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Teamworking to Develop Technology Strategy

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". . . gather all the food of those good years that come . . . and that food shall be store to the land against the seven years of famine . . ." Joseph, Genesis Ch. 41, verses 34-36.

1 Introduction

The strategy of an enterprise is embodied in its strategic decisions, which are basic to it because "they deal with the direction of the enterprise, its future size and pattern of outputs and markets, . . . they determine the kind of company which has to be managed and the kinds of talents which are called for." (Minkes [1]).

Technology Strategy is concerned with decisions to develop, exploit, or maintain the totality of organizational know-how in a defined set of technologies. Relevant activities in this connection are identifying and evaluating technologies in terms of their potential importance to overall strategy. The paper is concerned with assessing the feasibility and significance of various tabled technology development options in a team setting. The paper describes a group decision support system (GDSS) known as TEAMWORKER, designed to facilitate forward planning by a team, and demonstrates its use by means of a case application involving technological forecasting for the time-frame 2010 to 2030.

The literature on technology assessment and forecasting is large. For reviews of management techniques in these fields see, for example, Jantsch [7], Blake [2], Souder [13] and Ford [4]. Some techniques seek to make use of the collective intellect of an assembled group of "experts" rather than that of a single "expert", by means of juxtaposing disciplines and experiences in order to promote debate, creativity and intuition. The philosophy of this paper is based on the use of collective expertise to assess future technological possibilities in a feedback oriented approach, Gear [6]. Computer based technology is utilized to promote group communication, and is carefully designed to minimize deleterious effects of conformity, domination, reticence, indiscipline, deviation, reconditeness or vested interest.

The TEAMWORKER GDSS comprises hardware and software designed for the particular group context and process, and is described in a variety of applications by Gear [5,6] and Read [10, 11]. In the case described, the software (sometimes known as "Groupware") is aimed at improving communication for technology assessment. Mockler [8], and Finlay [3], have recently reviewed various forms of groupware and GDSS for aiding strategic management processes. TEAMWORKER software is aimed at facilitating group dialogue following feedback of judgements from group to individual and from individual to individual. This aspect of communication is also discussed in [17].

The software may be designed around alternative frameworks of decision analysis [6]. For example, [9] adopted a pairwise comparative framework, based on a two-level hierarchy, in order to rank a set of alternative technologies to meet a defined need. A critical survey of recent developments in applied multiple criteria decision making and their current status has been undertaken [12]. This work provides a useful input to the design of groupware, given that it is the group communication process which is of central concern rather than mathematical routines alone.

In the case described in this paper, a simple scoring scale was made the basis of individual judgements throughout the meeting. This meant that rapid interactions were easy, with the ability to repeat stages, formulate additional items, and respond to new requests "on the fly". (see also [14] in the connection). For the given purpose, technology assessment on long time-frames, refinement of the technique is not the main issue. As Blake [2] has pointed out: "Over-refinement of the system makes it possible to obscure issues with masses of detail, in turn causing error in forecasting". Complex approaches, while of considerable interest, may be totally unsuitable for certain business uses.

The underlying management technique behind the on-line system, TEAMWORKER, in application to technology assessment, is GROUP DELPHI. Some of the advantages of GROUP DELPHI over and above standard DELPHI are discussed by [15].

A further important aspect to take into account in the design phase of preparing process support software is the cultural setting and history of the situation, together with the skills and backgrounds of the participants. For example, [16] has described the "Emerging Technology Roadmap" framework of thinking, which is updated by a small committee of individuals within Motorola.

Each of the above issues needs to be born in mind in order to design a framework for the group process which can form the basis of group support software. In Section 3, a case study is described in order to illustrate design considerations. The group decision support system (GDSS) used in this application is described in Section 2, and some conclusions are identified in Section 4.

2. TEAMWORKER SYSTEM

The system comprises a set of hand-held devices, one for each group member. Digital signals from each unit are transmitted to a remote receiver, and fed into a micro-processor. The signals are analyzed in accordance with the software which is being used. Processed information is displayed on a large screen visible to the group. The screen is used to:

- request information from each group member during the meeting.

- display processed feedback information at a number of stages.

- provide expert advice and menu options during the meeting.

The arrangement of the system of feedback is shown in Figure 1.

Certain judgmental processes are especially useful, depending on the issues involved. Some important ones are itemized below:

(i) Voting

Uses include selecting an item or option from a set, and multiple choice questions.

(ii) Scoring

Uses include evaluating each of a set of items or options on a pre-defined scale, scoring as a means of producing lists in rank order, scoring as a means of quickly filtering long lists to short-lists for closer attention.

(iii) Comparing

Uses include weighting the relative importance of a set of criteria by means of pairwise comparison, evaluating subjective factors and parameters, assessing subjective probabilities and risks.

(iv) Direct Assessment

Uses include the estimation of parameters, probabilities, risks and other factors by direct and subjectively based input values.

The system design facilitates communication at a meeting in support of group work on four related activities:

(i) pooling of information, expertise, opinions and beliefs.

(ii) comparison and debate of areas of agreement/disagreement.

(iii) identification of key elements of the decision task for further group attention.

(iv) revision and redefinition of the task, options, criteria, etc. as the group progresses.

3. <u>Case Study: Technology Assessment</u>

Background: This case study concerns the Research and Development department of a large multinational oil company. It is known that the future market for petroleum products is uncertain, owing to the rising costs of production and discovery, and the increasing environmental concerns associated with the use of petroleum products.

These and other issues led the R&D department to consider the science and technologies it should be involved with by the year 2010. This is part of a continuing process led by a "Core Team" involving the study of two key aspects:

(a) "Business Drivers", i.e. Trends culminating in opportunities or threats to the organization

(b) "Business Options", i.e. A set of projected capabilities which would enable implementation of a specific technology for a defined business purpose at some future time period.

The organization decided that part of this continuing process should be a three-day workshop involving senior executives from the R&D function and from a cross-section of other business functions. A total of 42 senior executives took part in the workshop, 30 from the R&D function and 12 from other business areas.

The purpose of the workshop was to exchange views and pool judgements relating to the business options being considered by the organization, and to provide guidance to the Core Team on the high grade options, the options to drop, and the options requiring further work. It was stressed that this workshop was not so much a decision-making forum, bur rather an opportunity to exchange views, evaluate and grade the options.

Workshop Framework

The workshop mission was to define a statement that the Core Team could use to help frame a Strategic Plan. In this respect, the Core Team was seen as the "customer" of the workshop.

Initially, a report on each of the key business drivers was presented and discussed. This provided a framework for the subsequent assessment of the business options. After this, the full set of business options generated by the Core Team over the preceding months was presented by the Core Team. At this point the TEAMWORKER system was used as part of a structured process, involving a combination of discussion and polling, to determine a sub-set of up to 13 options to be studied more intensively at the workshop, and then to become the subject of post-workshop activities. This was called the "Screening Process".

The next stage involved a number of small teams each working on one of the sub-set of options. Each team was organized to have at least one delegate from a business function. Presentations were then made by each team in a plenary session, detailing the advantages and disadvantages of the business option studied by that team.

Following this, the TEAMWORKER system was used to score the sub-set of options on each of two criteria; the relative likelihood that the option would be feasible in the timescale under consideration, and the relative commercial impact that the option would have on the organization in this timescale. This was known as the "Mapping Process". The output from this process consisted of a two dimensional grid showing the workshop's evaluation of each of the sub-set of options on the two criteria.

The outputs from these two processes were used to formulate the final guiding statement to the Core Team. These processes are now described in more detail below.

The Screening Process

Each of the set of 35 Business Options was presented by selected participants. The details of these options cannot be listed in this paper, but included items such as "Chemical Vehicles Development".

Following the presentations, and some further clarifying discussions, each workshop delegate used a 1 to 5 scale to score each of the business options. The business option considered of most importance (in the opinion of a particular person) was given a 5, and the option considered of least importance given a 1. All other options were then given a unitary value of between 1 and 5 relative to the individually defined most and least important options. This approach served to anchor the end points of the subjective scoring scale of each participant independently.

TEAMWORKER was used to collect the scores and feedback summarized information to the workshop for discussion and debate. The first feedback screen provided to the delegates, following a particular option vote is shown in Fig. 2. This is a histogram showing the numbers of scores obtained for each value on the 1-5 scale, the overall average and standard error, and the level of confidence associated with statement that the sub-sets of scores from those R&D Function members were significantly different from those of the Business Function members. The average used was not a simple average of all 43 delegates, but the mean of the averages of the two sub-groups. This form of average was subsequently used to aid determination of the options to be considered at the next stage of the workshop, and the Core Team did not want the larger number of R&D delegates to have a more than equal (quantitative) influence in the process. Histograms of the type shown in Figure 2 clearly showed how much disagreement there was in the workshop for each option. In addition, the calculated confidence level indicated whether there was substantial disagreement between the two groups of members. A feedback screen was used in order to compare the sets of R&D and Business scores (Fig. 3). Each of these feedback screens frequently led to further discussion and debate, particularly when significant differences were revealed, often resulting in rescoring of an option by the group.

When all the options had been considered, a "High-Low" chart showing the average score for each option, together with the standard error, was presented to the group (Fig. 4). Included with this chart was a 'grey area' which depicted the zone where the cut-off for the sub-set of options to be studied further was located. This zone was established in a debate. Further discussion concentrated on this grey area, with some rescoring of options by the group.

The outcome of this process was a defined sub-set of 12 options for further attention at the workshop (the "Mapping Process"). Several other options were considered worthy of further work after the workshop (sometimes because there was not yet enough information to make a judgement), and other options were recommended to be discarded.

The Mapping Process

The 42 delegates were divided into 12 work teams, each to develop one of the selected options established in the Screening Process, by studying the feasibility and marketability of their option. Each team had a minimum of 3 and a maximum of 4 members, including one Business Function Member, and spent a day developing their option, and preparing literature which could be presented to, and discussed and evaluated by all, the other workshop members. A series of presentations was given by each team, when the results of team deliberations were disseminated to the rest of the workshop.

Following the presentations, all delegates used a 1 to 5 scale to score each of the subset of options on each of two criteria; the relative likelihood that an option would be feasible in the given timescale and the relative impact the option would have on the organization if it was feasible. As with the Screening Process, each delegate first (privately) gave the top option on each criterion a score of 5, and the bottom option a score of 1. All other options were then given a score of 1 to 5, relative to the individual's top and bottom options on each of the criteria taken in turn.

TEAMWORKER was used to collect the scores on each criterion. The first feedback screen showed the scatter of scores on the two criteria (Fig. 5). In this figure, the areas of the dark squares are proportional to the numbers of scores in each zone of the grid respectively. This gave a visual indication of the degree of disagreement existing within the group. It was also easy to view the histogram of scores for each of the criteria (Fig. 6). The Average is the simple mean of the two sub-group averages (R&D and Business), and the Standard Error shown is the standard error of this mean. These feedback screens led to further discussion and debate, particularly when significant differences were observed, sometimes resulting in rescoring.

Once all the options had been scored, a two dimensional grid was shown in order to display the position of each option on the two criteria, using the averages and standard errors in both directions (Fig. 7). The more important options were those with a high Relative Likelihood score and a high Relative Impact score, placed towards the top right of the figure. These were identified as the high-grade options in the advice given by the workshop to the Core Team.

4. Discussion and Conclusions

The TEAMWORKER system was undoubtedly useful in terms of providing a degree of structure to a complex task carried out by a large group of experts. It also enabled rapid identification of areas of strong disagreement, making it easy to prompt relevant debate. A number of aspects or issues which arise from this case application are identified as follows:

(i) The Core Team wanted to use a scoring approach which was easy to understand and implement, so a 1-5 scale was adopted in order to score each option rather than, for example, a pairwise or ratio scale approach.

(ii) Each participant was asked to identify independently their personal lowest and highest rated options, and to allocate scores of 1 and 5 to these respectively. This ensured that the full scale was used, and serves as a basis for producing a ranked list of options from each delegate.

(iii) The scores themselves were used in order to calculate average and standard deviation values. The rigour of this form of aggregation is questionable. An alternative approach could be aggregate rankings rather than scores. In discussion, the Core Team preferred to work with the scores in terms of clarity of the feedback, bearing in mind that this was intended to generate debate rather than create excessive dependence on a mathematical routine and associated output.

(iv) The group process achieved a high level of sustained attention and application, involving all the delegates over several days.

(v) The feedback screens frequently resulted in verbal expressions of surprise, typically concerned with differences of judgement, and easily served to generate focussed debate.

(vi) Re-scoring after feedback and discussion did not invariably reduce differences of opinion, but nonetheless opinions frequently changed at these stages.

(vii) There was an occasional review of the definitions of options, especially during debate following feedback.

(viii) The workshop resulted in the group reaching a collective decision: a defined short-list of options, to each of which a small group was assigned for further indepth review and assessment after the

Workshop. There appeared to be commitment to this on-going work, perhaps as a result of the high level of involvement of the participants.

(ix) The workshop was a collective highlight or episode in an on-going process of technology assessment and strategic planning, rather than a start or finish in its own right.

We conclude this paper with a quotation made by the organizing officer shortly after the event: "We might have had some other, more conventional, meeting but I don't think it would have been nearly as productive".

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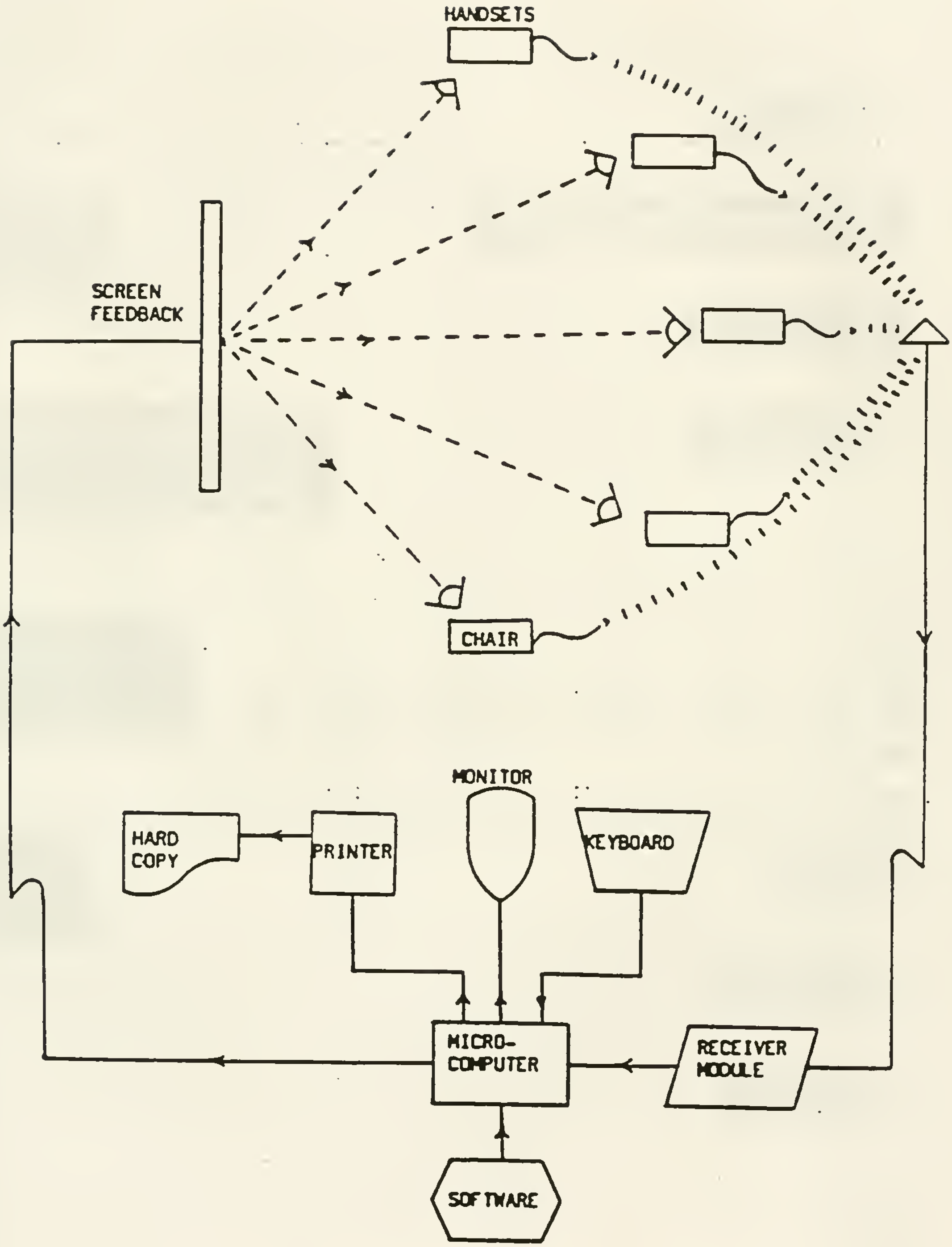

Figure 1. TEAMWORKER Feedback System

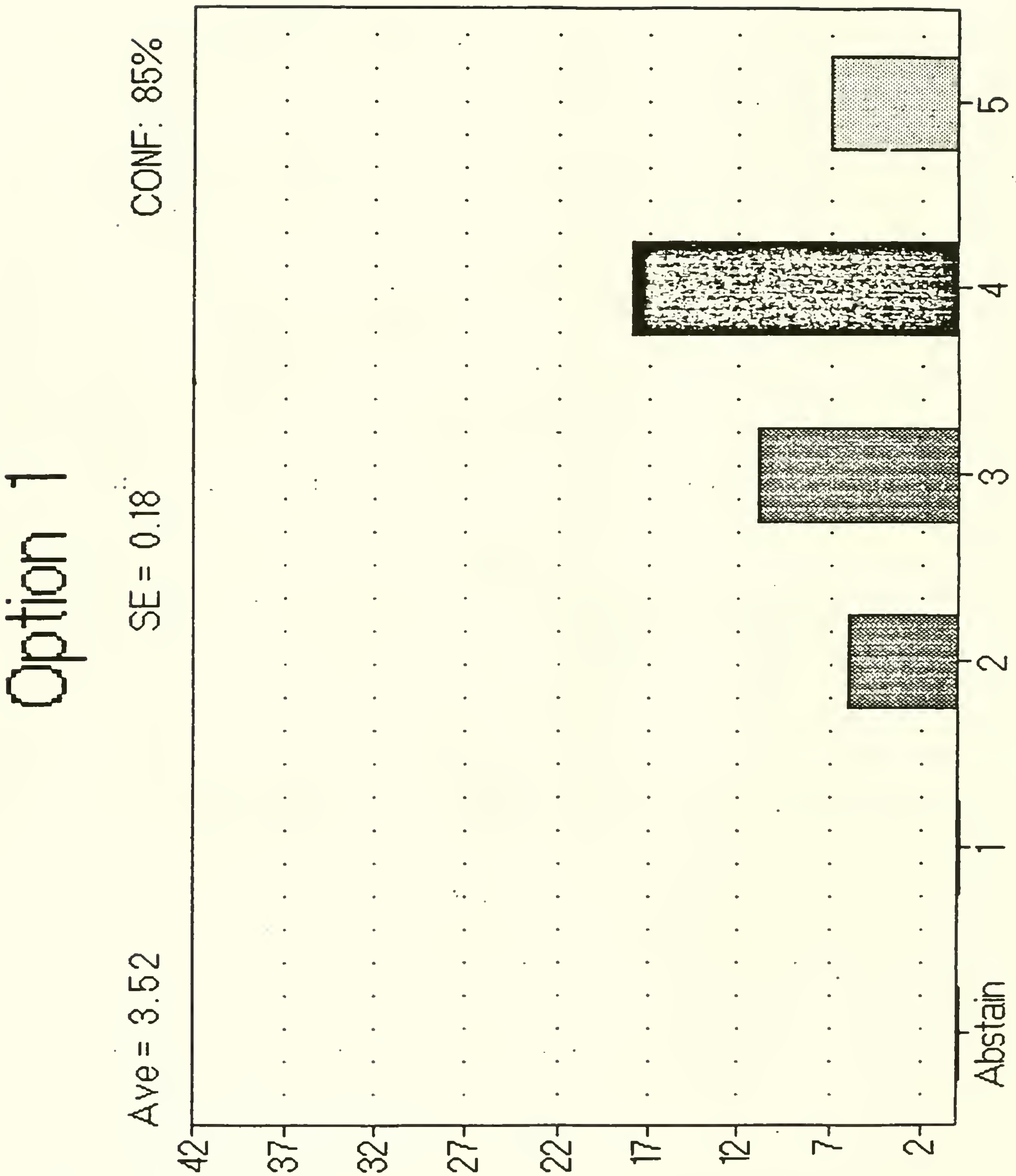

Figure 2. Histogram of Scores for Complete Group

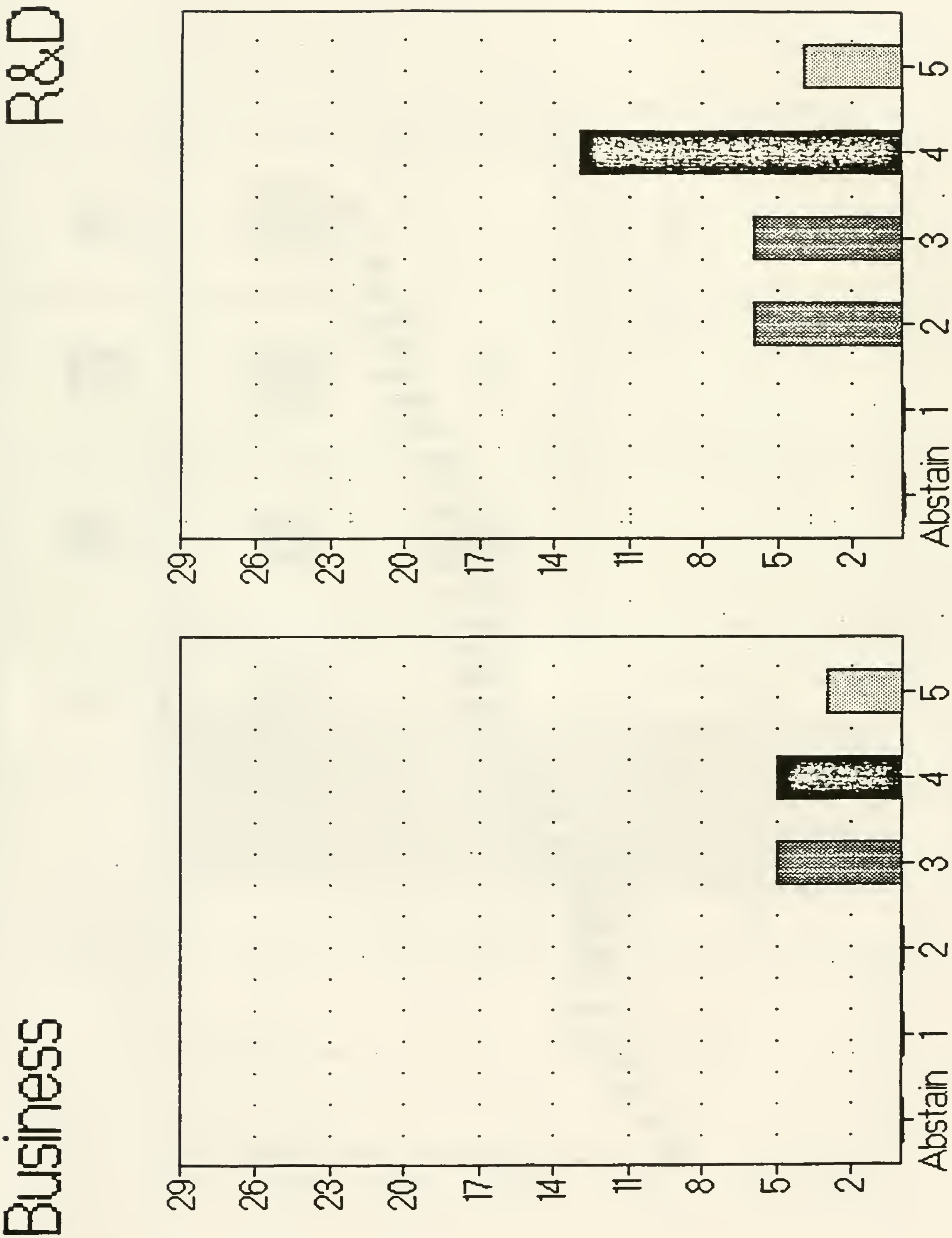

Figure 3. Histogram of Scores for R&D and Business Groups

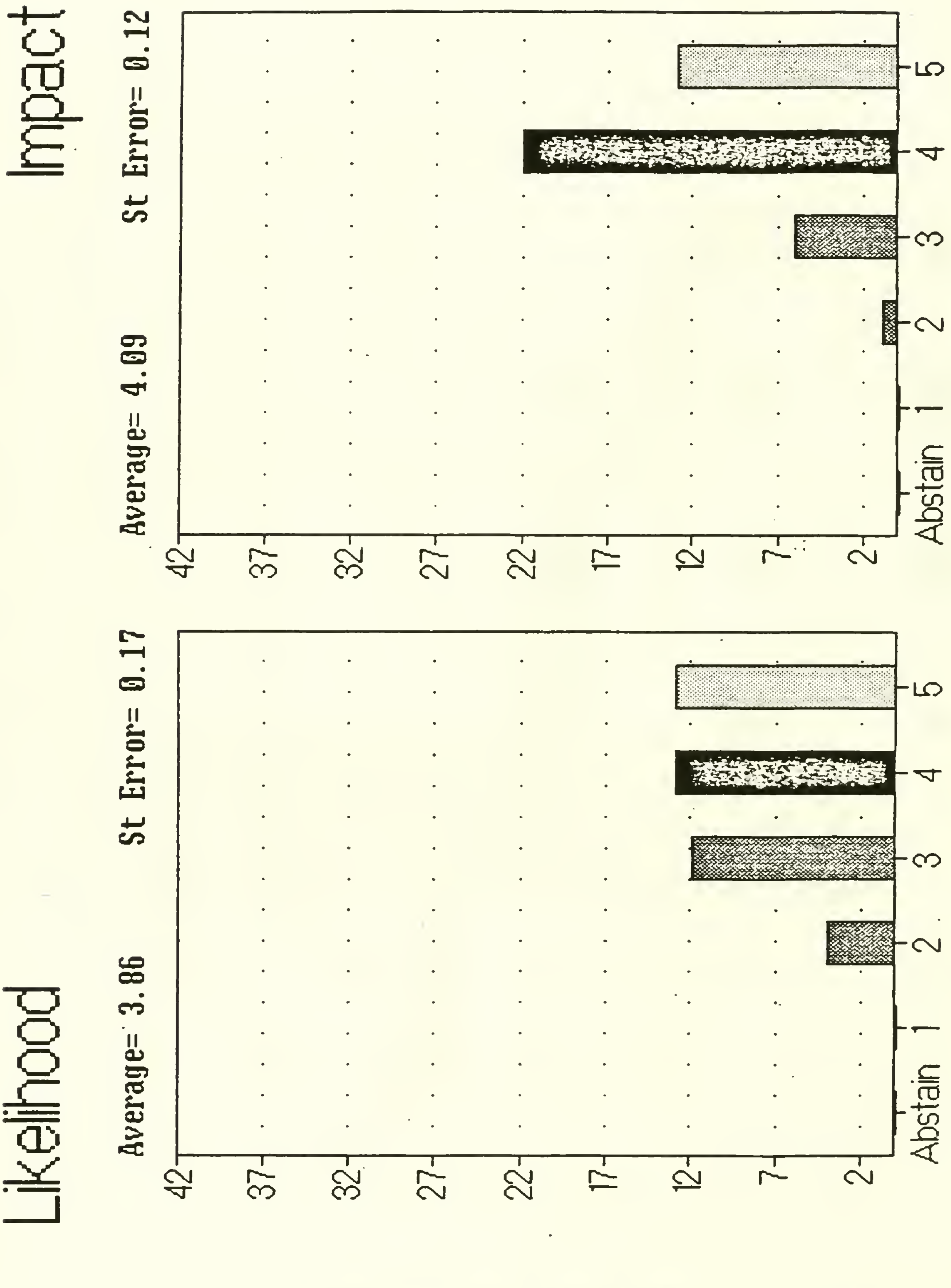

Figure 6. Histogram of Scores for Relative Likelihood and Relative Impact

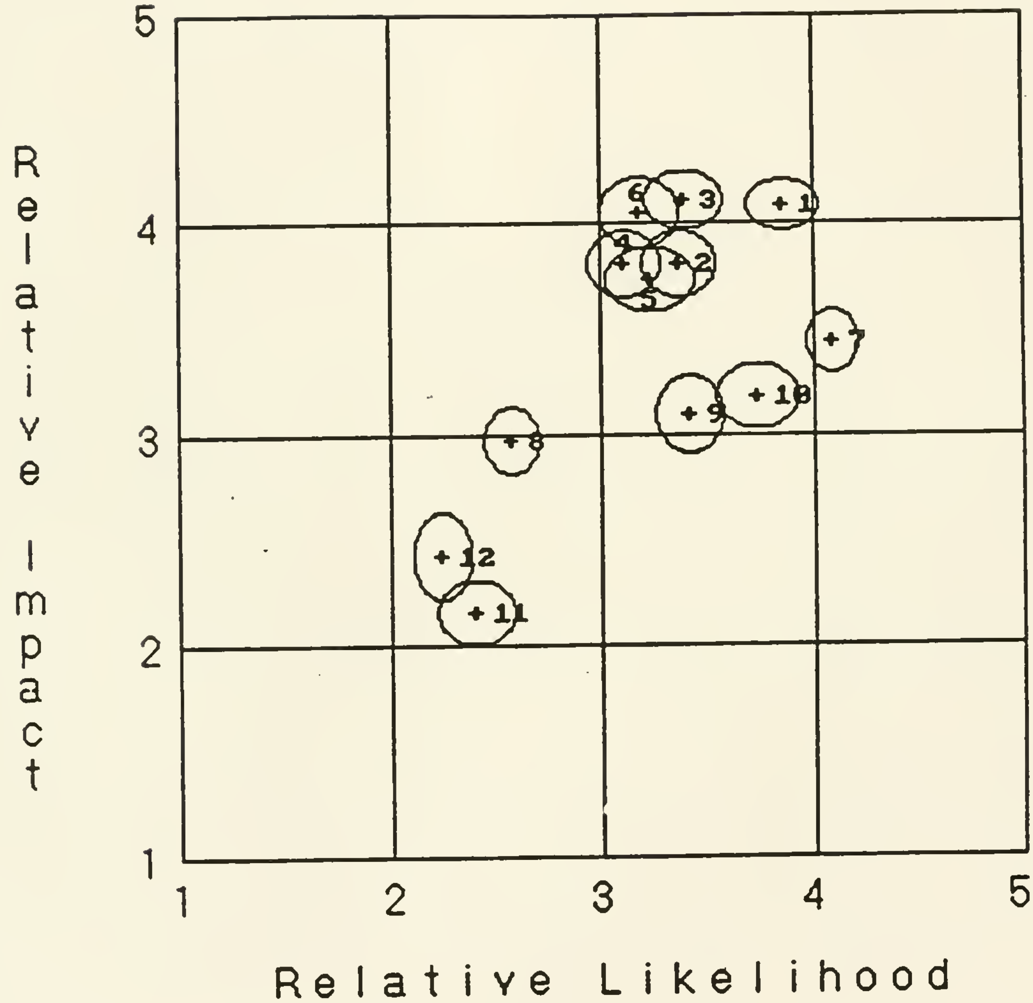

Figure 7. Grid Showing Average Scores and Standard Errors for Each Option