Choice Manipulation in Multicriteria Optimization Problems

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Abstract. The problems of manipulating the choice of decision options in situations of peer review are considered. The description of the task of expert evaluation in the form of a tuple. The possibilities of manipulation of choice are presented. Particular attention is paid to the problems of multicriteria optimization. The formulation of the CSF is described with emphasis on its components and heuristics, which can be used for manipulation. The classification of selection manipulation problems in expert evaluation situations that are formalized in the class of multicriteria optimization problems is proposed.

Keywords: expert evaluation, decision making, manipulation, heuristics, multicriteria optimization.

1 Introduction

In today's world, the problem of choice manipulation is becoming more urgent. After all, the problems of choice and decision-making arise in a wide variety of fields, and the possibility of choice is the basis of democracy. At the same time, it is well known that manipulation is a type of hidden management that provides ample opportunity to influence the distribution of resources in a wide variety of fields of human activity. Therefore, the study of manipulation opportunities for different decision-making models is currently a relevant and promising area of research. The study of manipulation problems is the most important because in modern conditions it is often not the case that the use of scales in measuring some phenomena turns into a trivial assignment of numbers. And not at all, declared by the researchers to measure the subjective components of the decision-making problem.

The manipulation of collective choice problems (voting theory) is well researched and the theory of the agent [1] is developed for such problems as manipulation of the "agenda", that is, the sequence of application of selection procedures.

Even natural, well-founded and logical voting systems are not protected from deliberately influencing election results, that is, from electoral manipulation. It is also known [2] that the choice rule is protected from manipulation if and only if it is dictatorial.

In addition, in many peer review situations, it is advisable to set not one scalar quality assessment of the objects, but a set of quality indicators and consider the problem in a vector formulation.

In this article we will consider the choice manipulation problems that arise when formalizing practical problems in a class of multicriteria optimization problems. The criterion approach is a common approach in solving decision-making problems. This approach to describing poorly structured models is associated with the assumption that each object can be estimated by a specific number, which is a criterion value, so comparing the objects is a comparison of the corresponding numbers.

Often, multicriteria is a way to increase the adequacy of goal description. At the same time, as will be shown below, multicriteria offers ample opportunity to manipulate choices.

Manipulation can be in the interests of different individuals and can be carried out by different participants in the process of selection and decision making:

– the voting participant does not use false criteria, but false criteria in order to achieve a collective decision that is more favorable to him by his true criteria [1];

– the organizer of the vote influences the partitioning of the voting participants into favorable subsets or splits the set of variants into such subsets which as a result will lead to the desired choice: due to their structure or sequence of their presentation [1];

– the decision maker (ODA) or ODA group can initiate or perform the manipulation;

– the expert or coalition of experts can significantly influence the results of the selection and manipulate the choice of options;

– the voting party may sometimes be able to manipulate the election, affecting in different ways each of the categories of voting participants mentioned above.

Given the existence of different sources of manipulation, we will refer to the person or group of persons who tries to influence or influence the results of the choice by applying some non-standard approaches, the term manipulator.

The purpose of manipulation can be different: choose the desired alternative, select the subset of objects, remove the unwanted alternative, remove the unwanted subset of alternatives, make some alternative a priori dominant, get rid of the influence of the dominant alternative, etc.

2 Expert evaluation tasks

Its symbolic representation in the form of a motorcade is used to describe the expert judgment (SEA) [3]

$$<A, S, R, E, C, P>,$$

where A is the set of objects (variants, alternatives, parameter sets), S is the set of constraints, R is the set of criteria, measurement scales by criteria, mapping the set of acceptable alternatives into the set of criterion estimates, the convolution of criteria, E is the set of formal characteristics of experts, C is the set of goals that the researchers face, P is the system of preference for the deciding element: the decision maker (ODA), several ODAs in collegial decision-making, or a group of experts.

Suppose that a set A, consists of n objects that are compared with each other:

$$a_i \in A,\ i \in \{1,...,n\} = I.$$

Objects are described by m parameters, that is, each object is a point of some parametric space Ω^m

$$a_i = \left(a_i^1,...,a_i^m\right),\ a_i \in A,\ i \in I,\ A \subset \Omega^m,$$

where $a_i^j,\ i \in I,\ j \in \{1,...,m\} = J,$ is the value of the i-th object j-th parameter.

From the set A, the deciding element is the best-fit object and the choice is justified. It is clear that already at the stage of substantiation of the approaches to the selection and the actual selection procedure, there are opportunities to manipulate the results of solving the problem.

SEA means a couple $\langle C, A \rangle,$ where $C -$ the principle of optimality, $A -$ is given by a set of objects. A solution to the SEA $\langle C, A \rangle$ is a subset of objects $A_0 \subset A,$ obtained using the principle of optimality: $A_0 = C(A).$ In the theory of operations research [4], a couple $\langle C, A \rangle$ is called:

– the decision-making problem, if C and A they are not a priori specified and can vary;

– the task of choice if the set of objects A is given and the principle of optimality $C -$ varies;

– is a general optimization problem when C and A is given.

Of course, in situations where variations in the principle of optimization of variants or multiple objects are allowed, there is an opportunity for manipulation. In this paper, we will explore the problems of multicriteria optimization problems and the possibility of manipulating the definition, justification and interpretation of the solutions obtained in such problems.

3 Formulation and solution specifics of multicriteria optimization problem

The problem of multicriteria optimization is formalized in the following formulation [3, 5]:

$$y_i = f_i(x) \to \max,\ i \in L_1, \tag{1}$$

$$y_i = f_i(x) \to \min,\ i \in L_2, \tag{2}$$

$$x \in A,\ A \subseteq E^m, \tag{3}$$

where $A -$ the set of objects, characterized by m parameters, that is, belongs to space $E^m;\ y(x) = (f_1(x),..., f_k(x))$ - the vector of object or criterion estimates, which is given by the mapping $f : A \to E^k,\quad L = \{1,...,k\} -$ of indexes of criteria, $L_1 = \{1,...,k_1\},\ L_2 = \{k_1 + 1,...,k\}$ the sets of indexes of criterion functions that are maximized and minimized, respectively, in some problems the set of objects stands out from the wider set by the constraints most often given by the inequality system.

Vectors $y=(y_1,\dots,y_k)$ and $y'=(y'_1,\dots,y'_k)$, $y\neq y'$, are relative $">"$, if $y_i\geq y'_i$, $\forall i\in L$, and at least one inequality is strict.

An evaluation of an object $y^0=f(a_0)$, $y^0=(y_1^0,\dots,y_k^0)$, is said to be effective (Pareto optimal, Pareto optimal, non-perfect, majoritarian, non-dominant), unless $">"$, there is another estimate y, that would strictly y^0, outweigh the relationship $y>y^0$.

Sometimes effective object evaluations are called compromise, but we will use this term for the final solution of the problem obtained from the effective set after applying heuristics.

It is known [5] that two effective objects are either equivalent or incomparable by many criteria.

The problem of determining the Pareto region is strictly objective and is solved without the use of any heuristics [5]. But the area of compromise is the set of points from which in most cases one has to choose. Narrowing down the area of effective objects and, moreover, choosing one of them basically requires the use of additional information from experts, since effective sets of parameters cannot be compared with each other formally.

Most practical problems of object estimation have different dimension, because they characterize different physical properties of objects, so it is advisable not to consider the absolute values of the parameters of the objects $a_i^j, i\in I, j\in J$, and their corresponding normalized values $\omega_i^j\left(a_i^j\right), i\in I, j\in J,-$ monotonous transformations, which bring the parameters to a dimensionless form and allow to compare them between yourself. As a rule [3], the following types of parameter values transformations are used in practice:

$$\omega_i^{(1)}=\omega_i^{(1)}\left(a^i\right)=\left(a_i^0-a^i\right)/\left(a_i^0-a_i^{\Gamma}\right),_z \tag{4}$$

$$\omega_i^{(2)}=\omega_i^{(2)}\left(a^i\right)=\left(a_i^0-a^i\right)/a_i^0, \tag{5}$$

$$\omega_i^{(3)}=\omega_i^{(3)}\left(a^i\right)=\omega_i^s\left(a^i\right),\ i\in J,\ s\geq 2, \tag{6}$$

where, respectively, is the optimal and worst value $\omega_i^s\left(a^i\right), i\in I,$ of the i-th parameter. In form (6), the values $\omega_i^s\left(a^i\right), i\in I,$ can be determined by relations (4), (5), and the figure s is an integer. Obviously, for the transformation (4) the values $\omega_i^{(1)}\left(a^i\right), \forall i\in I,$ always lie in the interval from zero to one, and for (5) the values may not lie in this interval.

In addition to these, there are several ways of normalization of parameters [3], the purpose of which is to eliminate the problem of incomparability of parameters in the formal relation. Among the most common methods of quantification are:

– rationing average, if the mean values $a_i^C, i \in J,$ of the i-th parameter on the set of alternatives are significantly different, and in their content they should be the same:

$$\omega_i^{(4)} = \omega_i^{(4)}\left(a^i\right) = a^i / a_i^C, i \in J,$$

– if not only the average but also the variance should match $\sigma_i, i \in J$:

$$\omega_i^{(5)} = \omega_i^{(5)}\left(a^i\right) = \left(a^i - a_i^C\right) / \sigma_i, i \in J, \tag{7}$$

– if $a_i^E, i \in J, -$ the reference (normative, true, perfect, measured, known, desired, etc.) value of the th parameter is known:

$$\omega_i^{(6)} = \omega_i^{(6)}\left(a^i\right) = a^i / a_i^E, i \in J,$$

$$\omega_i^{(7)} = \omega_i^{(7)}\left(a^i\right) = a^i / a_i^0, i \in J.$$

Sometimes the following method of normalization is used $a^i, i \in J$ [3]:

$$\omega_i^{(8)} = \omega_i^{(8)}\left(a^i\right) = \left(\left(a^i - a_i^C\right) / \sigma_i - a_i^{\Gamma}\right) / \left(a_i^0 - a_i^{\Gamma}\right), \; i \in J,$$

which is derived from methods (6) and (7) and results in the distribution of parameter values between zero and one.

There are many approaches to solving the CSF today [2]. Let us dwell on one of them [3]. Heuristics are introduced to describe this method of resolving STDs.

Heuristics E1. The type of monotonous transformation to translate the values of the object parameters to a dimensionless type is made by an expert using formulas that must satisfy the following requirements:

– take into account the need to minimize deviations from the optimal values for each objective function (CF);

– to maintain the ratio of preference to the set of objects being compared, across the set of CFs, and thus not to change the set of effective objects.

A CSF solution may not be optimal for any CF of the form (1), (2), but at the same time be in some sense the best solution for all the criteria functions at the same time.

Heuristics E2. The best object when solving the CSF should be considered to be the one for which the deviations from the best values at each estimate are minimal.

If the smallest deviation values for each criterion are not reached at the same time on any object, then there is a need to compare these deviations with each other due to the need to attract additional heuristics from experts. To constructively determine the best object, we present another theorem.

It is known that for every object $a \in A,$ such that in the space of transformed values of the CF of fair inequalities $0 < \omega_i(a) < 1, \;\; \forall i \in L,$ there exists a vector $\rho = (\rho_i, i \in L),$ that satisfies the normality ratio:

$$\rho_i > 0,\ \ i \in L, \tag{8}$$

$$\sum_{i\in L} \rho_i = 1, \tag{9}$$

and the number k_0, such that the object $a \in A$, satisfies both k equals

$$\rho_i \omega_i(a) = k_0,\ \ \forall i \in L. \tag{10}$$

We will introduce three heuristics.

Heuristics E3. The vector of the weight coefficients of the CF $\rho = (\rho_i, i \in L)$, which satisfies the relations (8), (9), will be interpreted as the ratio of preference between different CFs, given in quantitative form on the set of CFs.

Heuristics E4. By deciding the CSF for a given vector of weights $\rho = (\rho_i, i \in L)$, we mean a compromise object that belongs to the set of effective objects and is in the direction determined by the vector $\rho = (\rho_i, i \in L)$, or closest to the beam $\rho = (\rho_i, i \in L)$, for discrete problems.

Heuristics E5. The compromise solution $a_0 \in A$ of the STCF should provide the same minimum weighted relative deviations $\rho_i \omega_i(a_0),\ i \in L$, for all criteria at the same time.

It has been proved [5] that if $a_0 \in A$ it is an effective object for a vector $\rho = (\rho_i, i \in L)$, then this object corresponds to the smallest value of the parameter k_0, at which system (10) is executed simultaneously for all CFs.

It is also known [5] that in order for an object $a^* \in A$, to be effective $\omega_i(a^*) > 0,\ \forall i \in L$, at a given vector of weights $\rho = (\rho_i, i \in L)$, it is sufficient $a^* \in A$ to be the only solution of the system of inequalities

$$\rho_i \omega_i(a) \le k_0,\ \ \forall i \in L, \tag{11}$$

for the minimum value of the parameter k_0^*, at which this system is compatible.

Thus, the EBS heuristic compromise solution determined by the E5 heuristic can be found as the only solution of the inequalities of the form (11) for the minimum value of the parameter k_0, at which this system is still compatible. In the space of the relative values of the object parameters, the point of intersection of the compromise object corresponds to the point of intersection of which the directing cosines are determined by a given vector of relative importance of the CF $\rho = (\rho_i, i \in L)$, with the set of effective objects. If no such point exists, that is, no vector corresponding to the effective object lies on the beam determined by the vector $\rho = (\rho_i, i \in L)$, then the compromised object is considered to be the one for which the inequality system (11) holds and the nearest point corresponds to this object. to a given beam. If the compromise object is not unique, that is, there is some subset of effective objects equivalent to an accuracy of some sufficiently small number by the value of the parameter k_0, the choice of the compromise object on this subset is made by another criterion.

It should be noted that alternatives to the CSPS (1) - (3) may include, in particular, the ranking of objects [3] or objects or phenomena of a different nature. That is, the tasks of object ranking can be formalized in the class of CSF [3].

4 Classification of choice manipulation tasks when solving multicriteria optimization problems

In accordance with the general description of the problems of peer review and the approach described above for solving the CSF, we will present the classification of problems to manipulate solution choices in the problems of multicriteria optimization developed by the author.

4.1. Tasks of manipulating multiple alternatives

There is ample opportunity for manipulation of choice when there are means of influencing the initial set of alternatives to the task. Many alternatives can be changed in different ways:

− ODA voluntary approach;

− imitation of democratic procedures that result in a change of the initial set A;

− introducing additional restrictions and changing the conditions for participation of alternatives in further solving the multicriteria task;

− deliberately ignoring some restrictions in order to expand the initial set of alternatives;

− other approaches that change the initial set of alternatives in order to manipulate and "reasonably" select the ODA required for the ODA.

4.1.1. Supplementing the initial set of alternatives A by some subset A^*, $A^* \cap A = \varnothing$ containing the alternative $a^* \in A^*$ that, from the point of view of the manipulator, should be chosen as a solution as a result of the decoupling of the CSP of form (1) - (3). Then $a^* \in A^1 = A \cup A^*$.

4.1.2. Removing from the initial set of alternatives A some subset A^-, $A \setminus A^- = A^1$ containing an alternative $a^* \in A^-$ that, from the point of view of the manipulator, should not be chosen as a solution as a result of solving the BCO problem (1) - (3).

4.1.3. A combination of approaches 4.1.1 and 4.1.2: simultaneously adding an initial set of acceptable alternatives A to a certain subset A^* and removing a subset A^-, that contains undesirable alternatives. That is $A^1 = A \cup A^* \setminus A^-$.

4.1.4. Change the weight of the parameters that characterize the objects of the initial set A. To explore this approach to manipulating choice, the author developed a group of methods for adaptively determining the weights of object parameters [3].

In addition to purposefully changing the weight of object parameters, more drastic variations of this approach can be applied.

4.1.5. Supplementing the initial set of parameters of alternatives A by some subset of additional parameters $J^* = (m+1, m+2, ...)$. That is, increasing the dimension of the parametric space from Ω^m to Ω^{m_1}, where $m_1 = |J \cup J^*|$. Such manipulation may make it possible to select an alternative in the newly expanded parameter space that is desirable for the manipulator.

4.1.6. Removal from the initial set of parameters J of some subset $J^{-} \subset J$. That is, the reduction of the dimension of the parametric space from Ω^{m} to Ω^{m_2}, where $m_2 = \left| J \setminus J^{-} \right|$. In this case, there may be conditions for choosing the alternative for the manipulator to be chosen as a solution as a result of solving the problem of BCO (1) - (3). Or, at least, to remove from the subset of winners such alternatives that are undesirable for the manipulator.

4.1.7. A combination of approaches 4.1.5 and 4.1.6: simultaneously adding additional parameters to the initial parameter space and removing from the set of parameters undesirable for the manipulator. That is, changing the parametric space from Ω^{m} to Ω^{m_3}, where $m_3 = \left| J \cup J^{*} \setminus J^{-} \right|$. Such manipulation may allow the desired manipulator to be the winner or at least to remove from consideration the subset of the manipulator undesirable.

4.2. Manipulation of CSF limitations and measurement scales

4.2.1. Supplementing the initial set of constraints S by some subset of the new additional constraints S^{*}, $S^{*} \cap S = \varnothing$.

4.2.2. Removing a constraint S subset from the original set of constraints S^{-}, $S \setminus S^{-} = S^{1}$.

4.2.3. Combination of approaches 4.2.1. and 4.2.2: simultaneously adding restrictions to the original set of constraints and removing some unwanted subset of restrictions from the initial set S.

4.2.4. Manipulation of scales when measuring the parameters of alternatives: replacement of scales of measurement, use of unacceptable operations in operations on results of measurement, etc.

4.2.5. Manipulation of measurement scales in determining weights of parameters, relative weight of criteria, coefficients of competence of experts (weight of information sources [6]), etc.

4.2.5.1. When measured in ordinal scales, the organizers of the examination may invite the experts to determine their preferences in the space of strict preference relations, thus denying the participants of the expert group the opportunity to express a situation of equivalence or indifference, which can often arise due to peculiarities of the subject area and psychological properties of a person. That is, it may be deliberately narrowed the possibility of experts to determine their true advantages, inclining them to choose in an artificially narrowed space.

4.2.5.2. Limitations can be set in cardinal scales: for example, in the range from 1/9 to 9, which significantly disrupts transitivity already at the stage of initial examination and does not a priori allow to reach a situation of supra-transitivity of relations between parameters, criteria or competence of experts, depending on the formulation and interpretation of the task .

4.2.5.3. Establishing a requirement for a fixed setting of parameter values or preference ratios between objects, their parameters, criteria or expert competence, depending on the purpose of the examination. This often leads to a significant violation of the adequacy of modeling the subject area and the deliberate loss of information about the phenomenon being modeled.

4.3. Manipulation of many applicable metrics, criteria and methods of convolving criteria

To achieve the goal of manipulation, it is almost imperceptible for the untrained observer to select from the initial set of acceptable alternatives A practically any alternative that is desirable for ODA.

4.3.1. When solving a problem in ordinary scales, there are some of the most popular metrics - Heming, Cook, Euclid, etc. [3]. In some cases, applying each of the metrics produces results that do not overlap with the solutions obtained in the other metrics. Therefore, the manipulator just needs to choose the solution by which metric suits it the most and to set the requirement to unblock the CSF using the metric that is advantageous for it.

4.3.2. When applying formulas to switch to a dimensionless type of criteria, the limits of changing the criterion functions are essential. By choosing these boundaries hypothetically, you can choose the values you need to manipulate the value junction and significantly influence the final decision. The manipulation of the lower $\omega_i^H, i \in J$, and upper $\omega_i^B, i \in J,$ bounds of the dimensionless values of the criteria defined by formulas (4) - (7) is that in this way the order of change of deviations from the optimal values by those criteria for which variations of the boundaries $\omega_i^H, i \in J,$ and / or $\omega_i^B, i \in J,$ deviations are carried out $\omega_i,\ i \in J.$

4.3.3. During the preparation phase for the multicriteria optimization task in the previous steps, one or more rounds of sequential analysis can be applied. That is, to pre-establish such criteria that will screen out undesirable alternatives from the initial set A for ODA, as being in advance unpromising given the "legitimately" established criteria.

4.3.4. Changing the class of tasks in which the initial model of multicriteria optimization should be formalized. This automatically entails the sound application of the methods required to achieve the goal of manipulating the methods of solving the problem and applying the appropriate types of convolution to the criteria of the task. Such manipulations are unlikely to remain unnoticed by a person skilled in the art, hidden by complex formulas, supplemented by formal and comprehensive justifications.

4.3.5. Supplementing the initial set of criteria by some new subset or one, even insignificant criterion $k_1 > k.$ It is thus possible to make an effective alternative, which in the previous model, when the number of criteria was equal, was dominant. Such manipulation can significantly affect many effective solutions to the initial CSF. And then to determine the compromise solution to problem (1) - (3).

4.3.6. Removing from the original set of criteria $f(x) = (f_1(x),...,f_k(x))$ some subset of criteria or even one of them. That is, the narrowing of the criterion space of the problem: $k_2 < k.$ Such an interference with the modeling process can significantly affect the multicriteria model of the phenomenon under study.

4.3.7. The combination of 4.3.5 and 4.3.6 may have a synergistic effect over the autonomous application of each of these approaches. In particular, it can be deduced from the choice of a non-advantageous ODA dominant alternative under some reasonable excuse or initially transformed into an effective alternative.

4.4. Manipulation by influencing the expert group

4.4.1. Replacement of a dissatisfied expert when a single examination is appointed and the expert selected does not satisfy the manipulator's wishes.

4.4.2. Supplementing the initial pool of experts with some subset of experts affected by ODA or other decision makers interested in manipulation - to prepare and justify the required decision.

4.3. Removing from the initial pool of experts those who are uncomfortable with ODA and have their own personal opinions.

4.4. A combination of approaches 4.4.2 and 4.4.3 is the simultaneous addition of an expert team to new team members and the removal from the initial expert group of some of its members.

4.5. Manipulating many of the goals declared when solving a problem

4.5.1. Increasing the subset of choices in the course of solving a problem, which will introduce to the subset of winners the alternatives that are desirable for ODA.

4.5.2. Achievement of the desired ODA solution: with the help of a powerful tool, original mathematical support, you can achieve both the harmonization of solutions at different levels, and provide wide and unnoticeable opportunities for malicious manipulation.

4.5.3. In the case when the prepared and justified decision does not satisfy the ODA, the choice can be made invalid for various contrived motives and formal reasons.

4.6. Manipulation of the system of benefits of experts

4.6.1. Minimal changes in the preference given by the experts can be achieved by changing the initial compromise solution by changing the elements in the MPP at $n >> 3.$

4.6.2. Achieving the goal of manipulation may be to replace only some of the individual preferences of the expert in order to smooth his preferences or to agree on a group expert decision.

4.6.3. The manipulation of expert competence weights (the weight of information sources [6]) can be achieved by the desired ODA solution or at least blocking the decision that is most unacceptable to the manipulator.

4.6.4. The exclusion of some elements of the WFP from consideration - that is, transferring it to the category of incomplete matrices. This changes not only the information but also the methods of solving the peer review task. This may entail the choice of a compromise solution that is necessary or acceptable for the manipulator.

4.6.5. Adjusting the values of the element of the pairwise comparison matrix that most significantly affects the result is a way of indirectly influencing the final solution of the CSF.

5 Prospects for further research

The problems of choice manipulation have long and comprehensively been studied by domestic and foreign scientists. At the same time, the possibilities of manipulation in multicriteria formulation of the problem have wide prospects for development. In order to improve the approach described, the possibilities of manipulating the GCS solutions in the following directions should be considered and explored:

- formalizing the problem of manipulation for a class of object ranking tasks - strict and non-strict;
- study of resistance to manipulation of tasks that are formalized using different metrics and criteria of different kinds;
- generation and comprehensive consideration of examples that clearly demonstrate the ability to manipulate the described task classes;
- implementation of a series of computational experiments to determine the relationships between the methods of manipulation, identify the most effective of them and find options for preventing manipulation;
- development of approaches to visualization in the problems of choice manipulation, which is a significant evidential factor and a way of demonstrating the capabilities of the method, in particular the detection of manipulation;
- developing and investigating manipulation procedures or preventive detection of manipulation capabilities at the model development level or in the early stages of solving the problem;
- exploring the possibilities of using combinations of different approaches to manipulation in order to minimize the impact on each element of the model;
- study the sensitivity of the initial elements of the model and change the solution of the problem with a slight variation of the data and minor changes in the elements of the model;
- Investigate the possibilities of using system optimization problems to model and develop methods of decoupling in CSS.

6 Conclusions

Various aspects and possibilities of manipulation of choice in expert evaluation tasks in the case of formalization of them in the form of multicriteria optimization are investigated.

In general, various aspects and sources of possible manipulation in peer review tasks are considered.

The choice can be justified or voluntary. With well-organized manipulation, the ODA can be adjusted to the desired selection for the manipulator. That is why it is especially important for expert judgment to have a clear representation of the heuristics that researchers rely on when deciding on a compromise solution, documenting it, and disclosing it explicitly.

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