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Kesra Nermend
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Neuroeconomic and Behavioral Aspects of Decision Making

Proceedings of the 2016 Computational Methods in Experimental Economics (CMEE) Conference

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Preface

Neuroeconomics is a fairly new domain of knowledge that emerged in the 1990s. It is an interdisciplinary field that combines insights from neuroscience, psychology, and economics to build a comprehensive decision-making theory. The essence of neuroeconomics is to analyze the decision-making process not only in terms of external conditions or psychological aspect but also from the neuronal point of view by examining the cerebral conditions of decision making. Examining the decision-making process from these three perspectives leads to its more complete understanding.

Neuroeconomics was preceded by numerous young fields—behavioral economics, experimental economics, and cognitive neuroscience. Ever since, these fields have been witnessing a dramatic development—although independently. They are, however, bound by common interest areas based primarily on experiments whose results are used to test and to better understand theories in economics.

This book includes papers from researchers who are immersed in this subject with a certain level of experience in the field. Its main objective is to exemplify the links between various domains of knowledge which are part of neuroeconomics, behavioral economics and experimental economics. The book is divided into three parts:

- Theoretical Basis of Decision Making—Interdisciplinary Approach
- Behavioral Aspects of Economic Decision Making
- Practical Issues—Case Studies

The first part of the book presents the theoretical aspects of decision-making process from the point of view of various scientific disciplines. It frames the historical background of applying neurobiology and psychological determinants to measure and monitor emotions in the decision-making process during the economic experiments, as well as several other issues referring to the neuroeconomic and behavioral aspects of the decision-making process.

The second part of the book contains a broad outline of behavioral aspects of economic decision making along with instruments and tools that support the

decision-making process in various phases of study. Thus, it contains a wide overview of the applications of different methods that support the analysis of the impact of behavioral factors on the process of decision making in various areas. In sum, the aim of this part is to present the importance of the scientific toolkit of decision making in economics research.

The last part presents examples of broadly understood experiments in economics in the context of decision making. It refers to different areas and utilizes various methods, which are described in the methodological chapters of the book. However, it presents only selected experiments and approaches in neuroeconomics, behavioral economics, and experimental economics. It nonetheless outlines a wide range of topics and methods that can be used in this field of study. Recent advancements in technology pave the way for shaping increasingly advanced and interesting economic experiments related to decision making. Therefore, it can be assumed that this field of science will develop dynamically in the future.

The issues addressed in this book do not exhaust the subject of neuroeconomic and behavioral aspects of decision making. Yet, in the opinion of the editors, the book shows the diversity of areas, problems, methods, techniques, and domains concerning this subject.

Szczecin, Poland

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Part I
Theoretical Basis of Decision Making: Interdisciplinary Approach

Chapter 1
Neurobiology of Decision Making: Methodology in Decision-Making Research. Neuroanatomical and Neurobiochemical Fundamentals

Andrzej Potemkowski

Abstract The research into decision making relies on psychology, neurobiology, pathology as well as economics and it encompasses factors that play a leading role in the process of making decisions on the neural level, regardless of the fact if they are made consciously or subconsciously. From the psychological point of view decision making is a process where cognitive, emotional and motivational aspects play a vital role. Studies on the brain magnetic nuclear resonance imaging reveal that decision-making processes begin before an individual is able to realize it. Neurochemistry has identified several neurotransmitters that are differently associated with decision-making processes, the most important ones being dopamine, serotonin, cortisol, oxytocin and prolactin. Due to a complicated nature of neurotransmitters, the mechanisms that implicate their production are to fully understood yet and it is still not quite known how they work. From the neurochemical perspective, the control of decision-making processes is determined by good communication among different parts of the brain that is regulated by the levels of serotonin. Decision making is a complex process which is possible due to processes taking place in many parts of our brain. However, neuroanatomically speaking, it is the prefrontal cortex that plays a pivotal role in coordinating these processes. To some extent decision making is based on an assumption that people are able to predict other people's behavior and step into their shoes. This capability results from individual preferences and beliefs. Social neuroscience allows us to see neural mechanisms underlying the human ability to represent our intentions. Neurobiology, in turn, strives to explain how relevant moral decisions appear in our brains and how they can modify our emotions. Studies on neurobiological background of our decision-making processes give us better insight into the presumably bounded human rationality as well as into the role of emotions, morality and empathy. Also,

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these studies contribute to our knowledge about the course of decision-making processes and their adaptive value.

Keywords Experimental economics • Definition • Good experiment • Features

1.1 Introduction

Making decisions is a vital, but, at the same time, a trivial part of human lives. Decisions about even the simplest of choices can sometimes get difficult, thus forcing us to analyze gains and losses.

The study into decision-making processes is a field of science which, on the one hand, integrates the knowledge of psychology, medicine, neurobiology, physiology or pathology, while on the other hand—of economics, ethics, philosophy or law. Continuously progressing neurobiological research into decision making is a significant part of the neuroeconomic theories which deal with such problems as how much human behavior, including the economic one, is influenced by emotions, and how much it is ruled by rationality. These theories address factors that play a leading role in decision making on the neural level, regardless of the fact if decisions are made consciously or subconsciously. From the adaptive point of view, good decision making requires integration of many relevant data, motivations with the knowledge concerning potential consequences of the resulting action (Bayer 2008). In order to gain an insight to these processes neurosciences have turned to methods of neuroimaging, especially the functional one.

From the psychological point of view, decision making is a complicated and multi-stage process determined by cognitive, emotional and motivational aspects. In the pre-decisional phase a problem is defined and information about available options is collected; in the consecutive phase the preferred options are identified and the right decision is made, while in the post decisional phase the decision-making process is assessed and evaluated (Svenson 2003).

Neurobiology perceives the human brain as an organ which, as a result of evolution, stores and processes information. It is an organized system where the extensive number of operations, prepared and conducted by the brain itself, is taking place. Decisions associated with the undertaken actions arise out of the neuronal processes of self-organization as well as of a massive number of sensory data coming from the external and internal environment as well as from the knowledge stored in the functional brain architecture.

Complicated physical and chemical neural processes have brought the neurobiologists to the conclusion that decisions are determined by the pre-conditions influencing specific neural networks. The concept of the neural origin of decisions is in strong opposition to the view accepting the presence of free will and puts in question the importance of the decision making 'I' that could act as the free will which singlehandedly is able to induce the brain to initiate a series of processes. According to neurobiologists, a human being is able to make their decisions

consciously and rationally as a result of neural processes taking part in their brain that is subject to physical and chemical processes, similarly to any other function of the brain. However, the information processing in the brain which leads to conscious decision making involves neural systems that are completely different from the ones involved in unconscious events, thus bringing entirely different results (Merkel and Roth 2008). We still have insufficient knowledge as to how these processes differ (Singer et al. 2004).

1.2 Methods of Research into Decision Making

In order to understand and assess the role of individual brain structures and occurring there functional, bioelectrical and neurochemical processes which underlie and accompany decision making, specific studies need to be conducted. Non-invasive and constantly improved imaging methods make it possible to observe the activity changes in particular brain structures during initiating the decision, preference assessment, risk-taking or the execution of other tasks. What is more, the analysis of measurements obtained at rest and in experimental conditions enabled the researchers to recognize the parts of the brain that are activated in the course of performing different tasks.

The available monitoring methods can be divided into the ones that provide images of the brain structures (computed tomography—CT, nuclear magnetic resonance—NMR, anatomopathological tests) and the ones that monitor its functions (functional NMR—fNMR, electroencephalography—EEG, positron emission tomography—PET). Additionally, the researchers have at their disposal other, more technically challenging methods that create new opportunities for monitoring the neurochemical or neurophysiologic brain activity.

Today, the elementary method of brain imaging used in experimental studies and in pathology diagnostics is the nuclear magnetic resonance (NMR). Technological advancement has brought even more precise high-field imaging devices (7 T). The functional nuclear magnetic resonance (fNMR) is a brain imaging method monitoring changes in the magnetic field. It assesses the amount of oxygen transported to various parts of the brain, thus visualizing which parts of the brain become active when making specific decisions. The effect of structural changes (such as the focal lesions or the lesions in cerebral cortex) on decision making, e.g. in brain-aging processes, can be monitored by means of conventional neuro-imaging methods, such as computed tomography or magnetic resonance imaging.

The resonance technology facilitates the assessment of morphological lesions in the brain tissue. Metabolic irregularities are detected by means of proton magnetic resonance spectroscopy (1H-MRS) which allows for a quantitative viability measure of brain metabolites and for an insight into its chemical composition (Demaerel 1997). Another, relatively new technique of imaging is the diffusion NMR that resolves the diffusion water movement in the inter- and intra-cellular fluids within the brain (Thijs et al. 2001). The diffusion of water molecules within

the brain is anisotropic, therefore in a way of mathematic transformations we can obtain the so called Apparent Diffusion Coefficient (ADC) maps in the brain. Due to this neuroimaging technique the changes in the brain can be detected within minutes, in contrast to conventional tests such as KT and NMR that take hours. There are the following diffusion techniques: Diffusion Tensor Imaging (DTI) that can be used in diagnosing lesions in white matter tracts and Diffusion-Weighted Imaging (DWI) which is highly effective in resolving various forms of the brain pathology. The above methods have been recently applied in the neuroeconomic research.

Before the introduction of DTI specific tracts within the brain could be traced only by means of neuropathological tests. Apart from the analysis of lesions in some parts of the brain, DTI allows neuroscientists to focus their interests on the networks that link these lesions. Thus emerged the opportunities to study various networks within the brain, as well as their parts (Chiang et al. 2009). The diffusion tensor and a new technique called tractography, which also visualizes white matter tracts, have become the methods that can be used not only in the clinical practice, but also in behavioral psychology or in neuroeconomic research (Johansen-Berg and Behrens 2006).

PET is a very accurate scanning technique where a radioactive tracer is transported to the parts of the increased neuronal brain activity, thus allowing detection of the structures that are most activated during the performance of an individual task. The practical disadvantage of this method is the procedure of the tracer preparation, its stability and cost.

Other brain imaging methods use a laser beam with near-infrared wavelength, which allows to track the blood flow that absorbs light of different wavelength depending on its oxygenation. What is registered is the light reflected by the brain. Such methods include: NIRS (near-infrared spectroscopy), DOT (diffuse optical tomography) that enable researchers to build brain activation maps, and EROS (event-related optical signal) that shows changes taking place in activated neurons. Unfortunately, this method can only be used to examine cerebral cortex and its disadvantage is its poor spatial resolution.

EEG, that monitors solely the bioelectric brain activity, is a relatively cheap method whose accuracy was not initially appreciated but, along with the technological advancement and the introduction of multichannel devices, has become more and more popular.

There are also brain stimulation methods such as transcranial magnetic stimulation (TMS) where after transcranial stimulation the maps of brain activity typical of a given task are made.

Extremely interesting opportunities are created by methods of neurobiological observation due to which we can monitor processes in single neurons or in their groups. After placing an ultra-thin microelectrode in the cell body, the changes in neural stimulation can be monitored. These method are used in experiments on animal brains. In one of the first neuroeconomic studies the researchers analyzed how single neurons in a monkey's brain respond to the changes in value and to a reward (Glimcher 2003). It is also possible to map single neurons by means of

single neuron imaging (SNI) where electrodes are implanted in specific neurons, which can be done due to genetic engineering and imaging techniques (Kawasaki et al. 2007). Unfortunately, it is an invasive method that cannot be applied in studies on humans. Nevertheless, it creates the opportunity to measure directly the activity of neurons.

Other, interesting solutions are offered by optogenetics chosen "the Method of the Year" by the journal *Nature* in 2012. In a technologically complicated way genes of light-sensitive proteins are injected into specific animal brain neurons and then the secretion of neurotransmitters is monitored by means of light (Deisseroth 2011).

Psycho-physiological methods correlate various psycho-physical functions with physiologic responses, thus testing, e.g., what effect positive and negative emotions have on heart rate, ventilation rate, blood pressure or skin conductivity. One of the most common methods in this group is galvanic skin response (GSR). The method is used, for instance, to assess the reactions of anxiety associated with risky decisions (Bechara et al. 2000). Another interesting method is eye-tracking (ET). These methods have long been known, the observations are easy to record and interpret, which explains their popularity.

Vital information can be obtained by correlating the findings of examinations of anatomo-pathological brain structures associated with the decision-making related activity. This method is applied in diagnosing neurological patients with impaired decision-making skills and poor evaluation of the consequences of the decisions they have made. The example is a study where healthy individual's ethical opinions were compared with the opinions of patients with damaged ventral-medial part of prefrontal cortex (Koenigs et al. 2007). It was observed that the patients' choices were much more rational and ethical than those made by healthy individuals in the control group.

When analyzing methodology of neuroeconomic research it is clear that the majority of researchers use one or two methods. It seems to result from the cost of individual tests or from other kind of difficulties.

1.3 Brain Activity and Decision Making

The first answers to the question how human brain works in terms of volitional processes were suggested by the outcomes of B. Libet's experiments in the 1980s (Libet 1985). He observed the electrical activity of the brain during a simple task of voluntary flexing the wrist and discovered the so called readiness potential that occurred about a second before the motor act, while the very awareness of the will to flick the hand preceded the movement by about one fourth of a second. That meant that the brain had made the decision before the individual became aware of it.

The fact that the decision-making processes begin before the individual becomes aware of them has been confirmed by studies using the functional nuclear magnetic

resonance (fNMR). Subjects examined by the NMR scanner were asked to decide whether they wished to add or subtract two figures. It was observed that the neural activity allowing to predict if the subject intended to add or subtract emerged app. Four seconds before they actually became aware of that decision (Haynes et al. 2007).

The results of that study caused some controversy, primarily leading to a conclusion that there was no free will. Williams wrote in New Scientist: "Unconscious processes result in making a decision long before conscious thinking begins" and "the brain probably makes decisions before its owner does" (Williams 2013). Coyne, the evolutionary biologist, said in his column "So it is with all of our other choices: not one of them results from a free and conscious decision on our part." (Coyne 2012). The above concepts that our decisions associated with conscious acts and their planning are made solely in our subconsciousness should be approached with caution as it is still highlighted that free will plays an important role in decision making.

Studies on humans and apes found that principally two neural systems were involved in financial decision making (McClure et al. 2004). The first system, consisting of the structures of the limbic and paralimbic systems embracing the ventral part of striatum, prefrontal and orbitofrontal cortex and a part of hippocampus, became active when the option of immediate benefit or loss was available. But when the decision concerned the delayed option, the second system, composed of posterior parietal and lateral prefrontal cortex, took over. However, that hypothesis was not confirmed in subsequent studies. Instead, it has been revealed that the limbic system is not particularly involved in decisions concerning immediate options (Bayer et al. 2007). In subjects making decisions associated with obtaining most immediate benefits the highest activity was observed in the ventral striatum and the posterior and anterior cingulate cortex (Kable and Glimcher 2007). Those structures were also engaged in the delayed benefit decision making but their activity was much weaker than in the case of the decisions concerning immediate benefits.

1.4 Neurobiochemistry of Decision Making

Neurobiochemistry has defined several compounds—neurotransmitters—that are related with decision-making processes. The most important are dopamine, serotonin (Rogers 2010), cortisol, oxytocin and prolactin which are chemical substances controlling the transmission of electric impulses between neurons. Their role is to mobilize the brain to undertaking specific tasks (Bayer et al. 2007).

In order to assess the relationship of dopamine with various economic factors, such as risk or benefit delay, the studies were conducted on single neurons in monkeys. It has been found out that the dopamine midbrain neurons influence the decisions concerning consumption of fluids and foods (Schultz 2006) as well as

error prediction (Schultz et al. 1997). The studies suggest that the delayed benefit decisions are also connected with the dopamine neurons (Kobayashi 2008).

The studies on relations of serotonin with economic behavior were based on pharmacological interventions in humans. The researchers applied rapid tryptophan depletion (RTD), the technique of temporary reducing brain serotonin by ingestion of an excess of neutral amino acids in the reduced presence of serotonin precursor, i.e. tryptophan. The studies compared the economic behavior of the treatment and the control group. It was found that RTD considerably altered decision-making processes in gambling tasks and made the treatment group choose the more likely of the two possible outcomes more often than the control group (Talbot et al. 2006). On the other hand the subjects who followed RTD had poorer ability to distinguish the volume of the expected rewards attributed to specific choices (Rogers et al. 2003).

The findings of the research into the relationship between brain serotonin and the approach to risk are inconclusive. Some studies do not confirm the correlation between risk taking and the levels of serotonin (Rogers et al. 2003; Talbot et al. 2006), while the others provide evidence that there is a dependency between serotonin levels and neuroticism, loss avoidance or aversion which are individual attributes closely related with risk avoidance (Gonda 2008, Murphy et al. 2008). Another scientific project investigated the impact of two neurotransmitters, serotonin and dopamine, on risk taking and confirmed their mutual vital role (Kuhnen and Chiao 2009). It is generally assumed that serotonin interacts with dopamine in triggering the signals of prediction processes (Denk et al. 2005, Tanaka 2007). It has been observed that the importance of delayed rewards is ignored when serotonin levels are low (Schweighofer et al. 2008). The brain activity of both the dopaminergic and and serotonergic decrease with aging, which aggravates cognitive disorders. This explains specific changes in economic behavior occurring that are age-related or accompany neurodegenerative conditions such as Alzheimer's disease or other dementia syndromes (Mohr et al. 2010).

Also, the location of numerous subcortical nuclei in brainstem and hypothalamus that control the production and transport of neurotransmitters to various parts of brain as well as to specific parts of body apart from the brain. Due to complicated character of these chemical compounds it has not been fully explained yet what mechanisms implicate their production and what their effect is. In neurochemical terms, what conditions the control of decision-making processes is good communication among different parts of brain which is regulated by serotonin concentration. Its level rises at the moment of getting satisfaction from making an important decision, while its deficit can cause lowered self-control capacity. There are different levels of neurotransmitters in each cerebral hemisphere. In the right-brain the concentration of noradrenalin and serotonin, playing fundamental roles in activating and suppressing emotions, is higher. The left hemisphere is richer in dopamine that is responsible for concentration and attention, which are vital in decision making. It also controls the right-brain inhibiting the actions that are regarded improper from the social point of view. The more the right hemisphere controls one's personality, the individual will be vulnerable to their own impulses

and emotions in decision making (Denk et al. 2005; Rogers 2011). The influence on decision-making processes of other chemical substances present in the central nervous system, such as norepinephrine is increasingly being recognized (Eckhoff et al. 2009).

What is essential for the proper neurochemical functioning of the brain is the right concentration of glucose, the deficit of which can lead to anxiety, agitation and aggressive behavior.

It needs to be remembered that in decision making the functional state of the brain is important, but also the condition of the whole body. Fatigue, exhaustion, dehydration, misbalance of homeostasis contribute to making wrong choices.

1.5 Neuroanatomy of Decision Making

Decision making is a complex process that is possible only due to the processes taking place in many parts of the brain (Lee et al. 2007). From the neuroanatomical point of view, however, it is prefrontal cortex that plays a crucial role in their coordination (Krawczyk 2002). Neuropsychological studies, particularly the neuroimaging ones, have defined the areas of prefrontal cortex that are pivotal for decision making. Also, the research into the relationships of anatomopathological lesions with changes in the patient's functioning allowed for evaluating the importance in decision making of specific cortex areas such as orbitofrontal cortex (Volz and von Cramon 2009), dorsolateral prefrontal cortex (Lee and Seo 2007) and anterior cingulate cortex (Rushworth and Behrens 2008).

1.5.1 Orbitofrontal Cortex

Orbitofrontal cortex has extensive connections with sensory analysis structures—olfactory, gustatory, visual and somatosensory cortices, as well as with corpus striatum being a part of the reward system. Such neuroanatomic conditionality allows orbitofrontal cortex to participate in perception and generation of responses to stimuli of the primary reward value. It results in decisions associated with need satisfaction (Rolls 2004). Additionally, this part of the cortex is responsible for the analysis of the individual stimuli value. The example is a patient with damaged orbitofrontal cortex who, despite preserved high level of declarative knowledge and problem-solving skills, was experiencing difficulty in making decisions in simple, everyday situations as well as in adapting to the environment (Eslinger and Damasio 1985). It was observed that patients with lesions of orbitofrontal cortex performed tasks disregarding their high costs, expected immediate and big profits

and were not able to accept a long-term perspective (Bechara et al. 2000). That allowed to make the somatic marker hypothesis, according to which the emotional response related to the options to choose is possible due to the connections between orbitofrontal cortex with amygdaloid nuclei and with hippocampus (Bechara et al. 1994).

It has been proven that orbitofrontal cortex also participates in generating responses to abstract cues, such as the financial ones, and that it is where value is attributed to individual objects (Plassmann et al. 2007). The fNMR tests have clearly shown in which parts of orbitofrontal cortex are activated in response to financial benefits and losses (O'Doherty et al. 2001). Particularly strong activation of this brain area occurs when decisions are made in the circumstances of uncertainty (Hsu et al. 2005).

Particularly strong activation of orbitofrontal cortex with connections to the reward system facilitates active recognition and sustenance of profit-generating behavior and suppresses behavior resulting in financial loss. It occurs when the decisions are associated with substantial financial rewards or penalties (Elliott et al. 2000).

The sensitivity of the neurons in orbitofrontal cortex to a reward stimulus triggers subjective stimulus value on the continuous scale and dissociates the options to be chosen (Grabenhorst and Rolls 2009). What also takes place in this cortex is the adaptation to environmental changes, long-term monitoring of their effects and extinguishing the response to stimuli whose reward value is decreasing (Krawczyk 2002).

The activation of orbitofrontal cortex subside when the stimulus is delayed. Therefore it has been observed that in human decision making the value of delayed stimuli tends to decline (Green and Myerson 2004).

1.5.2 Dorsolateral Prefrontal Cortex

It is the dorsolateral prefrontal cortex where the decision-making process is recognized and where thus obtained information is used to control the decisions (Krawczyk 2002). What is essential for decision making, this cortex stores information about the decision maker's environment in the short-term memory and then processes this information (Lee and Seo 2007). The dynamics of human decision-making processes depends on intellectual evaluation and adaptation to the environment where the decisions are made (Gigerenzer 2007).

In the dorsolateral prefrontal cortex other relevant operational memory-related tasks are performed, such as storing information, including the affective ones, out of which the decision goals and options are chosen (Krawczyk 2002; Goldman-Rakic 1996). Other vital functions of the dorsolateral prefrontal cortex include:

- shaping the rules of proper decision making and referring them to new situations on the basis of previous experience (Wallis and Miller 2003),

- simultaneous processing of information about environmental conditions and about the reward value of environmental stimuli (Kobayashi et al. 2007),
- integrating information about physical and abstract attributes of individual decision options and their motivational importance (Sakagami and Watanabe 2007),
- distinguishing and categorizing newly perceived stimuli and, on that account, making choices out of options with similar attributes and similar subjective usability (Krawczyk 2002),
- categorizing new stimuli and attributing them with reward values (Pan et al. 2008),
- planning, controlling and adapting behavior to temporarily and prospectively important rules and consequences (Sakagami and Niki 1994),
- selecting responses adequate to the present stimulus, predicting its reward value and planning the response accordingly (Wallis et al. 2001),
- modifying behavior on the basis of previous decisions (Hare et al. 2009).

1.5.3 Anterior Cingulate Cortex

Anterior cingulate cortex plays a specific role in making decisions in the conditions of uncertainty as it is responsible for choosing between responses to two or more competing stimuli. The level of activity of this cortex is directly proportional to the intensity of the conflict. Basing on the observation of increased activity in cingulate cortex after having made wrong decisions it has been found that due to this mechanism a human being is able to continuously monitor the correctness of their behavior (Carter et al. 1998).

Other vital functions of the anterior cingulate cortex include:

- altering the chosen activity after the wrong decision has been recognized; predicting the potential value of the selected choices and evaluating their costs and pay-off (Walton et al. 2007),
- choosing between an available small reward and the substantial but effort-based one (Walton et al. 2002),
- decreasing the decision-making uncertainty (Yoshida and Ishii 2006),
- initiating the choice of the decision which is the most accurate in given circumstance (Rushworth et al. 2007),
- observing and collecting information about other people's behavior that leads to making interpersonal or broad-range social decisions (Rilling et al. 2002),
- predicting negative consequences of decisions that have been made and analyzing the uncertainty of the consequence assessment (Rilling et al. 2002),
- integrating cognitive aspects of the decision uncertainty with the autonomic arousal that accompany negative consequences of decision making; creating conditions for decision verification and correction (Critchley et al. 2005).

1.6 Brain Processes: People's Behavior Prediction and Empathy vs. Decision Making

Decision making is to some extent based on the assumption that people are able to predict the behavior of others and empathize with them. This ability results from individual preferences and beliefs. Social neuroscience provides insight into neural mechanisms underlying our capacity to represent intentions, beliefs and desires of other people and to share other people's feelings, e.g. to empathize. Empathy makes people less selfish, allows them to share emotions and feelings with others, thus motivating them to make decisions oriented at other people. Studies on empathy indicate that the same affective brain neural circuits are automatically activated when we are feeling pain as well as when we see others in pain. Therefore, while making decisions, empathy often directs our emotions at other people.

Developmental and social psychology as well as cognitive neuroscience focus on human ability to assess and predict various states, such as desires, opinions, intentions, of other people. A study was conducted on the brain activity during the choice- and belief-related tasks (Bhatt and Camerer 2005). It revealed the involvement of the medial part of prefrontal cortex, i.e. the anterior cingulate cortex. This part of the brain takes part not only in reading other people's thoughts, intentions and beliefs, but also helps refer to one's own states of mind. It assists in creating decoupled representations of our beliefs about the state of the world (Frith and Frith 2003).

Similar research concentrated on searching for neural mechanisms being a basis for human ability to represent other people's goals and intentions solely by observing their motor acts. Such an approach stemmed from the observation that neurons in premotor cortex in macaques' brains activate both when the monkey makes a hand movement and when it observes another monkey or a human making the same hand movement. It was a remarkable discovery of the fact that the so called mirror neurons reflect the neural origins of imitation which is vital in the decision-making context (Rizzolatti et al. 1996). The system of mirror neurons may be the basis for our ability to empathize with mental states of other people, ensuring that we automatically simulate their acts, goals and intentions and adapt our decisions to this.

Apart from the ability to understand other people's state of mind, people are also able to empathize, i.e. to share other people's feelings in the absence of any emotional arousal. What is more, humans can feel empathy toward others in many different emotional situations, both elementary such as anger, fear, sadness, joy, pain or desire, and more complex, such as the sense of guilt, embarrassment or love. Relying on the perception models explaining behavior and imitation, the researchers proposed a neuroscientific model of empathy, implying that the mere observation or image of a person in a given emotional state automatically activates the representation of this state in the observer together with the related responses of their autonomic and somatic systems, thus strongly influencing their decision-making (Preston and de Waal 2002).

The research by Singer has proved that both strong stimuli (pain) and the awareness that someone important to us feels pain activate the same pain neural circuits. That finding implies that if a person dear to us suffers from pain, suffering will also appear in our brain (Singer et al. 2004). It seems that the ability to emphasize could have developed from the same system which creates the representations of human inner states and it helps predict and understand other people's feelings associated with some event, e.g. with a decision that has been made.

The results of Singer's study suggest as well that empathic response is automatic and does not require active assessment of other people feelings. Volunteers subjected to neuroimaging did not know that the experiment examined empathy. The analysis confirmed that the ability to emphasize is individually diversified.

What is important for understanding decision-making processes is the fact that emphatic responses appear also when individuals who undergo brain imaging tests do not know the person who receives the pain stimulus. The findings of studies on empathy can contribute to better understanding of social preferences, especially of behavior considered honest and dishonest. These findings show that many people have a positive opinion about those who behaved honestly in their decision making and are regard negatively those who behaved dishonestly. Such a pattern of preferences suggests that people prefer to collaborate with honest partners, advocating penalties for dishonest competitors (Fehr and Gächter 2000).

1.7 Neurobiology of Moral Dilemmas vs. Decision Making

From Aristotle to I. Kant to J.S. Mill, moral philosophy theories say that the primary role in making moral decisions is played by brain. In the light of modern developmental psychology, rationality is perceived as the foundation of moral choices. On the other hand, sentimentalists contended that emotions play the primary role in moral decision making. A. Smith wrote in 1759 that morality comes from understanding other people and the feeling of sympathy toward them. His view finds its appreciation in the concepts of modern sentimentalists, such as (Haidt 2006).

Neurobiology attempts to find out how moral decisions appear in the brain and how these decisions van by modified by emotions. It is the doctors who face particularly controversial moral dilemmas in their everyday practice, having to choose between two bad solutions, e.g. which accident victim they are to help first, being aware that their decision reduces the other victim's survival odds. The economists also have to decide which poorly performing company or bank should be given access to funding.

The studies of lesser-evil decisions are based on M.D. Hauser's Moral Sense Test (MST). It is a series of hypothetical situations where subjects choose one of several difficult solutions (Hauser 2007). What is interesting, fNMR tests show that time of response is longer when the decisions are associated with the choice of a utilitarian solution than when they require violating personal moral standards (Hauser 2007).

In the famous Thomson's Trolley Dilemma where the decision has to be made whether to redirect the runaway trolley from the its current course and save five people standing on the track and kill one person standing on the alternative track. The question is: is it morally acceptable to hit the switch to turn the trolley to save five people at the expense of the one? (Thomson 1978). The majority of tested subjects decide to hit the switch, regarding such a choice as the utilitarian solution, thus following J.S. Mill's view that moral acts are the ones that make people happier.

The decision of another type has to be made in the Footbridge Dilemma where a trolley heading for a group of several people can be stopped by pushing a stranger off the bridge and onto the tracks. Unlike to the previous moral dilemma, most subjects do not decide to push off the stranger, which may result from the fear of violating the moral standard: Do not kill.

There is an interesting explanation of the above decisions based on the double effect doctrine credited to Thomas Aquinas which says "An act which causes a certain ethically negative effect and which would be morally unacceptable if performed intentionally can be morally justified when performed with the intent to cause another, morally justified effect and only becomes its unintentional, although predictable, effect" (Galewicz 2001).

Hence, the act which is an effect of specific decisions will be acceptable when: its effect is good, brings at least as much good as its abandonment, will not be performed in bad faith and will be an effect of the action rather than the bad outcome. According to such approach, saving people in the Footbridge Dilemma does not satisfy the last criterion (people have been saved as a result of killing one person), this is why most subjects do not make this decision. In the Trolley Dilemma the death of one person was caused by hitting the switch (the death was 'just' induced).

Modern moral psychologists J. D. Greene and J. Haidt maintain that although decisions concerning the above moral dilemmas are connected with violating moral standards, they still have ethical character. In the Trolley Dilemma the decisions are of non-personal nature, while in the Footbridge Dilemma, they are definitely personal decisions. When facing decisions that may lead to hard consequences, most people accept non-personal violation of moral standards, while rejecting personal violation of these rules.

1.8 Conclusions

Decision making is closely connected with neurobiological, neurostructural, neurochemical and psychological mechanisms. They take place in specific parts of the brain, particularly in the prefrontal cortex, an area integrating connections with individual decision options. This process prepares relevant preferences with reference to current needs of a decision maker. Studies on neurobiological background of decision making give better insight into the human implied bounded rationality

and into the role of emotions, morality and empathy. Moreover, these studies contribute to the knowledge about the course of decision-making processes and their adaptive value.

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Chapter 2
Psychological Determinants of Decision Making

Ernest Tyburski

Abstract Decision making has been a subject of study in many scientific fields. It is psychological studies, however, that have brought significant contribution to understanding mechanisms that underlie making choices by individuals. The purpose of this chapter is first of all the description of mental processes, also referred to as decision-making activities, that are involved in various stages of decision-making. The second purpose is to present two systems of information processing which are engaged in varying degrees in the process. Moreover, the chapter describes the strategy of decision making, i.e. the heuristics allowing for prompt and economical actions. It also defines the role of free will and self-control in the decision-making processes. What is of key importance is the explanation from the psychological perspective of the process of decision making under uncertainty as well as the discussion of potential negative consequences of complex decisions made by individuals, groups and communities.

Keywords Decision making • Cognitive functions • Cognitive dualism • Consequences of decision making

2.1 Introduction

The decision-making mechanisms have been in popular interest for a long time and the related research has been conducted at the interface of many scientific fields. Psychology has made substantial contribution to understanding the decision-making phenomenon. Thanks to theories developed on its basis it has become possible to explain how individuals make their choices in real-life situations. First of all, a distinction should be made between two notions, i.e. between a decision itself and decision making. The simplest definition of the decision states that it is a purposeful and non-random choice of one out of at least two alternatives, while

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decision making is a process that involves various mental functions, both the elementary ones, such as working memory and long-term memory, and the complex ones, such as thinking, reasoning or problem-solving, as well as executive functions lying in the middle, between cognition and action (Hastie and Dawes 2010; Toplak et al. 2010). Moreover, in the process a vital role is played by emotional and motivational functions because while making decisions individuals formulate their cognitive judgments basing on their own emotional experience (Lerner et al. 2015). Also, modern reference literature often discusses conscious and unconscious influences on decision making, including the power of impact of explicit and tacit processes on individual choices and the correlations between these processes (Newell and Shanks 2014). The above mental functions are subordinated to a specific goal, i.e. the choice. Hence, it can be assumed that they are decision-making activities (Falkowski et al. 2008).

The decision-making activities lead to the choice of one of two or more alternatives as well as to the so called alternative choice. For example, when planning their shopping, people do not have to choose the product in advance. If it turns out that product A is fresh, they can buy it, if it is not—they decide on product B as an alternative. In complex decision-making situations, mainly when facing crucial life dilemmas, the choice among a limited number of possibilities is usually preceded by long considerations aimed at reducing the complexity of the dilemma, which consequently leads to an "either-or" choice. For instance, theoretically speaking, a fresh high school graduate can choose among thousands of university courses basing their decision on such aspects as the reputation of the university, their own interests, financial conditions or career prospects. Therefore, the young graduate reduces this excessively complex dilemma to just several options to be considered.

This chapter presents the characteristics of mental processes that are activated at individual stages of decision making followed by the description of two systems of information processing that are responsible for human decision making. Additionally, the purpose of this review is to describe the decision-making strategies, i.e. the heuristics that facilitate prompt and efficient actions and to define the role of free will and self-control in the decision-making processes. What is of key importance is the explanation from the psychological perspective of the process of decision making under uncertainty as well as the discussion of potential negative consequences of complex decisions made by individuals, groups and communities.

2.2 Stages of Decision Making

In the psychological approach decision making is divided into three phases: the pre-decision phase (problem formulation and information gathering), the decision phase (the choice among previously defined options) and the post-decision phase (the evaluation of the decision made) (Svenson 1992). The basic activity in the pre-decision phase is identification of a problem, or in other words—defining the

discrepancy between the present state (no decision has been made yet) and the desired state (the decision has been made). The dilemma situations faced by individuals when making a choice can be categorized according to diverse criteria, such as (a) convergence, when the desired state is relatively well defined and just one solution is possible (Sloane and MacHale 1997), (b) complexity, when more complex problems require processing a considerable amount of data and generating their mental representation in a form of a mental model (Nęcka and Orzechowski 2005) and finally (c) definiteness, when the problem is well defined, which means that it has all the information about the goal, circumstances, the terms of acceptability of future solutions, limitations and other data necessary to find a solution (Reitman 1965). The settlement of a dilemma situation can be achieved by reducing the gap between a hardly satisfying starting point and a desired target point. A crucial element of the problem-solving situation is planning, i.e. examining the problem area in a systematic way and defining the directions of searching for solutions which require a certain budget of attention (Morris and Ward 2004). There are two major methods of planning: modeling (arranging steps of action in the mental space) and analogizing (using the correlations in one area to solve problems in another one). Creating a plan is conditioned by three elementary factors: (a) the complexity of a problem that determine the involvement of the cognitive system (e.g. simple problems engage primarily the working memory while more complicated ones occupy abstract thinking), (b) the impact of situational and environmental context (e.g. the capacity to verbalize the task, which facilitates its realisation) (c) individual preferences (e.g. strategies that help specialists to better cope with certain problems than laypeople, Davies 2004). When defining a problem, the decision makers are basing on boundary conditions understood as some kind of limitations imposed on future choices. They also mark out the level of risk that is acceptable in a given situation. The above restrictions may not be complied with at every stage of decision making. What is more, individuals may but need not rationally assume that the fewer consequences of the decision, the higher the acceptable risk. Therefore, people tend to accept a higher risk when buying less valuable goods, and lower risk when the goods to be purchased are expensive.

Another important activity in the pre-decision phase is to collect information about the problem, especially about potential solution options. The decision makers search for information in various sources, e.g. external (Internet sites or friends) or internal (semantic or episodic memory). When they are going to buy a computer, they look for technical specification on-line or consult a computer geek they know. When they are actually buying a computer, they mine in their semantic memory for general data for, say, specific components, while the episodic memory provides information about, for instance, a range of brands to choose from. It is worth remembering, however, that the more complex the problem, the more information is required but harder to find. In addition to this, the search for information is biased and made at random, which may lead to a wrong choice. Some research has shown that the relation between the amount of information gathered by an individual and their competences is non-linear. The least information is collected by incompetent

people because they do not know where to look for and are not able to tell which data are useful and which are not. The most data is obtained by those relatively competent as they know where the sources of information are and can distinguish between the relevant and irrelevant data. Interestingly, highly competent decision-makers find the optimum amount of data, looking only for the necessary ones or they recall the ones they have learned about before (Falkowski and Tyszka 2001).

In the decision phase, the choice is made out of the options previously defined as available (Svenson 2003). It is a step-by-step process and it allows for the choice of one option that is more and more favored in comparison to others, i.e. it is increasingly better justified as logical and subjectively regarded as reliable. Nevertheless, if the decision makers do not restrict themselves to the previously defined options, they can build completely new ones. To this end they change their interpretation of known facts. In the situation when create a new option on their own, they can single it out and justify it by making a decision, simultaneously considerably changing the structure of their knowledge. Such a mode of operation is typical of experts who make decisions using the knowledge, the quality of which differs from the knowledge of laypeople because the former often make decisions that are non-typical for their field of expertise (Shanteau 2012).

In the above phase the collected information is evaluated, which means that relevant data are separated from the irrelevant ones. This particular process is determined by several factors, the most important being cognitive processes, experience and context. When evaluating the information, people derive from their long-term memory as well as employ effective thinking, reasoning and well-operating working memory (Hinson et al. 2003; Zagorsky 2007). Moreover, superior mental functions of cognitive control, termed executive functions, are activated, especially the attentional switch and cued response inhibition (Tranel et al. 1994; Del Missier et al. 2010). The cognitive sphere is also subject to other factors, such as emotions that accompany decisions whose effect can be consistent or inconsistent with cognitive functions employed in decision making (Schwarz 2000; Andrade and Ariely 2009). Additionally, the cognitive processes are modified through anticipating and imagining the consequences of the choice made, through the capability to benefit from feedback as well as through the general decision-making policy (Wood and Bandura 1989; Bandura and Jourden 1991). Another relevant function is the ability to assess risk connected with individual options. No matter what kind of risk the individual can accept, they need to be able to assess that risk and envision the alternative courses of action after the decision has been made. Yet, human imagination is usually not creative enough, therefore people make their choices bearing in mind not what might happen after the decision but what they believe will happen inevitably (Falkowski et al. 2008).

The evaluation of data collected in the pre-decision phase also relies on individual experience which in turn is determined by individual differences in personality, temper and expertise. Certain role is attributed to neuroticism which is associated with the aversion to risk and the propensity to choose the most systematic strategy of information search that helps define the decision-making problem (Falkowski et al. 2008). Additionally, conscientiousness, integrity and openness are

involved in decision making because they are traits that reflect availability in terms of cognitive and behavioral control (Djeriouat and Trémolière 2014). Some authors suggest that in comparison to laypeople, experts are able to tell relevant information from the irrelevant one thanks to their previously obtained knowledge, reasoning schemes and easy access to information stored in their long-term memory (Shanteau 1992; Randel et al. 1996; Zsambok and Klein 2014). Hence, a highly experienced person is able to focus their attention on relevant information, while ignoring the irrelevant one. Yet, in particularly difficult situations (e.g. on the battlefield) experts make mistakes as well because they are not able to extract the most essential information from the noise of data that are irrelevant or even misleading.

Another group of factors that determine the evaluation of information validity is context. It can be problem-related or general, i.e. referring to a specific problem or to environmental conditions (Rohrbaugh and Shanteau 1999). The example of the general context is an overall economic or political situation that must be taken into account when making investment or military decisions. The problem-related context reveals itself depending on the wording used when describing the problem or on the associations evoked in the decision maker's brain. The example of an environmental factor that has a considerable effect on the judgment of the collected data is the pressure of time. In important areas of life, when people have to act under tight time pressure and it is not possible to follow a carefully devised strategy, it is recommendable to use automatic action schemes or to refer to one's intuition (Ordonez and Benson 1997).

In the last phase of decision making the post-decision processes set off that can take a form of doubt if the made choice was the best possible. Individuals can then attempt to convince themselves that they have chosen well by increasing the attractiveness of the selected option and simultaneous depreciation of the remaining alternatives. The mechanism is referred to as the reduction of post-decision dissonance or as the discrepancy between the option and the goal which they have been pursuing (Liang 2016). The strategies of reducing the above dissonance can take various forms, e.g. seeking confirmation of one's decision with other people by comparing oneself with people who made a worse decision in an identical situation or cognitive manipulating the value of information after the choice has been made, i.e. giving value to disadvantages and depreciating the advantages. Despite such efforts the decision maker can experience the so called post-decision regret. The more difficult the decision, the stronger the regret. In such situation individuals take measures to alleviate the emotional repercussions of that regret, thus preventing themselves from changing the decision they have made. This is an example of the decision makers' limited rationality when making critical life choices.

2.3 Dualism of Mental Systems in Decision Making

The way how individuals make decisions has been the subject of interest of researchers representing the range of scientific disciplines. The concepts originating from economics, termed normative theories, assume that decision makers have unlimited capacity, i.e. they are able to gather important information about various decision options, flawlessly analyze the data, correctly calculate the probability and eventually make a right choice. In other words, they always make rational decisions (Neumann and Morgenstern 2007). Psychological theories, defined as descriptive, presume that individuals do not always act in a reflective and logical way and they often make decisions that are satisfying but not optimal (Simon 1956; Zsambok and Klein 2014). Moreover, the cognitive psychology studies confirm that decision-making based on the analysis of all available data and following complex rules of behavior is accurate when performed in laboratory conditions rather than in natural circumstances (Payne et al. 1993; Ranyard et al. 1997; Juslin and Montgomery 2007).

Decision making is associated with a varying level of effort. People often make choices automatically, e.g. they go shopping to stores that are generally considered cheap. But decisions sometimes require conscious involvement and a thorough analysis of information, for instance, when a decision maker is buying a car. It is psychologists who search for an explanation how individuals make decisions, both the simple and the complex ones. In their deliberations they frequently refer to the division into two modes of reasoning proposed by James (1950/1980): intuitive/associative (recreative, based on comparisons) and logical/analytical (creative, based on the analysis of new data). Kahneman and Frederick (2002) claim that decision making depends on two competing systems of information processing. System 1 is called the intuitive system. Information is processed automatically, almost effortlessly, associatively, fast, parallel, unconsciously and often emotionally. This mode of operation is hard to control or to modify. System 2 is referred to as the reflective system. Information is processed in a controllable way, with substantial effort, deductively, slowly, sequentially and consciously. In this system the mode of operation is flexible and governed by general rules. In order to find out if a given mental process runs according to System 1 or System 2, we should observe the resistance to interruption caused by performing two tasks at the same time. In System 1 the operations are resistant to interruption, while in System 2 they can be disturbed (Kahneman 2003). The example is a situation where the subjects are asked to keep in mind several signs and simultaneously they are given another task. They usually respond automatically, following the first association (Kahneman and Frederick 2005). The differences between these two systems also lie in the content of the processed data. In System 1 the data content includes observations, temporary cues and their impressions that are non-voluntary and non-verbalized, based on emotions and specific. They are referred to as prototypes. Whereas in System 2 the data content represent ideas in a form of consciously generated judgments that are abstract and not affective. They create a set. The decision-

making process takes place according to the following scheme: first, System 1 is activated and proposes a solution, then System 2 joins and monitors the quality of mental operations. If the monitoring is disturbed and System 2 does not successfully intervene, what prevails are the judgments generated by System 1 on the basis of primary impressions.

Similar findings were published by Epstein (1994) according to whom individuals make choices relying on two systems that operate in parallel. Epstein calls the first one experiental as it is based on experience, He claims that it not only fast and automatic, but also that its operating manner is holistic, concrete, primarily non-verbal and minimally demanding of cognitive resources. It is highly dependent on emotions and on learning from affective experience, the effect of which is the pursuit of desirable outcomes while avoiding the undesirable ones. The second system is rational, basing on abstract and analytical reasoning. It operates according to general rules, reasoning and evidence. It is associated with culture and not directly affective. Epstein (2003) also believes that the system which is based on experience often gains advantage over the rational system. His opinion has been confirmed by the results of the experiment on the impact of stereotype priming on the accounts of the experiment participants whose responses were not consistent with their views (Bargh 1999). Moreover, Epstein's thesis has been supported by a study on two groups of children (aged 10–11 and 13–14). The study revealed that older children more often overestimate size over ratio than younger children. However, it may happen that System 2 influences System 1. In one of his experiments Epstein (2003) instructed participants to list three thoughts that came to their mind after imagining the following situation: Sophie bought a lottery ticket and crossed some numbers taking advice of a friend rather that following her intuition. Sophie failed to win a lottery. The participant's most common thoughts were that the friend was to blame. However, their next thought was that no one was to blame because the failure was due to chance. The second thoughts show that System 2 was activated.

Sloman (1996) defines the first system as associative and claims that information-processing in this system is based on similarity and temporal contiguity, where the source of information personal experience. It is a system that is automatic, reproductive but capable of similarity-based generalization and generally referring to the past. The second system is rule-based. Operations realized by the rule-based system are based on language, culture and formal systems. It is responsible for creative and systematic reasoning, abstraction of relevant features from irrelevant ones and strategic processing. Sloman believes that both systems are parallel and can simultaneously participate in solving the same problem. The examples illustrating this particular form of mental information processing are the considerations how to explain the Muller-Lyer illusion. The illusion consists of two parallel arrow-like figures. The fins of the upper arrow point inwards, while the fins of the lower arrow point outwards. The viewer's task is to tell which shaft is longer. At first glance they say that the bottom one is longer (the first system basing on perception is launched), but on the second thought they realize that both lines are of the same length (the second system basing on rules is activated).

Evans (1984) proposed a slightly different concept of the heuristic and the analytic systems. The former is not directly linked with consciousness, processes information fast and refers to the data associated with a concrete task. The latter is closely embedded in consciousness, processes information in a step-by-step and controllable manner. In contrast to the authors of above mentioned three concepts, Evans maintains that during decision making both systems operate sequentially because the process of analytic information-processing in the second system relies on representations coming from the first system. It often results in biased reasoning as the representations of a problem in the first system are the effect of heuristics (a cognitive shortcut), which means that some relevant pieces of information can be omitted in favor of the irrelevant ones. In his extended concept, Evans (2006) states that the second system operates basing on three rules: (1) generation of a single mental model which represents a single outside world situation, (2) adjustment of mental data mental data collected basing on information coming from the heuristic system, (3) satisfaction which results from testing the solution in a fast, or heuristic, manner. When making decisions, people usually follow the first and the second rule, which reflects their capacity to test one model and abandon it when it is not satisfying.

Similar concepts have been proposed by Stanovich and West (2000). Their concept states that the first system depends on the context, is launched automatically and unconsciously and relies on the heuristic information-processing. Therefore, cognition via the first system will always be burdened with an elementary error, i.e. automatic placement of the problem in a context. This is why individuals often fail to address tasks in accordance with their logical structure, use information originating from the context and interpret the problem situation in reference to the everyday life. The second system in turn is based on analytic reasoning isolated from the context. Mental information-processing taking place in the course of decision making is performed sequentially: initially, the first system instigates an automatic reaction that depends on the context; then, the second system generates the intervention function by stopping and fading out the first system responses on the one hand but, on the other hand, it suggests another, better response based mainly on analytic thinking, thus facilitating the isolation from the context (Stanovich et al. 2008). According to Sokołowska (2005), there is a controversy among the authors as for the characteristics of individual systems. What is questioned is the possibility of the two systems to cooperate (in a parallel or sequential manner) and the involvement of unconscious processes on the lower level (i.e. emotions or intuition).

2.4 Heuristics in Decision Making

In psychological literature the decision-making heuristics are defined as choice strategies. Their two main characteristics are fastness (the time criterion) and frugality (the criterion of the problem complexity and the engagement of processes

necessary to make a decision: Gigerenzer et al. 1999). Due to such strategies individuals can cope in a short span of time with highly complicated decisions, which would not be possible if they attempted to solve the problem in all its complexity. One of the most commonly used heuristics is the elimination-by-aspects strategy where decision makers create a set of criteria and then gradually eliminate the alternatives that do not meet one of the criteria. In the next step, they eliminate options that do not meet the next criterion from the set. Eventually, the number of alternatives is significantly reduced, which facilitates making the final decision (Tversky 1972). Another heuristics is the satisficing strategy which entails searching through the alternatives and finally making the choice which is sufficiently satisfying. Having made a decision a decision maker is satisfied not because their choice has been the best possible, but because it has been good enough, mainly from the point of view of satisfying their needs. This is an example of a compromise of some sort, as the option chosen is not the optimal one, but it has saved time and other resources and, first and foremost, the decision has been made at all. Moreover, it would not be possible to review all the options, particularly that many of them may become unavailable because of other competitors (Simon 2013). The next strategy is choosing what is most important, i.e. following cues of varying relevance. In other words, decision makers select one cue which they consider the most important and then compare individual options in pairs, each time rejecting the one whose value is lower or unknown in terms of the selected cue. If this system turns out ineffective, we can take into consideration the next ranked cue and repeat the process until the decision is made (Gigerenzer et al. 1999). There is another strategy where decision makers rely on what has worked well before. They apply the criterion which proved effective in the last trial of the same kind. The above outlined heuristics are simple decision-making formulas when the number of options exceeds the individual's capacity to analyze all the possible choices. The decision-making strategies not only govern our search for solutions, but also allow us to give up the search when there is no point for them to be continued.

The application of strategies in decision making may or may not be effective. One of the studies reveals that the outcomes of both simple and sophisticated strategies are similar in terms of the decision correctness as well as their universality (or validity in other life situations). What is more, the advantage of simple heuristics is that they the decisions are made faster (Gigerenzer et al. 1999).

However, the application of heuristics can lead to biased decisions. A classical example is replacing the natural probability judgment with the assessment of resemblance. The reason for this is that the probability judgment is more difficult and time-consuming, while the assessment of resemblance is easier and faster. Research has shown that when making choices individuals tend to replace the probability of some phenomenon with its resemblance to another, usually known, one, hence making an assessment error (Kahneman and Frederick 2002). It is an example of a kind of biased reality judgment, i.e. concentrating on irrelevant elements of the situation, which results in a biased decision.

2.5 Decision Making Under Uncertainty

Decisions made in the situations of uncertainty are the ones when we do not know what will happen or when we are not certain what results our actions will cause (Sokołowska 2005). From the economic perspective, the purpose of theoretical models is to provide answer to a question what choices should be made to be considered rational. The most popular concepts in this respect are: (a) maximisation of the expected value depending on which individuals calculate not only the potential losses, but also their probability (Bernstein 1997; Mlodinow 2009), (b) maximisation of the expected utility which means that the subjectively expected value is not a linear function of the objective value because in certain circumstances some people do not maximize the expected value (Bromiley and Curley 1992), (c) maximisation of the subjectively expected utility where the assumptions about the utility and about the subjective resemblance are combined (Bernstein 1998) and (d) minimisation of variance (the portfolio theory) according to which decision-makers minimize risk (variance) while simultaneously maximizing the rate of return, or gains (Markowitz 1952). Yet, the above models cannot be of use in all possible situations in which decision makers have found themselves because they mainly refer to known probability. Psychological studies show that making decisions under uncertainty does not follow the model of subjectively expected utility. Instead of maximizing the expected value, individuals tend to minimize or ignore it. There are several psychological concepts whose authors attempt to explain this discrepancy. One of them is the prospect theory by Kahneman and Tversky (1979). The main elements of this theory stem from the observation of real-life choices. The authors assume that economic decisions under uncertainty are made in two phases: editing and evaluation. In the editing phase we make a decision with a view to simplifying and ordering the decision-making process, usually by means of a specific heuristics (applied consciously or unconsciously). In the evaluation phase we decide on the value of individual alternatives and choose the one that has the highest subjective value. The research conducted by Kahneman (2003) point out that gains and losses are relative and evaluated according to a specified point of reference (e.g. a positive financial value can be perceived as a loss when the corresponding point of reference even more valuable). Moreover, individuals tend to change their risk preference which depends if they are in a loss or gain situation (e.g. when in the gain context the aversion to risk is predominant, while the loss context encourages the propensity to risk). Over the last few decades, plenty of studies have been published that confirm high applicability of the prospect theory, particularly when explaining decision-making mechanisms in business, law or medicine (Sunstein 2000; Camerer 2004; Schwartz et al. 2008). A similar approach is represented by Lopes (1987) who maintains that people make choices in the situations of uncertainty by referring to their adopted level of aspiration and to their individual propensity to risk. Brandstätter et al. (2006) believe that information about outcomes and probability are computed in a sequential manner, which means that in the first step decision makers analyze data about losses, then they focus on

gains. Zaleśkiewicz (2011) notes that out of the above outlined models the prospect theory has been most widely recognized by researchers.

2.6 Decision Making and Volition

Making choices is also associated with volition and self-control. Baumeister et al. (1998) claim that the acts of free will and self-regulation require some effort and people are able to exert limited self-control at the same time. Therefore, the resources allowing self-control are depleted. The power of self-control varies individually. The above mentioned authors describe the limitation of volition resources taking place in the course of diverse activities involving self-control (effort) as ego depletion. The loss of self-control may be detrimental to performance in the individual, group or social dimension, such as uncontrollable shopping, overspending, incapacity to save or risky borrowing (Baumeister et al. 2006). Similar views on the involvement of self-control in decision making are shared by Moller et al. (2006) who maintain that the resources are depleted when individuals are forced to make decisions, but they are not exhausted by autonomous decisions. Research has shown that the resource depletion can also be conditioned by the attributes of goods whose quality and prices are most difficult to estimate (Wang et al. 2010). In different situations people make choices in a similar way, which probably reflects the presence of a universal set of cognitive abilities. These abilities may fail at different stages of decision making; therefore some decisions may be perceived as inadequate or illogical (Hastie and Dawes 2010).

2.7 Consequences of Decision Making

Psychological concepts explain how individuals make their choices, including those made under uncertainty. Nevertheless, these concepts do not address the consequences of the decisions. The situations when we are not certain about the outcomes of our choices are usually associated with strong emotions. Yet, in some people they can cause mental conditions, such as severe stress, anxiety or even depression. One of such situations is the lack of job security resulting in an increased number of absentees, more health-related complaints or decreased general well-being (Davis et al. 2003; Quinlan and Bohle 2009). Additionally, people at risk of redundancy more often experience anxiety and depression (Avčin et al. 2011; Snorradóttir et al. 2013). However, the described above phenomenon has caused considerable controversy. The results of another study revealed that job insecurity is more likely to induce high blood pressure than depression (Modrek and Cullen 2013). Unfortunately, the findings of the aforementioned studies are difficult to compare because some of them are vitiated by methodological errors, e.g. the evaluation of staff's mental problems was made on the basis of their own

declarations instead of objective measurement tools or the analysis covered only the group of employees that were at risk of redundancy, while ignoring the general population of employees.

Usually the predictable consequences of simple decisions are not serious, in contrast to the situations when we are not able to foresee all the effects of our actions, such a decision to take a consumer loan or mortgage. It has not been scientifically proved yet if such a decision can be detrimental to our mental health. This may become a broader problem because mentally ill people tend to accumulate debt more often than the mentally healthy (Jenkins et al. 2009). It emerges that, on the one hand, mentally healthy individuals that become indebted because of various reasons (e.g. gambling, drug addiction or compulsive shopping) are more susceptible to anxiety and depression. On the other hand, however, psychiatric patients lose jobs more often and are less likely to receive government support hence they tend to accumulate debt (Meltzer et al. 2013). Nevertheless, study results reveal that consumer debt (Brown et al. 2005; Taylor et al. 2007), mortgage credits (Drentea 2000; Drentea and Lavrakas 2000) as well as consumer credit and mortgage credits as a whole (Cooper et al. 2008; Bridges and Disney 2010) are linked with diagnosed anxiety and depression. What is more, people who are in debt, disregarding what type, suffer from obsessive-compulsive disorders, phobias and panic attacks (Meltzer et al. 2013). Bentley et al. (2011) suggest that the correlation between mortgage credit and mental disorders is stronger in a group of low-income people. Other researchers have obtained contradictory results, indicating that the socio-economic status does not have effect on the relationship between debt and the prevalence of mental diseases (Drentea and Reynolds 2012; Mauramo et al. 2012). Also in this case the comparison of results is difficult because of the lack of uniform operationalization of debt (Martin-Carrasco et al. 2016).

2.8 Conclusions

The review of literature about psychological aspects of decision making allows for several elementary conclusions.

First, from the psychological point of view decision making is a complex process consisting of three stages: the pre-decision phase, the decision phase and the post-decision phase, each representing different activities. Mental operations preceding the actual choice presumably follow a similar pattern in all humans.

Secondly, basing on psychological theories, a universal model was built of two systems of computing information involved in decision making. The first one is termed intuitive or affective, while the second one—as analytic or logical. This distinction reflects the classical division existing in psychology into processes that are unconscious, fast and automatic and the ones that are conscious, slow and reflective. The controversy relates to such issues as the interaction between the two systems (parallel or sequential) and the role of unconscious processes in System 1 (emotions or intuition).

Thirdly, when making decisions, individuals tend to apply various strategies called heuristics (cognitive shortcuts). Thanks to heuristics they can make their choices in a fast and frugal manner in both simple and intricate decision-making situations. The authors reveal that the elimination-by-aspects strategy, the satisficing strategy, the strategy of choosing what is the most important as well as the strategy of relying on what has worked well before. However, recourse to heuristics may lead to biased decisions, e.g. by replacing the natural probability judgment with the assessment of resemblance individuals may inaccurately evaluate available options.

Fourthly, it is essential to understand how individuals make decisions under uncertainty, i.e. when they do not know what will happen next or they are not certain about the result of their choice. Concepts that have been built on the basis of economics are not applicable in every decision-making situation because they relate mainly to known probability. Psychological theories in turn aim to explain how individuals make actual decisions in the real world. They provide a way to understand better how brains of people dealing with law, medicine or business cope with decision making.

Fifthly, more and more researchers begin to recognize the role of volition and self-control in the process of decision making. Some psychological theories indicate that individuals can exert self-control only to a limited extent, so their resources become depleted in the process, thus leading to biased decisions.

Sixthly, the decision-making situations, particularly the ones when individuals lack certainty about the outcomes, are accompanied by strong emotions. Some people may experience mental problems, mainly increased anxiety, stress or even depression. Generally, it is essential to comprehend the potential detrimental effects of complex decisions made not only by healthy individuals but also by people suffering from mental disorders.

In sum, psychological theories explain what is happening in the minds of decision makers before, during and after the decision making. Also, the understanding of information-computing mechanisms that are involved in the decision-making process can be particularly useful in practice.

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