context). At the same time the picture was supposed to be perceived and possibly have an impact on the choice at an unconscious level.

The results from the experiment are presented in Table 1. They have shown small but significant difference between the performances of the three groups. Participants in the neutral condition (without a meaningful picture at the back of the cards) have been choosing the more risky option in 48% of the trials. Participants in the James Bond condition picked up the risky option in 55% of the trials. Finally, participants in the "Baby" condition opted for the risky alternative only 41% of the trials. These results confirmed the prediction of the model. Moreover, interviews with participants revealed that they have not consciously used the James Bond or Baby pictures in their decision-making strategy and thus were surprised to learn that their performance was influenced by these pictures.

Group	***Mean % risk choices***
Baby condition	*41*
Control	*48*
James Bond condition	*55*

Table 1. Mean % of risk responses of the subjects in each group.

Conclusions

The performed experiment expanded the known territory of context influences: not only elements of the task, but also distant and seemingly irrelevant elements of the environment can produce a contextual effect. This study has also potential relevance to the practice. It shows that even an incidental picture on the wall of a store may change the choices of the customers.

This new phenomenon raises also important theoretical challenges to the economic theories, that are based on the traditional rational theory of decision-making under risk, by showing that even though the choice task is the same in all conditions, people react in a different way depending on factors that are supposed not to have any relation to the optimal choice. It also challenges the reason-based choice theory since these effects may appear without subjects' awareness and without producing explicit arguments (arguments like "since we have James Bond on the back of the card we should risk more" seem odd to the participants).

The effects were predicted by the DUAL-based model of choice. These predictions are based on parallel local processing postulated by DUAL which allows for an interplay between various cognitive processes some of which might be conscious and other unconscious. In this example the process of unintended perception of the back of the cards (although irrelevant to the task) leads to unconscious and uncontrolled activation of various concepts in Long Term Memory and if they happened to be connected with some of criteria used (the comparison relations established) they will activate the corresponding hypotheses and thus influence the result of the constraint satisfaction process which determines the winning hypothesis and the preferred alternative.

Someone may be inclined to interpret the results from the experiment within a different theory. Thus one may try to interpret them using the emotional heuristics theory. The problem

with this interpretation is that both pictures (of James Bond and of a Baby) produce positive emotional states but they produce different responses (facilitation and inhibition of risk choices). Thus we need different types of explanations.

The presented model is by no way considered the only possible mechanism of decision-making. Moreover, Kokinov (2003, 2005) has argued that decisions can be made by analogy with a specific old case (or episode). Also in this case we can observe the interplay between the deliberate process of mapping and establishing correspondence between the two cases and the unconscious process of retrieving the old case which cannot be consciously controlled but could be influenced by accidental pictures or objects in the environment.

This was our first attempt to build a cognitive model of risky decision-making that should satisfy the criteria set out in the first section. It was based on a general cognitive architecture and is thus strongly integrated with other cognitive processes, it explains context effects on decision tasks, and it has made new predictions that were tested and confirmed. The usefulness of the model in building new economic theories is yet to be established.

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