7(2), pp. 22-116, 2009 ISSN 1334-4684

INTERDISCIPLINARY DESCRIPTION OF COMPLEX SYSTEMS

Scientific Journal

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INDECS, volume 7, issue 2, pages 22-116, year 2009
Published 28. December, 2009, in Zagreb, Croatia
Released online 28. December, 2009

Editions: printed (ISSN 1334-4684), CD-ROM (ISSN 1334-5230) and online (ISSN 1334-4676).

Published by *Croatian Interdisciplinary Society* (http://www.idd.hr) twice per year. Printed by *Ekološki glasnik, d.o.o.,* Donja Lomnica (HR) in 300 pieces. Recorded on 200 CDs. Online edition, http://indecs.eu, contains freely available full texts of published articles.

Journal INDECS is financially supported by Croatian Ministry of Science, Education and Sport.

Full content of the journal INDECS is included in the EconLit and EBSCO.

INDECS publishes original, peer-reviewed, scientific contributions prepared as reviews, regular articles and conference papers, brief and preliminary reports and comments to published articles.

The accessibility of all URLs in the texts was checked one weak before the publishing date.

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EDITORIAL
INTERDISCIPLINARILY ON DECISION MAKING

Decision making as a cognitive process has recently become a hot topic of various scientific fields from neurology to economics. As different disciplines are developing their specific research methods, hypotheses and vocabularies, an emergent need for a synthesis is becoming increasingly apparent. This special issue of INDECS is dedicated to cover the state-of-the-art in the major fields of cognitive science: philosophy, psychology, artificial intelligence and neuroscience, and, by doing so, search for the possibility of an interdisciplinary and interactive dialogue between these fields.

DECISION MAKING – A FAMILY OF PHENOMENA

Decision making is one of the central if not the very central cognitive process and activity expressing human capability for conscious (rational) coping with lived situations, and by that, for facing oneself. Decision making expresses all human mental, psychological and social skills. In our lives we have to make decisions in one way or another on daily bases, whether we are aware of it or not, whether we make it rationally or not, and whether we make it spontaneously and creatively or not. Successful decision making is the key to creative processing of problematic situations from stressful conflicts to positive challenges.

Psychology, neuroscience, social sciences and computer sciences usually consider decision making to be a special cognitive process which runs somewhat autonomously and is separated from other components of the human being. This might prove to be a useful abstraction in certain situations, e.g. when we are interested in decision making as a process that can be formally handled as a kind of calculation or computation. But such a view also brings us to untenable simplifications which are not in accordance with the actual forms and ways of human decision making. People make decisions with their whole selves, with “body and soul”, with the aid of emotions and reason, as members of social units and not merely as individuals and even less so as some kind of automata or computers. The context is what gives this process its character and content of decision making. When observing and explaining cognitive processes as dependent on man’s bodily existence in the world modern cognitive science tends to talk about “embodied cognition“, but when observing and explaining cognitive processes as dependent on the actions of an individual in one’s natural and social environment it rather mentions “situated cognition” [1-2].

The phenomena and processes various fields of research relating to the notion of decision making are extremely diverse. On the one hand, one could talk about decision making even when considering the most basic reactions of living beings (and machines) to external stimuli. As soon as there is the possibility of more than one reaction, one could already talk about decision making. Such decision making is usually carried out extremely fast and on reflex basis. Usually it is unconscious or partly conscious at best. Today it is mostly the different areas of neuroscience which research such decision making. On the other hand, we find “big“ and “complex“ strategic problems in decision making, like for example the decision about the social system of a country or the strategy of economic development of a large organisation. Such decisions can have important and long-term consequence. Usually they are carried out slowly and thoughtfully, with the cooperation of several agents. Here the emphasis is on communication, collaborative formation and evaluation of alternatives and the argumentation of suggested solutions, as well as on the solving of conflicts emerging from diverse interests and power relations among different agents.

Decision making can be understood either in the narrow or the broad sense of the word. In the narrow sense, we are interested in the decision itself as it is, i.e. as the choice of one of several options. In the broad sense, decision making can be seen as a process in which the choice of one alternative is only one of the steps. Prior to the choice itself, there are other activities taking place, e.g. gathering and checking information, formation of alternatives and foreseeing their consequences. Once the choice has been made, such an alternative can either be carried out or not. Each of these steps can itself become the object of special scientific research. Thus we can be interested in what way the decision maker formed the group of alternatives from which he tried to select the best one. What was the procedure he/she used to create these alternatives; did he/she rationally reflect on them at all; which ones were eliminated and why; were all the relevant alternatives considered or were there some left out etc. Usually it turns out that this encompasses a succession of smaller decision making problems which need to be solved prior to selecting the final alternative, i.e. prior to the actual decision in the narrow sense of the word. Another point of interest for the research is the phase of realization of the decision. The decision in the narrow sense does not mean that the selected alternative will actually be carried out. In order to make a decision, let alone to carry it into practice, we need „energy“, that is a motive, an intention, an emotional impulse or some other source, such as time, for example.

PATCHWORK OF PERSPECTIVES

There are many different angles from which the decision making process can be observed. The articles in the present issue reflect this diversity. Some of the approaches to the research of the decision making process differ one from another merely in their research perspective, while others are virtually mutually exclusive. As with other cognitive phenomena, there are still several fundamental questions left unanswered concerning decision making. One of them is undoubtedly the question about the possibility of unconscious decision making. The field of computer learning and decision making is an important part of artificial intelligence. It is therefore obvious that the research of the area of machine (i.e. unconscious) decision making deserves serious consideration, regardless of our intuition that decision making has to be conscious. In his article, Marko Bohanec classifies and concisely describes the basics of the computer analysis of decision making, computer systems supporting decision making and computer decision making systems. Bohanec also analyses the most important phases in computer decision making – the most important one perhaps being the analysis of the decision situation. The author hints at the possibilities and reach of computer decision making and concludes that the most perspective area is still the area of computer systems supporting human decision making, which can simplify the analysis of decision situations, while cannot make decisions instead of us.

An interesting point is that not only the artificial intelligence experts allow the possibility of unconscious decision making. Neuroscientists Zvezdan Pirtošek, Dejan Georgijev, and Milica Gregorič-Kramberger in their article introduce a division into three types of decision making: unconscious, half-conscious and conscious decision making, and two types of processes competing for the control of final decisions and actions: the simple, fast, perception-motor processes which appeared earlier in the evolution, and the complex, slow, more reflected cognitive-social processes with the elements of self-awareness which appeared later in the evolution and are characteristic of human beings. The first processes are related mostly to sensory-motor areas of the cerebellum, while the second ones are located in the frontal lobes. Basing on this division and proceeding from the experimental results of Libet's (and similar) research, the authors present a neuroscientific analysis of the experience of free will. In this they take sides with the relatively widespread view that the experience of free will as well as the experience of oneself as being the author of the decision mostly just accompany the experiencing of certain neurophysiological processes rather than being their causes (or the causes of our actions, to put it more accurately). The experience of free will is therefore a kind of illusion, or an explanatory means helping us to maintain a coherent world-view.

Such arguments are analysed also in the article written by Olga Markič. She is a bit more sceptical and careful in bringing conclusions about the illusoriness of our experience of free will. She points out the ambiguity of researches which form the basis of such thinking. Markič also points out the other extreme position often taken by researchers of decision making processes - the reduction of decision making to computation. Such a view improperly neglects unconscious processes and emotions, just like negating free will neglects the power of rational judgement and the role of personal responsibility for one's actions. In her paper, Markič presents Damasio's theory of the necessary role of feelings and emotions in decision making. Damasio develops the theory of "somatic markers". These are a kind of traces of emotional responses to situations, which have been formed in previous, similar situations. This way our emotional signals help us evaluate the possibilities and potential outcomes of decisions and thus help us decide about actions which are in accordance with our past experience.

The next article instead of finding general external (third-person) definition of the phenomenon of decision making, focuses on experience. From the phenomenological point of view, i.e. the perspective of the research of direct lived experience, the only expert able to answer the question whether a given process is decision making or not is the person who experiences this process. In the first part of his article, Urban Kordeš describes the emerging subdiscipline of cognitive science, phenomenological research, which concerns the studying of experiential processes. In the second part, he presents some results of the pilot study of the phenomenology of decision making. It appears that many experiential processes which subjects define as decision making are composed of two phases: rational weighing and analysing different options, and then waiting for an "impulse" or a kind of energization which ultimately tips the scales in favour of one of the options.

This phenomenological article is followed by the psychologist's report which focuses mainly on the problems of decision making in real-life situations. Marko Polič points out the phenomenon of intuitive decision making as the central feature of naturalistic decision making. He presents different models of decision making in a natural environment, specially emphasizing Klein's (basing on subject recognizing critical signs which mark the type of circumstances and causal factors of the goings-on). He also presents Rasmussen's model of decision making on the bases of skills, acquired rules and knowledge. The author is in favour of a sensible integration of diverse models of naturalistic decision making. He points out six features, significant for such integration: diversity of forms, evaluation of circumstances, use of mental images, environment dependence, dynamic processing and description based on prescriptions.

The mosaic of diverse angles continues with the article by Andrej Ule, who makes a step forward from considering decision making as an individual process to researching decision making in groups. The notion of collective decision making is presented in a mathematical form, as a process of actualisation of decision potentials. Ule takes into account also the context which ultimately brings to a simplified matrix of the attractiveness of the outcomes, which corresponds to collective decision making about one of the given alternatives. Collective decision making is thus presented as a process of gradual crystallization of dominant alternatives under the influence of diverse contexts of decision making from the primary potential represented by the starting matrix of the attractiveness of combined outcomes.

The special issue is rounded up by Simona Tancig's paper about the problems and advantages of collaborative expert decision making and problem solving. Many of her findings have already been personally tested by the collaborative efforts of the group of authors of the present issue, which makes this article a perfect conclusion. The author builds on the so-called naturalistic perspective (introduced in the paper by M. Polič), which puts the expert in the focus of research and sees the expertise as the core of decision-making research in natural situations. An expert team is more than a group of experts. It is defined as a group of interdependent team members with a high level of task related expertise and the mastering of team processes. Tancig discusses the characteristics of expert teams during their optimal functioning. These characteristics are discussed in terms of input, process and output factors. Cognitive, social-affective, and motivational characteristics are presented and correlated with individual and team learning, problem solving and decision making strategies. Author explains deeper structures of dialogue and discussion, and the phenomena of collaboration, alignment, and distributed cognition that emerge from them.

To a group of researchers, trying to understand decision making from a broader perspective, the questions that Tancig is tackling seem essential, because it would appear that truly interesting insights into the nature of this phenomenon (or families of phenomena) can only by gained by a synthesis of all individual disciplinary findings. Such collaboration is obviously not a simple task, especially when trying to overcome the epistemological barrier between natural and social sciences. Apart from that, as mentioned above, in attempting interdisciplinary research of decision making and processes related to it we have to face the first major problem in the very beginning, i.e. when trying to define what decision making actually is and thus what exactly is the subject of our research. In specialised fields researchers might even not be aware of this problem as their view of the phenomenon is determined by the area or by their specialisation which usually does not require broader understanding. But once we try to tackle decision making research collaboratively, in interdisciplinary meetings, it turns out that a psychologist, a neuroscientist, an A. I. expert, and a phenomenological researcher use the same terms to describe quite diverse processes (phenomena). Is it possible that the notion of "decision making" actually describes different processes?

Could it be that we are not even dealing with the same problem? The answer to these questions is definitely the first (and maybe foremost) task for an interdisciplinary team trying to grasp any cognitive process in a more holistic perspective.

Regardless of these problems, it seems that the truly interesting findings are lurking somewhere “in between“ the disciplinary views, precisely on the edge of each individual research paradigm’s perspective. How to enter these intermediate spaces? How to find the synergy between essentially different disciplines? And first and foremost – how to handle research in an interdisciplinary way?

The present issue of INDECS probably cannot answer any of the above questions. But it is at least not afraid to ask them. All the authors are aware that the synthesis and acknowledging of different perspectives is merely a first step on the long road to a broader, more high-level understanding of decision making – the phenomenon so familiar to us that we know virtually nothing about it.

THANKS

This introductory text is in parts based on Andrej Ule’s introduction to the monograph “The Contexts of Decision Making“, and on a text I am writing in collaboration with Marko Bohanec, in which we intend to present a kind of a map representing different modalities of decision making. Both papers are still works in progress. I would like to thank Olga Markič for invaluable help in preparing and editing this issue, and the entire team of the “Methodological aspects in researching cognitive processes – learning and decision making“ project for numerous fruitful discussions which planted the first seeds of a truly collaborative research process.

I would also like to thank Jaka Andrej Vojevec for help with translation and Karolina Radovanovič for double-checking the manuscripts.

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Ljubljana, 14 December 2009

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Žiga Knap	Miloš Pukl
Vitalij B. Novoseltsev	Andrej Ule
Vladimir Pavlov	Irina Nikolaevna Tschukina

their contribution to the quality of the Journal's content is acknowledged.

Zagreb, 16 December 2009

Josip Stepanić

Interdisciplinary Description of Complex Systems 7(2), 22-37, 2009

DECISION MAKING: A COMPUTER-SCIENCE AND INFORMATION-TECHNOLOGY VIEWPOINT

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Regular article *Received:* 3 November 2009. *Accepted:* 9 December 2009.

ABSTRACT

We address the phenomenon of decision making from the viewpoint of computer science and information technology. The basic question from this viewpoint is: what can the computer offer to decision makers and how it can support their work? Therefore, the main issue is to provide support to people who make complex decisions. In this article, we first present the taxonomy of disciplines that are concerned with methodological and operational aspects of decision support. At the main level, we distinguish between decision sciences, which are concerned with human decision making, and decision systems, which address computer decision making. This is followed by basic definitions related to decision processes and their components. We also describe properties that characterise different classes of decision problems. In the main part of the article, we present three prevailing approaches to decision support and give illustrative examples of their application: decision analysis, operational research, and decision support systems. Finally, we make a short overview of the area of decision systems and its achievements.

KEY WORDS

decision making, decision sciences, decision support, decision analysis, decision systems

CLASSIFICATION

ACM: D.2.2, H.4.2, K.4.3, I.6

APA: 4120

JEL: D83

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INTRODUCTION

Computers are everywhere: they are placed on tables in our offices and homes, they are installed in cars, washing machines and other equipment, we carry them around, and we even send them to other planets. With computers, we calculate, process data, solve problems, communicate with each other, and create art. When designing computer programs and applications, one of the key questions is the question of functionality: what can the computer offer to the users and how can it support their work? When dealing with decision-making problems and tasks, the question is therefore how can computers and information technology support people who are faced with difficult decisions, so that they can decide better, faster and more effectively. This is addressed in the area of decision support programs, systems, methods and techniques [1-3].

In decision support, we must answer many important questions. What exactly is decision making, how is it performed by people and how should we support it? Can we classify decisions and decision processes? Which of them can be effectively supported by information technology? Which are the main components of decision making? What are the input data and what are the expected output data of computerised processes? What exactly constitutes a "good decision"? In this article we present some answers to these questions from the viewpoint of disciplines, which are concerned with methodological and operational aspects of decision support. First, we present the taxonomy of these disciplines, give some basic definitions, and describe properties that characterize different classes of decision problems. In the main part, we present three prevailing approaches to decision support: decision analysis, operational research, and decision support systems. Finally, we make an overview of the area of decision systems.

BASIC DISCIPLINES

When talking about decision making, a computer scientist usually starts with the question: who or what is making decisions, the man or the computer? In decision support, we wish to help people who make decisions; therefore we are primarily interested in *human decision making*. However, in computer science and related disciplines, such as artificial intelligence, the aim is also to make "intelligent" systems, i.e., computer programs and machines, which are able to make autonomous decisions by themselves. That is, the focus there is on *machine decision making*. As a consequence, we classify disciplines which are concerned with decision making into two main groups (Figure 1): *decision sciences* and *decision systems*, which are concerned with human and machine decision making, respectively.

Decision sciences refer to a broad interdisciplinary field interested in all aspects of human decision making. It draws on economics, forecasting, statistical decision theory, and cognitive psychology, and is typically divided into three main groups (Figure 1):

1. The first group is concerned with *rational decision making*. The approach is referred to as *normative* or *prescriptive*, where the decision problem is defined in terms of identifying the best (or optimal) decision, assuming an ideal decision maker who is fully informed, able to compute with perfect accuracy, and fully rational. Methods developed in this area are mainly theoretical; typical examples include decision theory, multi-attribute utility theory and game theory [4].
2. The second group is interested in how people really do make decisions. It has been clearly shown that people are rational only to some extent; they tend to use rules of thumb and take shortcuts to choose among alternatives. Often these shortcuts do well, but often they

lead to systematic biases and serious errors [5]. This approach is called *descriptive* and is typical for the research in *cognitive sciences*.

3. The third group is concerned with *decision support*: given what we know about rational decision making and actual behaviour, how can we help people to improve their decision making? This is the main area of interest for computer scientists and information technologists, who try to provide effective methods and tools for supporting human decision makers.

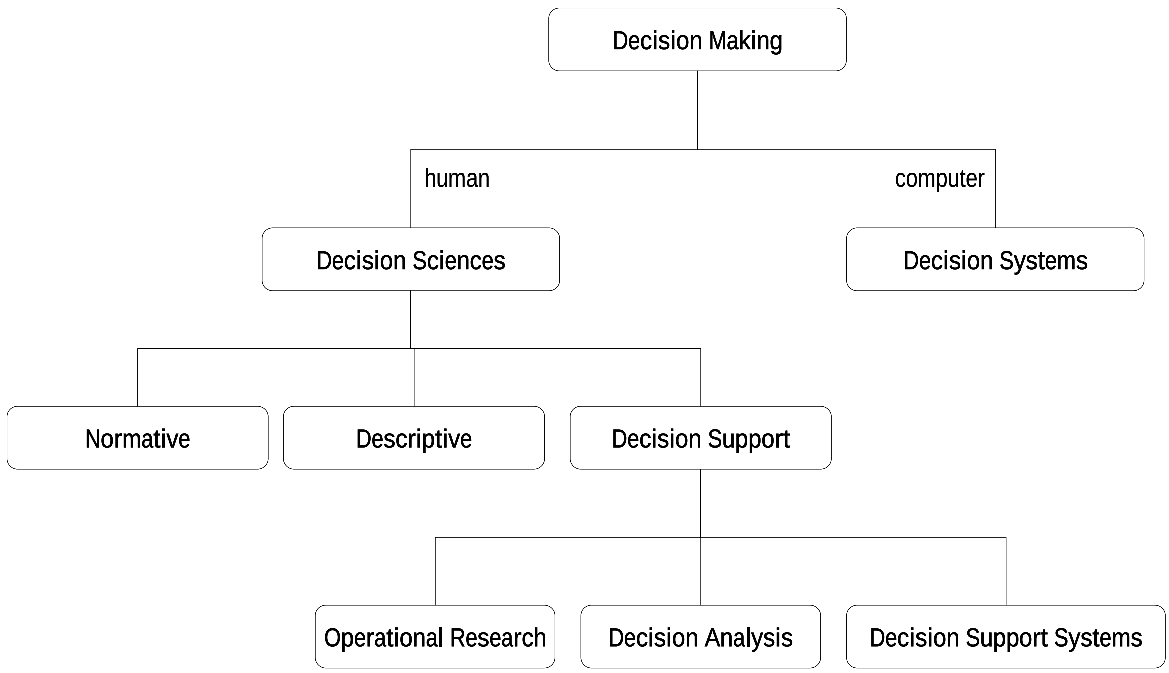

Figure 1. Disciplines addressing methodological and operational aspects of decision making.

In this article, we focus on the three decision support disciplines (Figure 1): operational research, decision analysis and decision support systems. However, before presenting them, we first give some basic definitions related to decision making and describe different types of decision problems.

DECISION MAKING

Decision making is usually defined as a mental process, which involves judging multiple options or alternatives, in order to select one, so as to best fulfil the aims or goals of the decision maker [1, 4, 6]. Therefore, there are two main components involved in decision making: the set of *alternatives*, judged by the decision maker, and the *goals* to be satisfied with the choice of one alternative. The output of this process can be an action or an opinion of choice.

Decision making is a *process*. This means that in general it takes some time and effort until the choice is made, involving several activities, such as [6, 7]:

- identification of the decision problem;
- collecting and verifying relevant information;
- identifying decision alternatives;
- anticipating the consequences of decisions;
- making the decision;

- informing concerned people and public of the decision and rationale;
- implementing the selected alternative;
- evaluating the consequences of the decision.

The key step of this process is making the *decision* itself, that is, choosing the most preferred alternative using judgement based on available information. With the decision, we give precedence to the selected alternative, assuming (and hoping) that this alternative will provide the best (i.e., the easiest, most efficient, cheapest, safest, etc.) solution to our decision problem. The decision is considered a conscious and deliberate act, what makes the decision maker responsible for its consequences. The *implementation* of the decision often consumes resources, such as time, energy, money and willpower, and is therefore *irrevocable* [6]. The consequences of a decision cannot be taken back; if necessary, they can only be affected by new decisions.

CLASSIFICATION OF DECISION PROBLEMS

Decision problems are incredibly diverse. On the one hand, we are faced with everyday problems, which are usually simple and easy to solve: when to get up in the morning, what kind of bread to buy, whether to stop at the red light or not, etc. On the other hand, there are difficult problems which require large resources, affect many people and have important consequences: which strategy to take on European market, how to organise public transportation in a capital city, etc. Somewhere in between are important problems of individuals (what to study?), families (where to live?) and organisations (how to survive in the economic crisis?).

In decision support, we are typically interested only in “sufficiently difficult” decision problems, which are “worth” approaching in an organised and systematic manner and which have sufficiently “important” consequences. In other words, it should make sense to collect information about these problems, think and discuss about the possible solutions, and in general support the process with some method, computer program or information system. It is also important to understand that it is possible to effectively support only decision problems and processes that are sufficiently well understood. When approaching a problem, we have to know what exactly we are deciding about, what are the goals and what are the possible consequences of the decision, we should at least partly know the alternatives and their properties, we have to be aware of possible uncertainties, etc.

Decision problems can be classified along different dimensions [4, 6-8]. One classification is into *routine* and *non-routine* problems, which often implies a considerable difference in *difficulty*. Routine decisions are taken frequently and repeatedly. The decision maker typically knows them well and feels familiar with the problem. All key factors, consequences and uncertainties are well understood and under control. Such decisions are usually easy. In contrary, non-routine decisions tend to be more difficult, particularly because of the lack of knowledge and experience in taking such decisions. Often, non-routine decisions are risky and have important consequences.

With respect to *frequency*, decision can be *one-time* or *recurring*. Although there is some overlap with the previous classification, the frequency dimension is important because it largely determines the focus of the decision-making process. With *one-time* decisions, the emphasis is on the decision itself: the goal is to find and implement the best alternative. The process ends when the alternative has been chosen (or implemented in some cases). From decision-support perspective, this usually requires the use of methods for the evaluation and analysis of alternatives, and the use of general-purpose decision support software. With *recurring* decisions, the focus usually shifts to finding the most effective method or procedure for choosing alternatives. Although it is still important to find the best alternative each time, it is often more important to implement an effective decision-making process. From decision-support perspective, this often requires to design and implement dedicated decision support software.

Another classification considers the *number of criteria*, which are taken into account when assessing alternatives. *Single-criterion* (or *single-attribute*) methods take into account only one criterion, most often some monetary value, such as profit or income. Many well-known decision analysis tools, such as decision tables and decision trees in their basic forms, consider only one criterion. However, most real-life decisions depend on *multiple criteria*; for example, in addition to return of investment (a single criterion), we may also want to consider the increase of market share and employment generated by the investment. The corresponding decision analysis methods are called *multi-criteria* or *multi-attribute*.

Uncertainty refers to a state of limited knowledge or information so that something is unknown or is not perfectly known [6]. *Uncertainty* occurs whenever there are external factors that influence the decision, but are beyond the control of the decision maker and are unknown to the decision maker at the time of decision. With respect to *uncertainty*, decision problems are classified in decision theory into [4; p.34]:

- *Decisions under certainty*: Here, the decision maker has all the necessary information about alternatives and the consequences of decisions are certain and accurate.
- *Decisions with risk*: The decision maker does not know the true value of external factors ("state of nature") for certain, but he can quantify his uncertainty through a probability distribution of possible outcomes.
- *Decision under strict uncertainty*: The decision maker feels that he can say nothing at all about the true "state of nature". In particular, he cannot quantify his uncertainty in any way.

Depending on the number and role of participants in the decision-making process, we distinguish between *individual* and *group* decisions. *Individual* decision problems typically involve a single decision maker. Alternatively, they can even involve more participants, provided that they have the same goals and decide "as one". In *group* decision-making processes, there are several individuals or groups that have different and often conflicting goals. In the latter case, decision support aims at resolving the conflict and finding the common solution, either by consensus or leverage.

For decision support in organisations, there is a very important categorisation of decision problems based on the *nature* of the decision to be made and the *scope* of the decision itself [8]. The *nature* of decision is represented with three categories referring to the level of *structure* of decision problems (Figure 2):

- *Structured decisions*: These are all decisions for which a well-defined decision-making procedure exists. This means that all inputs, outputs and internal procedures are known and can be specified. Structured decisions can be left to a clerk or a computer.
- *Semi-structured decisions*: Here, the decision has some structured elements but cannot be completely structured. We do not know how to specify at least one of the components (inputs, outputs, internal procedures). Computers can provide a great deal of specific help. Most organisational decisions are of this type.
- *Unstructured decisions*: Here, all decision components are unstructured. This may be because the decision is so new, so complex or so rare that we have not studied them completely. Computers can still help the decision maker, but only indirectly and with a low level of support.

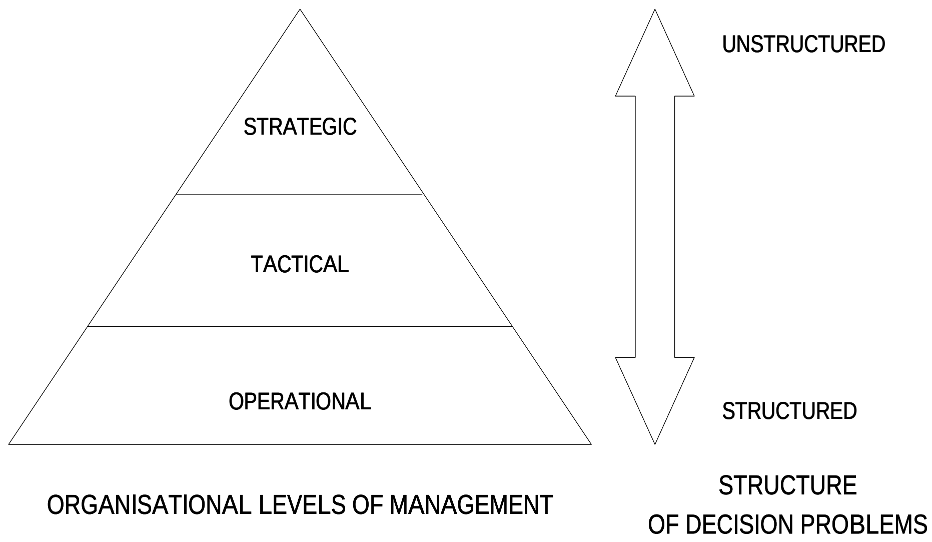

Figure 2. Classification of decision problems by scope (left) and nature (right).

Another dimension, *scope*, refers to the levels of management in an organisation (Figure 2):

- *Strategic decisions* affect the entire organisation, or a major part of it, for a long period of time. In most cases, they are made at the upper level of organisational management. Examples of strategic decisions are decisions about introducing a new product or service, entering a new market, or reorganising the production.
- *Tactical decisions* affect a part of the organisation for a limited time into the future. Tactical decisions are generally made by middle managers and take place in the context of previous strategic decisions. Typical examples are related, for instance, to personnel management: recruiting new employees and making expert teams.
- *Operational decisions* affects only current activities in an organisation; they have no or very limited impact for a short period of time. Operational decisions are usually made by lower level managers or non-managerial personnel. They are generally structured or semi-structured. Examples of operational decisions are whether to approve a loan to a client, or how to repair a malfunctioned machine.

The scope of decisions importantly affects the *characteristics of information* required in the process (Table 1). The understanding of information characteristics is an important factor for a successful design and implementation of any decision support system.

Table 1. Information characteristics by decision scope [8].

Information characteristic	*Operational decisions*	*Strategic decisions*
Accuracy	High	Low
Level of detail	Detailed	Aggregate
Time horizon	Present	Future
Frequency of use	Frequent	Infrequent
Sources	Internal	External
Scope	Narrow	Wide
Nature of information	Quantitative	Qualitative

Finally, let us mention *single*- and *multi-stage* decisions. In a *single-stage* decision process, there is only one key decision to be made. In contrast, a *multi-stage* decision processes consist of several related decisions, which can be taken *sequentially* or in *parallel*. Actually, the distinction between sequential and parallel decisions is sometimes difficult, because any decision process, even a single-stage one, consists of a series of other decisions. For example, when we encounter a decision process, we have first to "decide" how to approach it: intuitively, impulsively, ad-hoc, or in some organised way. We also have to "decide" which alternatives to take on board and which goals to consider. Who are the decision makers and with whom to collaborate? Where to get the relevant information? Which decision support method or computer program to use? And finally, after we have chosen the alternative, we have to "decide" for action. Essentially, this takes place as a decomposition of the decision process into a series of smaller and smaller decision subprocesses. We seek for a sequence of decision subproblems that are sufficiently easy to solve and can be combined together in order to solve the overall decision problem.

DECISION SUPPORT METHODS

In this section we present three typical approaches to decision support and illustrate them through examples: decision analysis, operational research, and decision support systems.

DECISION ANALYSIS

Decision analysis is popularly known as "applied decision theory" [6-7]. It is the discipline comprising the philosophy, theory, methodology, and professional practice necessary to address important decisions in an organised and formal manner. Decision analysis approaches a decision problem systematically by structuring and breaking it down into smaller and possibly more manageable subproblems. In doing that, it explicitly considers the possible decision alternatives, available information, uncertainties involved, and relevant preferences of the decision maker. It also attempts to formally represent these components and combine them in a form of decision models, which are used to assess, evaluate and analyse alternatives. In principle, rational decisions are proposed in this way. In the case of missing information and other difficulties, decision analysis tries to provide decisions which are not optimal but "satisfactory" or "sufficiently good".

Usually, the decision analysis process proceeds in stages, such as:

1. identification of the decision problem
2. identification of alternatives
3. problem decomposition and modelling
4. evaluation and analysis of alternatives
5. selection of the best alternative
6. implementation of the decision

If necessary, the stages can be intermixed or repeated. The most distinctive stages of decision analysis are the third stage, in which a *decision model* is developed, and the fourth stage, in which the model is used to *evaluate* and *analyse* alternatives. Usually, the model is developed by the decision maker using one of the many decision modelling methods or tools. If necessary, the decision maker can consult experts, who provide information and experience about the decision problem, and/or decision analysts, who give methodological advice and may even coordinate the whole process. Typical decision modelling techniques include decision trees, influence diagrams, and multi-attribute models [7].

Let us illustrate decision analysis concepts through a hypothetical decision problem. John is an economist who has just finished his MBA studies. He got four job offers from four companies, called A (a manufacturing company), B (banking), C (consulting), and D (information technology). John wants to take into account four important factors: *location*, *salary*, relation to *management science* (which he particularly likes), and *long term prospects* of the job. He wants to formalize these factors and use them to assess each job offer.

One of the most elementary decision analysis techniques is based on *pairwise comparison* of alternatives. Here, we do not actually consider any properties of alternatives, but only specify which alternative we like more than other. Given any two alternatives, A and B, there are three possible cases: we like A more than B (we write $A \succ B$), we like B more than A ($A \prec B$), or we equally like A and B (A~B). In theory [4], '$\prec$' and '~' are called *preference relations*; '$\prec$' is a *strict preference* relation, and '~' is an *indifference* relation.

Preference relations are conveniently represented in a *comparison matrix* (Table 2). In order to avoid comparing each alternative with itself, and to compare each pair of alternatives only once, more than half of the table is greyed-out and should be left empty. In the remaining cells, we enter 1, 0, or –1. The number 1 indicates that we prefer the alternative written in the first column over the alternative in the first row. The number –1 also indicates the strict preference, but in the reverse order. The number 0 indicates indifference.

Table 2. Comparison matrix of job offers.

Alternative	A	B	C	D
A		–1	1	0
B			1	1
C				–1
D				

John's comparison matrix (Table 2) indicates the following preference relations: $A \prec B$, $A \succ C$, A~D, $B \succ C$, $B \succ D$, $C \prec D$. With some reordering and taking into account the principle of transitivity (if $X \succ Y$ and $Y \succ Z$, then $X \succ Z$), we get the overall ranking of alternatives: $B \succ A \sim D \succ C$. Therefore, B is the best job offer, which is followed by equally good A and D, and C is the worst of all. We get the same order if we add up the numbers in each row: B gets 2 "points", A and D 0, and C gets –1. Let us remark that John's table is consistent (logically correct), however it is generally possible to define the table inconsistently. Consider, for instance, entering the value –1 instead of 1 into the (B,C) cell. Fortunately, there are methods and software programs that can detect such inconsistencies.

The next possible step is to look at job offers in more detail and consider their positive and negative aspects. Table 3 illustrates a simple qualitative comparison method called *pros and cons analysis* [9]. In the table, good things ("pros") and bad things ("cons") are identified about each alternative. Lists of the pros and cons are compared one to another for each alternative. The alternative with the strongest pros and weakest cons is preferred. Pros and cons analysis is subjective and is usually suitable for simple decisions with few alternatives (2 to 4). It requires no mathematical skills and can be used without computers.

Table 3. Pros and cons analysis of job offers.

Alternative	A	B	C	D
Pros	• relatively good salary	• very good salary • interesting work • good public image	• nearby location • safe position • clear promotion criteria	• easy and frequent promotions • two friends are working there • dynamic work
Cons	• work is not too interesting	• unfamiliar work • long drive to location	• not too interesting • low initial salary	• location is far • small company • unsafe position • low initial salary

Actually, pros and cons analysis takes an important step towards *multi-criteria* (or *multi-attribute*) methods. Table 3 contains words that describe some common properties of alternatives which are interesting for John: salary, location, promotion, safety, the presence of friends, etc. When assessing job offers, John confronts each of these alternatives' properties with his personal preferences and expectations. He tries to assess whether and to which extent the actual properties of job offers fulfil his objectives. *Multi-criteria methods* [10-11] aim to formalise these aspects of decision making. They require a definition of variables (parameters, attributes) that describe relevant properties of alternatives. Usually, variables are weighted in order to indicate that they are of different relative importance. Each alternative is assessed through the values of these variables. A final evaluation of alternatives is obtained by some aggregation procedure, for instance, a weighted sum.

Table 4 illustrates these concepts using the Kepner-Tregoe method [9, 12]. Kepner-Tregoe is a simple and commonly used multi-criteria method in which the attributes are assessed using the values from 0 to 10, where 0 indicates a very bad, and 10 a very good (ideal) value of the corresponding attribute. The same scale is used for weights: 10 indicates the most important attribute, and 0 an attribute of no importance for the decision. Alternatives are evaluated using the weighted sum, i.e., the sum of weights multiplied by attribute values.

The evaluation in Table 4 shows that the job offer B got the score of 244 and is the best. It is followed by C (228), A (204) and D (189). In the table, we can also look at individual properties of alternatives and assess their contribution to the final score. For instance, C obtained very high scores with respect to location, safety and promotion, but a low score with respect to the interestingness of the job.

An important aspect of multi-attribute models is that they can be used for various analyses of alternatives. In John's case, for example, he may feel that he has overestimated the importance of salary, but underestimated the importance of interestingness and promotion. Also, he may be uncertain about the promotions in company C. He can easily assess the effects of such changes by simply changing the corresponding values in the model and observing the new evaluations. For instance, he can take Table 4 and change the values as shown in Table 5 (the changed values are underlined). The result is that C has been degraded: it is still at the second place, but is now very close to A and D, whose order has changed. In any way, the decision is stable as B has remained firmly at the first place.

From here on, there are many ways to proceed towards more advanced decision analysis methods. For instance, when the number of relevant attributes grows and exceeds 10 or 15, we may want to use *hierarchical multi-criteria methods*, in which we structure attributes into a tree or a hierarchy. A typical representative of hierarchical methods is AHP, Analytical Hierarchy Process [13]. Figure 3 illustrates a possible way to organise John's job-offer assessment attributes into a tree.

Table 4. Multi-criteria evaluation of job offers using Kepner-Tregoe method.

Weight	Attribute \ Alternative	A	B	C	D
10	**Salary**	8	10	6	5
7	**Interestingness**	4	8	2	6
5	**Location**	4	2	9	1
5	**Safety**	4	6	9	2
4	**Image**	8	9	7	7
3	**Promotion**	6	4	8	10
3	**Co-workers**	2	0	4	8
	Evaluation	**204**	**244**	**228**	**189**

Table 5. What-if analysis of job offers. Changed values are underlined.

Weight	Attribute \ Alternative	A	B	C	D
8	**Salary**	8	10	6	5
10	**Interestingness**	4	8	2	6
5	**Location**	4	2	9	1
5	**Safety**	4	6	9	2
4	**Image**	8	9	7	7
5	**Promotion**	6	4	4	10
3	**Co-workers**	2	0	4	8
	Evaluation	**212**	**256**	**218**	**217**

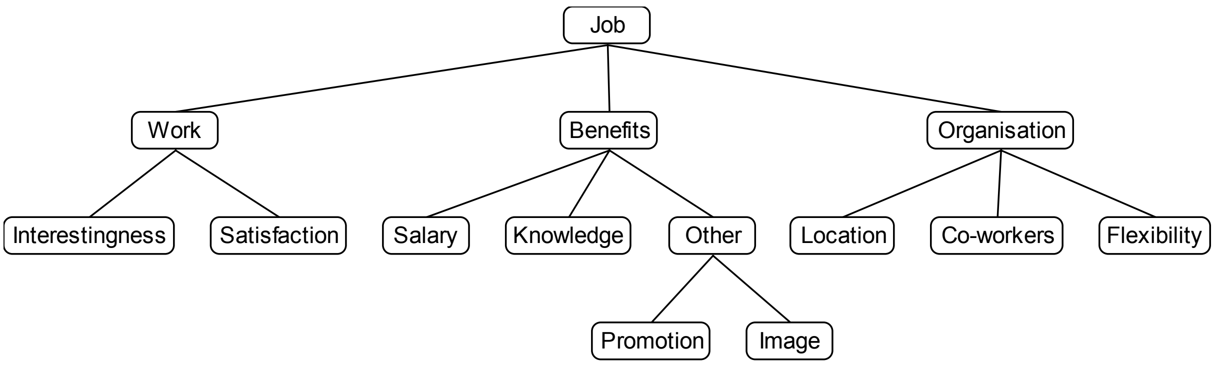

Figure 3. Hierarchical structure of criteria for the assessment of job offers.

When developing multi-criteria models, we often need methods that acquire attribute weights from the decision maker: examples of such methods are AHP, SMART and SWING [9]. Instead of the weighted sum, we may use more advanced value functions and aggregation methods [14]. Numeric attributes and quantitative assessment can be replaced or complemented with symbolic attributes and qualitative assessment, for example using the method DEX [15]. Uncertainty aspects and multi-stage decisions can be addressed through decision trees [16] or influence diagrams [7].

All these methods are supported by many computer programs. These can be of general or specific purpose. Typical *general purpose* programs are spreadsheets and mathematical toolboxes, in which the users can either define their own methods and procedures for decision analysis, or can use already implemented templates or dedicated plug-in software components. Examples include the programs Microsoft Excel, OpenOffice.org, MATLAB, Mathematica and R, and the plug-ins TreePlan in PrecisionTree.

Specific-purpose programs in general provide the following functionality: (1) acquisition, formulation and modification of a decision model and its components, (2) acquisition and representation of data about alternatives, (3) evaluation and analysis of alternatives, and (4) presentation of results through reports. Specific-purpose programs for decision tree modelling are, for example, TreeAge Pro and DPL. Influence diagrams can be developed with Analytica and GeNIe. There are many programs for quantitative multi-criteria modelling: HiView, Decision Pad, Logical Decisions, Prime Decisions, ELECTRE, Expert Choice, Criterium Decision Plus, HIPRE, V.I.S.A, Winpre, Web-HIPRE. Qualitative multi-attribute modelling is supported by programs such as DEXi and DoctuS. Further information about the mentioned computer programs is available through the WWW page *IJS Decision Support Resources* [17].

OPERATIONAL RESEARCH

The aim of *operational research* (or *operations research*) [18-19] is similar to decision analysis: the application of analytical methods and mathematical models for decision support. However, the emphasis in operational research is on *mathematical modelling* and finding *optimal* solutions of mathematically defined problems – rather than assessing given alternatives and finding "sufficiently good" ones, as in decision analysis. Typical applications of operational research are characterized largely by the need to allocate limited resources, such as time, energy and money. Such problems often occur in government, business, engineering, economics, and the natural and social sciences.

The contribution from operational research stems primarily from:

- structuring the real-life situation into a mathematical model, abstracting the essential elements, so that a solution relevant to the decision maker's objectives can be sought,
- exploring the structure of such solutions and developing systematic procedures for obtaining them,
- developing a solution, including the mathematical theory if necessary, that yields an optimal value of the system measure of desirability.

Typical operational research techniques include linear and nonlinear programming, network optimization models, combinatorial optimization, multi-objective decision making, and Markov analysis.

To illustrate the approach of operational research, let us show an application of *linear optimisation* for John's next decision problem. Namely, John has taken the job offer at the bank (alternative B above). Now, his work must be properly organised. According to his skills, John can perform the following tasks:

C: work with clients,
D: data and document maintenance,
E: education, attending courses and seminars.

C is most profitable for the bank and is worth 4 monetary units per hour. The value of D is 1, whereas the value of E is only 0.1. According to internal rules, John must spend per month at least 10 hours working on C, and at least 20 hours on E. However, John is a beginner and must be therefore supervised. Full supervision is necessary when working on C, but only one hour per day (1 out of 8) of supervision is necessary for D. E requires no supervision. The total number of working hours per month is 180, however the supervisor can spend with John at most 30 hours per month. The question is: how to organise John's work so that it will be most profitable for the bank?

The problem is formulated mathematically. Let x_c, x_d and x_e denote the number of John's working hours per month for each task. Using this notation, we can define the constraints:

$x_c + x_d + x_e$	$\leq$	180	the maximal number of John's working hours per month is 180;
$x_c + 1/8\ x_d$	$\leq$	30	the supervisor's work with John is limited at 30 hours; he fully supervises the task C, but only every eighth hour of D;
x_c	$\geq$	10	John must work with clients at least 10 hours per month;
x_d	$\geq$	0	John's time spent in the office must not be negative;
x_e	$\geq$	20	John must study at least 20 hours per month.

The total value of John's monthly work is

$$V = 4x_c + x_d + 0.1x_e$$

We wish to maximise this value.

In this way, we formulated the problem in terms of a *linear program*. There are efficient methods for solving linear programs, which are implemented in most general purpose computer programs mentioned above. In John's case, the optimal solution is:

$x_c =$ 11.43 h/month
$x_d =$ 148.57 h/month
$x_e =$ 20.00 h/month

With this solution, the value of V is maximal and equals to 196.29 monetary units.

DECISION SUPPORT SYSTEMS

Decision support systems (DSS) are defined as interactive computer-based information systems intended to help decision makers utilize data and models in order to identify and solve problems, and make decisions [1, 3, 8]. In contrast with decision analysis and operational research, where the emphasis is on making and using decision models, DSS focus on providing information technology for decision makers at various levels in organisations. The emphasis is on providing relevant information and presenting it in a suitable form so as to improve the decision making process and tasks.

The main characteristics of DSS are:

- DSS incorporate both data and models,
- they are designed to assist managers in their decision processes in semi-structured or unstructured decision-making tasks,
- they support, rather than replace, managerial judgment,
- their objective is to improve the quality and effectiveness (rather than efficiency) of decision making.

DSS can support decision makers in a number of different ways. They can store data and provide means to search for relevant data items. More advanced techniques include query languages and data warehouses. Data can be viewed and analysed using pivot tables and other methods of on-line analytical processing (OLAP). DSS can provide computational and statistical models, for instance for trend analysis. With data mining algorithms, the decision maker can find interesting patterns in data. The results can be presented in reports and tables, as well as graphically using advanced visualisation techniques. DSS can incorporate all types of decision analysis and operational research models presented above. Consequently, using these models, DSS can evaluate and assess decision alternatives or find optimal solutions of mathematically formulated problems. DSS can integrate data from different sources and of different types (relational data, documents, video, etc.). Also, DSS can contain rules that guide specific decision processes. Last but not least, DSS can provide communication and other means to support the collaboration of decision makers.

Taking into account all this variety and using the mode of assistance as the criterion, DSS are differentiated into the following types [1]:

- *communication-driven DSS*: support more than one person working on a shared task,
- *data-driven DSS* or *data-oriented DSS*: emphasize access to and manipulation of a time series of internal company data and, sometimes, external data,
- *document-driven DSS*: manage, retrieve, and manipulate unstructured information in a variety of electronic formats,

- *knowledge-driven DSS*: provide specialized problem-solving expertise stored as facts, rules, procedures, or in similar structures,
- *model-driven DSS*: emphasize access to and manipulation of a statistical, financial, evaluation, optimization, or simulation model.

DECISION SYSTEMS

For the final section, let us step from human to computer decision making – that is, from decision sciences to *decision systems* (see Figure 1). Computer decision making is fundamentally different from human decision making and has an advantage that we understand it very well. Computers make decisions according to programmed procedures, which can be easily analysed, modified and observed during their operation. Although we cannot really compare the mechanisms of human and computer decision making, we can still observe and compare the performance of the two.

The computer has to be *programmed* to carry out some given task. This means that the programmer has to define a sequence of instructions that are executed by the computer. When executing instructions (i.e., when the program is running), it is often necessary that the program reacts differently in different situations. On the basis of data, which is available to the program, it must "decide" which sequence of instructions to take for further execution. For this reason, one of the fundamental characteristics of computer programs is their ability to *branch*: programs contain instructions that "switch" between branches composed of other sequential instructions. All instructions are (in principle) pre-defined by the programmer, however the branching occurs while the program is running, depending on the current state of the program and data available to the program. In this way, the program dynamically chooses between different courses of actions. Externally, this appears as an ability of the computer to adapt and make decisions.

For example, let us consider a very simple mathematical operation: division of two numbers, say x/y. This operation makes sense only if $y \neq 0$. Therefore, even in this very simple case, the computer must "decide" whether to carry out the division or not. Before each division, the computer must check the value of y. If $y=0$, it should not make the calculation, but rather issue some message to the user or perform some other corrective action. Otherwise, the division is possible and the program should calculate the result. In a computer programming language, these instructions may be formulated as follows:

```
read(X,Y)
if Y=0 then
    write('Error: division by 0')
else
    R := X/Y
    write(X, ' divided by ', Y, ' is equal to ',R)
```

Every computer program contains instructions like these. Even though instructions are explicitly specified by the programmer and their execution is deterministic (fully predictable), we can gradually add more and more instructions and combine them into complex branching sequences. In this way, we can create computer programs that exhibit very complex behaviour, even to the point that is often referred to as "intelligent": intelligent control systems, intelligent agents, game playing programs, etc. For example, chess-playing programs are already capable of outperforming most human players, including the world chess champion [20].

Among "intelligent" computer programs, there is a particularly interesting class of programs which are able to "learn". These programs either observe their own performance or monitor some data generated through performance of other systems. Based on examples of successful or unsuccessful performances, machine learning programs can find patterns that explain the reasons for such behaviour, they can find rules that improve performance, or can even modify themselves (by modifying their own operating instructions) to achieve better performance in the future. The scientific discipline that is concerned with the design and development of algorithms that allow computers to change behaviour based on data is called *machine learning* [21-22].

Autonomous vehicles provide good examples of advanced decision systems. In order to explore the surface of Mars, two Mars Rover vehicles [23] were sent by the USA to that planet. The distance between Earth and Mars is so large that it takes 12 minutes in average for a signal to travel that distance. This makes it almost impossible to steer the vehicle from Earth. Therefore, Mars Rovers were designed as highly autonomous vehicles, which were receiving basic commands from the Earth, but were also capable to navigate challenging and unknown terrain, investigate targets, and detect scientific events [24].

Another example, which is currently at the borderline of decision systems, is related to the *DARPA Urban Challenge* [25], a prize competition held in 2007. The requirements were to build a fully autonomous vehicle, which must be entirely autonomous, using only the information it detects with its sensors and public signals such as GPS, and which would be able to drive autonomously between two given points in an urban area, obeying the driving laws. The main event took place on November 3, 2007, on a course in California, which involved a 96 km urban area course, to be completed in less than 6 hours. Six of 11 vehicles accomplished the mission, what is considered a groundbreaking success.

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ODLUČIVANJE: STAJALIŠTE RAČUNALNIH ZNANOSTI I INFORMACIJSKE TEHNOLOGIJE

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SAŽETAK

Razmatramo pojavu odlučivanja sa stajališta računalne znanosti i informacijske tehnologije. Osnovna pitanja tog stajališta su: što računalo može ponuditi donosiocima odluka i kako ono može poduprijeti njihov rad? Pritom, glavni je slučaj davanja podrške ljudima koji donose kompleksne odluke. U ovom radu, prvo je predočena taksonomija disciplina u kojima se koriste metodološki i provedbeni vidovi podrške odlučivanju. Na temeljnoj razini razlikujemo znanost o odlučivanju i sustave odlučivanja. Znanost o odlučivanju tiče se ljudskog odlučivanja, a sustavi odlučivanja računalnog odlučivanja. Na navedeno se nastavljaju definicije vezane uz procese odlučivanja i njihove komponente. U radu su također opisana svojstva koja karakteriziraju različite klase problema odlučivanja. U glavnom dijelu članka navedeni su najzastupljeniji pristupi podršci odlučivanja i popraćeni ilustrativnim primjerima njihove primjene: analizom odlučivanja, operacijskim istraživanjima i sustavima podrške odlučivanju. Na kraju je dan kraći prikaz područja primjene sustava odlučivanja i njihovih dostignuća.

KLJUČNE RIJEČI

odlučivanje, znanost o odlučivanju, podrška odlučivanju, analiza odlučivanja, sustavi odlučivanja

Interdisciplinary Description of Complex Systems 7(2), 38-53, 2009

DECISION MAKING AND THE BRAIN: NEUROLOGISTS' VIEW

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Regular article *Received:* 19 November 2009. *Accepted:* 9 December 2009.

ABSTRACT

The article reflects the fact, that concepts like decision making and free will have entered the field of cognitive neuroscience towards the end of 20th century. It gives an overview of brain structures involved in decision making and the concept of free will; and presenting the results of clinical observations and new methods (functional neuroimaging, electrophysiology) it postulates possible mechanisms of these processes. We give a review of the neuroanatomy, specially discussing those parts of the brain important to the present topic, because the process of decision making is dependent on deep subcortical as well as superficial cortical structures. Dopamine has a central role in the in process of reward related behaviour and hedonism. A list of brain structures, related to dopamine action, is also given. The article especially concentrates on the Single Photon Emission Computer Tomography studies in patients with Parkinson's disease (neuroimaging), as well as to the studies concerning the Readiness Potential and Endogeneous Potential P300 (electrophysiology). In the end, we discuss the volition, whose functional anatomy overlaps with the functional anatomy of free will and decision making processes.

KEY WORDS

cognitive neuroscience, brain, decision making, free will, electrophysiology, functional imaging, dopamine

CLASSIFICATION

APA: 2520 Neuropsychology & Neurology

JEL: Z19

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ANATOMICAL BASICS OF THE NERVOUS SYSTEM

From the non-dualistic perspective decision making is a brain process. Basic knowledge of the anatomy and physiology of the central nervous system is crucial for comprehension of the neurological substrate of decision making.

The nervous system is divided anatomically into central nervous system and peripheral nervous system. The peripheral nervous system consists of the cranial nerves and spinal nerves. The central nervous system is made up of the spinal cord, brainstem, diencephalon and telencephalon. The brainstem is comprised of three areas: the medulla oblongata, the pons and the midbrain (mesencephalon).

The telencephalon consists of two cerebral hemispheres. These include superficial grey matter of the cerebral cortex (neurones), the white matter (axons) beneath it, which interconnects distinct parts of the nervous system and the deep nuclei of the basal ganglia. (Fig. 6). Each of the hemispheres is divided into four separate lobes: frontal, parietal, temporal and occipital. In the centro–medial region is the limbic system, which comprises parts of frontal, temporal and parietal lobe and is crucial for the emotional processes and memory. Important structures in the limbic system are the cingulate gyrus, hippocampus, septum and amygdala.

The diencephalon consists of the thalamus (Fig. 1), the hypothalamus (the structure below the thalamus) and the epithalamus (the structure above the thalamus), which includes the pineal (glandula pinealis) and habenula.

The brainstem is the connection between the spinal cord, the cerebellum and the cerebrum. The nuclei of the cranial nerves III through XII are located in the brainstem along with long sensory and motor tracts that pass between the brain and the spinal cord. On the dorsal part of the midbrain there are the superior and inferior colliculi. The inferior collicus is part of the hearing pathway and the superior colliculus is important in the visual pathway. On the base of the midbrain is a functional part of the basal ganglia – the substantia nigra with cells that produce dopamine and give rise to fibers that project to the caudate nucleus and to the putamen. These fibers make up the nigrostriatal pathway (connection of the substantia nigra and basal ganglia). Mesocortical and mesolimbic pathway connect the surrounding structures in the midbrain with the frontal and limbic lobe respectively (Fig. 4).

The cerebellum (Fig. 5) overlies the pons and medulla and is separated from them by the cavity of the fourth ventricle. Phylogenetically it is divided into older median and younger lateral part. The cerebellum is involved in the control and integration of motor functions that determines coordination, balance and gait. Accumulating evidence suggests that the cerebellum also plays a role in affective and higher cognitive functions.

Physiologically, the nervous system can be divided into somatic and visceral (autonomic) divisions. The somatic nervous system deals with contraction of striated muscle and the sensations of the skin (pain, touch, temperature), the innervations of muscles and joint capsules (proprioception), and the reception of sensations remote to the body by way of special senses (taste, smell, hearing). The somatic nervous system senses and controls our interaction with the environment external to the body. The automatic nervous system controls the tone of the smooth muscles and the secretions of glands. It senses and controls the condition of the internal environment.

Wakefulness, alertness, arousal and decision processes are strongly dependent on circular connections between cerebral cortex, subcortical structures like basal ganglia, thalamus and

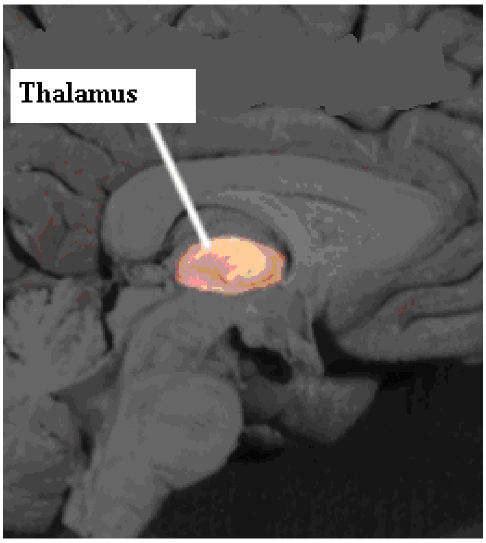

Figure 1. Thalamus.

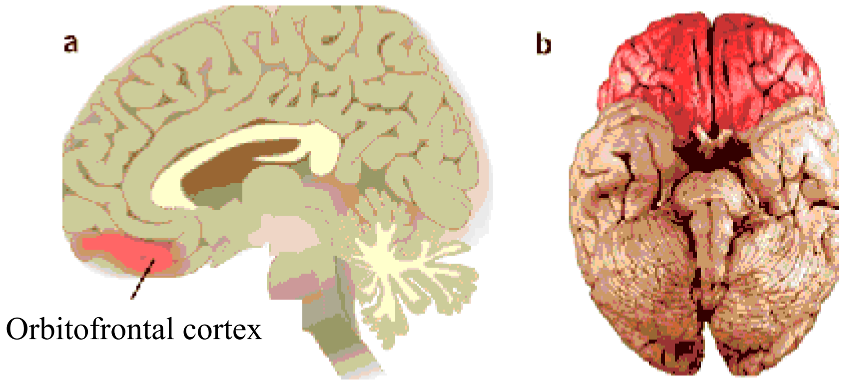

Figure 2. Orbitofrontal cortex.

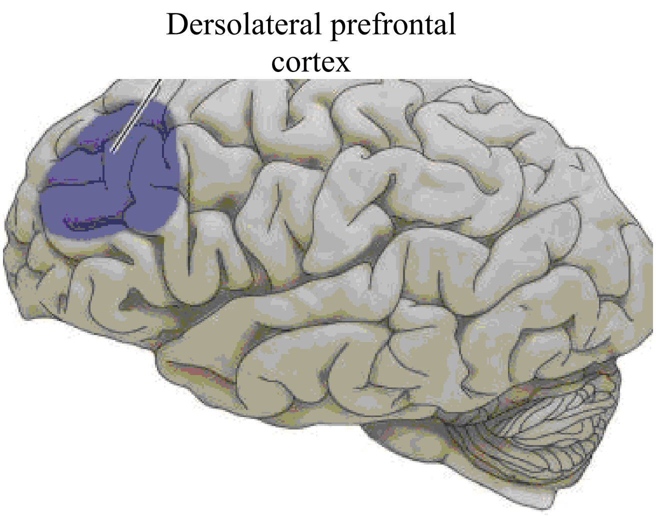

Figure 3. Dorsolateral prefrontal cortex.

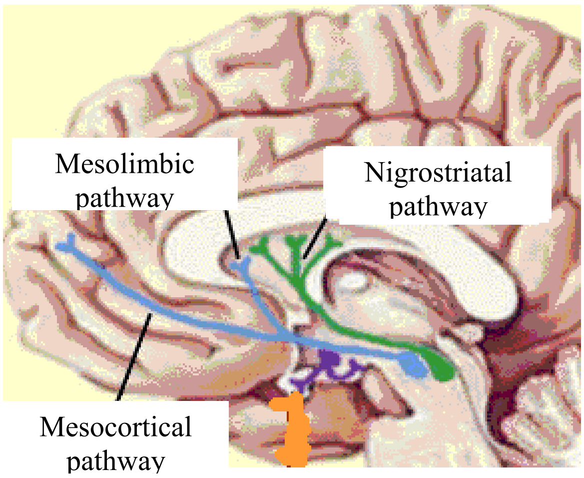

Figure 4. Mesocortical, mesolimbic in nigrostriatal pathway.

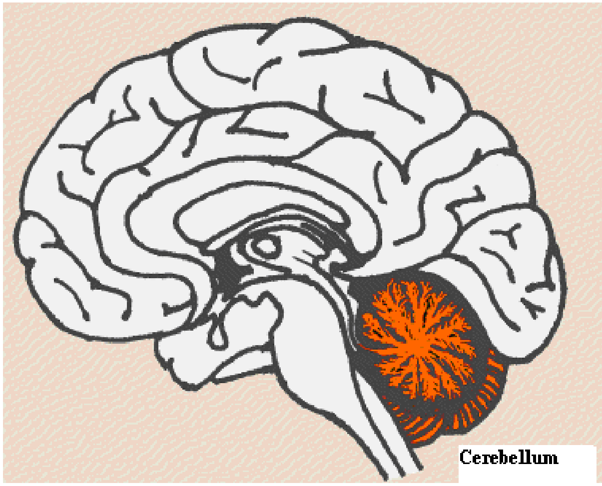

Figure 5. Cerebellum.

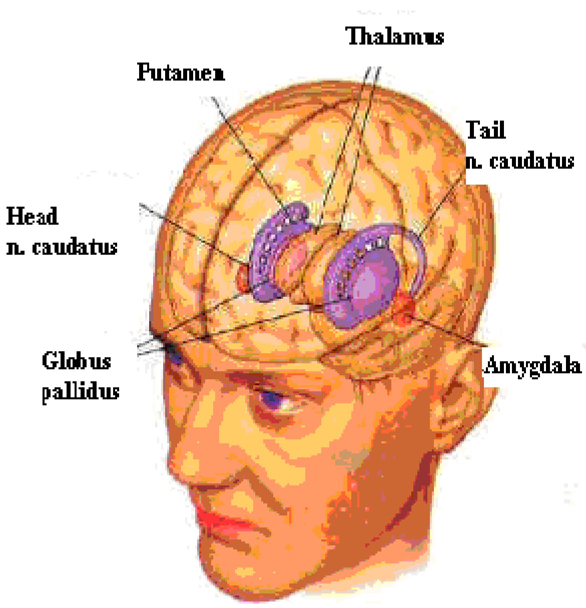

Figure 6. Basal ganglia.

frontal cortex where the programmes and decisions finally transform into acts; these connections are called cortico-subcortico-frontal pathways.

These connections are anatomical substrate for understanding the relationship between behaviour such as decision making and the brain. There are five pathways (loops), transferring either limbic, motor or cognitive information, following the same principle: the information from various parts of cortex converge to basal ganglia, from there to the nuclei of the thalamus and finally to different parts of frontal cortex [1].

The process of decision making is dependent on deep subcortical as well as superficial cortical structures. Among these are very important structures involved in process of reward related behaviour and hedonism.

Midbrain (mesencephalon): structures with predominance of dopamine as a neurotransmiter;

- substantia nigra
- ventral tegmental area
- mesolimbic pathway
- mesocortical pathway

- basal ganglia
  - ventral striatum (nucleus accumbens)
  - dorsal striatum
- limbic system (cingulate gyrus, hippocampus, septum, amygdala)
- prefrontal cortex
  - ventromedial and orbitofrontal prefrontal cortex
  - dorsolateral prefrontal cortex

These anatomical structures represent the basics for the process of decision making, which is the result of critical reasoning of possible multiple options and response choices, outcomes (reward/penalty) depending on motivational status.

ABOUT DECISION MAKING AND DECISIONS

Free and conscious decision making, if at all existent, is one the most complex presentations of human behaviour. Process of decision making was frequently explored from the philosophical and psychological aspect, but remains poorly studied topic in neuroscience. Research focused on the brain basis of process of decision making and acts of decision are only recent. The approach and topics vary, some scientists study simple, elementary physiological processes, i.e. decision making for wrist flexion, other researchers focus on complex moral, social and economical aspects of decisions. The study of the process of decision making in healthy and "normal" brain is very important for understanding the underlying mechanisms in healthy people as well as for understanding and treatment of neurological disorders with affected decision making i.e. Parkinson's disease.

Neuroscience needs an operational definition of decision making (as a process) and decision (as an action). One of the possible definitions of decision making determines three conditions:

1. at least two different options should be available,
2. each possible choice offers certain outcome expectation,
3. possible outcomes can be evaluated.

There is wide spectrum of possible neurological studies on decision making:

- electrophysiological recording from one cell (information on decision making process on the level of one neuron, temporal discrimination of the method being approximately 1 millisecond, little localisation data),
- electrophysiological recording from several points on the scalp (electroencephalography (EEG), event related potentials, EEG coherence –information on decision making process on the level of systems),
- study of molecular mechanisms,
- study of neurotransmitter and pharmacological mechanisms,
- functional imaging methods (Functional Magnetic Resonance Imaging – fMRI, Single Photon Emission Computer Tomography – SPECT, Positron Emission Tomography – PET) – imaging of the structures involved in reward related behaviour and decision making, good localization but poor temporal discrimination – approximately 1s),
- clinical studies of neurological patients,
- studies of primates.

The process of decision making can be divided according to the level of awareness:

- decision making without awareness,
- decision making with partial awareness,
- decision making with full awareness.

According to the phenomenological complexity we can describe two distinct decision making processes which compete for the control over the final decision and act:

- simple, fast, perceptive-motor processes, evolutionally older, similarity with animals, process in sensory- motor parts ob the brain, non dependent on prefrontal lobe,
- complex, slower, reflexive cognitive-social processes with elements of self-awareness, evolutionally younger, dependent on frontal lobe , limited with working memory capacity, correlation with general intelligence quotient).

It is thought that there is anatomical separation of the decision making process for

- pleasant stimuli,
- aversive and painful stimuli.

FROM REWARD TO DECISION

The core of the decision making is motivational evaluation of the reward, risk or penalty related to certain decision. This motivational rewarding aspect is extremely important in the evolution since it allows the development of the behaviour pattern for successful survival. It is a basis for several cognitive processes (i.e. learning) and is developed in the brain of human and primates as a distinct system. The main biochemical role in this system has neurotransmitter dopamine.

Central components of the rewarding system are in the limic-cortico-subcortico-frontal loop: dopaminergic neurons in the mesencephalon, ventral striatum and ventral pallidum, anterior cingulate gyrus, prefrontal cortex (especially orbitofrontal part) and amygdala. Limbic and all other loops follow the somatotopic organisation through the whole pathway in a distinct and occasionally convergent course therefore operating in parallel and integrative manner [2]. Information about the possible reward or penalty enters from the limbic into the relevant motor and cognitive loops and allows preparation of the appropriate motor and cognitive plans leading to the final decision.

Distinct parts of the limbic cortico-subcortico-frontal loop represent different aspects of the rewarding behaviour: anterior cingulate gyrus and orbitofrontal cortex are active in the prediction of a mistake in the rewarding process, evaluation and choosing among current and long term benefit; cells in the ventral parts of the basal ganglia (striatum and pallidum) respond to expectation and detection of the reward. Disturbance in dopaminergic and opioid transmission in ventral stiatum (accumbens) in rats caused compulsive decision making exclusively for the reward – food and pharmacological substances [3], which defines accumbens as a very "hedonistic" structure. Mogenson [4] suggests that the nucleus accumbens determines the goal of action – which we want to perform (food, drink, sex, material assets, reputation ...) or which we want to avoid (pain, suffering ...) and chooses among alternative goals and behaviours. This structure represents the intersection of motivation and action. Ventral striatum and dopaminergic pathways in the midbrain are interconnected and have similar function.

Dopaminergic neurons encode two sets of information (i) current disproportion between expected and actual reward and (ii) long-term maintained signal, which correlates with uncertainty or reliability of the reward.

Dopaminergic system can be studied with the electrophysiological methods. It is characteristic that the dopaminergic neurons are active primarily in events connected with reward and new stimuli in the aversive stimuli the activity stops. In the reward related situations the activity is pulsatile, phasic and correlates with disproportion between the expected and actual reward (reward prediction error) and represent a type of learning.

Different aspects of reward (size, probability, delay) are processed and integrated separately. Electrophysiologic studies show firing of the dopaminergic neurones during the process of decision making. One study concluded [5] that the dopamine represents the value of the choice, the other study showed higher dopaminergic cell activity for the better option even in the absence of that choice [6].

Dorsolateral prefrontal cortex (DLPFC) receives input information on reward and reward prediction error from hierarchically lower regions (limbic system, ventral striatum, orbital and medial parts of prefrontal lobe) and integrates them with cognitively relevant data for the problem. Cognitive functions of the DLPFC include behaviour pattern inhibition, changing a set cognitive and motor behaviour and planning [7]. Final goal is to perform sensible, useful and adaptive behaviour. Studies on primates show high activity of DLPFC during reward expectation leading to proper and effective task performance. Current process is combined also with integration of past responses and response outcomes (reward, no reward) which is a basis for successful decision making process learning and behaviour.

Structures for reward oriented behaviour are connected to cortical and subcortical regions and modulate decision making processes and also other relevant processes, i.e. working memory. For the correct decision it is very important to integrate different possibilities and possible outcomes and to project, manipulate and evaluate them in the in working memory.

Rewarding system and decision making processes are strongly influenced through dopaminergic system by hormones and genetic characteristics (especially those in-/directly related to dopamine and enzymes involved in metabolism of dopamine). Rewarding system dysfunctions are described in several brain diseases, i.e. schizophrenia, Parkinson's disease, eating disorders, addiction etc.

ON FREE WILL

"If the moon, in the act of completing its eternal way around the earth, were gifted with self-consciousness, it would feel thoroughly convinced that it was travelling its way of its own accord on the strength of a resolution taken once and for all. So would a Being, endowed with higher insight and more perfect intelligence, watching man and his doings, smile about man's illusion that he was acting according to his own free will." (Albert Einstein: *On Free Will*).

The complex, cognitive-social processes of decision making are tightly related to the concept of free will. Do my actions represent my own free will, or they are just a reflection of necessity, which is independent of me? This dilemma escorts the mankind for thousands of years already – from the beginnings of philosophy and religion, until know, in modern society, when it is being related to the law as well as to the question of criminal responsibility. Opinions of philosophers, theologians, lawyers, about this issue differed enormously, from a pure determinism to a pure libertarianism. Kant [8] classified the decision making as one of the three metaphysical problems which are beyond the human intellect.

Libertarianism defines the free will as 'the power of subjects to be the ultimate creators (or originators) and sustainers of their own ends and purposes' [9]. The free choices, as defined by this concept, are absolutely causeless, without a reason: – we make a free decision when – without a previous cause – our decision produces the desired action. For example, a free decision would be the decision to go towards the refrigerator at a certain point of time. Indeterminacy and non–causality emerges in the moment one has decided to act. The nature and the source of decision are in that moment unknown, although it could represent the quantum indeterminacy of that event. However, very important questions remain unanswered – for example – who is actually the agent, who makes the decision of a certain action?

On the other hand, Hume thinks that a relational choice could not be un-associated with choice without a cause. Simple choices that we make are caused by previous mental phenomena – emotions, beliefs and so on. The decision to head towards the refrigerator could be caused by the feeling of hunger (for which one could actually be unaware of), but could not be completely without a cause. We should emphasize that some causes do not allow the opportunity of free choice. Many of them are related to more or less coercious choices, as Hume has put it nicely in one of his books:

"Where (actions) proceed not from some cause in the characters and disposition of the person, who perform'd them, they infix not themselves upon him, and can neither redound to his honor if good, nor infamy, if evil." [10].

Science has closed its doors before the concept of free will; it was even hostile towards it and has been defining the world as, speaking in general terms, determined system and system, whose determinants could be anticipated. However, the public opinion, at least intuitively, has been that free will does exist. At the end of the previous century, free will slowly became an object of investigation of the neuroscience and the answer to the problem given by neuroscientists was surprising.

The observations of patients with neurological diseases and the cognizance of the new scientific disciplines from the end of the 20th centaury has recognized the concept of free will and the related processes of decision making as valid scientific objective. The causative mechanisms of these processes are in the brain and are result of the brain activity. Clinical neurology, functional brain imaging and electrophysiology could be of great help in studying these phenomena. These methods determine the neurological conditions in healthy subjects as well in patients that have disturbed volition to execute movements and/or thoughts. The answer that the electrophysiological methods gave to the problem of free will was unexpected and surprising.

CLINICAL OBSERVATIONS IN THE NEUROLOGY AND PSYCHIATRY

We know that both, a low (drowsiness) and high level of excitement (anxiety, pain, intensive emotions) can reduce the will and the ability to make decisions. Neurologists and psychiatrists have been describing clinical pictures of patients in which the 'sick' will was present, the symptomatology being consisted of abulia, akinesia (poverty of movements), poverty of thoughts and reduced ability of decision making in general. The reduced or 'sick' will was described in schizophrenia, depression, autism, ADHD, dementia, Parkinsonism.

The concept of volition has been described by the neurologists mainly on the example of the motor actions or movements:

1. voluntary movements
   a) intentional (planed, initiated spontaneously and internally),
   b) initiated externally as a result of external stimulation;
2. semi-voluntary movements
   a) motivated by internal sensory stimulation (itching, akatisia),
   b) motivated with compulsion or undesired feeling (compulsive touching);
3. involuntary movements
   a) movement that can not be suppressed (reflexes, seizures, myoclonus),
   b) movements that could be suppressed (tics, chorea, tremor, dystonia, stereotypies);
4. automatic movements (walking, speech, alternating movement of the upper extremities while walking) are learned behavior patterns, which we execute without the conscious effort. They are probably encoded in the basal ganglia circuits (Jog et al.).

FUNCTIONAL BRAIN IMAGING

The brain imaging allows us to study the regional differences in the activity of the brain with high special resolution. The processes of decision making and execution of voluntary movements have been shown by using different techniques – with 2D extracranial measurements of the regional cortical cerebral blood flow (rCBF) [11] as well as with high resolution positron emission tomography (PET) [12]. The results of the functional imaging showed that the voluntary movements and voluntary decisions emerge in the prefrontal cortex and reflect the relation between the volition and dorsolateral prefrontal cortex, especially at the left side. Reduction of the prefrontal activities was shown to be present in many syndromes, for which 'weak will and weak decision making competency' is characteristic, as in schizophrenia, depression, dementia and Parkinson's disease, for example.

Parkinson's disease is a neurodegenerative hypokinetic movement disorder presenting with subcortical pathology. A high percentage of Parkinson's disease (PD) patients show cognitive impairments in addition to the cardinal motor symptoms [13]. These deficits primarily concern executive functions most probably linked to dysfunctions in prefrontal regions due to decreased dopaminergic transmission in fronto-striatal loops. Executive function is a higher order cognitive capacity that involves memory, perception and performance of complex tasks. Disorders of the executive functions are sign of lesions in the prefrontal cortex, involving the prefrontal-striatal-thalamic networks and the parietal association areas [14]. Damage in posterior dorsolateral prefrontal cortex and subcortical nuclei causes the dorsolateral syndrome with impaired decision making, working memory and planning. If lesion spares the basal forebrain (the ventromedial-orbitofrontal syndrome) memory can be preserved, but poor social decision making develops. Decision-making impairments in PD are most likely associated with dysfunctions in fronto-striatal loops. The mesolimbic and mesocortical circuits are particularly involved in reward-related behaviour in humans. Because these systems may be in some way altered in PD, it is likely that some psychiatric manifestations of PD, such as hedonistic homeostatic dysregulation and pathological gambling, as well as impulsive decision making, may be ascribed to their involvement [15]. Impaired decision making is implicated in addictive behaviours, and decision-making abilities can be influenced by dopaminergic medications.

Dementia in the setting of PD (PDD) may be among the most debilitating symptoms associated with disease progression. Estimates of cognitive decline and dementia in PD suggest that up to 14 % per year of patients over age 65 with PD will develop some cognitive impairment. Unfortunately, PDD is not well characterized and the relationship of PDD to Alzheimer disease remains unclear. Cognitive dysfunction is common already in patients in early PD, affecting attention, psychomotor function, episodic memory, executive function and category fluency.

A small pilot study in mild to moderate stage of Parkinson's disease dementia (16 patients, 71.2 ±4.28 yrs, with MMSE (Mini Mental State Evaluation) 23.1 ±0.57) on clinical correlates of brain SPECT (Single Photon Emission Computer Tomography) perfusion confirmed previously reported generalized cognitive impairment with predominant executive, visuospatial and attentional deficits [16]. Performance on specific cognitive measures was correlated with brain SPECT perfusion findings. A detailed neuropsychological evaluation, using a "cognitive process approach" focused also on measures of quality of executive planning, problem solving and decision making which positively correlated with perfusion in bilateral frontal cortex. Speed of cognitive processing and habitual response inhibition positively correlated with perfusion in frontoparietal regions – correlations were bilateral but stronger in the left hemisphere.

ELECTROPHYSIOLOGICAL STUDIES

Electrophysiological techniques can determinate the brain activity with very good time resolution (in comparison to functional brain imaging, which has good spatial resolution and bad time resolution). These methods are very useful when studying the time course of conscious decision making for a certain action and the execution of the action itself.

P300 AND DECISION MAKING

The relationship between the EEG recording (representing the neurophysiological brain activity), and its psychological meaning has been of interest since the first human recording of the electrical brain activity done by Berger in 1929. Since then, different strategies were employed in order to evaluate this relationship. One way to catch up with this problem is by analyzing the spontaneous EEG background activity (applying the fast Fourier transform i.e. spectral EEG analysis). The other way to do it is to analyze the brain electrical potentials that are specifically time-locked to events – the so called event related brain potentials – ERPs.

The events that are able to produce ERPs, can be defined as a segment of time at a given location that is conceived by an observer to have a beginning and end [17]. These events could be perceived by different sensory modalities – visual, auditory, somatosensory. No matter what kind of sensory stimulus is being applied in an experimental condition (in which one tries to elicit response), the evoked potentials have similar characteristics. Traditionally, two major classes of evoked responses were identified – exogenous (sensory) and endogenous ERPs. The characteristics of the first ERP type are largely depended by the physical properties of the stimulus itself. This type of ERPs are always elicited i.e. they are obligatory when a stimulus is perceived (e.g. brianstem potentials, elicited by sound). The endogenous potentials, in the other, hand are largely determined by the nature of the interaction between the person and the event. This person-event relationship is by nature very complex. Some of the endogenous potentials are even elicited in the absence of an external stimulus.

The most widely investigated endogenous potential is P300. This potential was described by Sutton and colleagues in the sixties as a late positive ERP wave, which occurs to task-relevant stimuli which carried carries significant information. Because the wave has a latency of about 300 ms and it is positive, it was called P300, although it was latter elaborated by other authors that this wave can be found anywhere between 250 ms and 900 ms. The P300 wave is produced by the typical oddball paradigm, in which, if we consider the auditory modality for example, two different sounds (different in frequency and/or duration) at different presenting rates are presented [18]. Until know, it has been associated with variety of cognitive activities – signal probability, attention, discrimination, uncertainty resolution, stimulus relevance, information delivery as well as with decision making [19].

Decision making is one of the most complex human behavioral processes. Decision-making processes have been object of research in philosophy, psychology and lately also in neuroscience, in which it is however still not enough tackled by the researchers. Many different approaches are used to investigate this process. In one P300 study, the participants were given a visual task with the second of the two rapidly presenting and relevant stimuli gave the opportunity to the subjects to make a decision [20]. Only the second stimulus produced a prominent P300. The authors speculated that the subject's activity as an information processor determined the P300 amplitude. The psychological correlate of the information processing was defined as decision making. In another study [21] young adults were required to detect auditory stimuli in split-second intervals. The early evoked potential components (between 100 ms and 180 ms) were reduced in amplitude by stimulus repetition, whereas the P300 component fully recovered in less than 1s. Their interpretation was that the P300, as a cognitive, endogenous evoked potential is recovered in parallel with the high-rate decision processes with which they are associated, which was also a base to postulate that the origin of early and late ERP is different.

In addition, some data show that factors that increase the duration of the decision process by affecting the speed of evidence accumulation (e.g. stimulus degradation, reduced stimulus intensity, increased display size in visual conjunction search) have generally been found to increase P300 latency and a reaction time by a similar amount. In the other hand, factors that affect post-decisional processing (e.g. complexity of the response) slow down reaction time while leaving P300 latency essentially unchanged [22].

Confidence of the decision making process can be defined as the ability of the participant to predict whether a given response will turn out to be correct [23]. Confidence in decision has been positively correlated to P300 amplitude, meaning that greater confidence of decision making produces higher P300 amplitude [24]. Furthermore, when the decision task is made easy, P300 starts varying as a function of the probability of occurrence of the second stimulus, in a way that, the lower the probability of the signal, the greater the P300 amplitude.

In summary, the P300 could be correlated to the decision making process itself. The P300 amplitude is enhanced when subjects are required to make a decision about stimuli. Also, it could be that greater P300 amplitude is correlated to greater confidence in the decision.

OTHER ELECTROPHYSIOLOGICAL STUDIES

Grey Walter [25] was studying patients, in whom electrodes were implanted in the motor cortex; he asked them to follow a sequence of slides, which they projected by pressing a false button – a button not actually connected to the system; slides were triggered by the electrical brain activity, recorded from the electrodes implanted in the motor cortex. The patients felt as if the projector anticipates their decisions, so to say, as if the projector switches the slides in the moment when they only had intention to switch the slide and right before reaching the decision to press the button.

In the same time, neurophysiologists demonstrated that 1 to 1.5 seconds before the execution of the voluntary movement, above the motor cortex a slow negative potential emerges (*Bereitschaftspotential* – Readiness Potential – RP) [26]. RP does not appear in the context of involuntary movements, and also does not appear before movements, triggered by external stimuli [27]. RP probably reflects the activity of the Supplementary Motor Area (SMA).

The voluntary action starts with determination of the purpose of the action, which lasts some time. When studying the planned voluntary movements, the researchers have found out that RP, preceding the actual flexion of the finger or wrist lasts few seconds. Grey Walter found that RP was detected in the RAF pilots before they have voluntary decided to drop off (simulated) bomb [28]. Libet investigated, when, in the temporal course of voluntary decision, RP appears, in comparison to the conscious intention for execution of an action. He expected that the electrophysiological study would confirm the concept of free will – the hypothesis that the free will causes the voluntary action.

He studied [29, 30] spontaneous and voluntary movements (flexion of the wrist, for example) and with the use of a very fast laser clock hand tried to determinate the time, when, in comparison to the beginning of RP and the voluntary action itself (as represented by electromyography (EMG)) the conscious intention and/or will for wrist flexion appears. The result, from neurophysiologic point of view, was somehow expected, whereas the result was bitterly unexpected from the point of view of the advocates of the concept of free will – the conscious intention for motor action appeared before the EMG signal and before the beginning of RP (Fig. 9). Libet tried to 'rescue' the concept of free will. The explanation of the result of his experiment, which was by the way reproduced several times afterwards, was that the voluntary movements were started unconsciously and that there was still time of about 100 – 200 ms before the actual execution of the movement to stop the movements. The free will and the voluntary decision in Libet's experiments relay more on the prevention of the actions than on the promotion of it. "We don't have free will, but we have free won't.", says Libet.

FUNCTIONAL ANATOMY OF THE VOLITION

As we will see, functional anatomy of the decision making and functional anatomy related to free will, volition, overlap. There are some movements, which are internally generated and in which people have feeling that the movements are result of free decision i.e. that we are the generators of actions we perform. Voluntary actions are related to the future and our goals directed towards the future are mainly generated in the prefrontal areas. These are for example – serial programming of the motor behavioural actions, language and cognition. In the same time, a process of suppression of those representations runs, which does not participate in the generation and execution of the voluntary actions. There are some studies, which define the prefrontal and the cingulated cortex as a part of the brain suppressing the irrelevant mental representations [31].

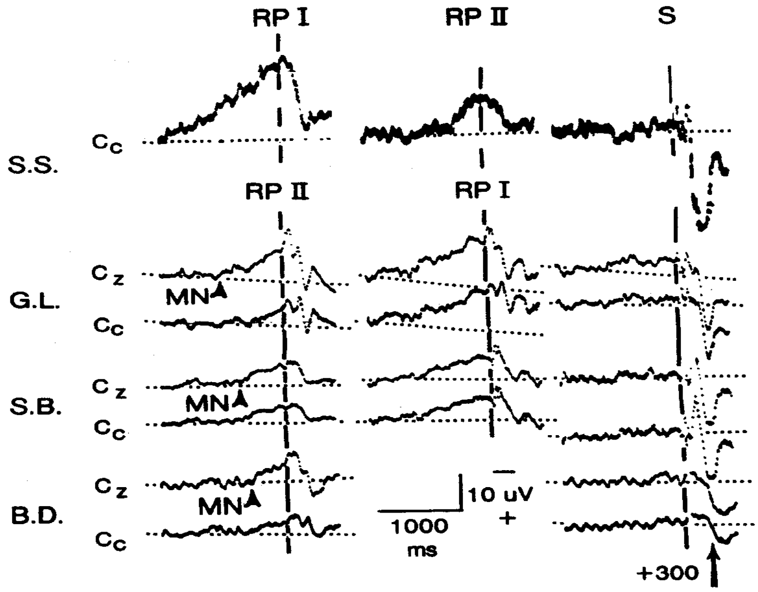

Figure 7. Libet's experiment – Readiness potential (RP).

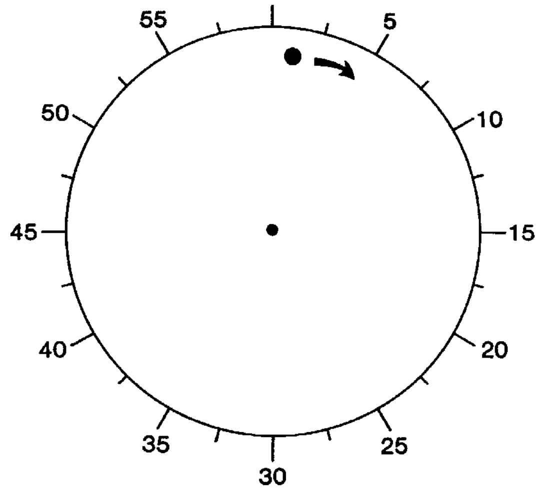

Figure 8. Libet's clock.

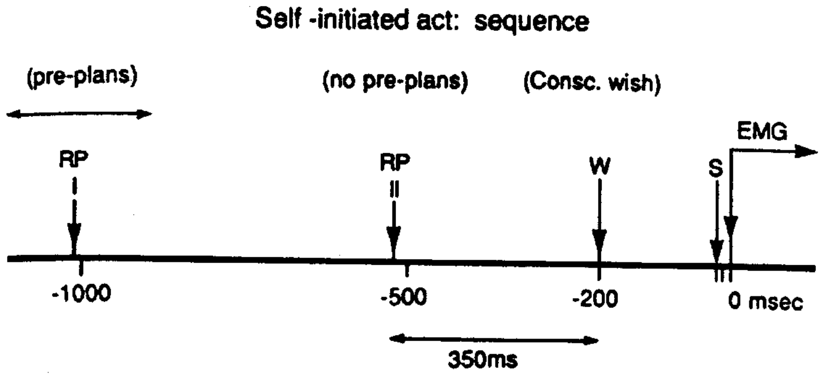

Figure 9. Time course of the readiness potential (RP), conscious intention (W) and movement execution (EMG) in the Libet's experiments.

Clinical examples of patients, electrophysiological studies and the new imaging studies confirm that free will (or at least the illusion of it), could be to a certain level prescribed to different brain regions. Different brain regions participate in the execution of consciously selected voluntary movements or thoughts. Most of them lie in the prefrontal cortex as well in the connection of the prefrontal cortex with the subcortical nuclei – already mentioned cortical-subcortical-frontal loops. The loops are half-opened. They connect wide areas of the cerebral cortex with the basal ganglia, thalamus and the frontal cortex [1]. There are at least five different loops. For the concept of free will two of them are of greater importance: (i) mesial loop, which ends in the anterior cingulate gyrus in the orbitofrontal region and in the in SMA and (ii) lateral loop, which ends in the dorsolateral prefrontal cortex.

The anterior cingulate gyrus (Fig. 10) is a place where motor, emotional, homeostatic and cognitive processes get in touch to each other and than mix in order to produce proper choices. SMA plays an important role in sequencing and programming of the course of motor actions, which are necessary for execution of a certain motor plan.

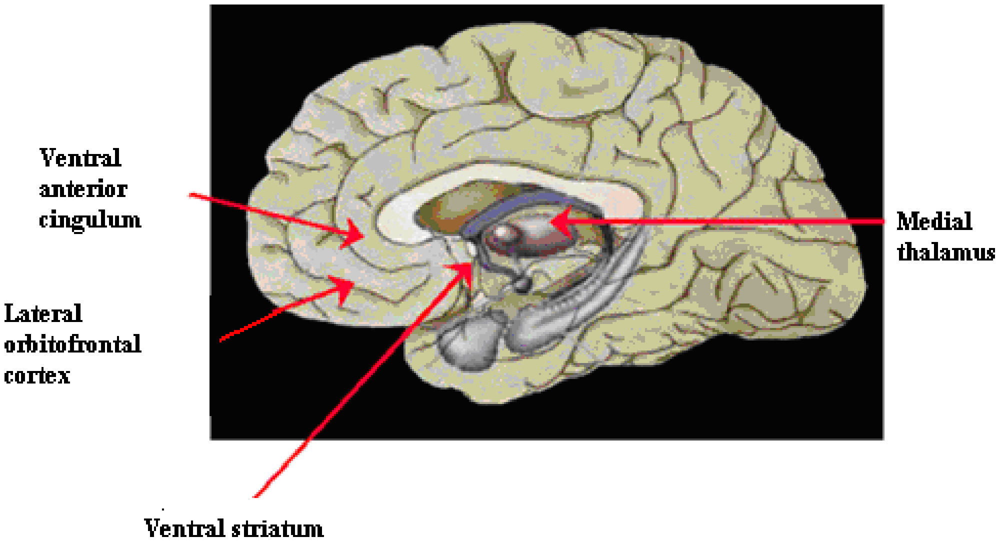

Figure 10. Cingulate gyrus.

As we have already mentioned, the orbitofrontal region participates during the modeling of actions with regard to reward, punishment or the social context, in the same time suppressing the exaggerated activity of the deep structures (basal ganglia, limbic system). The dorsolateral prefrontal cortex forms plans and sets goals and also participates in the process of choosing of the response, especially if the context is new, or if the action is generated internally. This part of the brain has an important role in the working memory.

So, the prefrontal regions are essential for decision making processes and the feeling of free will. Consequently, they are related to the feeling of "I", which in the western culture represents a complex net of goals, interests, fears, which affects our decisions at the conscious and unconscious level – in the former case, the feelings could be regarded to be the cause of our actions and in the later case, we would react, without knowing the reason for the reaction.

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ODLUČIVANJE I MOZAK: POGLED NEUROLOGIJE

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SAŽETAK

Članak oslikava činjenicu kako koncepti poput odlučivanja i slobodne volje ulaze u područje kognitivnih znanosti pri kraju XX. stoljeća. U članku je dan pregled struktura mozga uključenih u odlučivanje i koncept slobodne volje. Prezentiranjem rezultata kliničkih promatranja i novih metoda (funkcionalnog neuro-oslikavanja, elektrofiziologije) postulira novi mehanizam provođenja tih koncepta. Dan je prikaz neuroanatomije s posebnim razmatranjem dijelova mozga značajnih za navedene teme, jer je donošenje odluka ovisna o duboko subkortikalnim kao i kortikalnim strukturama. Dopamin je središnje uloge za ponašanje povezano s nagradom i hedonizam. Također, navedena je lista struktura mozga povezanih s dopaminom. Članak posebno naglašava studije SPECT za ispitanike s Parkinsonovom bolešću (neuro-oslikavanje), kao i studije povezane s potencijalom spremnosti i endogenim potencijalom P300 (elektrofiziologija). Na kraju, razmatramo želje, čija se funkcionalna anatomija preklapa s funkcionalnom anatomijom slobodne volje i procesa odlučivanja.

KLJUČNE RIJEČI

Kognitivna neuroznanost, mozak, odlučivanje, slobodna volja, elektrofiziologija, funkcionalno oslikavanje, dopamin

Interdisciplinary Description of Complex Systems 7(2), 54-64, 2009

RATIONALITY AND EMOTIONS IN DECISION MAKING

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Regular article *Received:* 23 November 2009. *Accepted:* 9 December 2009.

ABSTRACT

Decision making is traditionally viewed as a rational process where reason calculates the best way to achieve the goal. Investigations from different areas of cognitive science have shown that human decisions and actions are much more influenced by intuition and emotional responses then it was previously thought. In this paper I examine the role of emotion in decision making, particularly Damasio's hypothesis of somatic markers and Green's dual process theory of moral judgment. I conclude the paper with the discussion of the threat that deliberation and conscious rationality is an illusion.

KEY WORDS

philosophy of cognitive science, decision making, emotions, the problem of free will, ethics

CLASSIFICATION

APA: 2630

JEL: D83, D84, Z19

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INTRODUCTION

On the one hand, decision making is a process we are quite familiar with, because we often find ourselves in situations which can be described as decision making. For example, at this very moment I am deciding whether to attend a lecture or stay at home and write an article. I weigh my options: on the one hand, I would like to hear the lecture of a colleague I esteem highly and whose lectures are always well-prepared and interesting, but, on the other hand, I am haunted by the feeling of obligation, as – yet again! – I am late with my article and therefore have to finish it as soon as possible. I have to decide between these two choices and soon realize that I will be staying at home in front of my computer. This is my choice, and I feel it to be the final result of conscious deliberation and freewill, because I could have decided otherwise and went to the lecture, while staying up late to finish the article. On some other occasion, I decided to buy a book without any special deliberation, but with the distinct feeling that this was my decision. However, if we take a better look at the matter at hand and are not satisfied with such fairly stereotypical examples, we are faced – as with all other philosophically interesting notions – with a serious task. One does well to remember St. Augustine's often-quoted answer to the question on what is time: St. Augustine responded that, before the question was posed, he had been using the notion with no problems whatsoever, but as soon as he was confronted with the issue, he was dumbfounded.

The investigation of decision making is by no means limited solely to philosophy; it presents a challenge to scientists from a wide variety of disciplines who try to tackle the phenomenon from the third-person perspective (neuroscientists, psychologists, sociologists, economists, computer scientists) as well as to researchers who attempt to solve it with the first-person approaches. In the present article, we will be focusing primarily on the relationship between the conscious (voluntary) and unconscious (automatic) decision making processes. It will be shown how the dominant view in Western philosophy and science, according to which decision making was mainly a process of instrumental rationality, ignored the importance of emotions that often play an important role in decision making on unconscious level. On the other hand, recent investigations in the field of neuroscience have raised doubts as to whether the experience of conscious decision making is not merely an illusion. In my opinion, this conclusion is invalid and can be avoided, although many questions related to the philosophical problem of free will remain open.

RATIONALITY

A common person from the street would probably give a more balanced view on decision making then philosophers and scientist who mainly deal only with the rational part of the decision making (at least until recently). Decision making was from Plato on regarded as a rational process although the influence of emotions was not totally rejected. The role of emotions was in setting the goals and in motivation, whereas in reaching practical decisions, reason and emotion were in opposition. The age of enlightenment and rationalism stressed reason even more and later, as Scheff [1] points out, the requirement that we should act in accordance to reason changed into the statement that we actually do act in accordance to reason, and emotions have slowly disappeared from the serious discussions. The result is overvaluation of the self control and of the awareness of the situation and negation of the other side of human behaviour, i.e. impulsiveness and lack of self control. But as a man from the street could tell us, there are many important decisions in life where we do not deliberate about alternatives and do not think about the consequences.

Nevertheless when philosophers talk about decision making, they usually think about rational decision making. So let us first look at different senses of rationality.

Ronald de Sousa [2; p.7] distinguishes between categorical sense and normative sense. Taking the categorical sense, the contrary of rational is arational. The criterion for the inclusion into the category rational is in the ability to behave because of reasons and the explanation of behaviour refers to goals, norms or values (e. g. example, the behaviour of a person who helps the child to open the door). Arational behaviour is caused neither with choice nor with deliberation and could not be explained on the basis of reasons (e. g. the fall of the rock). Having normative distinction in mind, one can distinguish rational from irrational behaviour. In this case the criterion is the answer to the following question: Is the belief or behaviour appropriately grounded in specific reasons, norms or values. Agent who is not rational in a normative sense could be criticized. Aristotle's characterization of humans as rational animals took categorical sense. Just because humans are rational (in categorical sense) we can sometimes describe their behaviours as irrational (e.g. when we incautiously run across the street).

Second line of the distinction goes with the usage of the notion of rationality and refers to thoughts or actions [2; p.121]. In the first case we talk about epistemic rationality, where the question is in the matter of fitting representation with the world. The goal is to reach the truth and avoid falsity. Epistemic rationality is the concern of logic and epistemology. Second form is strategic rationality where the concern is the fitting of the world and the goals set by the agent's desires and choices. Disciplines dealing with these questions are decision theory and game theory, first is concerned more with individual decision maker and second with decision making in different social groups.

The third distinction is between theoretical and practical approaches. The theoretical approaches include scientific questions as are questions about explanation or prediction. The methods used are impersonal and in principle accessible to everybody. Practical deliberation concerns our individual actions like what should I do or what is the best to do.

Decision theory and game theory are normative theories based on the theory of rational choice. They thus presuppose an idealised rational individual who is informed, with ordered preferences and with the complete inside computer. For her to act rationally is to choose the action for which she computes the maximal utility or satisfies her preferences in the best way [3]. We can see that both decision theory and game theory are concerned with choosing between alternative possibilities and with computing the best outcome. Previous stages of decision making process, for example identification of the problem and obtaining necessary information, which are as important but may be more difficult to compute, are not represented in these theories [4].

Decision theory offers us different models that emphasize strictly rational approach and stress the importance of instrumental reason and the ability to calculate the best choice. But for describing the actual decision making processes these theories based on ideal rationality are not appropriate. Scientists were looking for more realistic approaches and Herbert Simon [5] proposed the notion of bounded rationality and Christopher Cherniak [6] theory of minimal rationality. Empirical investigation of reasoning in everyday situations which are uncertain or risky or require quick answers showed that people use heuristic instead of logical reasoning. These quick and economical processes do not need as much information as conscious reasoning. Some theoreticians take such processes as an origin for "cognitive illusions" [7] that are causes of conclusions and decisions not in agreement with the laws of logic and probability calculus [8]. Gigerenzer [9], in contrast, argues that these intuitive, unconscious processes have an adaptive value and must be appropriately valued. In recent years different "dual process" theories have been developed. They pose two systems, one for quick, nonconscious and automatic processes ("System 1") and one for slow, conscious and deliberative processes ("System 2") [10]. There are also other features that characterize the systems so it is questionable if there is really only one System 1 or there are more. There is also no agreement if the two systems are two parallel systems, first representing implicit system of knowledge and second the explicit, that are in competition, or it is more a question of how preconscious processes contextualize deliberation and decision making. We will concentrate on emotions (System 2) and their role in decision making.

THE ROLE OF EMOTIONS AND FEELINGS IN DECISION MAKING

Recently, many philosophers, neuroscientists and psychologists have pointed out that emotions play an extremely important role not only in goal setting but also in decision making. The philosopher de Sousa, for example, claims that when dealing with the issue of making decisions one can benefit significantly by accepting the hypothesis that emotions are active participants in decision making, as they make sure that only a small percentage of all possible alternatives and facts become relevant in the process [2]. Antonio Damasio has come to similar conclusions, but from the perspective of neuroscience and psychology. His definitions of emotions and feelings and the roles they play in decision making will be dealt with more thoroughly in the following sections.

DAMASIO'S VIEW ON EMOTIONS AND FEELINGS

Antonio Damasio is one of the leading researchers in the field of neurobiology of mental processes. In addition to numerous scientific papers, he published three very popular books [11 – 13]. His first book, entitled Descartes' Error, deals with the role of emotions and feelings in decision making. As its very title suggests, Damasio feels that Descartes wrongly identified rational decision making as being immaterial and separate from emotions.

In his book, Damasio describes the famous neurological case of Phineas Gage: an American construction worker who injured himself in 1848 while blasting rock. In the accident, the thrust of explosion carried an iron pole through Gage's head. However, and much to everyone's surprise, Gage, despite the gravity of his injury, managed to survive and was almost fully restored. But from a caring, working and tidy husband he became a completely different person: someone who was unreliable, impatient and incapable of following orders. The reconstruction of Gage's injury indicates that frontal lobes (especially the left one) were damaged.

Damasio was confronted with a similar case – patient Elliot who, after the removal of his tumour, had a damaged ventromedial prefrontal cortex. After the surgery, Elliot's character also changed significantly: his behaviour became inappropriate; at his work, he showed systematically lessened abilities of judgement. Even though standard tests of intelligence and memory failed to detect any significant changes, Elliot's everyday behaviour was highly irrational. He was having especially serious problems with systematic planning. It seemed that he was contemplating every little detail of possible future actions that never even occurred. Damasio describes how, during one of his visits, he asked Elliot, which of the two dates for the next meeting would suit him best. Usually, a person would come to a conclusion after a brief reflection. But in Elliot's case, this process became terribly prolonged, as he was going through all the possible reasons for and against a given date, until – after half an hour – he was interrupted by Damasio with a suggestion. Elliot accepted Damasio's decision calmly and thereby ended his calculations [11; pp. 193-194].

Damasio noticed that other patients with damaged ventromedial prefrontal cortex have similar problems with decision making in their everyday lives. Such situations – in contrast to solving problems in the laboratory where problems are limited and clearly defined – always contain a certain amount of uncertainty and vagueness. But how are we to explain the irrational behaviour of such patients, if their abilities of rational calculation seemed to remain intact? The prevailing theories of decision making emphasized the rational aspect of the process, as it was traditionally thought that the ability of rational decision making was what separated humans from other creatures. As mentioned above, the history of philosophy was dominated by the “negative view of emotions”, and many philosophers (e.g. Plato, Descartes and Kant) defended the view that in the process of rational decision making, emotions were a hindrance to clear thinking.

But clinical experience induced Damasio to start investigating the roles of emotions in decision making. With the help of his co-workers he examined and tested even more patients with the damaged ventromedial prefrontal cortex. He established that emotional responses play an important role in decision making processes both in everyday life and in laboratory conditions, which stimulate such circumstances. Since emotional responses were not detected in his patients, he concluded that their absence is the source of problems in decision making.

SOMATIC MARKER HYPOTHESIS

Why do patients with damaged ventromedial prefrontal cortex have problems in uncertain situations and frequently fail to act in accordance with social rules? Damasio started tackling this problem by investigating the mechanism which enables emotional processes to guide or direct behaviour, most notably decision making. He named his approach the somatic marker hypothesis.

Damasio established that, when faced with situations which could lead to different types of action, these patients are unable to activate emotion-related memory that would help them pick the most advantageous alternative. It turned out that such patients are having especially serious problems with situations, in which they have to choose between mutually exclusive options and vague outcomes, such as choosing a career or making business decisions. And it was already seen that even seemingly simple tasks, such as choosing a date for the next meeting, posed grave problems for patients like Eliot.

Damasio states that an important part of the decision making process consists of the comparison of potential alternatives with emotions and feelings from similar past situations. Furthermore, the process also involves the estimation of results brought about by these past events and potential rewards or punishments that might have been gained during such events. This procedure enables us to simulate potential future outcomes based on our past experiences and then opt for a move that will lead to the best possible solution. People tend to classify situations, experienced under the influence of social emotions and emotions of joy and sorrow, which are, in turn, triggered by rewards and punishments, in conceptual categories. These categories are formed on both mental and corresponding neural levels, and are then connected with brain apparatus responsible for triggering emotions. This enables appropriate emotions to come about quickly and automatically. This is how Damasio describes the mechanism in neurological terms: “When circuits in posterior sensory cortices and in temporal and parietal regions process a situation that belongs to a given conceptual category, the prefrontal circuits that hold records pertinent to that category of events become active. Next comes activation of regions that trigger appropriate emotional signals, such as the ventromedial prefrontal cortices, courtesy of an acquired link between that category of event and past emotional-feeling responses. This arrangement allows us to connect categories of social knowledge – whether acquired or refined through individual experience – with the innate, gene-given apparatus of social emotions and their subsequent feelings.” [13; p.147]

Damasio and his co-workers did a series of tests, in which they simulated decision making in conditions of uncertainty. They used a psychological test designed by Bechara with co-workers from the University of Iowa, commonly referred to as the Iowa Gambling Test [14]. The test is carried out in the following manner: Participants are confronted with 4 decks of cards. They are told that every card they pick will bring them a certain amount of money, but occasionally a chosen card can also bring about the loss of money. A drawn card can therefore bring either punishment or reward. Bad cards are arranged differently in sets, so that some sets are "good", because in the long run they bring profit, while some sets are "bad", because in the long run they bring loss. The goal of the test is to make as much money as possible. The results of studies conducted by Damasio and his co-workers demonstrate that, after a certain number of drawn are cards, healthy individuals choose only cards from the two "good" decks, while patients also opt for "bad" decks, even though they know they were causing them to lose money. Also, the participants' skin conductance was measured, which is one of the physiological indicators of emotional reaction. It turned out that healthy individuals showed stressful reactions a lot sooner than they consciously realized that a given deck is "bad". In contrast, patients with the damaged ventromedial prefrontal cortex did not have these reactions to "bad" results. Damasio therefore concluded that, because of their lesions, patients failed to develop physiological reactions to the threat of punishment. The emotion-related signal was therefore weakened, which, in turn, brought about problems with decision making.

Emotional signals can be conscious and can make us re-live the corresponding feelings, or they can be hidden and automatic. In this case, emotional signals mark the possibilities and outcomes as positive or negative (a kind of alarm) and thus help us decide to take actions that are in accordance with our past experiences. Since such decisions are made relatively quickly and without conscious thinking, they are often called "intuitive". Damasio agrees with de Susa when he says that emotions narrow the decision making space and, simultaneously, increase "the probability that the action will conform to past experience." [13; p.148]. It is this narrowing of the decision making space that was lacking in Damasio's patients.

Let me conclude this presentation with the observation that irrespective of the final judgement on the Damasio's theory of emotion and feelings, he has given a strong push to a further investigation of the role of emotions in decision making.

DECIDING IN MORAL DILEMMAS

Philosophers are particularly interested to investigate decision making in the situations when the agent is in a moral dilemma. They question the similarities and differences between decision making in moral and in ordinary context. Some think that in the case of moral dilemma we judge rationally and after conscious deliberation [15] while in the everyday situations without moral significance decisions are often left to automatic and unconscious processes. Others suggest the opposite. They regard decisions as results of automatic, unconscious processes and rational justification only as a form of later rationalization [16]. I think that both extremes are missing out important aspects and that Joshua Green's dual-process theory of moral judgement is much more promising. Green [17, 18], has synthesized both emotional and rational processes and hypothesized an explanation of why and when each of them occurs.

Green investigated people confronted with different moral dilemmas. One set of the dilemmas was inspired by a well known philosophical puzzle known as the Trolley Problem. In the first dilemma, named the footbridge dilemma, a runaway trolley is headed for five people who will be killed if it proceeds on its present course. You are standing on a footbridge next to a large stranger. The only way to save the lives of these five people is to push the stranger off the bridge and onto the tracks below. His body will stop the trolley from reaching the others but he will die as a result. Would you push the person from the bridge? In a second, named the switch dilemma, there is a similar situation as before and a runaway trolley threatens to kill five people. The only way to save these people is to hit a switch that will turn the trolley onto a side track, where it will run over and kill one person instead of five. Would you push the switch? It turns out that the majority of people are willing to push the switch in the second dilemma while they think it is morally wrong to push the person from the bridge in order to save five lives.

Green and his co-workers performed several experiments in which they exposed persons to these two dilemmas. On the basis of the results obtained by brain imaging (fMRI) and with the measuring of the reaction time, Green developed dual-process theory of moral judgment. According to this theory, characteristically deontological judgements, as the one formed in the footbridge dilemma ("it is wrong to kill one person for the benefit of five others") are driven by automatic negative emotional response. In contrast, characteristically utilitarian or consequentialist judgments, as the one formed in the switch dilemma ("better to save more lives") are driven by the controlled cognitive processes (e.g. reasoning, planning). Green is in agreement with Hume and accepts that moral judgment have both components. But he suggests that the function of emotions in characteristically deontological judgments is different from the function in characteristically consequentialist judgements. In the former they are functioning more like alarms and in the latter more like a currency. I think that in this respect Green's theory is in accordance with the Damasio's somatic marker hypothesis presented in the previous section. Koenings and his co-workers [19] have shown that patients with patients with the damaged ventromedial prefrontal cortex decide on the basis of "cold computations", much closer to the utilitarian moral judgements.

Green has tried to explain why people respond differently to the proposed dilemmas. He has proposed a hypothesis that the distinction is primarily based on the distinction between personal and impersonal setting. In the case of the switch dilemma, the agent is not directly confronted with the killed person and for that reason ratio prevails. In contrast, in the case of the footbridge dilemma, the agent is in a direct contact with the person that will be killed and is much more emotionally involved. He also proposed other possible explanation, as for example that in the latter case direct physical contact is present, or that there is a combination of personal force and intention. Green thinks that even if there are justified critiques about the hypothesis on personal/impersonal distinction, it does not present a threat to the dual-process theory in general.

IS CONSCIOUS DECISION MAKING AN ILLUSION?

Research in cognitive science, particularly in cognitive neuroscience, offers us an improved picture about the working of the brain. On the basis of the knowledge of neural mechanisms some scientists question the very possibility of deliberation and conscious rational decision making. Are our intuitions that at least sometimes our choices are voluntary and free just an illusion? Namely, if neuroscience will discover (deterministic) mechanisms of our decision making – will that still allow us to talk about free choice?

Wegner [20, 21] has contributed to these worries from the neuroscientific and psychological perspective. He analysed many experiments, neurological disorders and psychological praxis and argued that "the experience of consciously willing an action is not a direct indication that the conscious thought has caused the action" [21; p.2]. He concluded: "Although our thoughts may have deep, important, and unconscious causal connections to our actions, the experience of conscious will arises from a process that interprets these connections, not from the connections themselves. Believing that our conscious thoughts cause our actions is an error based on the illusory experience of will – much like believing that a rabbit has indeed popped out of an empty hat." [20; p.490] He supported his thesis by numerous examples and experiments from neuroscience and psychology, including Libet's famous studies on the unconscious cerebral initiative [22] and the role of conscious will in voluntary action, experiments with transcranial magnetic simulation and examples of absence of the experience of will in the case of motor automatisms (table-turning, Ouija-board spelling, pendulum diving).

Wegner suggests that the experience of consciously willing our actions arise primarily when we believe our thoughts have caused our actions. This happens when the following three principles are satisfied [20; pp.483-486]: priority – the thought should precede the action at a proper interval, (ii) consistency – the thought should be compatible with the action, and (iii) exclusivity – the thought should be the only apparent cause of action. The interpretative process that creates the experience of conscious will works according to the theory of apparent mental causation [20, 21]. The theory tells us that the actual causal paths are not present in the person's consciousness. It is the principles of priority, consistency and exclusivity that govern the inferences people make about the causal influence of their thoughts on their actions, and thus underlie the experience that their actions are willed.

Wegner discusses experiments that show that conscious willing of an action can be separated from the action. Sometimes people have a conscious feeling of not owning an action and not being responsible for it, but they in fact are, and vice versa. He also supports his theory by Libet's findings that conscious experience of free will is about 400 ms late – it is possible to predict the movement on the basis of the measured brain activity (readiness potential) before the subject is subjectively aware of his wish to move. According to Libet's interpretation the conscious will can not function as the initiator of the action, but because it does appear some 150 ms before the muscle is activated, it might block or veto the process in the brain so that no act occurs [22; p.51].

So, do the data gathered by Wegner really support the interpretation that conscious will does not play a causal role? In my opinion such inference is invalid and can be avoided from at least two directions. First concern the interpretation and methodology of the experiments while the second points to the rich history of philosophical discussions about determinism and free will.

Let me first shortly present some of my doubts that concern the experiments. Wegner described situations in which subjects felt as if they caused the action, but in fact they did not, and vice versa. This shows there are situations in which our experience that we consciously initiated the action (or that we did not), is wrong. But this does not mean that conscious intention in general is not causally relevant. I think it is a hasty generalization to conclude from these specific examples that conscious willing is never causally relevant, as would be wrong to conclude that perceptual illusions show us that our perception is always misleading.

I agree with Nahmias that Wegner's examples show "that there are various exceptions to the rule that our conscious experiences of our actions correspond with those actions. But the fact that there are these exceptions does not show that, in the normal cases of correspondence, conscious will is causally irrelevant." [23; p.533]. In my opinion the psychological experiments to which Wegner refers support only the weaker interpretation of illusion, i.e. we do not have direct access to the causal link between thought and action. Wegner is right to take our folk-psychological belief in direct access to the causes of our action as false. But in contrast to him I believe that this is not enough to infer that conscious intentions could not cause actions. This weaker interpretation does not say that we could not have causally relevant conscious intentions, it just indicates a false understanding of mental processes and of our own agency. As we have seen in previous sections, research in neuroscience suggests that taking a process through which a person makes her decision as purely rational is false. Damasio's and Green's theories suggest that we have to look at the emotional aspects and subjective feelings in constructing more sophisticated model of agency [17, 18, 20, 21].

In my opinion both Libet and Wegner take as a starting point a very naïve picture of intentional causation which presupposes a simple causal relation between a thought and an action. For example, in Libet's experiment the author was asking for the causal effect of the conscious wish or urge for the flick of the wrist which occurred next to the action. But it was totally overlooked that the subject previously agreed to participate in the experiment and therefore to complete the action once in the future. It is most likely that she formed the intention already at that time.

I also think that interpretations of experiments and neuroscientific investigations often overlook philosophical attempts to find the solution to the problem. Questions like "Is deliberative, free willed decision making possible?" and "Is deliberative, free willed decision making compatible with determinism?" are hard questions without obviously correct or accepted answers. It turned out that accepting compatibilist or incompatibilist solution largely depends on different understanding of involved notions of determinism and free will [24, 25]. It seems to me that both Libet and Wegner presuppose a very strong metaphysical notion of free will, according to which free willed action is equated with non-caused action. Wegner himself said that we could not help to look at our own causal influence as something supernatural, that it is essential for perceiving ourselves as humans. "We are enchanted by the operation of our minds and bodies into believing that we are "uncaused causes", the origins of our own behavior. Each self is magic in its own mind. Unfortunately, the magic self stands squarely in the way of the scientific understanding of the psychological, neural and social origins of our behavior and thought." [26; p.226]. Such libertarian position about freedom is close to our common sense western view and is part of our manifest humanistic image [27, 28]. It is usually supported by a dualistic position in the mind-body problem and kind of extra factor strategy, as for example an immaterial soul or agent causation. It is not surprising that such understanding of the self is in opposition to the scientifically oriented interpretations. Scientist like Wegner and Libet – maybe not fully aware of their presupposition of such a strong notion of free will, therefore conclude that free decision making is only an illusion. But this viewpoint, generally called "hard determinism" is only one of the possible answers. Some try to preserve this strong libertarian notion of freedom and argue for the indeterministic processes in the brain at naural and/or quantum level [29] and thus save conscious rational decision making. And there is also a third group called compatibilism. Compatibilists argue there are strong reasons that determinism and free will are compatible, we only have to understand freedom in a weaker sense, not as something uncaused, but mainly as expressing our own control, our ability to do otherwise and to do without a coercion [30]. This compatibilist position is totally overlooked by those who on the basis of neuroscientific research deny the possibility of free decisions. But as Adina Roskies [31; p.421] states: "A view of ourselves as biological mechanisms should not undermine our notion of ourselves as free and responsible agents. After all, some causal notion is needed for attributions of moral responsibility to make sense. The predictive power of our high-level psychological generalizations grounds our views of agency, so further evidence that we behave in a law-like fashion should not undermine our notions of freedom."

In questioning the possibilities of free will we are relaying on subjective experience and on our understanding of the nature and self. Recent investigations in neuroscience and psychology have given a new push to old question. But solving the problem of free will is connected to other metaphysical and epistemological problems, particularly the mind-body problem. Dualists and libertarians "set the bar for free will ridiculously high" [32; p.124] and combine dualistic view with the subjective experience. I do not see why we should accept this combination for granted and as a base for the in principle objection to any attempts to explain deliberation and decision making as free.

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RACIONALNOST I EMOCIJE U ODLUČIVANJU

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SAŽETAK

Odlučivanje se tradicionalno smatra racionalnim procesom u kojemu razum određuje najbolji način postizanja cilja. Istraživanja iz različitih grana kognitivne znanosti su pokazala kako su ljudske odluke i djelovanja u znatno većoj mjeri pod utjecajem intuicije i emocionalnih odziva nego se prije smatralo. U ovom radu ispitujem ulogu emocija u odlučivanju, posebno Damasiovu hipotezu somatskih markera i Greenov dvojni proces moralne prosudbe. Članak zaključujem diskusijom stava kako su namjere i svjesna racionalnost prividi.

KLJUČNE RIJEČI

filozofija kognitivne znanosti, odlučivanje, emocije, problem slobodne volje, etika

Interdisciplinary Description of Complex Systems 7(2), 65-77, 2009

THE PHENOMENOLOGY OF DECISION MAKING

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Regular article *Received:* 23 November 2009. *Accepted:* 9 December 2009.

ABSTRACT

It is becoming apparent in modern cognitive science that the lack of knowledge about human experiential landscape implies the loss of a very important element, perhaps the very essence. Consequently, a rather new area of research has emerged recently: an attempt at a systematic observation and study of experience. This is the so-called *phenomenologically inspired research* (or just *phenomenological research*).

Part of this article aims to present this new area of research – it describes the common fundaments of the field and some of its characteristic methodological derivates, relating them to the possibility of studying *decision making* from the first-person point-of-view, i.e. decision making as an experiential phenomenon (and not as a neurological or behavioural process). The article also presents some of the findings phenomenological studies have led to and some theoretical reflexions encouraged by these insights.

KEY WORDS

experience, experiencing, phenomenology, phenomenological research, reason, first-person

CLASSIFICATION

APA: 2340 Cognitive Processes, 2380 Consciousness States

JEL: D83, D84, Z19

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RESEARCHING LIVED HUMAN EXPERIENCE

The research of cognition, consciousness and everything connected to these two fields is probably one of the biggest enterprises modern science has undertaken in recent decades. This is mostly due to enormous progress made by neurosciences, finally allowing for a scientific perspective of the processes which we were unable to observe in vivo until very recently. It is an interesting point that the very development of objective (third-person) research of cognition has stirred the revival of the research of direct lived (first-person) human experience. It was neuroscientists themselves who first began to realise that the gathering of the so-called "experiential data" is not that simple. It does not suffice to merely ask people about it or to prepare good questionnaires. If we are to categorise experience theoretically – how are we to research it, if even the person reporting it does not know how to observe it?

In the areas where we are faced with a direct contact with living, concrete, unique human beings, the ignorance about their (our) experiencing usually means the loss of a very important element, maybe even a crucial one. This is why a new field of research has emerged recently: the attempt at a systematic observation of experience. This consists of the so-called phenomenologically inspired research approaches, or phenomenological research, in short.

Before I embark upon the presentation of phenomenological research, let me state that it does not imply a negation of psychological theories or neurological explanations. Quite the opposite, the research of experience in modern science appears to be complementary to the progress made by neuroscience. It merely proposes that the naturalistic scientific method of gaining knowledge should not be taken as the only relevant instrument for "measuring" cognitive phenomena. The most important approaches in phenomenological research (e.g. neurophenomenology [1]) propose a balanced synthesis of both perspectives. Nevertheless, a certain degree of polarisation remains necessary, in order to enable the young and still very fragile field of phenomenological research to establish itself, and even more so to overcome the idea that we already know everything there is to know about experience and that there is not much left to study. Let us therefore start the presentation by describing the foundations on which experience research is based.

THE BASIC METHODOLOGICAL APPROACHES IN RESEARCHING EXPERIENCE

The science of lived human experience that I wish to describe is interested in experiencing itself, such as it is; such as it appears in the field of consciousness. It does not inquire about what is "behind" experiencing, what causes it, or about the things "out there" – things as they would be without the intervention of our subjective properties (i.e. the properties characteristic only for me – the observer – which are therefore not shared by others)[1].

The fundamental phenomenological insight here is that experience, more accurately my first-person experience, is primary. Not only does it come first – it is all I have. I cannot get to know anything outside the domain of my experience. Thoughts, meanings, descriptions, visions, images, feelings, emotions… nothing exists outside of one's conscious experience (or my lived experience). The experiential world can be organised (e.g. by classifying it into feelings, thoughts etc., or by explaining the observed phenomena with the help of science, or by classifying it to "outer" and "inner"), but I cannot get to know anything outside my experience. Phenomenological research therefore focuses on the observation of direct lived experience as it presents itself. The term "phenomenological" comes from a philosophical movement established, initiated by Edmund Husserl around 1900, which posed the above mentioned statement as its basic epistemological credo. Some of the basic methodological guidelines of Husserl's research programme were:

- bracketing or epoché. Husserl suggests putting the usual early judgement calls about things as they appear in our experience into "brackets" and applying phenomenological reduction – the reduction of the observed phenomena "as the only thing given and certain in experience". As Kotnik [2; p.102] says, the emphasis is on "the research of what is given in experience only, but it is imperative to include experience in its entirety". The first step towards achieving this is to recognise the complexity and infinity of this field.
- rule: "Never explain, just describe!" This is the single most important methodological guideline of phenomenological research. This instruction may seem simple at first sight, but it is extremely difficult and complex to carry out in practice. It takes a great deal of reflection and skill. Only once we try to merely describe experience without classifying or explaining or situating it into frameworks in any way, we become aware of how deep our need to explain is and how hard it is to give it up. Kotnik [2; p.103] quotes Ihde [3] in talking about "how difficult it is to distinguish between the actually describable experience as it shows itself directly, and non-experiential elements such as assumptions or presuppositions. Any kind of theory, idea, notion or construction tending to go beyond the phenomena is already an explanation."
- refrain from convictions or evaluations of the "reality" of the observed phenomena. Without intersubjective verification (typical of the scientific method) we cannot distinguish between "illusion and "reality". From the stance of the priority of direct experience such distinctions are merely one way to classify the experiential world (and as such no more valid than other possible distinctions), that is why Husserl recommends that even this – at first sight primary judgement – be bracketed and we observe the field of experience as it shows itself, without judging it.

As Husserl believed that only by abiding to the above stated guidelines we would get "lost in phenomena" [3], he added a fourth guideline recommending the search for structure and invariable properties of the observed phenomena. Husserl believed that this way it would be possible to create a "transcendental" science – a system surpassing the ephemeral uniqueness of concrete experience by extracting the essential ("transcendental", intersubjective) elements from it.

Phenomenological research (as a qualitative-methodological approach) takes the described epistemological-methodological standpoint after phenomenology as a philosophical discipline. However, it does not follow its philosophical distancing from empirical research, but rather endeavours to base as many of its assumptions as possible on the empirical research of experience. As the article explains below, the methods of gathering these data vary and have not yet been perfected, but all of them aim to avoid the so-called "armchair introspection", the opinion that we already know everything there is to know about experiencing. Phenomenological research can thus be generally defined as a methodological category encompassing all empirical methods, approaches, means of gathering and/or analysing materials based on the above-mentioned (phenomenological) epistemological foundations and guidelines.

DIVERSE APPROACHES IN PHENOMENOLOGICAL RESEARCH

Recently, there has been a variety of attempts at a systematic observation of experience. This wide area could be subdivided according to several essential properties, the most important one perhaps being the research perspective, in other words: the question whose experience we are observing. First-person perspective implies the observation of one's own experience, while third-person perspective means that we are interested in the experience of others. But there is also the possibility of second-person approaches, which are based on dialogue. The second-person approach represents a kind of synthesis of the first- and third-person ones.

The role of memory

At any moment, direct living experiencing can at best be observed, but hardly researched; therefore the research of experience is basically the research of memories of past experiences. In phenomenological research, memory is the fundamental medium enabling us to access the area of research. As mentioned above, in recent decades a number of alternative ways of researching experience has been developed. The fundamental question each of these methods has to deal with is how to approach lived experience as accurately as possible. There is no doubt that memory does not represent the ideal interface between me (the researcher, the observer) and the experience I am interested in. Thus the question arises how to preserve the past as incorrupt as possible.

In this regard, one might mention two schools of phenomenological research, distinct in their respective attitudes towards the problem of the "purity" of memory. The difference being that one of them attempts to reduce retrospection to the minimum, while the other tries to train the interviewer in the dialectical skill of "purifying" the constructs brought about by memory.

The Paris based phenomenological school with its most renowned representative Claire Petitmengin [4] is trying to perfect the art of interviewing to the level where it would become possible to approach even the memories which are no longer entirely fresh and cleanse them of the constructs accumulated in the meantime. Such "purification" is possible and often quite successful. There have been reported cases of séances after which people were able to recall incredible details (of which some could be verified).

A different approach is taken by Russell Hurlburt [5], the founder of the descriptive experience sampling (DES) technique. The goal of DES is to compose a kind of encyclopaedia of the basic elements of experience and their interconnections. DES could be compared to a geological ground survey, in which samples are taken at random locations in order to be analysed in a laboratory. Similarly, in DES experience is probed (sampled) at random moments, and the subjects are debriefed by researcher. In practice, such probing is carried out with the help of special devices subjects carry around with them. The device emits a gentle acoustic signal at random moments. The subject then tries to "freeze" his/her experiencing immediately prior to the beep – by describing it as accurately as possible into a handy notebook. No later than 24 hours after the probing, the subject has to meet with the researcher who tries to extract accurate data through an interview about the samples. Hurlburt instructs that the interview is to be stopped as soon as the subject begins to hesitate or becomes unsure about his/her answers ("hm…", "I don't know…", "I think that…" – these are the so-called "subjectifications"), thus attempting to reduce retrospection to the minimum.

As one can see, the two conceptions of experience research are complementary. Approaches such as DES are a useful tool for "mapping" everyday experience, while dialectical methods often delve deeper into a specific (chosen) aspect. Let us now take a look at some of the results (related to the experience of decision making) gained by both kinds of approaches.

PHENOMENOLOGICAL RESEARCH AND DECISION MAKING

As mentioned above, the development of modern phenomenological research as an empirical scientific discipline and its recognition in the field of cognitive science was initiated by Francisco Varela with his *neurophenomenology* project, the beginning of which marks a new era in the scientific interest in experience. Already in his fundamental article on neurophenomenology, he defined the research of volition and consequently decision making as one of the principal tasks and most promising potentials of the (neuro)phenomenological field: "The nature of will as expressed in the initiation of a voluntary action is inseparable from consciousness and its examination. Recent studies give an important role to neural correlates which precede and prepare voluntary action, and the role of imagination in the constitution of a voluntary act. ... Yet voluntary action is preeminently a lived experience which has been thoroughly discussed in the phenomenology literature, most specifically in the role of embodiment as lived body (*corps propre*, [6]), and the interdependence between lived body and its world (Leibhaftigkeit)". [1; p.345]

Even though notions such as *volition*, *decision making*, *free will* etc. are apparently primarily experiential (i.e. they are descriptions of experiencing and not theoretical concepts), there have been so far few relevant researches in this direction. Often we are able to read in introductions to cognitive studies that "the phenomenology of the phenomenon is clear…", while the task of the cognitive scientist is to research its neurological correlates. But all phenomenological studies without exception confirm that phenomenology, i.e. the specifics of experiencing, is anything but clear.

As explained in Varela's quote above, philosophical phenomenology has already worked out the idea of voluntary activity, while so far there have been no experience studies carried out to empirically research decision making (at least not to the knowledge of the author of this article). Nevertheless, modern phenomenological researchers have sporadically considered this topic in the scope of more general experience research. Before presenting some of the empirical phenomenological findings in more detail, let me recapitulate some of the theoretical points which emerged from philosophical reflection upon detailed analysis of experiential reports related to decision making.

WHAT DOES DECISION MAKING MEAN FROM THE PHENOMENOLOGICAL POINT-OF-VIEW?

The first thing to point out in considering decision making from the phenomenological perspective is that most of the studies of this phenomenon (process) fail to define clearly whether decision making is a behavioural category (third-person perspective) or an experiential one (first-person perspective). In considering decision making, researchers tend to view this process as something "out there", independent of the observer and of the way the subject experiences it. Decision making (like most of experiential phenomena) is reified – it is dealt with in a way similar to the one taken in the case of physical phenomena (for example gravity, which is "out there" whether I notice it or not).

From the point-of-view of phenomenological research, such attitude is completely inappropriate. Obviously, first of all we must clarify what we mean when we talk about decision making (this goes also for all other cognitive phenomena, of course). It would appear that in modern cognitive science there are (at least) three possible aspects, each determined by the epistemological background of the respective science, each one plausible inside the scope of its area:

- *the psychological aspect*; The category (e.g. decision making) is defined by the expert mostly basing on the observation of behaviour. In this sense, observing can include questions (usually in the form of a questionnaire), which are again interpreted by the expert according to other gathered data. The final categorising therefore lies in the domain of the expert, not the subject,

- *the neuroscientific aspect*; Neuroscience is not yet precise enough to be able to deduce cognitive functions taking place merely by looking at the physiology. But the efforts of this discipline are definitely aimed at this goal,
- *the phenomenological aspect*; phenomenological research does not ask about the causes of a given experience (unlike psychoanalysis, for example), nor about its physiological correlates. It is interested exclusively in what the subject experiences and it declares the subject the only expert on that. A phenomenological researcher can help a reporter focus his/her view on experiencing, he/she can help one inquire into one's own experiential landscape, but he/she cannot judge whether a report is true or not. The only expert on experiencing is the experiencing person himself/herself. From the point-of-view of phenomenological research, the subject who's experience is studied is the only one with the authority to evaluate what kind of experience he/she had.

This implies that, from the phenomenological point-of-view, what counts as *decision making* is only the experience recognised as such by the subject.

Many behaviours which could be defined as decision making when viewed from the outside are – from the experiential point of view – merely acting according to circumstance (in other words: appropriate acting in given circumstances). One can find numerous similar cases in psychological literature on decision making. For example, the founders of the so-called naturalistic decision making theory ([7, 8] and others) often mention their research conducted with firemen who have had to "make a decision" (this way or another) in situations of crisis, without experiencing their behaviour as decision making. The fireman who "decided" to leave the room immediately after he had entered it, at that moment experienced his behaviour as the only option and not as just one from an array of choices. Only later did he rationalise it and discovered (constructed) its causes or, to put it more accurately, its reasons.

The phenomenological reports I have analysed in the course of our study presented a number of cases which probably appeared as decision making from the outside, while the reporters did not perceive their experiencing in this way at all. E.g. in the case of purchasing an item in a bakery shop or choosing a meal in a restaurant, where the reporter, despite the large selection on offer, simply "felt" what he wanted to eat and did not experience the order as making a decision.

But phenomenological reports also present cases which are the exactly opposite: sometimes we experience decision making even in situations when our behaviour does not imply it. A good example is the report of a man with a Tourette syndrome. After taking a shower he experienced an intrusive thought of having to kill his father in case he left the shower. From the point-of-view of an outside observer one could probably detect some hesitation in leaving the shower, but one could hardly call it decision making as there are no visible alternative options.

Thus we can conclude it is not the nature of the world forcing us to make decisions. There is no decision making outside human reality, in other words, outside man's rational interpretation. The idea of choice and consequently the notion of decision making is a rational invention. Decision making only exists in language or in thought. According to the research carried out by Russel Hurlburt [5], decision making often appears in the form of "unsymbolized thinking". This means thinking without experiencing the thoughts as being represented by words.

By no means are we forced to make decisions by lived situations. It is our interpretation of our lived situations which induces us to make decisions.

This raises the question for phenomenological consideration: What is it that makes certain lived situations "demand" decision making? Why do we start to "decide" in some situations, while in others – apparently quite similar – we do not? The answer to this question lies beyond the scope

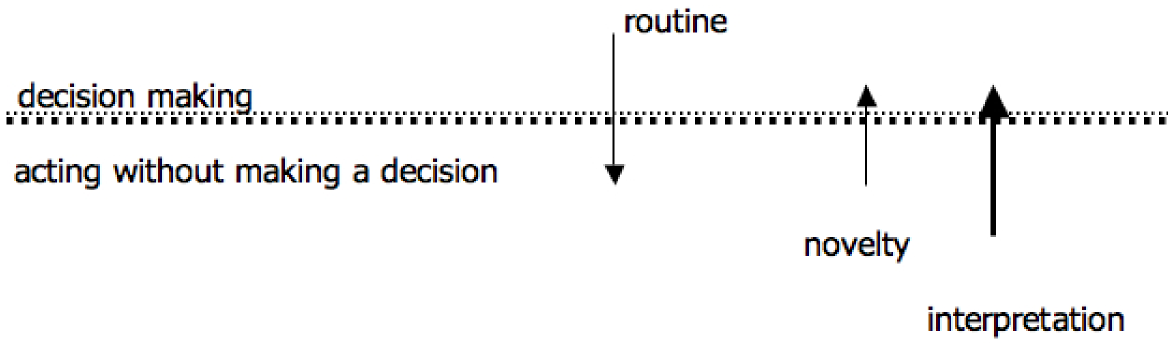

Figure 1. Factors that affect the subject to perceive one's experiencing.

of this article, but we can nevertheless graphically present some of the factors that affect the subject to perceive one's experiencing either as decision making or as a continuous flow.

SOME PARTIAL FINDINGS AND ASSUMPTIONS ABOUT THE PHENOMENOLOGY OF DECISION MAKING

What follows is an incomplete, but nevertheless telling compendium of phenomenological findings in the field of decision making. The compendium presents partial results gained by a phenomenological study of decision making carried out in the scope of an interdisciplinary research project entitled "Methodological aspects in researching cognitive processes – learning and decision making". As part of the project, some phenomenological surveys in the field of decision making were made, as well as an analysis of existing phenomenological reports related to this topic.

Contemporary phenomenological research offers a wide repertory of concrete techniques and approaches to the research of experience, which are quite diverse in their application. The patchwork of insights referred to bellow was gained by two approaches: phenomenological dialogue and descriptive experience sampling. Both approaches have already been mentioned in the first section of the article as representatives of two different views on solving the problem of introspection. Let us give a somewhat more detailed description of each method.

Phenomenological dialogue

A serious reflection on this phenomenon should make it clear that simple psychological experiments cannot grasp the experiential essence of decision making. This confirms the need (and ethical urge) for a dialogical approach in which both – the subject and the researcher – train their sensibility for one another, while the subject in turn gradually perfects the skill of observing his/her own experience. In phenomenological research, a basic epistemological question arises: who is actually the researcher? Is it possible to research the experiencing of another being unless that person has an honest and deeply existential interest in observing his/her experience? As the method in question is an example of the so-called second-person paradigm, it would perhaps be most accurate to say that both participants of the dialogue are researchers. What we are dealing with is thus not a case of observation "from the outside", but rather one of participatory co-research.

At times, dialectical phenomenological research is related to the so-called phenomenological case study [9]. It is based on the dialogical method in which the researcher poses questions in an attempt to open up the respondent's experiential space (or better: the awareness of it). The researcher has no fixed conception of the topics he would like to address, but rather attempts to direct the dialogue towards the topics most relevant to the respondent. This way he allows the respondent's awareness of his/her experience to widen. The questions help one "discover" areas of one's experiential world one might earlier not have been aware of. The questions merely offer support – we use them to show our interest, our participation. It is imperative for the interviewer to maintain an open mind and to persist in the "I don't know" position. The more priory judgements, ideas and beliefs we manage to get rid of, the more space we create for new insights. The respondent must feel that his/her words "hit the spot", that he is being heard and seen. In a phenomenological dialogue, there is no place for questions beginning with "why", as it is not intended to encourage explanations and interpretations. Its primary interest is "how". Of course, it is useful to have an idea about the cognitive categories which are to be addressed before starting the interview, but this is merely a plan B in case that the respondent loses track. If possible, the respondent should determine the direction of the interview and it is not unusual for the dialogue to stray into completely unexpected terrains.

It is imperative for the interviewer to be as skilled as possible in putting his/her expectations and desires into brackets. The goal of the dialogue is to gain deeper insight into experiencing. Experience shows that the dialogue might stray into a dead end as soon as the interviewer tries to become a therapist and "solve" some "problem". The hardest task for the interviewer is to preserve curiosity and to trust experiencing such as it shows itself in a given moment.

It is characteristic of the phenomenological dialogue to make use of the hermeneutic circle when delving into the fields of research. The interviewer and the respondent gradually become more skilled in observing and describing, thus they often touch upon the "same" topics. It is used as a research method helping us to describe the experiential world of the respondent. Such a description, the result of a longer series of dialogues, is also called a phenomenological case study. The result of such a study is a clear, explicit and systematic description of the experiential landscape of the researched person – without attempting any theoretical comparisons, classifications etc. Sometimes the result can be also a thorough insight into specifics of experiencing of a certain cognitive phenomenon.

The method

In autumn 2008 I started a phenomenological case study with a young man with the Gilles de la Tourette syndrome. It was he who came to me first, acting on the advice of his neurologist, mostly because he realised that talking about his experiences related to the Tourette pathology offered him great relief. My intention was to inquire as much as possible into experiencing related to decision making. With regard to the above mentioned facts on phenomenological dialogue, this was merely my plan B, of course. In our work I tried to adapt to the respondent's interests and put my own expectations into brackets which included my desire to find out more about the processes of decision making. Nevertheless, several insights or rather interesting experiential reports about the topic did emerge in the end.

I also gathered some experiential reports from other phenomenological dialogues I have been leading during the first few months in 2009. Since those dialogues were not focused to the topics of decision making, I only selected relevant segments of reports.

Virtually any phenomenological case study I carry out, starts with a couple of days of descriptive experience sampling (described briefly in the first section). Descriptive experience sampling offers a relatively smooth introduction to phenomenological research and easy learning of how to observe one's own experience. The DES method is relatively simple (the subject reports about his/her experiencing at random moments), nevertheless it can sometimes render surprisingly profound insights into experiencing. The data gathered with the help of this method resulted in several interesting findings about the experiencing of decision making.

When searching for reports about experiencing decision making in other phenomenological studies, I found the collection of cases collected by Russell Hurlburt to be most helpful. In his work he listed some typical categories of experiencing and also equipped them with video-cases of reports.

A PATCHWORK OF INSIGHTS

The patchwork of findings presented below is a more or less arbitrary collection of data from studies, not necessarily aimed exclusively at the present topic. A focused phenomenological study of decision making is thus still pending.

Decision making is connected to unsymbolized thinking

As mentioned above, the DES method aims to provide a kind of map of subject's experiencing. Its founder Russell Hurlburt and his collaborators have determined several dozens of categories describing the most characteristic elements of experiencing, for example categories such as *inner speech, sensation, just observing* etc. [10]. One of the more interesting categories is the one designated as *unsymbolized thinking*[2]. This is how Hurlburt describes this category: "*Unsymbolized thinking* is the experience of thinking some particular, definite thought without the awareness of that thought's being represented in words, images, or any other symbols" [10].

A striking feature is that approximately 80 % of reports Hurlburt listed in this category are connected to decision making or to processes in which subjects report about "weighing" different options. (These last ones are not necessarily decision making processes. E.g. "I was interested whether Joe will pick me up with his new car or not". But they are experientially very similar.)

As a rule, subjects studied experienced their thoughts in other ways as well (e.g. inner speech). Unsymbolized thinking therefore does not represent the only modality of their thinking. This begs the question if unsymbolized thinking is perhaps "reserved" for processes connected to decision making.

Free will

All my respondents report about the experience of free will. This observation is of course hardly enough to prove anything conclusive, as the sample is so negligible. Besides, there is always the possibility that the feeling of free will is culturally conditioned – that is to say, we might not get unified results if we researched this feeling in other cultures, for example the more community-oriented Asian societies.

But the sureness of all the reports I was able to gather is nevertheless indicative. Virtually all respondents gave reports about the feeling of freedom in their decisions without a shadow of a doubt. Such agreement in reports is extremely rare in researching subjectivity and therefore probably deserves some attention.

With this it is also interesting that in explaining our past decisions we very rarely tend to evoke our free will. As a rule, subjects explain their decisions as "necessary" results of given circumstances or their knowledge at the time of deciding. (This is related to the so-called attribution error – a phenomenon well-known to psychologists. Human beings are inclined to attribute other people's decisions to their free will, while our own decisions are often seen as inevitable.)

Reports on decision making depend on the world-view of the reporter

The conclusion that experience reports are culturally and socially conditioned is by no means surprising. Let me here mention an anecdotal example (not taken from any research, it was witnessed in a simple "just ask" situation; nevertheless it is quite to the point). When some colleagues from our interdisciplinary group for decision making research reported about how they decided to choose their desserts after a meal,

- the artificial intelligence expert reported that he decided which dessert to choose by inspecting the decision tree,
- the neuroscientist described his decision as "an undulating viscose liquid" in which at a certain point one wave (the desire for a given dessert) became strong enough to reach a certain perceptive threshold.

Both views appear to be a kind of a (metaphorical) report on how each reporter's home science perceives the process of decision making. This is partly because humans tend to take the metaphors we use from the array closest to our interests – this is the part which can be "neutralised" by a well executed phenomenological dialogue (and later analysis). But there is more to it.

This phenomenon is somewhat similar to the research of dreams which indicates that prior to the invention of colour TV in the vast majority of cases people reported about dreaming in black and white [11]. But ever since the appearance of films and TV in colour, most people tend to report that they dream in colour. As already mentioned, the conditioning of our experiencing by our cultural background is no surprise, but nevertheless it poses several crucial epistemological questions related to the definition of truth in experience research. I.e. what exactly is the difference between a world-view and the world itself. Such difference might be easy to define in the case of things belonging to the "outside" world, but how about reports of experiencing? Is there any difference at all between the next two claims?

1. The B&W generation used to dream in colour too, but people have problems remembering it (i.e. socially conditioned conceptions overshadow the "real" picture).
2. The B&W generation dreamt in black and white.

The principal problem lies in the fact that truth in experience research cannot be defined in the context of correspondence. For a given claim to correspond to outside facts there must be – outside facts. But what is supposed to correspond to what in the case of recalling experience?

After having conducted numerous experience researches, I have a feeling that the advantage of dialogical phenomenological methods is not so much in gaining new propositional knowledge about cognitive processes, but rather in reaching a balance between rational ideas (assumptions about "how it should be", ideals and values) and lived reality. The cases I referred to, demonstrate the extraordinary power of our conceptions: in many occasions they are able to interrupt our contact with the most basic experiential contents. They also indicate that one of the major tasks of thinking is actually to provide "excuses" for our behaviour (a fact neuroscience has been pointing out for quite some time now). But one can hardly say this tells us much about the phenomenon of decision making itself.

Decisions which will be carried out are experienced in a different way from the ones that will not

It appears that the destiny of the emerging decision is often known already during the process of decision making. The respondents report that they often experience decisions which will be carried out differently from the ones that will not be. They mention a "more fulfilling" feeling, a feeling that "this is the right thing to do", a feeling of fluidity, as opposed to the feeling of being "forced" into a decision or making one "off the top of one's head" or simply because they "knew this is the right thing to do".

Let me point out a difference between "feeling that this is the right thing to do" and "knowing that this is the right thing to do". In the second case, the decision is usually a result of rational knowledge about which of the two options (choices, ways of acting etc.) is the better one. E. g. "I will start doing regular exercise" (because I "know" that this is the right thing to do, the healthy thing to do, etc.). On the other hand we have the "feeling that this is the right thing to do" which is not necessarily related to rational arguments. Sometimes it even opposes them. Such feelings are usually described as being more fulfilling and the probability of actually carrying out the decision made according to them is much higher. The extreme case of such experiencing is the feeling of "it is so" - these are the experiences which reporters do not perceive as decision making at all, but merely as acting upon their knowledge about the circumstances. A good example is the report of a young man who in a certain moment "became aware" of the fact that he and his girlfriend "do not get along". This was experienced as an insight which dictated further action (breaking up). It pertains to the group of cases I mentioned above in describing the phenomenology of decision making: even though from the outside we could describe the young man's actions as an important decision, this is not how he experienced it at all.

From the philosophical, as well as from the phenomenological point-of-view, decision–making is clearly a very broad category – or rather a family – of experiencing (processes), the big question here being how much do the different members of this family actually have in common. There is a dramatic difference between deciding "when" (I will put a glass on the table, for example) and "how" (I will present an article in a conference – this being rather an act of creativity than one of making a decision), thus begging the question if the two processes are indeed members of the same family at all.

TWO MODALITIES OF DECISION MAKING

Phenomenological studies confirm the neurological findings that a very important role of reason is to block certain processes which might otherwise manifest themselves in actions. The majority of reporters mention that thinking takes up most of their experiential time (and space). Often its role in containing spontaneity becomes even stronger than necessary for normal functioning in social situations. In the context of our research, I had an interview with a Tourrette syndrome patient, whose experiencing was affected by characteristic mental vicious circles triggered by intrusive thoughts (an example being his report of how he thought he would have to kill his father if he left the shower – and as he could not stay in the shower forever, this led to an intense internal argument). Such complicated mental circles are not typical merely for pathological states, of course. Virtually anyone can at times experience them in their less emphatic varieties. A good example is a report of a respondent about weighing the options whether to visit the girlfriend he had a fight with earlier or not. He was able to find rational arguments to support each of the options. But even though at some stage it became clear to him that this balancing does not bring him any nearer to the solution, he was unable to resist the painful (and not entirely rational) pondering of the alternatives.

The solution finally emerged in the form of an impulse, when he suddenly "felt" that he had to visit her and did it at once (before a new mental circle could consolidate). In the case of the Tourrette patient such circles usually result in a semi-voluntary movement (a tick), which might also be seen as a kind of energization, strong enough to short-circuit the rational vicious circle for a couple of seconds.

This shows that a rational process is rarely, if ever, capable of tipping the scales to either side. In this point phenomenological research agrees with neuroscientific findings that a kind of energy surge is necessary to break the uncertainty crisis. In this light, one might see decision making as waiting or active searching for the impulse (energetization which reinforces one of the options so that it overpowers the others). The process of thinking appears more as an obstacle or as a cover for an entirely different process, one that is not rational at all. But contrary to the neuroscientific expectations, the impulse tipping the scales in most cases is not experienced as an emotion.

There have been reports about decision making strategies which are in accordance with the above mentioned insights. The famous cognitive scientist Max Velmans in a conference in Ratna Ling in 2009 recommended a strategy which included a reflection on all the predictable options, before – instead of getting caught in the circle of balancing – "switching" to an entirely different activity while at the same time waiting for the energetic impulse in the form of "knowing which choice is the best one".

Above mentioned leads to a question: What if the art of decision making lies in using our reason to "view" different alternatives and silencing it afterwards in order to allow some other part of us to make the choice in the end? Or rather, in learning to perceive non-rational impulses in certain moments and train our reason to allow for synchronised action in such moments (therefore, to give some kind of approval by giving an appropriate interpretation of the decision).

HOW TO CONTINUE (INITIATE) A SYSTEMATIC STUDY OF THE PHENOMENOLOGY OF DECISION MAKING?

This article can provide merely an introduction to the research area, bits and pieces which cannot bring us to any final conclusions. A real, wide-scope phenomenological study of decision making is still pending. But hopefuly, this can give us a sense of the potential of phenomenological decision making research. Here are some guidelines for future research that can be extracted from what we have learned so far:

- a more in-depth research of the experience of free will. If possible, on an intercultural scale,
- research of the modes of decision making. Probably this would be most effectively done by a prolonged DES study conducted long enough to gain sufficient samples about decision making.

Perhaps the most promising direction of phenomenological inquiry is researching correlations between different ways of experiencing decision making process and their outcome (will those decisions indeed be carried out or not).

REMARKS

[1]It is obvious that such research is problematic from the point-of-view of traditional science, which usually takes great pains to subtract anything unrepeatable, specific, or subjective from the phenomenon.

[2]Interesting because many believe it is not possible to think without experiencing symbols.

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FENOMENOLOGIJA ODLUČIVANJA

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SAŽETAK

U modernoj je kognitivnoj znanosti sve očitije kako nedostatak razumijevanja profila ljudskog iskustva vodi na gubitak značajnog elementa, možda i same srži. Slijedom navedenog, relativno novo područje istraživanja nedavno je razvijeno kao pokušaj sustavnog promatranja i istraživanja iskustva. To je tzv. *fenomenologijom inspirirano istraživanje* (ili *fenomenološko istraživanje*).

Dio ovog članka teži prezentiranju tog novog područja istraživanja te opisuje njegove osnove i neka svojstva metodoloških izvedenica, povezujući ih s mogućnosti proučavanja odlučivanja sa stajališta prvog lica, tj. odlučivanja kao pojave iskustva (a ne kao neurološkog, ili biheviorističkog procesa). Članak navodi neke rezultate do kojih su dovela fenomenološke studije i njima potaknuta teorijska promišljanja.

KLJUČNE RIJEČI

iskustvo, sticanje iskustva, fenomenologija, fenomenološka istraživanja, razlog, prvo lice

Interdisciplinary Description of Complex Systems 7(2), 78-89, 2009

DECISION MAKING: BETWEEN RATIONALITY AND REALITY

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Regular article *Received:* 15 November 2009. *Accepted:* 9 December 2009.

ABSTRACT

Almost by definition decision-making is typical human activity, and therefore important psychological subject. The starting point of its classical conception within psychology could be traced back to economy and mathematic, with ideas of human as rational economic being, and conceptualising decision making as choice between two or more alternatives, and as such being a separate event in space and time. Already in fifties Herbert Simon challenged such a view with his concept of bounded rationality, emerging from the joint effect of internal limitations of the human mind, and the structure of external environments in which the mind operates. During the last decades with the shift to the real word situations where decisions are embedded in larger tasks, becoming so part of the study of action, the lost rational human appeared again as efficient creature in the complex environment. Gigerenzer showed how heuristics help in this process.

KEY WORDS

bounded rationality, decision making, heuristics, macro cognition, naturalistic decision making

CLASSIFICATION

APA: 2340 Cognitive Processes

JEL: D83, D84, Z19

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INTRODUCTORY OVERVIEW

Decisions are regular part of human everyday life and they strongly influence either life of individuals, or even the lives of many others, depending on the position of decision maker. Understanding of the decision-making processes could help us in preventing bad decisions and in stimulating the good ones. Nevertheless there are many factors that influence decisions and we do not know each one or the totality of their relationships. At the same time decision-making processes are – due to their complexity – approached from different points of view, even inside particular science. Therefore this presentation will be incomplete. It will be focused mainly on the contemporary decision making theories appearing inside psychology, as they are offering quite different view of the matter in comparison with the classical ones. Their understanding of decision-making is more realistic, they are not demanding humans to be either a computer or incompetent irrational creature. Yet development is traceable, from concept of economic rational being, through bounded rationality to the theories of naturalistic decision making.

Montague (after [6; p.72]) believe that moving organisms need inner model of the world regarding value attribution, to be able to choose and classify the goals. To decide about relevant behaviour nervous system must assess value of every possible action, transform them into joint scale and based on it decide about activity. The question is only if assessment of *every* action is really necessary, what argues classical approaches but reject some of the naturalistic approaches, following that joint scale is also disputable. Is therefore only one mechanism for the assessment of different kinds of stimuli necessary, and if it is, how it is working?

Although research work on decision-making has long history in economy and philosophy, thorough research work is connected to the end of the Second World War, when in statistics and economy influential theories about rational decision-making appeared. Classical decision theories were based on the principle of *optimization* developed by well known mathematician and pioneer of modern computer science John von Neumann and economist Oskar Morgenstern in the book *Game theory and economic behaviour*. Psychology took over these economic and mathematical theories of decision making and based on them formed its decision-making models, and tested them experimentally. As an empirical science, it could not take them for granted. Very soon it appeared that regarding the criteria of these models humans are very bad decision makers. But let us overview the main phases in the development of psychological views on decision-making. After Collyer and Malecki [7; p.6] in the development of decision-making theories we could distinguish three periods:

- *rational decision making models.* Models based on rational choice and behaviour, (e.g. SEU, multiattribute utility theory, Bayesian inference models) prevailed during the period between 1955 and 1975. Within these approaches decision problems were decomposed into their elements so that the choices, the uncertainties and the outcomes were explicitly given,
- *descriptive models.* Stemming from the rational models descriptive ones argue that humans usually do not make decisions in this way and regarded deviations from the prescribed procedures as *heuristics* and deviations from the correct responses as *biases*. This approach was compelling during the period between 1965 and 1985. Herbert Simon [1] with his influential concept of *bounded rationality* was pioneer of this way of thinking,
- *decision models in natural settings.* This approach starting in 1980s is offering quite different emphasizes, and moved research from laboratory into dynamic natural settings, from naive to the expert decision makers and from the decision events to the real processes, to the greater tasks of which decisions are part. Decision-making is not devoted

to itself but is serving achievement of a wider goal. Therefore studying decision-making means studying the activity and not studying the choice.

Also the contemporary findings about *situation awareness* (SA) as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" [8; p.5] should be taken into account. All these approaches by their very nature emphasize the meaning of expertise. During the last years the field of naturalistic decision making and related concepts were classified under the concept of macro *cognition* [9], presenting a broader frame for macro operational situations characterised by the need for decision making during the tasks, like setting the goals, fault management, and planning, i.e. the role of cognition in real tasks, in interaction with the environment. As Schraagen et al. [9; p.9] believe, it is about 'the study of cognitive adaptations to complexity'. And really, the failure of classical decision making models stem from their neglect of complexity on one side, and emphasize of abstract rationality on the other.

SOME HISTORICAL REMARKS

The majority of the classical decision making theories stemmed from economy, statistics and philosophy. Psychologists only adopted them as long as they did not make theories of their own. Therefore these first theories reflected the economic perspective. Between early decision making models prevailed model of economic human, assuming that decision makers are (after [10; p.481]) (1) fully informed regarding all possible options for their decisions and of all possible outcomes of their decision options, (2) infinitely sensitive to the subtle distinctions among decision options, and (3) fully rational in regard to their choice of options. Very soon deficiencies of this approach became evident and correction in the form of Subjective *Expected Utility* (SEU) appeared, taking into account psychological aspects too. The goal of human activity is the search for pleasure and avoidance of pain. During decision-making people try to maximize satisfaction (positive utility) and minimize dissatisfaction (negative utility). In this process they apply *subjective utility* (based on individual judgment of utility and not on objective criteria) and *subjective probability* (based on individual judgment of probability and not on objective calculations). People then calculate subjective probability of each subjective positive utility for each option and subtract subjective probability of each subjective negative utility and make decision on this base. The prediction of the optimal decision for the given individual is based on the belief that people want to make rational decision taking into account all known options, using maximal quantity of available information, careful, although subjective, weighting of the potential costs and benefits, careful, although subjective, calculation of the probability of different outcomes, and the maximum degree of sound reasoning. Although SEU is taking into account subjective variables as well, human decision making is much more complex, and people are not deciding like computers, measuring and weighting different utilities and probabilities either objectively or subjectively.

Nevertheless already in 1950s some psychologists challenge the concept of unbounded rationality. American psychologist and economist Herbert Simon in his papers published in 1955 and 1956 introduced the concept of bounded *rationality* [6, 10]. He believed that people are not necessary irrational, but they show bounded rationality. Namely our world is too complex to be understood in its totality, and therefore people form its simplified model, and behave according to it, using heuristics as a kind of mental shortcuts. According to Simon people use strategy of *satisficing*. They do not take into account all options and do not calculate which ones will give the greatest benefit and the smallest loss. They consider options one after the other and choose the first one that satisfies, i.e. meets the lowest level of acceptability. They consider the smaller number of options in forming the decision.

Simon (after [11; p.4]) uses the metaphor of a pair of scissors, where one blade represents cognitive limitations of actual humans and the other the structure of the environment. Bounded minds can nevertheless be successful using structures in the environment, or in Simon's words (after [11; p.4]) "a great deal can be learned about rational decision making... by taking account of the fact that the environments to which it must adapt possess properties that permit further simplification of its choice mechanisms". The model, believe Gigerenzer, describes how the decision is reached (heuristic processes) and not only its outcomes and the class of environments in which these heuristics will be un/successful. Bounded rationality is neither optimization, neither optimization under constraints or irrationality. As Gigerenzer and Selten [11; p.8] believe, the bounded rationality is about 'step-by-step rules that function well under the constraints of limited search, knowledge, and time, whether or not an optimal procedure is available'. The repertoire of these rules or heuristics they called 'adaptive toolbox', which is (1) collection of rules (heuristics) and not general-purpose decision-making algorithm, (2) heuristics are fast, frugal, and computationally cheap, rather than consistent, coherent, and general, (3) heuristics are adapted to particular environments, where this *ecological rationality*, i.e. match between the structure of a heuristic and the structure of an environment allows just mentioned characteristics of heuristics, and (4) the bundle of heuristics in the adaptive toolbox is coordinated by some not well understood mechanism reflecting the importance of conflicting motivations and goals.

Kahneman and Tversky [12] – following Herbert Simon – link attitudes toward risk with the nature of outcomes (gain or loss) and the size of probability. Their *prospect theory* represent psychological variant of the SEU theory [6]. Decision-making begins with structuring of the decision problem, which simplifies subsequent evaluation and choice. Coding of possible outcomes as gains or losses relative to some reference point (usually status quo, but also an expectation or an aspiration) is important. The nature of the reference point, i.e. evaluation of the outcome, is affected also by the description of the problem, subsumed under the concept of *framing*. Value function is different for gains and for losses (Figure 1).

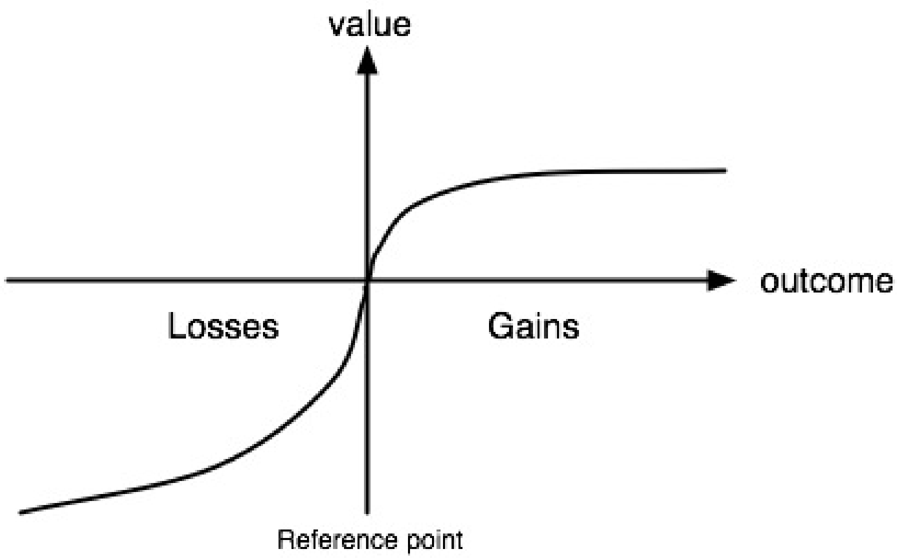

Figure 1. Hypothetical value function as proposed by Kahneman and Tversky prospect theory. Function is convex and relatively steep for losses and concave and gradual for gains (taken from http://en.wikipedia.org/wiki/File:Valuefun.jpg, after [13]). Value is similar to utility, only it is evaluated regarding the reference point.

Decision problem is determined with acts or choices, their possible outcomes or consequences and links or conditional probabilities that connect outcomes with acts. *Decision frame* is about decision-makers conceptualization of the acts, outcomes, and dependencies connected with particular choice [13]. This is the context of choice or different possible models of the world in the Simon's sense. The frame is determined on one side with the formulation of the problem, and on the other with norms, habits, and personal characteristics of the decision maker. This means that particular decision problem could be framed in different ways. Different frames reminds on different views of the scene. Reliable perception demands that relative heights of two neighbouring trees would not change depending on direction of viewing. Similar demand holds also for the rational choice: choice preference should not change with the frame change. But with people – because of the imperfection of the senses and decision processes – both is occurring. With the change of the acts, links or outcome frames, we could systematically change their preferences.

Decision context does not influence only the values of choices, but also the values of outcomes, e.g. the amounts expressed as gains or losses. If choices are framed in such a way that reference point is low on the scale of values, the gain will be greater in comparison with high positioned reference point. Fifty Euros is a lot for poor and a little for rich.

Framing effect contradict the invariance axiom of the utility theory, which demands that wording should not influence deciding, because preferences should be defined only with outcomes and connected probabilities, while because of framing effect different coding of outcomes (as gains or losses) change the outcomes assessment. This is evident in the famous Kahneman and Tversky task regarding efficacy of the health programmes expressed either as a number of survivors or as a number of victims. It seems that negative frames demand greater degree of cognitive processing and have longer response times [6].

NATURALISTIC DECISION MAKING

Main research work in the field of the so called *naturalistic decision making* was going on mainly in the frame of the crisis events and radically change the view of the nature of crisis decision making. It is not by chance, that US Army devoted a lot of resources and time to the study of these questions, e.g. in the project TADMUS (*Tactical Decision Making Under Stress*). Many bad decisions whose outcomes count in human lives demand this. Up to then decision-making researches study only one segment of the decision-making, the decision event. Main part of the decision making should be going on when decision maker (usually one person) overview known and defined set of choices, weight probable consequences of particular choice and then select one, depending on his goals and values, which should be stable and known. Researchers focused on the selection process of the best alternative. Involved participants were usually inexperienced, e.g. students. But then psychology went out of the laboratory in the real life, joined firemen, police officers, medical staff, etc. that is experienced participants. Quite different image of the decision making appeared. Classical decision-making models were not adequately describing the situation. Decision makers focused on the definition of the situation, and on the base of their experience in similar previous events, while taking into account constraints of the given situation, choose the most adequate response. Possible responses were assessed on the base of the projection of their possible consequences into the future and search for the possible unwanted effects. If unwanted effects were not predicted, the response was selected. This new approach differs at least in three ways from the classical one, which emphasizes simultaneous assessment of a number of alternatives, being based on analytical methods of values and probabilities connection, and was searching for the optimal solution [3]:

- decision maker pays his attention mostly to *situation assessment* or to the discovering of the nature of the problem,
- particular alternatives are judged successively with the help of *mental simulation* of outcomes, and
- alternative is accepted if it is satisfying (not necessary optimal).

Fundamental difference lie in the fact that in everyday situations *decisions are the part of the larger tasks*, which decision maker try to accomplish. In the laboratories decision-making was going on outside the meaningful connections, while in reality it is the mean of achieving the wider goals. Decisions are the part of the broader tasks consisting of the problem definition, understanding of meaningful solutions, acting for goals achievement, and effects assessments. As one of the researchers said [2], studying decision-making in dynamic, real time context changes it into the part *of the study of action,* and not study of choice. Decision making is the matter of guiding and maintaining the continuous flow of behaviour directed toward the set of goals and not the set of separated events of choice dilemmas. Decision-making in reality is a joint function of two factors [3]:

- task characteristics, and
- individual's knowledge and experience relevant for the task.

Decision-making is often going on in stressful conditions. Stress is caused mainly by the following characteristics of the situations, called stressors [14]:

- multiple information sources,
- incomplete, conflicting information,
- rapidly changing, evolving scenarios,
- requirements for team coordination,
- adverse physical conditions,
- performance pressure,
- time pressure,
- high work/information load,
- auditory overload/interference,
- threat.

They represent important factors and conditions in decision-making, which often determine the nature of decision, consequent behaviours and their outcomes.

SITUATION AWARENESS (SA)

Mica Endsley [15], leading expert in planning, developing and assessing systems in support of SA and decision-making, is discovering new ways and understanding of human decision-making and action. Evidently field has SA and decision-making in natural environments complement and stimulate each other. Behind their development stand also Herbert Simon's conceptions of bounded rationality, heuristics, etc. This is evident from the starting idea that contemporary technical systems offer more information than is needed and that the needed one is hard to discover (Figure 2). Therefore, the system is too complex and should be simplified to be able to master it.

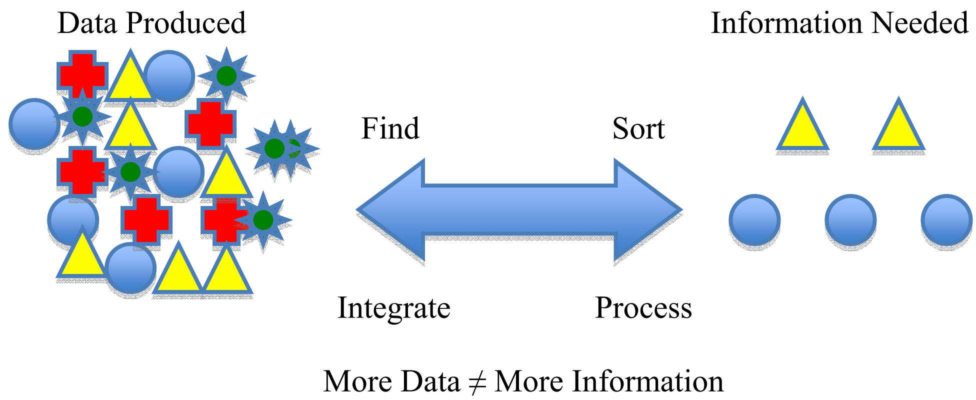

Figure 2. The Information Gap [8].

Need for the solution of practical decision problems leads to this development. Contemporary systems should not only provide needed information but it must be cognitively and physically usable. SA simply means that we know what is going on around us, and are able to select important information from the surrounding, what enable somebody to make decisions. SA depends on tasks and goals demanded by certain work or activity.

Mica Endsley [8] believe that elements of SA differ depending on the field, but its nature and mechanisms could be described generically. Three levels of SA could be distinguished (Figure 3), the first one referring to the cues perception. Without perception of the important information our image of the situation would be incomplete or false. Endsley [8] indicate that 76 % of the pilot errors appeared because of the problems with perception of the important

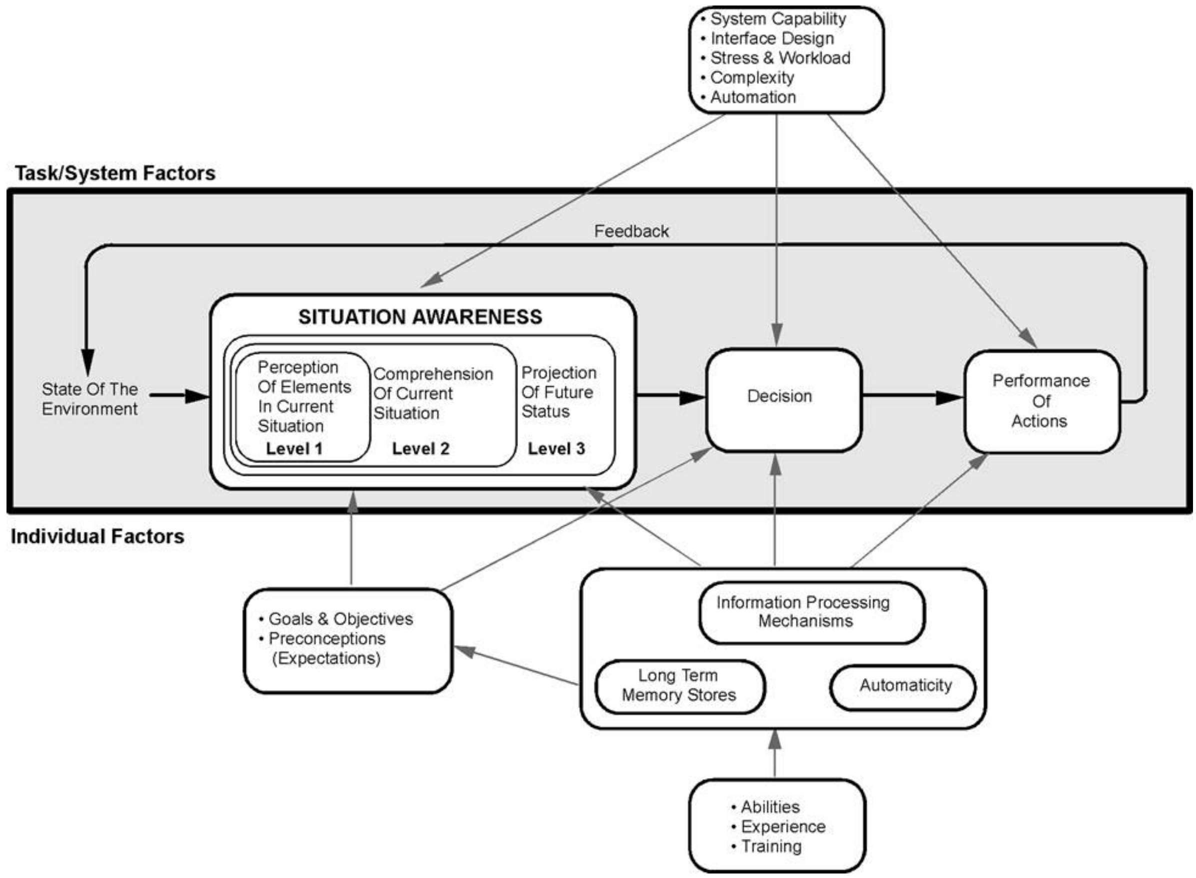

Figure 3. Model of Situation Awareness (SA) in Dynamic Decision Making [8].

information. Yet SA construct exceeds mere perception and take into account how human combine, interpret, store and retain information. It is necessary to integrate multiple pieces of information and determine their relevance for the person's goals. But this is not the end of the story. On the highest level of SA, the ability to forecast future events and dynamics is taking place. Only this enables relevant decision-making. SA is certain internal model of the state of the environment and based on it humans decide what to do about the situation. SA depends on the limitations of the working memory and attention. Use of the attention in the complex environment offering multitude of competing cues is critical for determination of those aspects of the situation that will become the content of SA.

INTUITION: MIRACLE OR EXPERTISE

The term *intuition* (from lat. *intueri*, meaning *to look inside* or *to contemplate*) is quite often used in everyday life, but the majority of people would hardly define it precisely. We know something and believe that it is correct, that the consequential decision will be the right one, but we do not know neither why nor how. Corsini's [16] psychological dictionary define intuition as 'Immediate insight or perception as contrasted with reasoning or reflection. Intuitions appear to be products of feeling, minimal sense impressions, or unconscious forces rather than deliberate judgment.' Herbert Simon [1] uses the term in the sense of a belief, judgment or decision arrived at by the process of recognizing cues in the surrounding situation, and using them to access information already stored in long-term memory. It permits problem solving without awareness or with incomplete awareness of the solution process. Also contemporary considerations go in this direction. Without doubt intuition is mental process. Input into this process is given by the knowledge stored in the long-term memory, acquired mainly with associative learning. Input is processed automatically and unconsciously. Output of the process is the *feeling*, that could serve as the basis for the judgment and decision making [17]. Klein [4] too, is linking intuition with experience that enables humans' recognition of situation (judgment) and necessary reactions (decision making). Therefore decisions are fast and without conscious effort.

Nobel prize winner for 2002 Daniel Kahneman in his prize lecture devoted a lot of attention just to intuition. In his paper, he said that he and his close co-worker Amos Tversky were guided by the idea, that intuitive judgments take place between the automatic operations of perception and deliberate operations of reasoning. Dual system approach distinguishes intuition from reasoning (Figure 4).

Working of the intuition is fast, automatic, effortless, associative and is hard to control or modificate. Reasoning is slow, serial, effortful and controlled, relatively flexible and rule-governed. Working characteristics of System 1 are very similar to perception. Working of both systems is not limited to stimuli processing. Intuitive judgments too are dealing with concepts as well as stimuli and could be evoked by language. Perception system and intuitive operations generate impressions of the objects of perception and thinking, which are not voluntary and explicitly verbal. Contrary to this, judgments are always explicit and deliberate, irrespective of explicitness of their expression. System 2 is included into all judgments irrespective of their source (from impressions or from deliberate reasoning). Intuition refers to judgments that directly express impressions, while System 2 is controlling the quality of both mental operations and behaviour. The control is not rigorous.

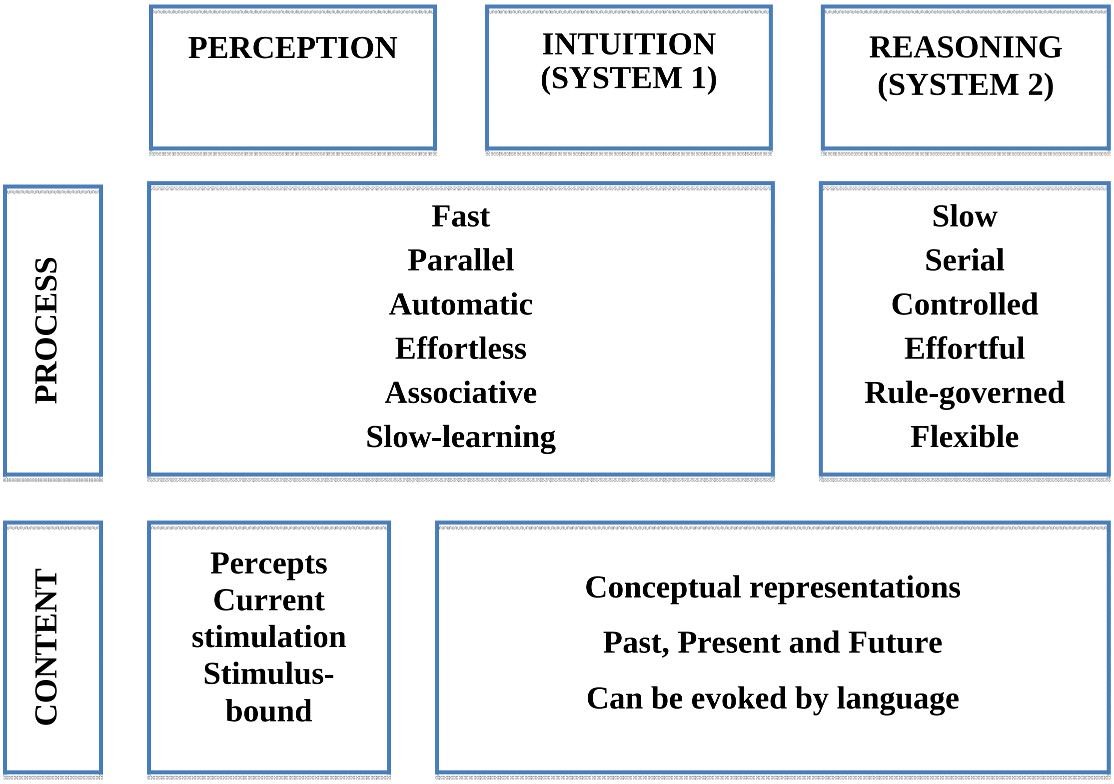

Figure 4. Kahneman and Tversky dual system view of cognition [18].

Therefore two kinds of cognition exist, intuitive and analytical, where the first is subconscious and the second conscious. Betch [17; p.4] believe that intuition is a process of thinking, the input to which is mostly knowledge stored in long-term memory and acquired mainly via associative learning. The input is processed automatically and subconsciously, thus differing from the deliberate processes of thinking. The output of the process is a feeling that can serve as a basis for judgments and decisions. Intuition is therefore based on previous knowledge and is not consequence of certain innate factors (is not instinct or reflex). Key difference between rehearsal and intuition is that the output of the former is a mental representation of an entity, whereas the latter is a feeling toward it, which serves as the basis for decision. While higher order processes of thinking determined with the limitations of attention and memory capacity and are focusing on information serially, the automatic processes are considering it simultaneously. Due to parallel processing intuition is capable of processing a great amount of data. Findings of the neuropsychological studies, especially of parallel distributed processing, support this possibility. Experience provides the organisms with a rich database on which intuition could reveal its power. Intuition could offer highly accurate judgments and decisions if the prior sample of experiences is representative for the current task [17]. It was already mentioned that Herbert Simon reveals the true nature of intuition, but close link between intuition and his concept of bounded rationality, otherwise related to conscious thinking, should be added. Within bounded rationality people help themselves with heuristics that simplify decision tasks. Betch [17] classify heuristics into the field of deliberate thinking that is into system 2 in Kahneman's [18] model, because they are mostly based on the reflection, and are therefore shortcuts to consideration and not intuitive strategies. Remember that Kahneman [18] linked availability heuristic with intuition. But both kinds of processes (automatic and deliberate) as a rule are acting simultaneously and jointly shape the thinking and acting. We could agree with Betch [17] that neither kind of thinking exists in pure form.

Deliberate, conscious processing does not enable fast and complete decisions, enabled by intuition. Epstein [19] goes even into more detailed picture of both ways of thinking, and connects them with his cognitive-experiential self-theory. People are using two cognitive systems, *experiential* system (nonverbal automatic learning system) and *rational* system (verbal system of reasoning), referring to intuition and conscious thinking.

Systems are equivalent and strengths of one are limitations of the other. Experiential system is directing everyday behaviour and can solve problems that are beyond the capacity of the rational system, because they required holistic and not analytic approach [19]. According to Epstein [19], people without experiential system would be like robots with computer in a head. Rational system understand experiential one, while the opposite does not hold. Because the experiential system is reacting faster, the starting response to the situation is experiential. If rational system recognize starting response tendency as inadequate it represses or adapts it.

Gary Klein's [4] understanding of intuition, relatively more concrete and connected to decision making in crisis will be presented too (Figure 5).

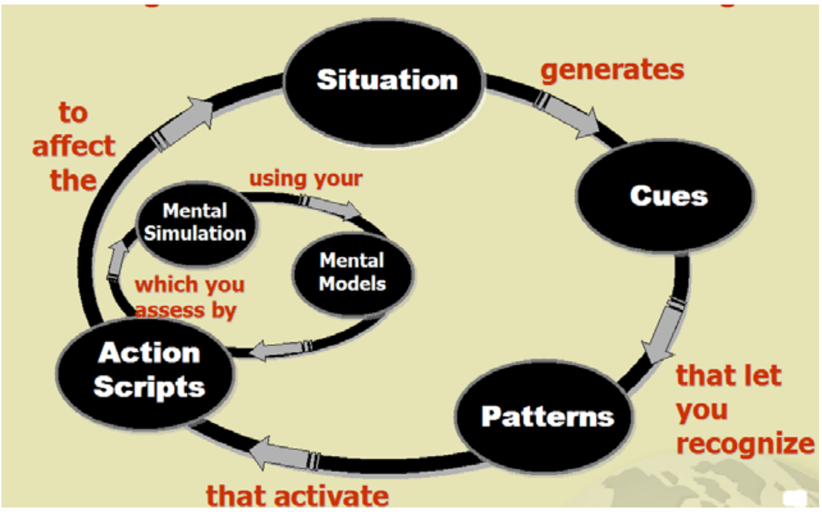

Figure 5. Klein's [4] model of recognition primed decision-making.

According to his theory expert decision makers judge the situation on the base of comparison with the similar, already experienced situations. In this way they choose relevant activity for the situation. Confronted with new situation, decision makers use memory of some previous situation and create trial representation of the new situation. The representations interpret perceived data, forms expectations about the future activities and define limitations of those situation characteristics that perhaps would not be perceived. Situation representation is constantly tested with the new data. Those in accordance with it are confirming it for the prediction of future events and for the reasoning about non-perceived event characteristics. Discordant data may either improve representation or show that it must be entirely changed. Klein [4] called this process *recognition primed decision-making.*

On the base of repeating experience intuition enable unconscious connection of the cues into pattern. Pattern is multitude of cues that usually appear together, so that if some are perceived, others could be expected. More patterns that we know, it is easier to connect the new situation with one of them. During the appearance, the new situation is recognized as known on the base of comparison with known patterns. Because pattern match is going on fast and without the conscious effort, people are not aware how they reach intuitive judgment.

CONCLUSION

Decision making as one of the most characteristic human mental activity is shown to us – or better studies and thinking about it are showing this – as a very complex phenomenon. The image of the human decision maker is circling between irrationality and bounded rationality. If classical models of rational (economic) human took him from time and space, and put him with his decision making, that should be rational, but was not, into certain abstract frozen space, with the development of knowledge he is gradually coming back, to find himself in the theories of naturalistic decision making. The image of the alive concrete human, adapted to his environment, is exchanging its artificial abstract image.

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ODLUČIVANJE: IZMEĐU RACIONALNOSTI I STVARNOSTI

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SAŽETAK

Gotovo prema definiciji, odlučivanje je tipična ljudska aktivnost, a time i značajna za psihologiju. Polazište njene klasične koncepcije u okviru psihologije može se pratiti do izvorišta u ekonomiji i matematici te pripadnim idejama o ljudima kao racionalnim ekonomskim bićima. Pritom, odlučivanje je konceptualizirano kao izbor između dvije ili više mogućnosti te je kao takvo izdvojeni događaj u prostoru i vremenu. Još u pedesetim godinama XX. stoljeća Herbert Simon je preispitivao takvo gledište sa stajališta svog koncepta vezane racionalnosti. Taj koncept izvire iz zajedničkog učinka unutarnjih ograničenja ljudske misli i strukture vanjske okoline u kojoj ljudska misao djeluje. Tijekom zadnjeg desetljeća i stavljenog težišta na situacije u stvarnom svijetu u kojemu su odluke uklopljene u veće zadatke, čime odlučivanje postaje dio proučavanja djelovanja, zagubljeni racionalni čovjek javlja se iznova kao učinkovito biće u kompleksnoj okolini. Gigerenzer je pokazao kako heuristika pomaže u tom procesu.

KLJUČNE RIJEČI

vezana racionalnost, odlučivanje, heuristika, makro kognicija, naturalističko odlučivanje

Interdisciplinary Description of Complex Systems 7(2), 90-105, 2009

COLLECTIVE DECISION MAKING AS THE ACTUALIZATION OF DECISION POTENTIAL

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Regular article *Received:* 5 November 2009. *Accepted:* 9 December 2009.

ABSTRACT

This paper presents some characteristics and dilemmas of collective decision making. Collective decision making could be presented as the process of successive crystallization of dominant alternatives under the influence of different decision contexts from primary given decision potentials. This process is presented as the many-phased process of the acting of contextually dependent "energizing factors" of the collective decision making on the "attractiveness matrix" of outcomes of collective decisions. The attractiveness matrix determines the attractiveness for each alternative of decision, and the most attractive alternative in the given situation presents the rational decision in the given situation. In the final phase of decision making holds a context which gets a simplified attractiveness matrix. It corresponds to the common decision for one of the alternatives.

KEY WORDS

collective decision making, rationality, decision potential, joint outcomes, energizing

CLASSIFICATION

APA: 3020 Group & Interpersonal Processes

JEL: D79, D83

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DECISION MAKING AND RATIONALITY

Decision making is understood here as the process and act of making a choice by agents (individuals, groups, institutions) among many possible courses of action, evaluation, feeling, and thinking in a given situation. Decision making as an act can be entirely "mental" or it may also be physical, i.e. expressed in the external environment. Decision making can help us reduce the complexity of a situation and bring down its associated doubts and uncertainties to a manageable level. It is an act which (usually) leads to another act, for example the execution of one of the alternative actions. Very few decisions can be made with maximal certainty. Thus the majority of decisions merely reduce the complexity of a situation or problem: the problem is not completely eliminated or fully resolved. This is because agents only rarely possess perfect knowledge about all alternatives and possible results, and likewise they also do not have entirely clear and uniform preferences (desires, interests, needs). For this reason decision making normally contains elements of uncertainty and risk. Experience as well as scientific research show that these uncertainties are fewer if our thoughts and decisions take place based on "sound reasons" and not *ad hoc*, by chance, under the pressure of circumstances, and so on. In this sense *rational decisions* are exceptionally important, i.e. decisions that are based on good, appropriate, and sufficient reasons. But what these reasons are and how we arrive at them and at rational decisions is a difficult and unresolved question.

1. In this text I take *rationality* to mean *the ability to think or act on the basis of reasons which can stand up to criticism.*[1]
2. Under "thinking" I include an extensive field of human cognitive processes to which we may give propositional content, i.e. content expressed in the form of propositions. Under "acting" I include behavior to which we can ascribe teleologicality.

Research on the rationality of decisions is important because it can improve the so-called intuitive decision making of individuals or groups. This is a process of searching for mental or practical options which evoke the optimal intellectual and emotional responses of agents in a decision making situation. Although intuitive decision making can frequently be rapid and it is accompanied by feelings of satisfaction and strong motivation for the realization of the decisions taken, it can also mislead, since agents may not take sufficiently into account all the alternatives and in this way may they may miss a better solution to the problem. Intuitive decision making frequently overlooks important factual information, and it is powerfully influenced by the prejudices, feelings, and desires of agents. Intuitive group decision making is particularly prone to numerous psychological pressures such as the pressure to achieve the greatest consensus in a group (the phenomenon of "groupthink"), overlooking critical information [3].

Evaluating the rationality of decision making is frequently quite complex, since we must take into account a whole range of cognitive and contextual factors. For this reason in practice we often simplify things by, for example, taking as the norm of rationality a certain idealized model of rational decision making. Among such models are, for example, logical models of problem solving, the classical model of rational choice, models from game theory and models of practical reasoning. These models contain some fundamental idealizations such as the assumption of logical coherence of the beliefs of agents, the assumption that in their decisions they always strive for the maximization of expected utilities, the assumption of the perfection of comparisons among possible choices (for any choice we can say that one is more attractive than another or that we do not give priority to any among them), the transitivity of choices (if an agent prefers choice A over choice B and prefers choice B over choice C, then she will prefer A over C), the assumption that rational agents follow the basic principles of logic and the theory of probability, etc. [4, 5; p.261-277]. These models further assume that people make decisions based on the expected benefits offered by individual alternatives of action and with respect to preferences among choices, that they are capable of "calculating" the benefits (and costs) for each of the choices, and that in this way they maximize their benefit.

According to this model of decision making, among several alternative possibilities we select the alternative which has the greatest expected benefit with respect to the other alternatives, i.e. the greatest sum $u_1p_1 + u_2p_2 + ... + u_mp_m$, where u_i is expected benefit (or utility) and p_i the expected probability of i-th outcome of decision making for the given alternative. I do not think this terminology is the most suitable, since the given sum represents more the *degree of attractiveness* (or simply *attractiveness*) of the alternative, not the expected benefit, since only individual outcomes can be beneficial in the light of the decision for the given alternative, and not the alternative itself. The product u_ip_i represents the *attractiveness of the outcome* for the agent in his decision making for the given alternative.

In seeking a rational decision we identify the expected benefits for all alternatives and then look for the alternative with the highest expected benefit. This represents the rational decision in the given circumstances. To the extent that this concerns a choice in social situations where our choice is dependent on the choices of other persons, we must then utilize the concept of *strategic game*, which is usually (though not always) a group situation in which participants on the basis of familiarity with their own preferences and assumptions about the preferences of their "co-players," and assuming the rationality and knowledge of co-players, select a strategy of action in such a way as to achieve with the greatest probability the maximization of the result for themselves (i.e. realizing the greatest number of their preferences and *eo ipso* minimizing possible "costs" or "losses.").

It is well known that idealized models and methods of rational decision making are not sure, since empirical research on decision making shows that they set measures of rationality which are too high, and people frequently diverge from them, even in cases of relatively elementary forms of deduction or probability reasoning. Our preferences are rarely as coherent as that required by the classical model of rational decision making. Moreover, we usually do not act as "rational egoists", that is, as persons who maximize (only) their own benefit. Many researchers have drawn attention to these facts; hence these findings have become generally accepted in modern studies of rationality, [6 – 9].

In discussions of the connections between everyday thinking and rationality, concepts have been developed of bounded and embodied rationality, which attempt to determine the optimal (if not the ideally maximal) means of problem solving and decision making under certain conditions, in which our cognitive limitations, the characteristics of the environment, the problems which people try to solve, and the architecture of human cognition are taken into account, [10 – 13]. From this perspective criticism of certain thoughts, decisions, and acts is possible as to whether they are rational or not, or even irrational, but at the same time it is also possible to explain the action, which does not imply indirect justification of the action.

A somewhat different direction of thought is one that introduces two or more kinds of rationality or systems of thought in which not all errors in thinking and decision making can be explained by means of accidental errors in thinking or by means of computational limits to the human cognitive apparatus. It seems reasonable to infer systemic sources of these errors, though this does not eliminate rationality in general[2].

COLLLECTIVE DECISION MAKING

When I refer to collective decision making, I limit the discussion to relatively small, informal groups, and exclude a discussion of the rationality of large collectives or institutions. I accept this limitation first of all due to the limited scope of the discussion and secondly because an analysis of decision making in relatively small, informal groups is of crucial importance for all collective decision making, since many features of collective cognition in small groups are "inherited" in larger and more formally constituted groups. Similarly, I limit this paper to only those characteristics of cognitive processes in groups which can be captured in the repertory of modern cognitive science and for which we can for example find heuristic computer models.

At first glance we may assume that the interaction of individuals who strive towards rational decisions would as a rule lead to rational collective decisions. Although this is often the case (for example the operation of the market under conditions where there are no major disturbances in the flows of labor, goods, and money), we know from everyday practice as well as scientific observation of the functioning of groups that this is not always so. Some examples of this type are standard dilemmas of individual decision making in a collective context and they are often formally treated using game theory.

These problems belong in the wider set of *problems of collective action*. John Elster notes that a group encounters a problem of collective action when it is better for everyone if some of its members participate in an action than if no one participates, but it is better for each individual to not participate, [17; p.126]. It is interesting that people often solve these problems without excessive complications. Experiments with real people in real situations of a similar type have shown that people are more cooperative and more successful in cooperation than indicated by various theories of individual rationality. Strictly speaking, according to these theories cooperation among people is often not even possible simply because it is an irrational behavior. Experiments and computer simulations on strategic game behavior have shown that cooperation increases if the "games" continue (and it is not specified when the repetitions will end), or if the actors know their partners and have cooperated with them on other occasions, [18]. Roughly speaking, the following holds: the more cooperation there was in the past, the more we can expect in future.

In his well known work "The Logic of Collective Action" [19], Mancur Olson noted that people generally cooperate in order to provide some common good when *they work in relatively small groups and members can expect a clear benefit from cooperation*, or if *members are required to cooperate* or if there exist *particular incentives for cooperation*. The organization of a group can contribute to the greater cooperation of its members, but not necessarily. Organization is essential in large groups, where the contributions of individual members are not at all evident to others ("anonymity of cooperation"). Elster's view is that it is a mistake to assume that we cooperate purely due to our own interests, or that we are always driven by some particular motive. Different motivations of individuals, which may be rational or non-rational, are connected to one another in groups, and reinforce one another [17; p.397].

In many instances of cooperation there is a need to coordinate the actions of many individuals. For this reason decision making for cooperation takes place under the tacit or explicit assumption that others are prepared to coordinate their actions with other individuals. Such for example is decision making for a trip taken together, a dance with a partner, playing music in a band, cooperating in some group game, and even for such simple things as decision making for a walk together in the park. Here people rely on a *joint* assumption of all those involved in cooperating: that each among them will strive to fairly perform their part of the joint activity. All further decisions of the members of the group then take place alongside this tacit assumption. If we tried to establish the thinking of the agents as some sort of practical conclusion, then we would have to make a *joint* practical conclusion for all participants with several premises which sum up their particular mutually coordinated aims and means of action and a *common rule of rationality*, which alongside the given premises would necessarily require the execution of the decision on the mutually coordinated action of all agents[3].

This would exceed the scope of so-called methodological individualism in explanations of collective actions and decisions.

THE CRYSTALLIZATION OF COLLECTIVE DECISIONS

It seems that we must assume a process of gradual or rapid crystallization of the mutually coordinated rational decisions of individual actors in collective decision making, which clashes with schemes of rational decision making by individuals (with either "perfect" or "limited" rationality). The concept of gradual crystallization of rational common solutions, rules, and norms is reminiscent of the concept of *focal points*, which is the topic of much discussion by game and rationality theorists. This is the explanation of the finding by Thomas Schelling: that people coordinate their behavior in such a way that all benefit, even though they do not have any explicit shared beliefs or perceptions which would lead them to coordination [21]. But there exist certain implicit guidelines for coordination, which in a given situation are salient. These guidelines are called "focal points of coordination."

I assume that the *extent and quality of reasons and arguments* for various assertions or decisions which members of the group put into "circulation" and the mutual attachment of these reasons contribute significantly to the crystallization of collective decisions. Some arguments in the flow of discussion contribute more to guiding the discussion towards a possible solution of the problem, while others express the "mood" and give the discussion a special feeling of, for instance, "energizing" the discussion. For a successful decision or series of decisions that lead to the solution of a problem, both elements are needed: "the right direction" as well as adequate "energy".[4]

This can happen through a series of opposing viewpoints and arguments which continues until no one has anything more to add, or it comes to an end due to time limits, or it is an explicitly collaborative discussion in which each person strives to support a joint conclusion or finds the best possible answer to some question, but everyone avoids conflict within the group.

The process can be compared to the collapse of a wave function in quantum mechanics, which due to the influence of measuring the space of potential activations of the physical system is reduced to one of the possibilities. The structure of implicit values of different possibilities (alternatives) of functioning is adequate for the space of potentiality, but these alternatives do not appear as elements of logical disjunction but rather as some sort of "entanglement" of possibilities which is resolved only by the process of decision making or more precisely by the viewpoints and arguments in the discussion and the energizing of the discussion. According to this analogy, the decision plays a similar role to the effect of an experiment or observation in quantum physics: the dissolution of entanglement to a given "observable value". An important difference is that physical observation is usually a single and almost momentary intervention in the microprocess which in one step collapses the entanglement, while decision making is frequently the result of a discussion in a group, which is a process which takes place in different phases and in which a given choice is (usually) actualized gradually. There are some mathematical models of decision making based on the quantum mechanical model, but none are structured for collective decision making, [23 – 25]. However, the question arises as to what the possibilities are for their extension to an analysis of collective decision making. I do not myself attempt to imitate the quantum mechanical formalism, but rather simply apply merely some general ideas which require a different formalism. I will illustrate my idea in a simple case of collective decision making.

JOINT OUTCOMES AND JOINT ATTRACTIVENESS OF OUTCOMES

Let us take the simple case of decision making between two alternative actions in a group of two $G = (a, b)$, who are deciding between just two alternatives A and B. In so doing they take into account just two significant outcomes or results of the action, e and f. Each of them evaluates these alternatives according to different measures, for example, according to how expected (probable) the outcomes appear to them. Let us assume that we have available the assessments of the conditional probability $p(A, e)$, $p(A, f)$, $p(T, e)$, $p(T, f)$ for both individuals and how beneficial or desires these outcomes appear to them $u(A, e)$, $u(B, e)$, $u(A, f)$, $u(B, f)$ for both alternatives. Let us assume that all benefits are normatised in the interval [–1, 1], and probabilities in the interval [0, 1]. The product of the probability assessments and the assessments of the beneficiality (utility) of the outcome of the person for the given alternative expresses the *attractiveness of this outcome* for that person in deciding in favour of the given alternative.

Let us take as a specific case of this collective decision making a husband (a) and wife (b) who are deciding where to go in the evening. Let us assume that there are only two possibilities which are of interest to them, that they go to the cinema (A) or to the theatre (B). In this they take into consideration two significant outcomes or results of the action, entertainment (e) and cultural enjoyment (f).

Let us assume that for them the following estimates of probability and beneficiality apply:

$p_a(A, e) = 0{,}7$	$p_a(B, e) = 0{,}5$	$u_a(A, e) = 0{,}7$	$u_a(B, e) = -0{,}2$
$p_a(A, f) = 0{,}4$	$p_a(B, f) = 0{,}6$	$u_a(A, f) = 0{,}6$	$u_a(B, f) = 0{,}5$
$p_b(A, e) = 0{,}6$	$p_b(B, e) = 0{,}6$	$u_b(A, e) = 0{,}5$	$u_b(B, e) = 0{,}6$
$p_b(A, f) = 0{,}4$	$p_b(B, f) = 0{,}7$	$u_b(A, f) = -0{,}1$	$u_b(B, f) = 0{,}8$

Thus for the husband and wife going to the cinema as well as going to the theatre bring a certain measure of entertainment and cultural enjoyment, but the husband and wife evaluate these two outcomes with differing conditional probabilities and differing degrees of beneficiality (usefulness)[5].

Under realistic conditions the assessments of probability and beneficiality of outcomes are dependent on how each individual assesses their partner, for example how competent and reliable they are, and how willing they are to cooperate. This means that for example the probability $p_a(A, e)$ is dependent on what a expects person b to do if he observes that a is leaning towards or deciding for A, and that a expects outcome e. Likewise for the beneficiality of expected outcomes. For the sake of simplicity I assume that at least at the beginning of the process of decision making these evaluations do not change much, hence the individual then in all combinations of decisions of members of the group for given alternatives calculates the same assessments of probability and beneficiality of outcome as they would be if he were deciding by himself. These assessments can later change under the influence of discussion between two personas and other interactional factors. In this case the assessments of probability and beneficiality of a given outcome for an individual in his decision for a given alternative can change with respect to how other members of the group decide or with respect to what the individual expects other members of the group to do[6].

In the case of collective decisions we must observe *assessments of possibility* that actors simultaneously decide in favour of different alternatives and count on (in general) different outcomes of their decisions. It is essential that these decisions occur simultaneously and in mutual association. I am referring to "joint decisions" and "joint outcomes". In order to assess the attractiveness of these possibilities we must take into account *the average of the probabilities* of the expected outcomes and the *average* of the assessments of *beneficiality or desiredness of outcomes*. The joint outcome of decision making of *k* members of a group can be presented in a series of *k* pairs (selected alternative, expected outcome), where each pair suits the possible outcome of the decision in favour of a selected alternative for a given member of the group. Each member of the group assesses the conditional probability of the occurrence of an outcome (given the decision in favour of a given alternative). The assessment of the conditional probability of a joint outcome is equal to the average of the probability assessments of all particular outcomes which appear in the joint outcome, and similarly the assessment of beneficiality of a joint outcome is equal to the average of the assessments of beneficiality of all particular outcomes which occur in a joint outcome. The product of the assessments of conditional probability and assessments of beneficiality of the joint outcome express the *attractiveness of the joint outcome*, while the sum of attractiveness of all such joint outcomes in which all members of the group decide in favour of the same alternative expresses the *attractiveness of this alternative*[7].

To the extent that all members of the group simultaneously decide in favour of the same alternative, it is a *coordinated* or *collective decision*. In this respect members of the group in general count on different possible outcomes of their individual decisions. I refer to "coordinated (joint) outcomes."

In my model of collective decision making I assume that members of the group weigh their alternatives for action from the perspective of the group, i.e. they implicitly assess the *attractiveness* of the joint outcomes and alternatives and compare them to one another. In this it is not necessarily the case that they make a decision *only on the basis of these comparisons*. Other factors also influence the actual decision, but this does not necessarily mean that the group is irrational. Among some of the most important factors are changes in the attractiveness of outcomes of decision making for particular alternatives due to the assumptions of actors involved in the decision making, the extent to which other members of the group are interested in or committed to the alternatives given, and how they assess the individual joint outcomes. The group of actors decides rationally if it decides in favour of the choice of alternatives which in the given circumstances has the highest degree of attractiveness.

The decision making situation in the group of actors can be illustrated using different formal methods, for example with the help of appropriate vectors or matrices of joint outcomes. We can specially design a matrix of probability estimates and a matrix of beneficiality estimates of joint outcomes. For our purposes the most suitable is the *outcomes attractiveness matrix* $\boldsymbol{At}_G$ for group G (in general this is a more than two dimensional matrix), which merges both matrices mentioned into one. Such a matrix illustrates the mutual implicit complexity of the alternatives of action in the space of common action (in our case the space of joint action by a pair). It represents a kind of *potential for decision making* of the group.

In the case of two people (a, b), two alternatives (A, B) and two possible outcomes which are important for decision making (e, f), we can create the following table or initial outcome attractiveness matrix:

e / *f*	*A, e*	*A, f*	*B, e*	*B, f*
A, e	$(p_a(A, e) + p_b(A, e))/2$ $(u_a(A, e) + u_b(A, e))/2$	$(p_a(A, e) + p_b(A, f))/2$ $(u_a(A, e) + u_b(A, f))/2$	$(p_a(A, e) + p_b(B, e))/2$ $(u_a(A, e) + u_b(B, e))/2$	$(p_a(A, e) + p_b(B, f))/2$ $(u_a(A, e) + u_b(B, f))/2$
A, f	$(p_a(A, f) + p_b(A, e))/2$ $(u_a(A, f) + u_b(A, e))/2$	$(p_a(A, f)\ p_b(A, f))/2$ $(u_a(A, f) + u_b(A, f))/2$	$(p_a(A, f) + p_b(B, e))/2$ $(u_a(A, f) + u_b(B, e))/2$	$(p_a(A, f) + p_b(B, f))/2$ $(u_a(A, f) + u_b(B, f))/2$
B, e	$(p_a(B, e) + p_b(A, e))/2$ $(u_a(B, e) + u_b(A, e))/2$	$(p_a(B, e) + p_b(A, f))/2$ $(u_a(B, e) + u_b(A, f))/2$	$(p_a(B, e) + p_b(B, e))/2$ $(u_a(B, e) + u_b(B, e))/2$	$(p_a(B, e)\ p_b(B, f))/2$ $(u_a(B, e) + u_b(B, f))/2$
B, f	$(p_a(B, f) + p_b(A, e))/2$ $(u_a(B, f) + u_b(A, e))/2$	$(p_a(B, f) + p_b(A, f))/2$ $(u_a(B, f) + u_b(A, f))/2$	$(p_a(B, f) + p_b(B, e))/2$ $(u_a(B, f) + u_b(B, e))/2$	$(p_a(B, f) + p_b(B, f))/2$ $(u_a(B, f) + u_b(B, e))/2$

If we use our case of the husband and wife who are deciding where to go in the evening, we obtain this initial outcome attractiveness matrix[8]:

e / *f*	*A, e*	*A, f*	*B, e*	*B, f*
A, e	0,390	0,165	0,423	0,525
A, f	0,275	0,100	0,300	0,385
B, e	0,083	-0,038	0,110	0,180
B, f	0,300	0,110	0,330	0,423

So long as no decision is made, then the two people remain at the implicit entanglement of different possibilities. If they decide on one, then each of them "chooses" the appropriate alternative (*A* or *B*) and expects a certain outcome (*e, f*). It is not necessarily the case that both persons decide for the same alternative or they expect the same outcomes. Only when the persons choose the same alternative can we refer to their *common decision*. In the case where they choose different alternatives in their mutual interaction we can refer only to their *individual decisions under the influence of the group*.

The outcome attractiveness matrix expresses the *implicit entanglement of possible choices*, similar to the quantum entanglement of the states of several mutually interacting subatomic particles. The aggregate quantum state of particles which are connected by for example, common origin, can be shown mathematically by means of the so-called direct (or tensor) product of the vector spaces of the states of particles which participate in the collective state. In simple cases this is the direct product of two vectors[9].

This product is illustrated by a matrix which expresses the quantum entanglement of possible associated states of the particles. Some of the possible associated quantum states represent the possible outcomes of observations or interactions of the system with the environment. As is known from quantum physics, the interaction of such a system of particles with a measuring apparatus can collapse the wave function of the system in such a way that one of the possible outcomes is actualized as the "measured result." Metaphorically we could say that the quantum system "decides" in favour of a certain possibility [26; pp.255-262]. Here we can predict only the probability of the system "deciding" for that possibility, we cannot predict with any certainty.

Similarly we can say that the influence of the context of collective decision making operates on the fact that the group chooses one among the possible collective decisions. In the case of our couple who is deciding whether to go to the cinema or to the theatre, based on the given attractiveness matrix, the (initial) attractiveness of alternative A amounts to 0.930, and the attractiveness of alternative B to[10] 1.043.

If we take into consideration only those two values, it is rational for both to go to the theatre. In the example given there also appear nonzero degrees of attractiveness for non-coordinated outcomes, and thus we must take into account in the assessment of the rationality of decisions the attractiveness of non-coordinated decisions, i.e. the situation in which *a* chooses A, and *b* chooses B, and the situation in which *a* chooses B, and *b* chooses A. The attractiveness $At((A)_a(B)_b)$ of the first situation is 1.633, and the attractiveness $At((B)_a(A)_b)$ of the second situation is[11] 0.455.

If we consider all four possibilities for the joint decision making of two people, we see that the non-coordinated decision in which *a* chooses A and *b* chooses B predominates. If there is no additional motive for a *common* decision, then the husband decides to go to the cinema and the wife decides to go to the theatre. But there is a problem, which may inhibit their common decision in favour of the same alternative. In the case given, the difference between $At_{ab}(A)$ and $At_{ab}(B)$ is relatively small. Even if the two people gave priority to a coordinated decision over a non-coordinated decision, it is not clear in advance whether our couple would decide based on the initial attractiveness of the alternatives. If the difference between the (initial) attractiveness of A and of B is large, then it is quite probable that our couple would decide to go to the theatre. But it is more probable that the discussion between them would continue further. They might seek additional information about both alternatives and all this would change the context of decision making, in particular their commitment to the given alternative. They could also form some further alternative, such as “let’s stay home”, which changes the decision making situation and along with it the matrix of attractiveness of outcomes. Decision making then takes place on a new level. If even then they do not arrive at a decision, the two continue to discuss and seek additional information and arguments in favour of or against the relevant alternatives. This takes place until such time that the actors arrive at a final decision. This can be a common decision for one of the alternatives or a junction of two different decisions (for example, the husband goes to the cinema and the wife goes to the theatre)[12].

Even then, if individuals aspire to a common decision, the matrix of attractiveness of outcomes does not entirely determine the decision of the group. We may speak only of a certain probability of a decision in the given context of decision making. An important role is played by the *context of decision making*, for example the emotional commitment of the cooperating individuals to a common decision and the power of arguments provided in the discussion. This context changes the matrix of attractiveness of outcomes, which is set up for the initial or previous phase of decision making. I say that the context of decision making creates different *energizing shares of the group for particular joint outcomes* and indirectly for deciding on particular alternatives. This context can change the attractiveness of joint outcomes in such a way that the attractiveness of a given alternative is increased while the attractiveness of other alternatives (and in general, joint outcomes) is reduced. This is a systemic factor of the context of decision making which is dependent on the entire group of actors and the context of decision making. Each joint outcome corresponds to a particular energizing share of the group for that outcome. To the extent that we can observe the energizing of the group for coordinated outcomes which belong to the common decision in favour of the same alternative, we obtain a *degree of energizing of the group for decision making by the group regarding that alternative.*

The simplest formal determination of the energizing shares of the group for different joint outcomes is for them to appear as a group of factors which increase or decrease the attractiveness of joint outcomes. To the extent that this is a group which strives for coordinated action and common decisions, the energizing shares for non-coordinated joint outcomes can be simply ignored (they have a value of 0). It is reasonable to expect that in groups which strive for common action and decision making, the energizing shares of the group for various coordinated outcomes in decision making regarding the same alternative can be made uniform in the final phase of decision making. This suits the greater homogeneity of the group in the final phase of decision making and the unwillingness of members to engage in mutually clashing decision making. A more complex determination of the energizing shares would be if specific factors of the energizing of decision making corresponded to each possible decision of two persons (for example, both go to the cinema, both go the theatre, the first goes to the cinema and the second to the theatre, the first goes to the theatre and the second goes to the cinema). These factors can be in mutual associations which are listed by certain functional associations.

If factors of energizing of the group for particular joint outcomes are determined in this way, these factors operate simultaneously on the probability assessments and the assessments of the beneficiality of outcomes, in which we cannot precisely determine on what it operates to a greater extent and to a lesser extent. The energizing shares describe the system effects of the changes of the context and the internal interactional structure of the group on members of the group. Different energizing shares with respect to different joint outcomes also imply changing the probability assessments and the assessments of the beneficiality of individual outcomes with respect to which joint outcome an individual outcome belongs.

I assume that collective decision making takes place in several phases, and in each one the energizing of the group changes, i.e. the energizing shares for individual joint outcomes change. In each phase of decision making we may provide an assessment of the rationality of the decision making, namely, that it is rational for the group of actors involved in the decision making that they decide commonly for the alternative which has at that the highest degree of (common) attractiveness.

The energizing share of group $E_G(I)$ of group G for the joint outcome I increases or decreases the attractiveness of that outcome $At_G(I)$ achieved in the previous phase of decision making. Formally presented, the energizing share can be expressed as a real number $0 \leq E_G(I) \leq (At_G(I))^{-1}$. The new attractiveness $At'_G(I))$ is then equal to the product $At_G(I)E_G(I)$. The energizing of different joint outcomes operates in such a way that we obtain a new matrix of attractiveness $\boldsymbol{At'}_G$ of outcomes, in which the product of previous degrees of attractiveness and corresponding shares of energizing appear in individual fields.

It holds that decision making is all the more rational the more that the energizing shares of the group for coordinated outcomes (outcomes of collective decision making on equal alternatives) are mutually coordinated. Then a clear structure for the attractiveness of alternatives is formed, in which the commitment of members in favour of one of them corresponds to the “lack of commitment” to all the other alternatives. The homogeneity of the group means that members negotiate with one another as equal partners and do not form minority subgroups which oppose one another.

In the case that we have a group G consisting of two persons (a, b) who are deciding between two alternatives and count on two possible outcomes and there exists a high motivation of the group for common decision making, we obtain the following *matrix of energizing of group*[13] $\boldsymbol{E}_G$:

$E_{ab}(A, e, e)$	$E_{ab}(A, e, f)$	0	0
$E_{ab}(A, f, e)$	$E_{ab}(A, f, f)$	0	0
0	0	$E_{ab}(B, e, e)$	$E_{ab}(B, e, f)$
0	0	$E_{ab}(B, f, e)$	$E_{ab}(B, f, f)$

In this matrix we find the energizing shares of groups for different joint outcomes, in which those shares in the fields which belong to "mixed" selections of alternatives are equal to 0. This corresponds to the absence of motivation for different decisions by individual members. Both submatrixes which lie along the diagonal of the main matrix correspond to all possible joint outcomes in common decision making by two persons for *A* or for *B*. I call such a matrix a "polarized" matrix of energizing. If we apply this matrix to the previous matrix of outcomes, we obtain a new polarized matrix of attractiveness.

If in the process of decision making the energizing shares of the group become even more uniform, we obtain uniform shares of energizing in decision making by the group about individual alternatives, independent of the joint outcomes. Then we obtain (two) constant values: one ($E_{ab}(A)$) represents the degree of energizing of the group in deciding in favour of *A*, and the other ($E_{ab}(B)$) the degree of energizing of the group in deciding in favour of *B*.

In the case that the group is itself the context for decision making and it is willing to make only common decisions, we may take as the degree of energizing of the group in deciding for a certain alternative the *reciprocal value of the average of the common attractiveness of all other alternatives*[14].

This is of course an idealization of the conditions, which is acceptable if we assume that the group is homogenous and that its members decide rationally on the basis of implicit or explicit assessments of the outcomes of decision making. Then in the group there exists a correspondingly greater (or smaller) share of energizing in deciding about a given alternative according to the smaller (or greater) average common attractiveness of all other alternatives.

In our case of the husband and wife who are deciding about whether to go to the cinema or to the theatre, and who are determined to go together and the external context of decision making does not influence them, we may assume that in the phase of decision making which follows the initial situation (given by the original matrix of outcomes $\boldsymbol{At}_{ab}$), the share of energizing $E_{ab}(A)$ is equal to the reciprocal values from $At_{ab}(B)$, and the share of energizing $E_{ab}(B)$ is equal to the reciprocal value from $At_{ab}(A)$. This means that $E_{ab}(A) = 0.958$, $E_{ab}(B) = 1.075$. This gives us a new polarized matrix of attractiveness $\boldsymbol{At'}_{ab}$:

0.374	0.158	0	0
0.263	0.096	0	0
0	0	0.118	0.194
0	0	0.355	0.455

If we now calculate the common attractiveness of both alternatives, we obtain $At_{ab}(A) = 0.891$ and $At_{ab}(B) = 1.122$. Here too *B* is a more attractive alternative than *A*, but the difference between them has increased. If at the beginning the difference between alternatives *B* and *A* amounted to 0.113, it is now 0. 231, which may mean that our couple would commonly decide for *B*, that is, for going together to the theatre. We see that in the *situation* where the group is itself the context for decision making and it is motivated for common decisions, the advantage of those alternatives which had a slight advantage at the beginning increases gradually. This corresponds to the well known phenomenon from group dynamics, the already mentioned *groupthink*. This phenomenon can shift the group from the truly rational decisions that critical and frank discussion among members of the group would lead to. Such discussion can change the inventory of arguments for and against particular alternatives and along with this the energizing shares of the group in deciding on particular alternatives. In this case the energizing shares change in the flow of discussion in such a way that the alternative which has been backed by the best arguments gains in attractiveness[15].

In the case that some external contextual factor has entered into this phase of decision making, the energizing of the group can be completely changed and turned around. Our couple may receive the information that the theatre performance has been moved up an hour and as a result they find themselves short of time. In that case it is probable that their somewhat greater commitment to go to the theatre is reduced in a moment and going to the cinema will gain in attractiveness.

The desire for coherence among the assessments of possible outcomes of decision making of members in common decision making for the same alternative probably has a strong influence on the dynamics of collective decision making. This tendency leads to members of the group having the same assessments of conditional probability and beneficiality (usefulness) of anticipated outcomes of decision making.

It is important that we determine how the context of the decision, in particular the commitment of the participants to making a decision, the intensity of the discussion, and the arguments provided combine to turn the potential for decision making into an actual decision. Viewed mathematically, the influence of the context is such that in the *final phase* it reduces the matrix of attractiveness $\boldsymbol{At}_G$ to a polarized matrix of attractiveness, in which one of the diagonals is located in the non-zero submatrix which corresponds to the joint decisions for individual alternatives, and the other fields acquire the value of 0.

On the basis of the finding that for a given group $G = (a_1, ..., a_k)$ and a particular alternative A_i, the attractiveness $At_G(A_i)$ is maximal, we can formulate a practical conclusion which illustrates a rational decision for this choice in a *certain phase* of decision making:

1. members of group G are deciding between A_i and other (n-1) alternatives,
2. they are trying to achieve the most attractive results possible through their decision,
3. in a given phase of decision making there exist two polarized matrices, the matrix of energizing $\boldsymbol{E}_G$ and the matrix of attractiveness $\boldsymbol{At}_G$,
4. for members of G the attractiveness $At_G(A_i)$ is maximal with respect to all other possibilities of decision making.

Members of G *commonly* decide in favour of A_i.

It is interesting that here it is not necessary to add the complicated explicit assumptions of *common knowledge* or *common belief*[16] of the members of a group, for example the demand that the members of the group have common knowledge about how they assess the conditional probabilities and beneficiality of possible outcomes. However, these assumptions are present implicitly in the premises given. The practical conclusion cited does not determine the common decision of members of the group, but only illustrates in another way our (and perhaps their own) assessment of rationality of the given collective decision: it contains rational reasons for the given decision.

A formal presentation of the potential for decision making requires increasingly complex and mutlidimensional matrices of choices (if there are k actors, n alternatives and m possible results, we obtain a k-dimensional square matrix of attractiveness of results with $n \times m$ columns and rows)[17], but in principle we can present the collective decision for one of the alternatives as a reduction of the original matrix of attractiveness to the corresponding polarized matrix of attractiveness.

To the factors of attractiveness of some alternative we could add some new conditions, for example, “starting constraints” of decision making. These are actions or states of things which must be realized for particular alternatives to be realized (and for certain outcomes to follow). We could also add (emotional, ethical) valuations of these conditions for particular actors.

My view is that these and similar additions to the principle would not change the essence of things. Decision making is formally presented as in general a multi-phase process of the actualization of collective potential for decision making. In the final phase of decision making there emerges a context in which we obtain a simplified and possibly polarized matrix of attractiveness of outcomes which corresponds to the common decision making in favour of one of the alternatives. For each phase of the decision making we may formulate the corresponding matrix of attractiveness and matrix of energizing of the group and assess what we can expect assuming that the actors decide rationally. Collective decision making can thus be presented as a process of gradual crystallization of the dominant alternatives under the influence of different contexts of decision making as represented by the initial matrix of attractiveness. Contexts of decision making are represented by the corresponding matrices of the energizing of the group for all possible joint outcomes.

REMARKS

[1]This definition is close to that of Toulmin's definition of the rationality of belief “open to argument” [1; p.13] and Habermas’s definition of rationality as the capability of a belief, statement, or action (*Äusserung*) to be subjected to a trans-subjective process of justification and critique [2; p.27], but it implicates neither Toulmin’s theory of argumentation nor Habermas’s theory of discourse as the medium of communicative rationality.

[2]Various authors have proposed a division of ways of thinking into more automatic, fluid, spontaneous, implicit, unconscious thinking of people in interactional situations and more conscious, reflective, normatively guided explicit thinking and similar for two types of rationality [8, 14 – 16].

[3]I write more about this in [20; pp.262-268].

[4]Here I rely on the theory of collective rationality and collective reasoning developed by C. McMahon in his book *Collective Rationality and Collective Reasoning* [22]. In his view collective thinking and decision making essentially contain a kind of “pooling” of the reasons provided [22; p.109]. McMahon emphasizes that there is mutual coordination of beliefs and collective decision making only when members of the group mutually coordinate on the “scheme of cooperation”, i.e. that they interpret their situation in the same way and in so doing a given combination of their actions gains priority over noncooperation.

[5]In this example I allow for the possibility that for the individual both outcomes can be conjunctive, i.e. they can occur simultaneously, but with a different measure of beneficiality (desiredness). In theories of decision making disjunctive outcomes are frequently assumed. This of course simplifies the analysis of decision making, but the assumption is not necessary. But I make some other assumptions which simplify the further analysis: rationality as the maximization of attractiveness of alternatives, mutual independence of probability assessments and assessments of beneficiality. In addition I assume linearity of the attractiveness of alternatives with respect to the attractiveness of particular outcomes. These assumptions allow me to provide a relatively simple account of my basic idea; in the continuation of the discussion we may replace them with more realistic ones.

[6]If we were to do an empirical study, we would ask the following questions for each combination of decisions of member of the group in favour of a particular alternative and for each possible outcome *i* of a decision in favour of alternative *A:* "How do you assess the probability and beneficiality of outcome *i* of your possible decision for *A* in the event that the other members of the group decide in favour of a given combination of decisions?" Answers to these questions would give us for each outcome and alternative information on how each member of the group assesses the conditional probability and beneficiality (usefulness) of this outcome of decision making in favour of the given alternative in the given group of actors involved in decision making.

[7]The attractiveness of an alternative can be normatized to values between –1 and 1 if the sum of attractiveness of all relevant joint outcomes is divided by the number of all those outcomes. For the sake of simplicity I do not consider this possibility.

[8]Results are rounded to three decimal points.

[9]I leave aside for now a more precise determination of this direct product. The matrix of joint expectations can also be presented as the direct product of the corresponding "vectors of expectations of outcomes" for individual members of the group, and the matrix of joint beneficiality can be presented with a similar pseudo-direct sum of "vectors of the beneficiality of outcomes", but I leave aside for now this presentation.

[10]Their normalized values are 0.233 and 0.358.

[11]Their normalized references are 0,408 and 0,114.

[12]This outcome is of course closer to or further from the "anticipated" rational collective decision in the given circumstances.

[13]Here and in the following tables I omit the row and column with the references to the given joint outcomes.

[14]This is only one possibility for the determination of the energizing factors which works well if the products of attractiveness and the respective energizing factors are less than 1. A somewhat more sophisticated determination would be if we took the ratio of the attractiveness of the given alternative and the average of the common attractiveness of all other alternatives.

[15]D. Moshman and M. Geil presented an interesting experiment on deductive reasoning in which groups of students showed a greater degree of rationality in deductive reasoning than (on average) their members. The increase in the rationality of the group relative to individuals was clearly connected with the quality of the discussion and arguments [27].

[16]Common belief is a minimal assumption which can in some circumstances (for example in the case that there is a rational discussion based on correct information and facts and good mutual familiarity on the part of both persons) become strengthened to common knowledge. Some authors refer to "mutual knowledge" or "mutual belief'. This is a situation in which all members of the group have some knowledge (or belief) and they know (or believe) that all members of the group know (or believe) that they know (or believe) and so on to infinity. It turns out that each coordination of the action of multiple actors or cooperation among them assumes by them a kind of common knowledge or common belief (see [20, 28, 29]).

[17]The multidimensional matrix cited can by means of appropriate mathematical "tricks" be translated into a two-dimensional matrix, for example by the appearance of different combinations of four in the rows and columns *(person, alternative, outcome).*

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KOLEKTIVNO ODLUČIVANJE I AKTUALIZACIJA POTENCIJALA ODLUČIVANJA

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SAŽETAK

Rad predstavlja karakteristike i dileme kolektivnog odlučivanja. Kolektivno odlučivanje može se prikazati kao proces uzastopnih kristalizacija dominantnih mogućnosti pod utjecajem različitih konteksta odlučivanja proizašlih iz primarnih, zadanih potencijalâ odlučivanja. Takav proces je prikazan kao višefazni proces djelovanja kontekstualno ovisnih "faktora energiziranja" kolektivnog odlučivanja na "matricu privlačnosti" ishoda kolektivnih odluka. Matrica privlačnosti određuje privlačnost svake od mogućnost odlučivanja. Najprivlačnija mogućnost u danoj situaciji predstavlja racionalnu odluku u toj situaciji. Zaključna faza odlučivanja odvija se u kontekstu u kojemu je matrica privlačnosti pojednostavljena. To odgovara uobičajenom odlučivanju za jednu od mogućnosti.

KLJUČNE RIJEČI

kolektivno odlučivanje, racionalnost, potencijal odlučivanja, zajednički ishodi, energiziranje

Interdisciplinary Description of Complex Systems 7(2), 106-116, 2009

EXPERT TEAM DECISION-MAKING AND PROBLEM SOLVING: DEVELOPMENT AND LEARNING

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Regular article *Received:* 18 November 2009. *Accepted:* 9 December 2009.

ABSTRACT

Traditional research of decision-making has not significantly contributed towards better understanding of professional judgment and decisions in practice. Researchers dealing with decision-making in various professions and natural settings initiated new perspectives called naturalistic, which put the expert in the focus of research and the expertise thus entered the core of decision-making research in natural situations.

Expert team is more than a group of experts. It is defined as a group of interdependent team members with a high level of task related expertise and the mastering of team processes.

There have been several advances in understanding of expertise and the team. By combining theories, models, and empirical evidence we are trying to explain effectiveness and adaptation of expert teams in problem-solving and decision-making in complex and dynamic situations.

A considerable research has been devoted to finding out what are the characteristics of experts and expert teams during their optimal functioning. These characteristics are discussed as input, process and output factors. As input variables the cognitive, social-affective, and motivational characteristics are presented. Process variables encompass individual and team learning, problem solving and decision-making as presented in Kolb's cycle of learning, in deeper structures of dialogue and discussion, and in phenomena of collaboration, alignment, and distributed cognition. Outcome variables deal with task performance – activities.

KEY WORDS

decision-making, paradigm, expert team, learning, adaptation

CLASSIFICATION

APA: 2340 Cognitive Processes

JEL: D83, D84

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INTRODUCTION

Experts, expertise and expert decision-making have been the subject of numerous interdisciplinary studies, often focused on particular professional areas. Several research approaches were initiated, ranging from philosophical, psychological, and computational to most recent in neurosciences. As traditional empirical studies were not able to explain professional decision-making in practice qualitative methods have been applied in the research of decision-making in natural settings. Models explaining the complex field of expert decision-making were being developed.

There have been several advances in understanding of expertise and the team. By combining theories, models, and empirical evidence we are trying to explain effectiveness and adaptation of expert teams in problem-solving and decision-making in complex and dynamic situations.

PARADIGMS OF DECISION-MAKING

Traditional research of decision-making has not significantly contributed towards better understanding of professional judgment and decisions in practice. This led researchers to challenge the prevailing, normative, classical paradigm, called *judgment and decision-making*, with its numerous models and approaches [1]. Researchers dealing with decision-making in various professions and natural settings initiated new perspectives called *naturalistic*, which put the expert in the focus of research and the expertise thus entered the core of decision-making research in natural situations.

Cohen [2] provided a framework for the discussion of three basic paradigm of decision-making process: the *formal-empiricist* paradigm (also known as classic decision-making), the *rationalist* paradigm, and the *naturalistic* paradigm (Table 1). The goal of the rationalist paradigm was to make the research more oriented towards cognition, while the naturalist paradigm placed the expert in the natural environment with his/her cognitive and affective processes at the center of the research focus.

Table 1. Decision-making paradigms.

FORMAL-EMPIRICIST PARADIGM	RATIONALIST PARADIGM	NATURALISTIC PARADIGM
normative (prescriptive) models of rational behavior	normative models	context-bound informal modeling
formal, context-free and abstract models, free of decision-makers cognition	retaining evaluation standards of decision quality	construction of descriptive models of proficient decision makers in natural contexts
discrepancies in performance are the fault of the model	discrepancies in performance are the fault of the decision maker, not of the model	
input-output orientation	orientation on cognitive processes and their limitations	orientation on processes and contexts: focus on experts' cognitive processes and naturalistic contexts
comprehensive information search		situation-action matching decision rules

choosing among concurrently available alternatives		mental simulation

Nearly all early quantitative models of decision-making in psychology and cognitive science were based on static theories, according to which the decision maker is supposed to choose the alternative with the highest expected *utility function*, while no explicit psychological dynamics is being taken into account.

Towsend and Busemeyer [3] developed the *Decision Field Theory* (DFT), a dynamic and stochastic framework for modeling decision-making, which takes into account the psychological processes involved in decision-making. DFT is based on learning and motivation theories, information processing theories, and theory on human decision-making.

Naturalistic decision-making paradigm (perspective) includes a number of theories and models about the functioning of expertise. For instance, Endsley [4] developed a model of *situation awareness in dynamic decision-making*. According to Endsley [5], effective decision-making depends on high levels of situation awareness, which involves three levels (perception, comprehension, and prediction) and mechanisms for selecting goals and action.

In addition to environmental or external factors (system capability, interface design, stress and workload, complexity, and automation), the model involves many individual factors determining how well people are able to develop good situation awareness (perceptual processing and limited attention, limited working memory, goal-driven and data-driven processing, expectations, pattern-matching schemata, and the use of mental models).

FACTORS OF EXPERT TEAMS DECISION-MAKING AND LEARNING

Expert team is more than a group of experts. It is defined as a group of interdependent team members with a high level of task related expertise and the mastering of team processes.

A team member must acquire task-related work skills for task performance and teamwork skills to function effectively as part of an interdependent team [6]. Consequently, it is not sufficient for the creation of expert teams that their members are task specialists or technical experts; they must also be experts in social relations and interactions that lead to adaptive coordinated actions (i.e. teamwork) within the context of technical expertise (i.e. team task) [7].

There have been several advances in understanding of expertise and team. By combining theories, models, and empirical evidence we are trying to explain effectiveness and adaptation of expert teams in problem-solving and decision-making in complex and dynamic situations.

A considerable research has been devoted to finding out what are the characteristics of experts and expert teams during their optimal functioning. These characteristics are briefly discussed as input, process and output factors as shown on Table 2.

Table 2. Feedback loop from outcome to input factors – variables.

INPUT VARIABLES	PROCESS VARIABLES	OUTCOME VARIABLES
individual and team characteristics: cognitive, social-affective, motivational	individual and team learning, problem solving and decision-making	task performance - activities
**	**	**
knowledge: declarative, procedural, strategic, tacit	collaboration, coordination	fluent and high level performance

metacognitive awareness	alignment	adaptation
mental model	adaptation	innovation
shared cognition	knowledge building	efficiency
distributed cognition	emergent understanding	better decisions
transactive memory	negotiation of shared meaning	
adaptive expertise	discourse: dialog, discussion	
beliefs, attitudes		
self-efficacy, self-regulation		

EXPERT TEAMS – COGNITIVE AND CONATIVE CHARACTERISTICS

Experts and expert teams must possess good team situational awareness, declarative, procedural, and *tacit knowledge* necessary for functioning in complex environments. This knowledge is referred to as *domain specific* knowledge. Like procedural knowledge, tacit knowledge is action-oriented, gained from experience, applied unconsciously, and is often difficult to verbalize [8]. Tacit knowledge underlies a wide range of expert skills. Wagner and Sternberg [9] noted two ways for enhancing tacit knowledge: (1) by making it explicit and sharing it; (2) by learning from experience. Tacit knowledge acquisition can be facilitated with reflection on one's experience and action (see Kolb's learning cycle and team learning).

According to Wenger [10], teams can learn and develop a special kind of memory, named *transactive memory*, which is a coordinated and distributed storage of knowledge. This kind of memory is the "property of a group". Is seems to be differentiated when group members possess different domains of expertise and there are incentives to remember different kinds of information [11]. Such situations occur in interdisciplinary expert teams.

Expert teams seem to hold *shared mental models* of the task, their teammates, situation and equipment [12]. These compatible mental models allow them to communicate and coordinate actions without explicit communication. Team members are able to interpret situations in a similar manner, make compatible decisions, and take coherent actions [13]. Expert teams are building also other kinds of shared cognition, e.g. *team metacognition* and *common ground*. With *shared vision* they build a sense of commitment on the base of their values and goals. Shared cognition is a necessary precursor to effective team processes as it forms the foundation for decision-making and problem solving.

Beside knowledge and skills, expertise involves also *self-regulatory competence* and perception of *self-efficacy*. Self-regulation is defined as self-generated thoughts, feelings, and actions that are strategically planned and adapted to the attainment of personal goals [14]. Expertise involves self-regulating of three personal components: one's covert cognitive and affective processes; behavioral performance; and environmental settings. Self-regulatory processes can help a person to more effectively acquire knowledge and skills and to develop perception of self-efficacy – a belief in his/her capacity to perform effectively [15]. This construct can be understood also on group or team levels. Thus, collective efficacy is a sense of a collective competence, shared among individuals in a team [16].

Expert teams need to possess also *adaptive expertise*, which is a special kind of expert knowledge. It helps an expert to know when, why, and how various aspects of his/her vast repertoire of knowledge and skills are relevant in particular situations. Schwartz et al. [17]

have proposed that the concept of adaptive expertise involves two dimensions: (1) processes that lead to innovation (invention); (2) processes that lead to efficiency through well practiced routines. The development of adaptive expertise helps expert teams to continually adapt to changes in dynamic environments. A *metacognitive awareness* has an important role in the development of adaptive expertise. Thus, to increase adaptive expertise, learning environments should include activities rich with reflection and metacognition, as is the case in team learning (see Kolb's learning cycle).

EXPERT TEAM PROCESSES

The collaborative team members need to be able to build an effective group process. The quality of the team's work depends on the group process, sharing knowledge with one another, understanding one another, elaborating one another's ideas, engaging in critical discussions, etc.

In recent decades, the cognitive complexity and demanding nature of issues dealt with in modern societies has increased, the problems are often ambiguous, unstructured and ill-defined, causing a need for flexible and *adaptable problem solving strategies* and frameworks by expert teams (composed of professionals from multiple subject fields).

One possible answer to such complex issues could be the development of interdisciplinary collaboration work culture and teams of varied experts from different disciplines combining perspectives of various fields. They should be able to perceive highly specific aspects of a problem that might be overlooked from a vantage point of a single perspective.

Collaborative or team learning puts into practice major conclusions from advanced cognitive theories, research and methodologies. A social constructivistic perspective is applied to collaborative learning by focusing on the group process, without excluding individual processes, with a particular reference to how the processes of cognition and communication can be conceived as situated, dialogic, distributed and emergent.

Understanding collaborative or team learning requires making sense of the conversation the participants engage in and the tools that mediate their learning [18]. Group thinking and reasoning are reflected in a collaborative discourse which provides evidence of interaction and semiotic structures (structure of information) that are being generated and used in an activity.

Decision-making and Kolb's cycle of learning

Decision-making can be presented [19] as a special case of Kolb's learning model which represents one of the fundamentals of our understanding and explaining human learning behavior. According to Kolb, the 'cycle of learning' is a central principle of his experiential learning theory, in which the learner follows a repeating sequence of *experiencing, reflecting, thinking,* and *acting*.

Decision-making in simple situations usually does not require profound or prolonged reflecting, so the decision-making process can be represented in a *single-loop reflection* cycle consisting of: *observing, reflecting, deciding* and *doing* (left cycle in the Figure 1).

Reflecting on the implications of our observations, drawing conclusion from them, and preparing and planning for decision process usually requires more profound processes of questioning and *reconsidering* our basic assumptions and conclusions, exploring and articulating new ideas and possibilities (*reframing*), considering new possible approaches and perspectives (*reconnecting*). *Double-loop reflection* cycle contains these component processes and contributes through more thorough deliberations towards better functioning of the primary (single-loop) cycle.

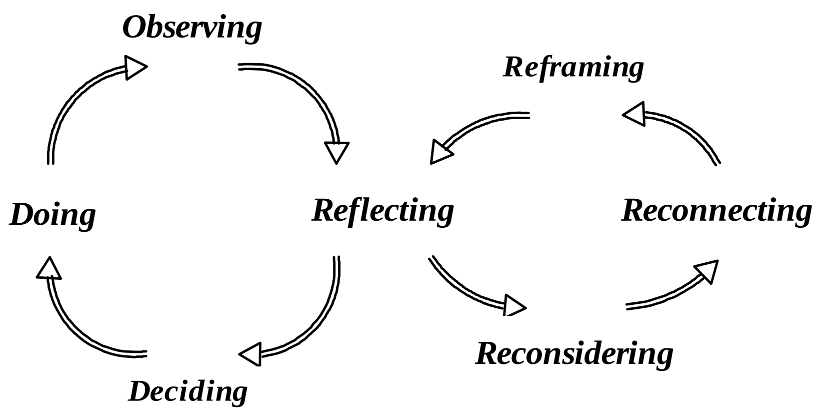

Figure 1. Learning wheel – single and double-loop cycle (adapted from [19]).

Another variant of Kolb's cycle is represented [20] with a slightly altered 'wheel of learning' of an individual (the inner wheel in the Figure 2). It dispenses with the *observation* component (before *reflecting* in the Figure 1) and introduces *connecting* (after *reflecting* – a postmortem about a previous *doing*) as a preparatory phase for *deciding*. During this *connecting* phase, which actually corresponds to *reconnecting* in a *double-loop reflection* cycle in the Figure 1, one creates new ideas and possibilities, generates hypotheses, and obtains new insights.

This 'learning wheel' is also suitable for representing a transition from an individual to a team as shown by the outer wheel in the Figure 2. Phases in the inner wheel (individual's) have equivalents in the outer wheel (team's): *reflecting* ↔ *public reflection, connecting* ↔ *shared meaning, deciding* ↔ *joint planning, doing* ↔ *coordinated action*.

Public reflection: The silent reflecting stage of an individual turns into a public one as members of the team discuss their assumptions, beliefs, convictions, etc., and engage in interactive and iterative processes of open communication.

Shared meaning: Eventually, the team is able to arrive to a mutual understanding which entails refined shared mental constructs (meaning, values, beliefs, values, etc.)

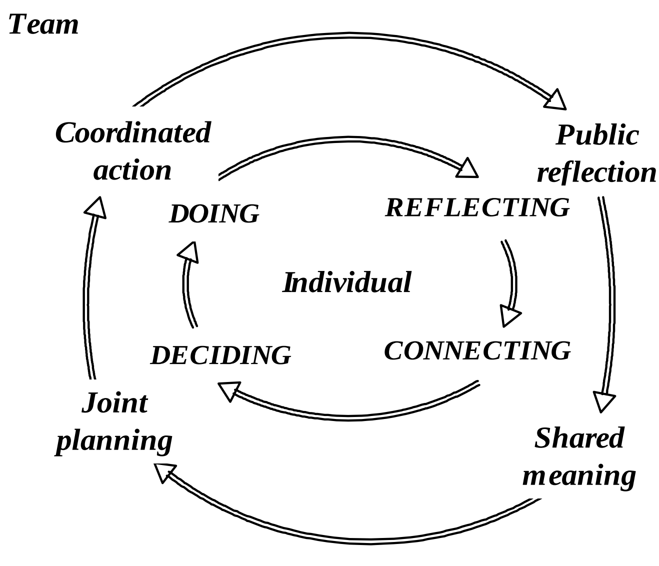

Figure 2. Learning wheel: individual and team (adapted from [20]).

Joint planning: A preparation phase for the subsequent action of the whole team, which can encompass various more or less formal facets.

Coordinated action: Joint planning is not necessarily followed by a joint action, while members of the team follow an agreed agenda of tasks spread over time and space.

Dialogue and discussion

In his seminal book, *The fifth discipline: The art & practice of the learning organization*, Peter Senge [21] cites firm beliefs of two very famous founding fathers of modern physics, Werner Heisenberg and David Bohm, in the importance of dialogue and discussion in the development of science in particular, and society in general. Dialogue and discussion are beneficial and fruitful on several levels - individual, team, discipline – and, conducted properly, are unleashing the full potential of collaborative or team learning. Collectively, we can be more creative, intelligent, and insightful than we can be thinking and acting as individuals.

It is important to be aware of an essential distinction between *dialogue* and *discussion*, both being a type of discourse, as only such awareness allows for their powerful synergy, which could be lost if the difference between the two is not acknowledged. Bohm likened a discussion to a game, in which the arguments about a subject under scrutiny are tossed from one participant to another, with the final goal of winning the argument, virtually regardless of others' views. While in a dialogue, coherence and truth are of the paramount importance, and participants must literally allow the words-meaning (*logos*) to come through (*dia*) and not fruitlessly bounce forth and back.

Bohm suggested that the dialogue should focus on bringing to the surface the "tacit infrastructure" of thought. He was later developing a theory and method of a deeper "dialogue" [22], aiming to allow participants to examine their preconceptions, prejudices and patterns of thought: "*...it is proposed that a form of free dialogue may well be one of the most effective ways of investigating the crisis which faces society, and indeed the whole of human nature and consciousness today. Moreover, it may turn out that such a form of free exchange of ideas and information is of fundamental relevance for transforming culture and freeing it of destructive misinformation, so that creativity can be liberated.*"

The discourse is primarily a way of sharing knowledge and subjecting ideas to criticism. It can also play a creative role with actively improving ideas in collaborative environments concerned with shared understanding.

Collaborative discourse results in the emergence of *new representations* and *shared knowledge*. In group's discussions both the overall group dynamics and individual's collaborative learning emerges from the group's conversation. For a complete understanding of collaborative interactions, both discourse and communication as externally visible distributed *emergent knowledge* and participants' thoughts and actions are needed [23]. In other words, the emphasis is on both representations: individual (mental) ones and socially distributed ones in practice.

A community of practice refers to the creation of a learning environment in which the participants actively communicate and engage the skills involved in an expertise [24]. Such communities are characterized by common intention, personal involvement and mutual dependency. Collaboration in a community can be stimulated by common projects and shared experiences. The participants are engaged in the development of understanding and *knowledge building* through problem identification, research and discourse.

Collaboration, alignment, and distributed cognition

Hutchins [25] pointed out in his studies that *cognition is distributed* across people as they collaborate with each other and with tools designed to aid them in cognitive work, like data gathering, planning, reasoning, and problem solving. The idea is that cognition is not only individual but is also distributed across individuals in a group, other people, and cultural tools and institutions. Especially with such mental tools as language, cognition is distributed not only across individuals and material objects but also across ideas and communication with other people [26].

Distributed cognition refers to cognition and understanding as the interaction among the participants and the tools in the context of an activity. In the context of the workplace rethinking the meaning of expertise is needed. In many cases expert knowledge among professionals is less a matter of what each individual knows than their joint ability to produce a right decision. In other words, expertise is a social affair [27].

Alignment is developed when participants of a collaborative or team group feel involved in their joint engagement (activity). Alignment in a group or community is based on an ability to see and respect each other, on positive interdependence, on individual accountability, and on establishing some common mental models. Building alignment is about enhancing the team's capacity to think and act in a new, *synergistic* manner with coordination and sense of unity.

Effectiveness of a collaborative group depends to a large extent on coordination or alignment among various components of an activity system – participants, materials and technical tools in the environment, cognitive structures (prior knowledge, mental models), and practice of the participants in the subject matter domain of their activities [28].

Our knowledge in the global society is constantly challenged by an increasing complexity, unpredictability and diversity of the world we live in. Thus we are faced with many common problems, which are most frequently ill-defined, open-ended, and very complex, and therefore requiring collaborative or team engagement of scientists and professionals across various domains for discussing, elaborating, explaining, and evaluating solutions from multiple perspectives.

Complex problems are thought to require integration of knowledge from different disciplines [29]. Hence, the team's diversity has to have positive effects on team's performance, and numerous situations are calling for multidisciplinary and interdisciplinary teams with wide range of knowledge and expertise.

As Bruffee [26-27, 30] pointed out: "*In general, heterogeneous decision-making groups work best because ... differences tend to encourage the mutual challenging and canceling of unshared biases and presuppositions ... Groups that are ... too homogeneous tend to agree too soon ... There is not enough articulated disagreement or resistance to consensus to invigorate the conversation ...*" But he also emphasized: "*On the other hand, members of decision groups that are too heterogeneous may have no basis for arriving at a consensus – or no means for doing so: they find that they can't 'come to terms' because they 'don't speak the same language.*"

According to Bromme [31] that means that multidisciplinary teams need to develop sufficient *common ground* (shared cognitive frame of reference). Collaborative environment is very suitable for fulfilling such a task, and ICT tools can be useful for supporting negotiation of common ground in multidisciplinary teams.

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ODLUČIVANJE I RJEŠAVANJE PROBLEMA U EKSPERTNOJ GRUPI: RAZVOJ I UČENJE

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SAŽETAK

Tradicionalna istraživanja odlučivanja nisu znatno doprinijela boljem razumijevanju profesionalnog prosuđivanja i odlučivanja u praksi. Istraživači koji su se bavili odlučivanjem u različitim strukama i prirodnim postavima inicirali su nove perspektive, nazvane naturalističkim, koje su stavile stručnjake u središte istraživanja. Time je istraživanje odlučivanja stavljeno u prirodne situacije.

Ekspertna grupa je više nego skupina stručnjaka. Ona je definirana kao grupa međuovisnih članova grupe s visokom razinom ekspertize vezano za aktivnosti grupe kao i za visoku razinu usvojenosti grupnih procesa.

Nekoliko je napredaka bilo u razumijevanju ekspertize i grupa. Kombiniranjem teorija, modela i empirijskih rezultata nastojimo objasniti učinkovitost i adaptaciju ekspertnih grupa u rješavanju problema i odlučivanju u kompleksnim i dinamičkim situacijama.

Znatan dio istraživanja posvećen je nalaženju karakteristika eksperata i ekspertnih grupa tijekom njihovog optimalnog djelovanja. Te karakteristike se razmatraju kao ulazni, procesni i izlazni faktori. Kao ulazne varijable javljaju se kognitivna, socijalno-afektivne i motivacijske karakteristike. Procesne varijable odnose se na individualno i grupno učenje, rješavanje problema i odlučivanje kako je prikazano u Kolbovom ciklusu učenja, zatim u dubljim strukturama dijaloga i diskusija kao i u pojavama kolaboracije, usklađivanja i distribuirane kognicije. Izlazne varijable tiču se aktivnosti vezanih uz odvijanje predviđenog rada.

KLJUČNE RIJEČI

odlučivanje, paradigma, ekspertna grupa, učenje, adaptacija

MANUSCRIPT PREPARATION GUIDELINES

Manuscript sent should contain these elements in the following order: title, name(s) and surname(s) of author(s), affiliation(s), summary, key words, classification, manuscript text, references. Sections acknowledgments and remarks are optional. If present, position them right before the references.

SUMMARY Concisely and clearly written, approx. 250 words.

KEY WORDS Not more than 5 key words, as accurate and precise as possible.

CLASSIFICATION Suggest at least one classification using documented schemes, e.g., ACM, APA, JEL, PACS.

TEXT Write using UK spelling of English. Preferred file format is Microsoft Word. Provide manuscripts in grey tone. For online and CD-ROM versions, manuscripts with coloured textual and graphic material are admissible. Consult editors for details.

Use Arial font for titles: 14pt bold capital letters for titles of sections, 12pt bold capitals for titles of subsections and 12pt bold letters for those of sub-subsections.

Include figures and tables in the preferred position in text. Alternatively, put them in different locations, but state where a particular figure or table should be included. Enumerate them separately using Arabic numerals, strictly following the order they are introduced in the text. Reference figures and tables completely, e.g., "as is shown on Figure 1, *y* depends on x …", or in shortened form using parentheses, e.g., "the *y* dependence on *x* shows (Fig. 1) that…".

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ISSN 1334-4684 (printed)
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