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AN UNIFYING THEORY FOR SOCIAL CHOICE AND SYNERGITIC GROUP DECISION MAKING: THE ANALYTIC HIERARCHY PROCESS (AHP)

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Abstract: The process of aggregating individual judgments in a population at large and in a synergistic group (team) is fundamentally different. Arrow's Impossibility Theorem shows that it is generally impossible to derive a rational group choice from individual ordinal preferences with more than two alternatives. This general impossibility has led to the development of a distinct branch of knowledge for each group type, quantitative for the former and qualitative for the latter. By using ratio scales, AHP has removed the impossibility conclusively and be the theory that makes group decision making a continuum between pure voting on one end and consensus building on the other end. This paper discusses a technically feasible voting process with AHP, ranging from eliciting voters' intensity judgment of preference to a full multicriteria voting. As for a synergistic group, the AHP offers tools to address major problems and issues in teamwork, as well as to promote organizational learning. The AHP enables a facilitator of a synergistic group decision making to use consensus building and voting in different parts of the problem on hand to come to a group decision.

Introduction

Group decision making is essentially a process of aggregating a set of individual preferences into one of the group, be the group is a *population at large* or *a synergistic group* (*a team*), but the process is fundamentally different between the two. Having a unifying theory that covers both areas has been considered unthinkable, especially after Kenneth Arrow [1963, 1970] showed that it is generally impossible to derive a rational group choice from individual ordinal preferences with more than two alternatives. This general impossibility (also called Arrow's barrier) has led to the development of a distinct branch of knowledge for each group type, quantitative for the former and qualitative for the latter.

The AHP is a theory for multicriteria decision making with geometric average as the procedure for aggregating individual votes [Aczel and Saaty, 1983; Aczel and Roberts, 1989]. By using ratio scales, AHP has removed Arrow's barrier conclusively [Peniwati, 1996]. Hence, AHP can be considered as the unifying theory, which creates a continuum in group decision making, ranging between pure voting on one end and consensus building on the other end. The purpose of this paper is to outline how one can use AHP to move voting within a range of the more synergistic processes, and to improve the interpersonal process of a team making a decision and to facilitate organization learning.

AHP: a general theory for group decision making

Prior to the AHP, attempting to develop a theory to aggregate individuals' cardinal preferences was considered as *chasing what cannot be caught* [MacKay, 1980]. The existence of Arrow's barrier also means that it is generally impossible to derive a composite preference of a multicriteria choice problem with more than two alternatives. This situation explained why getting around Arrow's barrier created so

much interests in the electoral and social choice research. There are about 100 different formal conditions being proposed as desirable properties for election methods and social choice functions [Fishburn, 1987], leading to a situation where the outcome of an election or voting is *method-dependent* [Dummett, 1984].

The Arrow's barrier created a distinction between electoral or social choice and synergistic group or teamwork, in terms of the prevalent approach they each use in developing knowledge in their respective field. Research in electoral and social choice generally use more of the formal approaches (normative, quantitative, axiomatic science), with well-formulated voting questions representing the choice problem, assuming no interpersonal interactions. Research in teamwork uses more of the descriptive approaches, due not only to the intensive interaction among individual members, which characterizes the process, but also to the complex nature of the problems on hand. It is in this latter context that the term *group decision making* is usually used. Team building, communication, and leadership become the focus of research in this area, involving practically no quantitative method.

In the AHP, two fundamentally different approaches are used to synthesize group judgments: deterministic and statistical. The deterministic approach is appropriate for a synergistic group, and the statistical approach is for a population at large [Saaty, 1994]. The process of a synergistic group is assumed to estimate a single underlying measure that is unknown to the group, hence its estimation is obtained by simply aggregating the judgments of the individual members mathematically. The question of interest here is whether or not one can simply aggregate the judgments of individual members of the group, regardless the range of the individual judgments. In practice, in general one cannot expect to have a small range of individual judgments, indicating the need for an interaction process to improve the level of group coherence. Judgments from the individual member of a population at large, on the other hand, are assumed to come from a true but unknown population of judgment values. The question of interest here is whether or not the individual judgments are homogeneous. Basak [1988] maintains that only judgments from a homogeneous group can be synthesized. The AHP creates a continuum between the two otherwise completely separate disciplines, voting and synergistic group decision making.

A more synergistic voting process with AHP

Although it may not be realistic to expect that a more synergistic voting with the AHP will be implemented in political or social election in the near future, we can speculate of how AHP makes it feasible. The removal of Arrow's barrier opens up a wide range of voting approaches, at least from the aggregating methodology point of view.

There are ranges of voting designs that can be employed that can be grouped into three key approaches, with a given set of alternatives:

1. *Direct comparison (assumed single criterion problem).* Rather than assuming that one alternative is preferred infinitely more to the other, as implied with an ordinal choice, one can elicit voters' pairwise comparison judgments using the AHP's fundamental scale. The procedures range between assumed consistency (by eliciting minimum number of judgments) to ensured consistency (by allowing full judgments with inconsistency feedback and revised judgments).
2. *Multicriteria voting - predetermined criteria and their priority.* The voters evaluating the alternatives, with respect to a predetermined set of criteria and their priority. Aggregation is done at the alternative level. The range of procedures is the same as the above.
3. *Full Multicriteria voting.* The voters can be asked either to judge the priority of a given set of criteria, or to construct their own criteria hierarchies and judge their priority before evaluating the alternatives. With the former, aggregation is done at the criteria level first, then use the resulting priority to obtain the aggregated global priority of the alternatives. With the latter, aggregation is done at the alternative level. The alternatives are common for everyone and are determined outside the voting process.

AHP facilitates group collaboration and group learning

Teamwork and project orientation is among the key characteristics of smart, flexible, and cost effective organizations for the 21st century. There are two key relationships concerning group goals that must be addressed through teamwork, i.e. between personal (unit) goals and group (organizational) goals, and between achievement and group maintenance goals [Brightman; 1988]. Effective communication among group members is not enough to achieve these goals - the group needs to collaborate productively. Unlike communication, collaboration adds a new dimension to conversation. It produces a tangible thing and needs a medium of shared space [Schrage, 1990]. With its supporting software *Expert Choice*, the AHP model being developed by the group is the shared space, the model in progress represent the memory of the group, and the final model is the tangible output of the group collaboration.

The following are major problems and issues in teamwork [Parker, 1994; Glacel and Robert, 1996] and how AHP addresses them.

1. *Goal ambiguity.*
   Structuring a hierarchy articulates and clarifies the team goal systematically. Hence, the AHP model is essentially the description of the team goal.
2. *Difficulty to keep complete attendance or physical distance of team members.*
   The AHP, with its supporting software *Expert Choice*, makes use of technology and opens up a possibility for people to work in *virtual teams* that transcend distance, time zones, and organizational boundaries [Lipnack and Stamps, 1997].
3. *The process of pursuing achievement (content) and maintenance (process) goals are inextricably linked.*
   The AHP, with its supporting software *Expert Choice*, provides a tool to enhance the collaborative relationship [Schrage, 1990]. The AHP model shifts the focus of attention from the individual members talking about the problem to the problem itself. It prevents ego issues from distracting the process.
4. *A team leader sets the agenda and shepherd the process, but leadership for content actually rotates.*
   The systematic process of structuring an AHP model facilitates a team leader to guide and control the rotation of leadership roles during the process, in line with the progress of the task on hand.
5. *Teamwork takes a lot of time.*
   Applying AHP also takes time; however, AHP makes group decision making on a complex problem intrinsically efficient. This is an important issue and improving group efficiency with AHP will be discussed more below.
6. *It is hard to keep a team focused.*
   By having a medium for shared space, the AHP model in progress is both a record for the status of the task and the means to bring the group back on track.
7. *The team should capture learning by reflecting on the team process.*
   Reviews of the AHP models against progress over time, together with careful documentation, provide the group with highly summarized information for learning.
8. *Personal agendas get in the way when striving for team consensus.*
   With the AHP, the outcome of a decision problem is derived out of pairwise comparison judgments on which it should be easier for a group to agree.
9. *Lack of management support. They need to be educated and be updated with the team progress.*
   The AHP model itself does most of the job, since it gives a comprehensive explanation that is easy to understand.

Improving group efficiency

The AHP makes group decision making intrinsically efficient for at least three reasons:

1. It provides a framework and tools for group collaboration that systematize the group process,
2. It enables the group to break its task into distinct sub-tasks, with each managed almost independently with respect to the manpower allocated and the group techniques used, while still keeping them integrated.

3. It provides feedback measures to facilitate judgment improvement while allowing a certain degree of inconsistency in the judgments. When necessary, the group may decide to do quick and dirty evaluation for certain parts of the hierarchy(ies).

The amount of man-hour utilization can be minimized, without losing group effectiveness, by:
1. dividing group task into a set of sub-tasks,
2. determining the smallest number of people possible to complete each sub-task,
3. allowing reduced number of judgments [Harker, 1987],
4. allowing an acceptable level of inconsistency,
5. Improving judgments by looking for both the most inconsistent judgment and the individual that causes it (using AHP's ratio scale metric) [Saaty, 1994].

A group facilitator can also improve group efficiency by:

1. *Using the underlying intentions of deferred judgment and structured communication.*

   The AHP generalizes the application of the concepts of deferred judgment in brainstorming, and structured communication in the NGT (Nominal Group Technique). It separates the process of problem structuring (which in turn consists of two distinct processes of identifying the elements of the problem and of defining dominance relations), judgment elicitation, and evaluation. The group can conduct brainstorming, NGT, or Delphi sessions to identify alternatives and criteria efficiently. During problem structuring, differences with regard to structuring the hierarchy do not need to be resolved. This is a win-win kind of disagreement. The group effort should be focused on establishing dominance relations among elements rather than arguing too early whether or not an element should or should not be in a hierarchy. If some elements do not fit logically in a hierarchy, consider another hierarchy (such as costs, benefits, opportunities, and risks hierarchies).

2. *Constructing a simple but adequately comprehensive model,*

   Ensuring an optimal size of the hierarchy can facilitate efficiency in judgment elicitation. If the structure is too deep, encourage the group to remove some of its levels, as long as its resulting ambiguity does not create difficulties in judgment elicitation. During judgment elicitation, agreeing on a pairwise comparison judgment should be the end of a discussion. The members do not have to agree on the reasoning behind the judgment.

3. *Maintaining balance between consensus and voting.*

   What makes conventional group decision making demanding is that it is expected to reach consensus on which alternative(s) to select, although the group may generally agree on the criteria and their relative importance. It is reasonable to assume that it would be easier to reach consensus on comparing two things than on many things at once. The AHP makes it even easier by not requiring a group to reach consensus on a judgment. If voting is necessary for efficiency reason, its effect must be minimized. The need for voting indicates incompatibility among group members, and may lead to inconsistency of judgments. Discussing the differences first and selecting the appropriate individuals to vote can ensure a narrow range of judgments. In fact, disagreement and incompatibility between an individual and the group provides an opportunity for organizational learning. The majority is not always right.

By using AHP and the Expert Choice, it should be easier for a group leader to carry out his responsibilities to:
- handle the passion of commitment which is both exhilarating and draining,
- be open for different viewpoints,
- set clear objectives and milestones,
- focus on excellence,
- focus on the task and include everyone involved in the task,
- stimulate the free flow of ideas,

- foster non-threatening environment,
- encourage the appropriate level of participation,
- Look for common grounds before trying to resolve differences.

Team roles

The work of Meredith Belbin [1981] is arguably the most significant piece of research into team effectiveness undertaken to date [Stott and Walker, 1995]. His result does not support common wisdom which dictated that if the best people are put together, inevitably one will get a high performance team. He discovered that the tendency of individuals to take certain roles in a group process were more important than technical ability in determining the success of a team. He identified nine ideal roles: the coordinator, the shaper, the plant, the resource investigator, the monitor evaluator, the implementer, the team worker, the completer, and the specialist. He suggests that a group should have diversity in terms of team roles. It is not always easy for an organization to establish a team whose members have both the relevant knowledge regarding the task on hand and complementing characteristics in terms of team roles. The AHP reduces the need for such diversity. For example, the ideal characteristic for a group facilitator applying AHP may be more of the participative type of a coordinator, as opposed to the more directive type of leader, the shaper, since AHP is usually applied when the group is not pressured to make urgent decisions. However, a shaper may find that using AHP and Expert Choice enable him to make conscious effort to behave more like a coordinator. He or she can use his directive strength to the success of the group process instead of to a certain decision outcome. The systematic process with the AHP facilitates an individual with multi-roles ability to pick the proper role at different times as suggested by the progress of the AHP process.

Conclusion

The use of ordinal group aggregation in the past was justified because there had been no scientific method available to aggregate the individual preferences of a group. Now that the AHP exists, and has been validated with many applications, there is no reason for one to continue using methods that have problems and paradoxes. We must conclude that ordinal aggregation is obsolete.

Operating in a complex turbulent environment, organizations have to rely on a group of managers or executives to make major decisions. The success of a group in making decisions largely depends upon how well the group produces a decision that reflects the diverse information provided by the members of the group and how well that group settles their unresolved differences. In the AHP, differences in the structure of a problem are included in the hierarchy and differences in judgments are resolved first by assigning the task to the appropriate individuals (decision-makers or experts). Difference in judgments are then discussed to make them close (without having to be completely in agreement) and combined geometrically or weighted and combined geometrically. We conclude that AHP is the method for a group to describe a decision problem to address and integrate judgments of individual members scientifically to come to an outcome, which represent the group decision.

References

Arrow, K.J. (1963, fourth printing 1970). *Social Choice and Individual Values*, 2nd ed. New Haven and London: Yale University Press.

Belbin, R.M. (1981). *Management Teams: Why They Succeed or Fail.* Heinemann, Oxford.

Basak, I. (1988). When to combine group judgments and when not to in the Analytic Hierarchy Process: A new method. *Mathematical and Computer Modeling*. 395-404.

Brightman, H.J. (1988). *Group Problem Solving: An improved Managerial Approach.* Business Publishing Division, Georgia State University.

Dummett, M. (1984). *Voting Procedures.* Clarendon Press.

Fishburn, P.C. (1987). *Interprofile Conditions and Impossibility.* Harwood Academic Publishers.

Harker, P.T. (1987). Incomplete pairwise comparisons in the Analytic Hierarchy Process. *Mathematical Modeling.* 9(11). 837-848.

Lipnack, J. and J. Stamps (1997). *Virtual Teams: reaching across space, time, and organizations with technology.* John Wiley& Sons, Inc.

MacKay, A.F. (1980). *Arrow's Theorem: The Paradox of Social Choice: a case study in the philosophy of economics.* Yale University Press.

Peniwati, K. (1996). The Analytic Hierarchy Process: The Possibility Theorem for Group Decision Making. *Proceedings of the Fourth International Symposium on the Analytic Hierarchy Process.* Simon Fraser University, Burnaby, B.C. Canada.

Saaty, T.L. (1990). *The Analytic Hierarchy Process: Planning, Priority Setting, and Resource Allocation.* RWS Publication, Pittsburgh, PA.

Saaty, T.L. (1994). A ratio Scale Metric and the Compatibility of Ratio Scales: On the Possibility of Arrow's Impossibility Theorem. *Appl. Math. Lett.* (7)6. 51-57.

Schrage, M. (1990). *Shared Minds: The New Technologies of Collaboration.* Random House, New York.