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Towards assisted rationality switching in negotiations*

by

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Abstract: The text attempts to provide a comprehensive outlook on negotiation processes and support procedures, by deriving a mathematical description based on psychological and managerial context. The authors merge psychological and formal descriptions of the principles underlying the perception of rationality in negotiation problems. The framework allows for explaining the violation of perceived rationality as a result of the deprivation of human needs. The argument, supported by pilot experiments, allows for recommending a procedural approach to negotiation, focused on monitoring perceptions of rationality of proposal submission. The paper is concluded with an attempt to foresight further developments of theoretical investigations and expansion of application fields.

Keywords: negotiation process, rationality, deprivation of needs

1. Introduction

The purpose of this work is to introduce conceptual and mathematical descriptions to explain violations of classical rationality (hereinafter referred to as switching or pulsing rationality) in negotiations. Switches of rationality are explained as results of persistent periods of parties' deprivation in meeting their needs. The starting for the argument is the adoption of two assumptions.

According to the first assumption, it is proposed that the general goal of the decision-maker is to meet needs that have a hierarchical structure. The decision maker searches for and selects actions to meet these needs, with the hierarchy having a significant influence on the order, in which actions are taken. According to the second assumption, the difficulty in choosing actions can have a long-term character, which causes a violation of the order of satisfaction,

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corresponding to these actions and thus behavior is perceived as irrational. The authors intended the study to be a prelude to formulating a novel method of analyzing the negotiation strategies. This method attempts to identify and explain the negotiating parties' rationality disorders. The explanation is based on behavioral concepts (presented in the area of psychological decision theory). It translates Maslow's hierarchy to the area of rationality of the negotiating parties. Namely, parties are assumed to follow the three level hierarchy of operational, tactical and strategic objectives.

A similar study was presented in Nieciecka and Szapiro (2019), a technical report presenting experimental confirmation of research hypotheses, describing the dynamics of rationality pulsing. The experiment dealt with managerial context, evaluated by students. The study was limited to general and everyday issues, merely signaling an understanding of the switching of rationality in a managerial context. The authors attempted to verify the assumptions on rationality violations, presented in twin scenarios, which corresponded to different actions of decision makers. This idea is here redescribed in the negotiation context.

The paper is organized as follows. The present Introduction is followed by Section 2, which presents a formal model of negotiating. Next, in Section 3, Maslow's hierarchy in the context of bounded and analytical rationalities is introduced and the disturbances of rationality are invoked. The section comments also on psychological and mathematical perspectives in viewing rationality in the context of deprivation on the one hand and permutations within Maslow's hierarchy scheme on the other. Section 4 starts with the assumptions of empirical analysis of the perception of rationality switching on the basis of psychological literature of decision making. Here, empirical hypotheses are recalled and two pairs of cases are discussed. The scenarios take into account an individual negotiation and negotiating teams (in the sequel called parties) in situations with both the lack and the presence of reverse rationality switches. The exemplary scenarios to be used in experiments are invoked and justified. The study concludes with final remarks (Sections 5 and 6) and references involving recommended readings.

2. A negotiation framework

In the sequel we consider the following formal description of negotiation of parties tackling a problem with interdependence of proposals and its multiple criteria evaluations. The mathematical description of the conflict allows for including the subjectivity and learning through the negotiation process.

The model, introduced by Kersten and Szapiro (1986), considers N parties, which evaluate options $\mathbf{x}=[x_1,\ldots,x_n]^{\mathbf{T}}$ consisting of decision variables x_i, $i \in\{1,...,n\}$, forming the set $X \subset\mathbf{R}^n$ of feasible decisions. The set of feasible decisions consists of solutions of inequalities $g_l(\mathbf{x})<b_l$, $l \in\{1,...,k\}$, which represent

hard constraints. Each party evaluates options using their own criteria. For the sake of simplicity, let us consider only two parties with m^1 and m^2 evaluation criteria. The mappings $f_j^1{:}X \to \mathbf{R}$ and $f_{j'}^2{:}X \to \mathbf{R}$, where $j \in \{1, ..., m^1\}$ and $j' \in \{1, ..., m^2\}$, represent the j-th and j'-th criterion functions. Thus, for instance, $f_j(\mathbf{x})$ represents the evaluation of the decision $\mathbf{x}$ with respect to the j-th criterion. The mapping $\mathbf{f^1}{:}X \to \mathbf{R}^{m^1}$, is understood in terms of $\mathbf{f}(\mathbf{x})=[f_1(\mathbf{x}),\ldots, f_m(\mathbf{x})]^T$, and similarly $\mathbf{f^2}$ represents also the vector evaluation of the decision $\mathbf{x}$. In negotiation, the set σ of the structural elements of both parties consists of $\mathbf{g}^j(\mathbf{x})$, $\mathbf{b}^j$, $\mathbf{f}^j$, $j \in \{1,2\}$. Sometimes the upper indexes will be omitted to simplify the formulae. We also assume, without loss of generality, that objective functions are to be maximized.

In the multiple criteria problems the code of rationality which underlies decisions (principles for option comparison) is defined as follows. For each party an outcome $f(\mathbf{x}_1)$ of the decision $\mathbf{x}_1$ is said to be *weakly dominated* by an outcome $f(\mathbf{x}_2)$ of the decision $\mathbf{x}_2$ and denoted as $f(\mathbf{x}_1) \preceq f(\mathbf{x}_2)$ when $\forall j \in \{1,\ldots,m\}\ f_j(\mathbf{x}_1) \leq f_j(\mathbf{x}_2) \Leftrightarrow f(\mathbf{x}_1) \preceq f(\mathbf{x}_2)$. The decision $\mathbf{x}_2$ is said *to be preferred* to $\mathbf{x}_1$ (the notations is $\mathbf{x}_1 \preceq \mathbf{x}_2$) when the relevant comparison of outcomes is compatible i.e. $\mathbf{x}_1 \preceq \mathbf{x}_2 \Leftrightarrow f(\mathbf{x}_1) \preceq f(\mathbf{x}_2)$. For linear structures with the structural elements $\sigma^{(j)} = (\mathbf{A}, \mathbf{b}, \mathbf{C}^{(j)})$ we have $X=\{\mathbf{x}{:}\mathbf{A}x \leq \mathbf{b}\}$, $\mathbf{f}^{(j)}(\mathbf{x})=\mathbf{C}^{(j)}\mathbf{x}$.

Given the set of structural elements σ, each party in each round of negotiation looks for the most preferable feasible option, i.e. solves the problem of multiple criteria maximization in the set $\mathbf{X}$ of feasible decisions (denoted $\mathbf{f}(x) \to \max$ w.r.t. $\mathbf{x} \in X$). When the ideal point, which maximizes all criteria f_j is not feasible or compromised, the decision maker reviews the set of efficient solutions with nondominated evaluations in order to propose another option. The review of nondominated solutions may be assisted by a negotiation support system (NSS) and parties can be supported by relevant procedures for individual decision problems (e.g. the linear case by the Bireference Interactive Procedure, BIP, of Michalowski and Szapiro, 1992, or fuzzy fBIP procedure of Wojewnik, 2010).

We consider the situation with subsequent rounds 0,1,2,3..., of the negotiation. In the subsequent rounds each party submits the proposal of compromise $\mathbf{x}(0)^{(j)}$, $\mathbf{x}(1)^{(j)}$, $\mathbf{x}(2)^{(j)}$, $\mathbf{x}(3)^{(j)}$,..., j =1,2, next they are individually analyzed by each party in their criteria spaces, respectively, until persuasion during rounds does not result in subsequent proposals or leads to overall agreement. The procedure can assist parties jointly or individually in *mediator* or *advisor* mode, respectively, see, e.g., Polak and Szapiro (2001). In the *mediator mode* the negotiating parties provide the information on their problem structures and obtain immediate recommendation for compromise based on information revealed to the third party, i.e. the mediator. The alternative *advisor* approach supports only one party based on her information set.

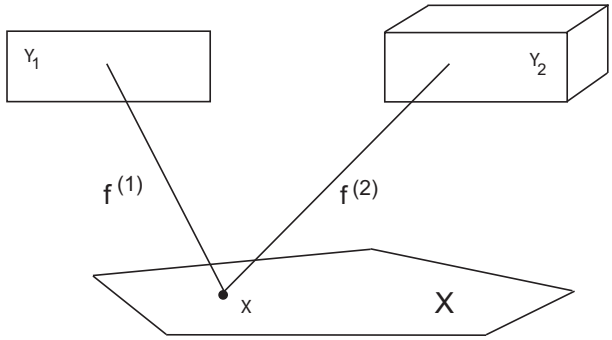

Figure 1. The negotiation starting proposal x is evaluated by two parties, which use two and three criteria for evaluation, respectively. In outcome spaces Y_1 and Y_2 comparison is performed using Pareto principle. If evaluation is not satisfactory, parties react with their proposals - usually different (not shown here)

This above sketched model frames the individual and common rationality codes following rigid Pareto optimality principle. Thus, the model simultaneously respects parties' independence and preserves space for flexibility in a persuasion process. The behavioral research proves that in real process one faces preference reversals (Kim, Seligman and Kable, 2012), which in our frame for negotiation, have to be explained as irrational behaviors or oversimplification of the model. We take the latter perspective and in the next section review some concepts of psychological decision making theory, which can be used to elaborate on the instability of the rationality codes. This includes introduction of rationality marker, which reflects the importance of needs satisfied in the case of acceptance of a negotiation proposal.

3. Decision-making processes with perturbed rationality structures

As mentioned in the Introduction, the decision-making process can be derived from the assumption of a deficit in meeting human needs, cf. Yu (1990). A person, in order to function, needs to take actions, which place the levels of satisfaction of his/her needs between the two limit values that make up the "safety box". If the level of a need is out of the box, an action is undertaken to ensure that the needs are met at the level within the safety range. The identification of needs can take place at an abstract level (e.g. staying in good health) or at a technical level (the results of the inspection are in the norm interval). E.g. body temperature between 35.8-36.8 is not alarming if other parameters do not fall out of similar ranges. A need deficit is a "falling out" of such a range. When the level of meeting the needs of the decision-maker at

a given time (state) is not satisfactory (falls out of the safety box), it initiates the process of looking for actions that will reduce this deficit. Actions (more precisely – action plans) are called decision options. If there are several such actions, then the process involves optimization. In the literature, the principle of maximizing the level of satisfaction of the need, the principle of the fastest time to reach the safety box are considered as optimization criteria. Needs determine human actions. They have a diverse structure. According to the Maslow's model, the needs are diverse and form a hierarchy. His idea is constantly being revised, but still the researchers agree that the fundamental structure of the hierarchy should be preserved, see, e.g., Kenrick et al. (2010).

3.1. Maslow's hierarchy and bounded rationality

The classic Maslow's model assumes that needs can be grouped into five groups: A/ physiological, B/ safety, C/ love, feelings and belonging (affiliation), D/ respect, recognition and acceptance of the environment and E/self-realization. The first four together form the group of so called *deficiency needs*, i.e. their goal is to remove elicited dissatisfaction, and the last one is a so called *being need*, related to the perception of the consistency of one's actions and identity as a person. Satisfying this need is perceived as personal growth, cf. Maslow (1950).

The proper functioning of an individual requires meeting all needs at a certain level (in the safety range), specific for different persons. If there is deprivation of need (deficit in the level of meeting the need), people take steps to secure a way of meeting the need at the necessary level.

In addition to separating the groups of needs, the essence of Maslow's model is the hierarchy of needs. However, Maslow (1987) did not assume that satisfying a higher-level need requires a hundred percent fulfilment of every lower-level needs. He argued that when a group of needs is partially, at an acceptable rate, satisfied, an individual can proceed to the next group of needs. Yet, there is a point of deficiency in one group (meaning a threshold of satisfaction), which may result in a disability to perform actions in the remaining domains. This assumption leads to formation of the hierarchy, which is usually presented in the form of the so called *pyramid of Maslow*.

Two observations lead to the identification of two different decision-making processes. Firstly, the existence of the deficit of meeting a need is not equivalent to its identification. Secondly, the deficit often leads to functional disorders (e.g. apathy) and emotional states (e.g. feelings of anxiety or frustration) and physiological reactions (e.g. hand sweating, fly-out vision, etc.). Experiencing these symptoms leads to an effort to identify their causes (the need and scale of the deficit itself) and, consequently, to the creation and implementation of corrective measures aimed at deficit reduction, as schematically illustrated in Fig. 2.

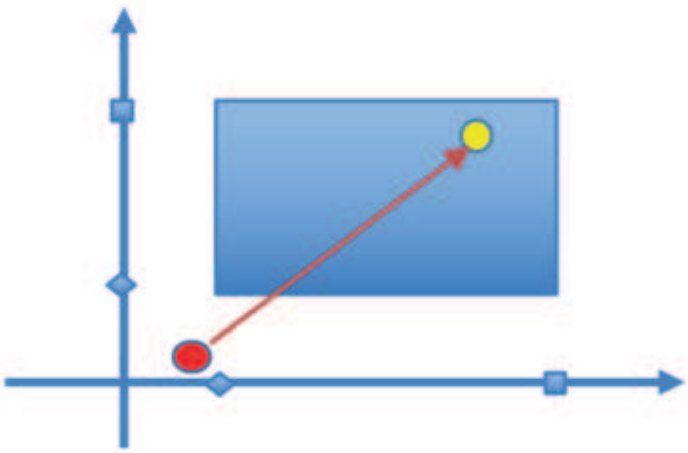

Figure 2. On the axes the minimum (diamonds) and maximum (squares) levels of satisfactory satisfaction of two hypothetical needs are marked. The action of decision-maker leads from an unsatisfactory output state (red circle) to a satisfactory one (yellow circle) in the acceptable levels box

As a consequence, we can face the processes, in which the symptoms of the deficit are identified, as well as the cases of unconscious frustration of needs. We will leave this issue to the next section.

In emerging psychological literature neuroeconomists hypothesize that the decision making process is conducted in accordance with an accumulation model. The latter assumes that in the decisive situation brain structures integrate the pieces of information 'for and against' each option. Then, the difference regarding the options is calculated and when it crosses a threshold, the impulse is sent – the decision is made, in favor of the dominating option, see Shadlen et al. (1996), or Heekeren et al. (2004). This hypothesis is in line with Maslow's hierarchy, as it suggests the competitive nature of information processing. Moreover, applying the hierarchy of needs to such a decision-making process would imply the existence of cognitive representations of needs. In other words, the representations of worth, which enable an individual to categorize, order and thus faster satisfy their needs.

The literature also points out that the structure of the hierarchy of needs has implications for the perception and awareness of the meaning of observed disorder symptoms and for prioritizing actions. Yu (1990) cites the studies, which show that individuals can be made aware of the insights recorded in their brains (subject to processing leading to conscious action differently). Such insights attract the attention of the decision-maker if they are associated with a deficit need. The degree of deficit awareness depends at a monotonous rate

on the place in the hierarchy of needs and the size of the deficit. If different actions lead to a reduction in the deficit of the same need, the decision-maker minimizes the effort, i.e. she first chooses the action with the closest effect. An optimization of choices of an activity aimed at satisfying needs usually requires considerable time for the process of comparing activities.

The Maslow model allows to explain the process of compromising actions in situations with deficits of different needs with conflicting levels of satisfaction of needs, see Fig. 3.

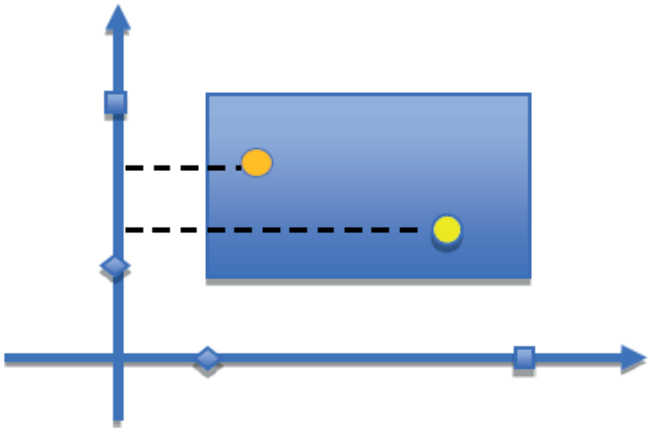

Figure 3. The level of demand that is marked on the vertical axis is higher for the state represented by the amber circle than for the condition specified as a yellow circle. For the need marked on the horizontal axis, the opposite is true. The hierarchy of needs therefore determines the preferences for activities

From the point of view of this study, it is important that needs can be grouped into a hierarchy, that needs deficits trigger a process of focus, identification of needs and, consequently, the creation of actions, and finally that the hierarchy prejudges priorities in the selection of alternative conflict actions. We leave aside the question of the number of levels in the hierarchy and issues related to anthropological analysis of the importance of the highest level in the Maslow's hierarchy, see, for instance, Kaplan and Tausky (1977), Reese (1974), Kesebir, Graham and Oishi (2010).

3.2. Decision-making model – analytical rationality

The variability of the environment causes the changes in level of needs. If the needs are not met, the decision-making shall create measures leading to the elimination of the deficit. Thus, we are dealing with a series of cyclical behaviors: a change in the environment or an internal one affects the level of satisfaction

of needs, which can trigger the process of creating actions to counteract this, effective till the next change in the environment.

We assume that *the general objective* (meta-goal) of the decision-making process is to meet the needs shaped hierarchically – not by determining the final form of the pyramid of needs, but by adapting it during experiments. A decision-maker can be aware of the deficit of one or more needs or perceives unexplained discomfort. In both cases they create options for action that will at least reduce the gap in the desired and current satisfaction levels of meeting needs.

The operational goal of the decision maker process is to meet the identified need. The meta-goal is to meet all the needs that require the setting of operational objectives and their implementation by explainable variants of action or by variants identified on the basis of tacit knowledge, the manifestation of which can be intuition, see Hogarth (2001), Szapiro (2019).

If unmet needs are identified, then their satisfaction requires actions (otherwise: identification and implementation of decision options, action plans), with the catalogue of actions being based on the knowledge or experience of the determining entity. The creation of actions to reduce the deficit of needs and the identification of operational objectives is not described in the literature in general, see Bernstein (2017).

We assume in the sequel that the decision-maker can define a set of actions and can identify a mechanism regarding their impact on reducing the deficit of needs satisfaction. The structure defined by the decision-maker, which is composed of operational objectives and a set (variants) of actions, will be called *natural decision-making structure*. The decision-making problem may in specific cases be reduced to a mathematical task, which consists in assigning a variant of action using an appropriate mathematical method to choose a solution. A mathematical solution to a task is interpreted as a decision that reduces the deficit with respect to identified needs. Solving the decision-making problem in the situation of many possible options therefore requires the definition of a method for choosing a solution. Often the easiest decision is chosen, or "the best one", or the first in the waiting line, according to the so-called simplification strategies. The result of the choice of such a structure and method is a *formalized decision-making structure*, i.e. a model of decision-making problem, cf. Anderson et al. (2017), Figuera, Greco and Ehrgott (2005). If unmet needs are not identified, then the natural decision-making structure is created without a model based on unconscious knowledge (tacit knowledge).

3.3. Disturbance of rationality

We will now deal with decisions that lead to behavior that is perceived as irrational. Behavior is not rational if the decision-maker decides to increase the level of the needs deficit. In the event of a change in the hierarchy of needs (a

change in the order of needs in the pyramid of Maslow), the behavior may be rational from the point of view of the changed hierarchy, although it violates the order of the generic hierarchy, or it is irrational in the new hierarchy, even though it is rational in the generic hierarchy. To describe this behavior precisely, we will now provide a mathematical description of the concepts introduced in this chapter.

The hierarchy of needs with five levels will be called the H string, consisting of the level labels P_1, P_2, P_3, P_4 and P_5 in the hierarchy of Maslow, $H = (P_1,P_2,P_3,P_4,P_5)$. Since the levels are ordered, we will denote by (1,2,3,4,5) the classic Maslow's hierarchy while the 5-tuple (2,1,3,4,5) stands for the hierarchy, in which the levels P_1 and P_2 interchange their places and the other levels are in their previous (original) places. The hierarchy that corresponds to the starting hierarchy of Maslow in the sequel is denoted by H_M or H_0. A set of all hierarchies, i.e. a set of five-element strings of H_M elements that differ in the order of elements, will be marked H. Each $H \in$H hierarchy will be interpreted as a code of rationality. There are 5!=120 different codes.

3.4. Deprivation

The planned variants of actions may encounter practical barriers in implementation. Thus, for instance, the need to give medicine prescribed to a sick child by a doctor after a late-night home visit may have to be postponed temporarily due to the necessity of reaching a remote pharmacy. In business situations, typical barriers are the limitation of the time available for the implementation of decisions, the limitation of the type of resources (human, financial, information, technological, scientific, etc.) that are necessary for the implementation of decisions (actions). Consider the example of a country that needs to choose before the end of the year (time barrier) how to reduce greenhouse gas emissions. The identified action is the replacement of a method of producing energy previously obtained from the combustion of coal by the nuclear energy, produced in a nuclear power plant. However, implementing this decision requires overcoming many obstacles. These include the lack of a working nuclear power plant and the need to build it, and in the meantime the lack of energy resources other than coal (resource barrier). In cases, where nuclear energy is already used in the country, the increase in energy production may require imports of uranium and, consequently, the problem of raising additional funds (*capital barrier*), and the one of the public protesting against the implementation of such an investment (social barrier).

The impossibility to meet the need in a period of time that is perceived as long is said to be the deprivation regarding this need. Deprivation may perturb the order of satisfaction of needs in the next period. The decision-maker then postpones the need to meet the deprived need for a more basic one (dominant) and moves to higher (dominated) activities. Thus, there arises a long-term disruption of the structure of the hierarchy of needs (replacement of

adjacent levels with deficits). Because the deprivation regarding a given need may cease, and in subsequent periods there may be deprivations with respect to other needs, so there may be multiple, different deformations of rationality rules in the individual, which we perceive as the *waving of rationality* and name the *pulsing rationality* behavior.

Meeting needs is in many ways related to the functioning of the groups (communities) in which one operates. This relationship is obvious in the event of a need for affiliation or recognition, or indirect in the case of other needs, which require cooperation within the group. Consequently, the code of rationality reshapes in the context of norms and group values, which influence the perception of rationality of individual actions. The decision-maker internalizes group norms and values, which are a moral requirement for respect for the principles of social coexistence. The social environment defines the area of requirements for action to be taken. Standards become rules that determine the socially preferred way of dealing with certain situations. In some areas, becoming an injunction or prohibition on a particular conduct does not necessarily refer to the category of good and evil. Units stubbornly not subject to these standards are marginalized and stigmatized, see Florczykiewicz (2016). In a situation of waving rationality, the decision-maker experiences a dissonance of rationality - a new rationality, with a changed order of the hierarchy of needs, is perceived as abnormal behavior, which affects (adversely) the level of satisfaction of the needs associated with functioning in the group. People with rationality dissonance make socially irrational decisions (not in line with norms) as a result of the formation of (a) a disturbed hierarchy of needs or (b) a completely different hierarchy of needs. Deformation in this decision-making structure can occur both when tacit knowledge is involved and when the situation is consciously perceived.

3.5. Permutations of hierarchy of needs levels

To describe precisely the codes of rationality and their transformations we introduce the concept of permutations, cf., e.g., Bagiński (2002).

Let us recall that the bijective transformation π of that set P, π: $P \to P$, is said to be the permutation of a finite set $P = \{p_1,p_2,...,p_N\}$. A permutation π of the set P will be denoted by $\{\pi(P) =\{\pi(p_1), \pi(p_2),...,\pi(p_N)\}$ or briefly $\pi(P) =\{\pi(1), \pi(2),..., \pi(N)\}$. For instance, the 5-tuple (2,1,3,4,5) is the permutation of the tuple (1,2,3,4,5), representing the classical hierarchy of Maslow. The α cycle with the length of k in the permutation π of elements of the set P is the permutation $\alpha(\pi) \to \alpha(\pi)$, where $\alpha(\pi)\{\alpha(p_1), \alpha(p_2),...,\alpha(p_k)\}$, such that: $\alpha(p_1) = p_2$, $\alpha(p_2) = p_3$,..., $\alpha(p_{k_{-1}}) = p_k$, $\alpha(p_k) = p_1$, and $\alpha(p_j) = j$ for $j \in\{1,2,...,n\}$-$\{p_1,p_2,...,p_k\}$. Thus, in particular, for the above permutation, we have the α cycle of the length 2, α:$\{1,2\}\to\{1,2\}$. From the theory of permutations we know that each permutation is composed of disjoint cycles and each

cycle consists of transpositions. Therefore, the permutations of the n-element set $\{1,2,..,n\}$ are generated by a set of the transpositions $\{(1, 2),(1, 3),...,(1,n)\}$.

Let us notice that therefore in our case each hierarchy is a permutation of the set of levels in the pyramid of Maslow and it is the composition of transposition of levels in the starting pyramid. The set of the following transpositions $\{(1,2),(1,3),...,(1,n)\}$ is said to be the *generator*. Thus, the description in terms of perturbations framework leads to an interesting hint in the context of rationality. Namely, if a deprivation leads to pulsating rationality behaviors, then such behavior can be decomposed into a sequence of importance of needs transpositions using the generator.

3.6. Rationality code trajectories

Let us consider the sequence of subsequent actions of the decision-maker, indexed by N=$\{1,2,...,N\}$. Let us denote by T=$\{t_1,t_2,...,t_N\}$ the set of time moments of taking these actions. The pair $r_i = (t_i,H_i)$, $i \in N$, represents the code of rationality at the time of taking the i-th action. The sequence $\beta = \{r_1,r_2,...,r_N\}$ is said to be a rationality trajectory of the length N. The space B of rationality trajectories is huge – for a five-level pyramid of needs from the space H, the space B has $(5!)^N = 120^N$ elements. For trajectories describing the process of the interchange of two levels and return to their initial state in all hierarchies we have $N = 3$ and the trajectory length 120, so there are almost two million rationality trajectories (1 728 000).

Two rationality trajectories $\beta^A = (r_1^A,r_2^A,...,r_N^A)$ and $\beta^B = (r_1^B,r_2^B,...,\ r_N^B)$ will be called *adjacent* if β^B differs from β^A by only one transposition of adjacent levels, e.g. trajectory $\beta^B = (r_2^A,r_1^A,r_3^A...,r_N^A)$ is adjacent to the β^A trajectory. The transformation of a rationality trajectory into another one can be decomposed into a sequence of adjacent trajectories. The mapping T:B$\rightarrow$B different from identity will be called the *operator of the rationality transformation*. The concepts introduced can be interpreted on the basis of psychological theory of decision and management sciences.

4. Rationality switching in negotiation

The theorem on permutation decomposition motivates to consider short rationality trajectories of length 2 (in the sequel they are said to be *rationality switches*).

Let us consider the occurrence of order violations in the Maslow hierarchy. Such disturbances are perceived as irrational behavior, which is not consistent with the H_M hierarchy, but which can be perceived as rational with respect to another, a disturbed one.

In the negotiation context this situation happens when the proposal of consensus is not accepted by parties and they submit new proposals. Let us consider that the party "1" has assumed, e.g., a reservation $R(p_3)$ level of the party "2" for the need p_3 in the Maslow's hierarchy H_M and submitted the proposal seemingly exceeding this level and other levels. Then, rejection of this proposal by the party "2" is perceived as irrational behavior. But the party "2" may follow a perturbed hierarchy $H = T(H_M)$.

Nieciecka and Szapiro (2019) presented the results of an experimental pilot study of trajectories of rationality. These results support the hypothesis on the existence of situations, in which the decision-maker exhibits behavior indicating a perturbation in the order of needs. The other hypothesis concerns the possibility of identification of situations, in which a disturbed behavior of the decision-maker is perceived either as irrational or as rational. Subjects were investigated in scenario analysis with cases using three periods. In these cases, first the rationality of the decision-maker was determined by the generic hierarchy H_M with decisions that met all needs at satisfactory levels. Then, subjects faced the deprivation of the need for the self-realization. A protracted state of deprivation resulted in the second period in a switch of the principles of rationality H_M to the new hierarchy $T(H_M)$ and then the return switch to H_M.

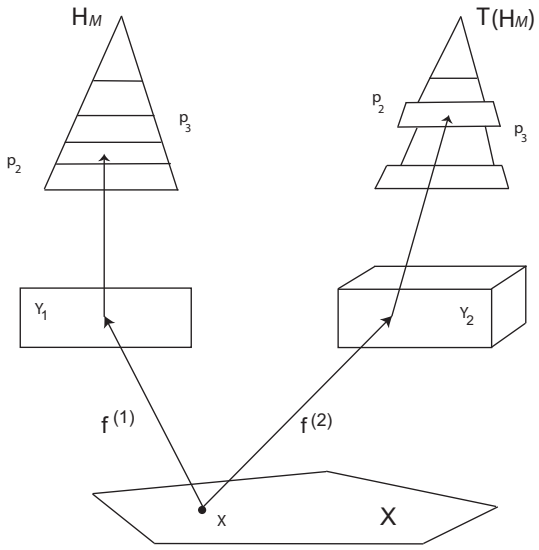

Figure 4. The starting proposal x in negotiation is evaluated by two parties and follows the rationality principles given as H_M and $\mathrm{T}(\mathrm{H}_M)$ respectively. The rejection of the proposal x by the party "2" may result from the fact that it does not satisfy the need p_3, which, as a result of switching, is placed below the satisfied need p_2

In order to verify the previously stated hypotheses, scenarios were developed to match the theoretical descriptions presented to student subjects. In each experiment, students were presented with the task of familiarizing themselves with the basic elements of knowledge about Maslow's hierarchy of needs, and getting acquainted with the studies of mini-cases of decision-making behavior. Next, the subjects were asked to assess their evaluation of rationality of presented behaviors in nine mini-studies of decision-making, presenting behavioral disorders. On average, the resolution time for the entire set of eleven tasks was about an hour. The hypotheses were confirmed; however, the size of sample was not satisfactory from the point of view of statistical inference assumptions. Still, the experiment has shown that the majority of subjects was able to correctly identify disorders in Maslow's needs hierarchy with some gender imbalance.

The results of experimental study suggest including the ability to investigate rationality switches in negotiation supporting procedures, see Fig. 5. In the mediator mode the general procedure consists of the following steps:

Step 1. Identify the set σ of structural elements of all parties' models.

Step 2. Identify the strategy for individual proposal submission (e.g. non-dominated outcomes in individual evaluation space).

Step 3. Submit the proposal of compromise. If there is an agreement, then terminate the process, otherwise got to Step 4.

Step 4. Identify individual rationality markers (evaluation of outcomes of proposals in terms of hierarchy of needs).

Step 5. Evaluate the submitted proposals (in the sequel called the negotiation protocols of parties) in terms of their models using rationality markers.

Step 6. Identify the switches of rationality in protocols. If there are no switches, follow the procedure from Step 2, otherwise go to Step 7.

Step 7. Modify the rationality markers.

Step 8. Go to Step 4 and use modified rationality markers.

The procedure is illustrated in Fig. 5. In the pre-negotiation phase a common set of feasible decisions is defined and the structure is determined by the definition of variables and the set of common hard constraints. Given the constraints, parties define their individual criteria and arrive at the definition of individual multiple criteria problems and identify the strategy of proposal submission, e.g. using a MCDM method, like, for instance, BiP, Michałowski and Szapiro (1992). The submitted proposals are subject to negotiation. The process of persuasion reveals the declared rationality of decision makers and may lead to a compromise, which terminates the process. Otherwise, the parties mark the negotiation issues violating the assumed rationality of other parties and decompose observed rationality level switches into a sequence of adjacent levels switches. Thus, they create an adjacent trajectory serving to reengineer the strategy in the next round. If rationality markers are not identified, then

a party modifies its strategy through manipulation with aspiration levels, conform to a negotiation support procedure selected at the beginning. Otherwise, rationality markers are used to construct compromise proposals, corresponding to the identified adjacent trajectories.

Maslow's hierarchy of needs is reflected in negotiation modeling in parameters, defined by the structural elements. The identification of rationality markers can drive the process of redefinition of such parameters, sketched in the procedure.

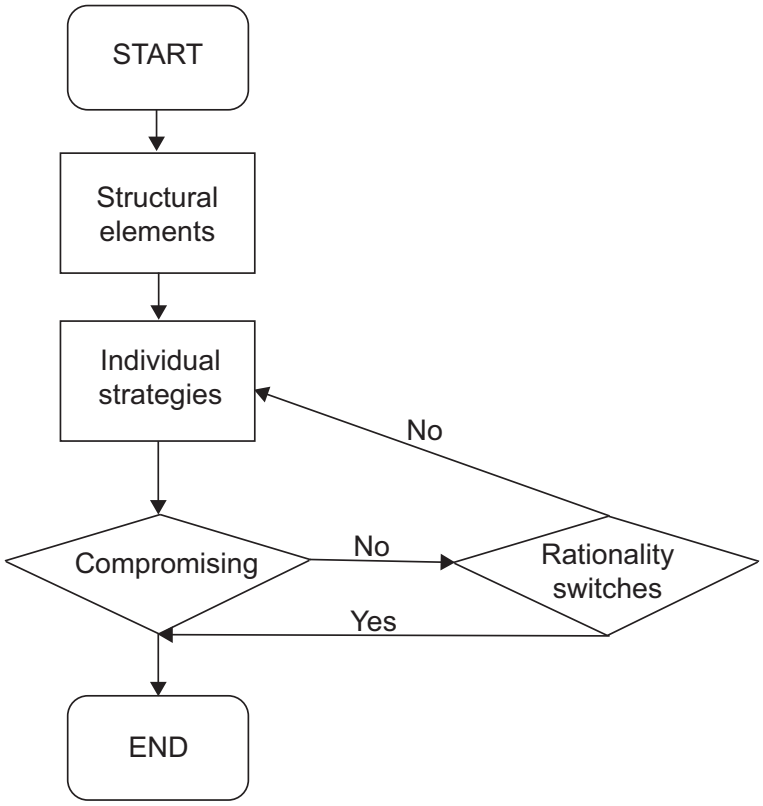

Figure 5. Parties are assisted in negotiation in steps through the use of identified switches of rationality and decomposition of these switches into adjacent ones. This information can be used directly in persuasion or in the creation of new proposals

5. Final remarks

This study analyses the dynamics of rules that determine the rationality of behavior or decisions of entities, in particular in negotiation. The conceptual and experimental proposals presented in the work can be developed in many directions.

The presented approach can be transferred to the managerial context. It appears that rational behavior can be regarded as irrational, in particular the perception of unreasonable decisions of companies at a strategic, tactical or operational level can be expected as fully rational decisions, which may lead to the collapse of those companies. Using an analogy to psychology, the hierarchical structure of the company's goals can be presented as an instrument for assessing the rationality of the company's actions, see Cyert and March (1963), March and Sevon (1998). In particular, the dynamics of the rules forming rationality codes (described, in particular, by means of the concepts of transposition of levels in the hierarchy) requires addressing company needs. Thus, the proposed classification of rationality perturbations (pulsating or waving of different types) might be utilized to describe the functioning of the company in the market economy, where it can be used in analyzing the strategic position of companies and recommending corrections of the company strategy.

We also argue that those findings could serve in the negotiation process in the form of a general, preliminary procedure. This is due to the fact that the negotiating parties' interests might be structured in the form of hierarchies of needs, the accordance of which modulates the area of effective solutions. By taking into account the waving of the rationality in the structure of the negotiating process, one may achieve an effective, dynamic model, useful in different negotiating contexts.

From the point of view of general group problem analysis, an interesting research field seems to be the analysis of military-political plans and decisions, which is the area of international negotiations, similarly as the subject of sustainable development and globalization.

Using the elements of permutation theory, it has been shown that any rationality pulsation is an assembly of cycles and these cycles are compositions of the finite number of transpositions of adjacent levels in the hierarchy. This approach allows to decompose general types of waving (dynamics) of rationality into elementary ones. The introduced concepts were, in the precedent paper, used in an experiment to identify the subjectivity of rationality assessments and the use of hierarchies. Also the deformation of the perception of rationality has been demonstrated there.

In the cognitive area, both theoretical and experimental approaches presented here encourage a research on hierarchies of different levels based on case studies. Another interesting direction of research is the development of theory concerning the three-stage cycles, as well as a broader experimental study.

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